VOLUME 2 ISSUE 1 DECEMBER 2007

MADAGASCAR CONSERVATION & DEVELOPMENT

INVESTING FOR A SUSTAINABLE NATURAL ENVIRONMENT FOR FUTURE GENERATIONS OF HUMANS, ANIMALS AND PLANTS OF MADAGASCAR

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MWC

Jane Goodall Institut Schweiz

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EDITORIAL

The Forests of Madagascar do matter

Madagascar had a rough start into the year 2007. After cyclones Anita, Bondo and Clovis in December, Gamede and Favio in February, Indlala cut across Madagascar just two weeks before Jaya came ashore at the northern tip of Madagascar at the beginning of April. They caused flooding, displacement, crop and forest damage, as well as other detrimental short-term effects. The cumulative impacts of these seven cyclones will be immense and hard to quantify. On average, there was more precipitation per day during these four months in 2007 than averaged over the last ten years. While the northern part of the island was suffering from flooding, an extended drought created struggle amongst the Malagasy people in the south, once more demonstrating how diverse the climatic influence can be even on a single island. In total, around half a million people were directly affected by these erratic weather events.

In June 2007, the Antsinanana rainforests were inscribed to the UNESCO's World Heritage List comprising of six national parks distributed along the eastern part of the island. These rainforests harbor more than 80 % of endemic species, which is important to be under best possible national and international protection, since threats are omnipresent. The IUCN / SSC Primate Specialist Group just recently published an updated list of the 25 most endangered primate species for 2006-2008. The 'representatives' for Madagascar are four lemur species of which the Greater bamboo lemur, the White-collared lemur, and the Silky sifaka were reconfirmed on the list, and the Sahamalaza sportive lemur, a recently described species, replaced the Perriers sifaka. These lemurs share a common tragedy: they live in more and more isolated and patchy forest habitats.

The forests of Madagascar cover about 20 % of the island's surface, presenting a variety of ecosystems, hosting the majority of terrestrial faunal and floral species. These forests are characterized by a high degree of endemism, and, as Goodman and Benstead (2005) consequently point out, they contribute a "critical component of the global biological diversity." Forests also function as a 'seemingly endless' resource of energy and food for a majority of the Malagasy population, with its timber being appreciated beyond Malagasy borders. The list of forest processes like water or nutrient cycling, carbon sequestration, decompositions, etc. seems almost endless. However, these forests are faced with a fast growing human population, needing more and more fuel wood (just to name one major human need), and must cope with enormous impacts from natural disturbances like cyclones and droughts. Together, there are incredible accumulative pressures, both human and natural, which continuously affect and reshape these ecosystems. However, forests in Madagascar "were not just born yesterday," as Lucienne Wilmé points out in the foreword for this issue, and they are probably more resilient than we can assume. Nevertheless, if we want to maintain this broad array of forest values to meet present needs without compromising the ability of future generations to meet their own needs, we have to understand how forest ecosystems work, to properly implement sustainable forest management policies and applications. We should try to achieve deeper understanding of how structures and compositions affect ecological functions and processes and how the latter interact with and react to biotic and abiotic forces and dynamics, especially in times of rapid global climatic changes.

Hence, the Editorial Board of the journal Madagascar Conservation & Development is happy to present an issue focused on forests, with articles dealing with the past 100 years of Malagasy forest use, development and management. Articles include discussion of recovery after a cyclone (e.g., Hudah), and disclosure of illegal extraction of precious wood in the Marojejy forest. For the future, we hope to be able to present a great variety of studies about forest related issues in this journal aiming at encouragement of more discussions and exchanges of ideas about this overarching resource termed 'forest'.

Thanks to the broad scope of the journal, it has the potential to move far beyond forest issues. Forests are an important component of Madagascar's diverse landscape, and the more we understand about the subject the more we can appreciate its range of values. However, there are far more aspects the island of Madagascar covers in terms of conservation and developmental realms. The UN declared the year 2008 campaign as the "International Year of the Reef." Coupled with the fact that Madagascar has a coastline of more than 4,800 km, we hope that the perspectives of oceanographers will induce some interesting projects about ocean initiatives reflecting conservation, developmental challenges and appropriate solutions in Madagascar.

REFERENCES:

Mittermeier, R.A., Ratsimbazafy, J., Rylands, A.B., Williamson, L., Oates, J.F., Mbora, D., Ganzhorn, J.U., Rodríguez-Luna, E., Palacios, E., Heymann, E.W., Kierulff, M.C.M., Yongcheng, L., Supriatna, J., Roos, C., Walker, S., and Aguiar, J.M. 2007. *Primates in peril: the world's 25 most endangered primates, 2006-2008.* Primate Conservation, 22, 1-40.

Goodman, S.M. and Benstead, J.P. 2005. *Updated estimates of biotic diversity and endemism for Madagascar.* Oryx, 39:1, 73-77.

Patrick O. Waeber, Founder Editor

FOREWORD BY MERVYN BROWN

The wealth of trees and the pressures of population

It is a pleasure to introduce the second in what promises, and deserves, to be a long series of this journal on the important areas of conservation and development in Madagascar.

The first edition was impressive both in its breadth of subjects and in its depth of detail. This edition has more of a focus, and the subject is principally trees. The richness of the forests in Madagascar and the wealth of remarkable creatures they support are well-known. The pressures on the forests are equally well-known, and lie at the heart of the issues that dominate debate on the balance of development and conservation. It is now increasingly evident that the need to conserve natural assets is not only compatible with economic and social development but is to a large extent dependent on it: people desperate for resources to live cannot be expected to be as sparing of precious trees and the like as others would want them to be. But it is also clear that the potential drivers of economic development in Madagascar can bring their own pressures on the environment, in areas such as mining (due to increase its contribution from 4 % of GDP now to 30 % by 2012), road-building and even tourism, even though sensible eco-tourism is the type of development that seems well-suited to satisfy the interests of all parties. The proposals in President Ravalomanana's Madagascar Action Plan do at least reflect his concern to protect the natural resources of the country, and he has made substantial steps in increasing protected areas of the natural environment while promoting a better business environment to encourage investment.

The pressure of population growth is of critical importance. When I was first in Madagascar in 1967 the country's population was 6 million. Now it is estimated to be some 19 million and is forecast to grow to more than 50 million by the year 2030. Substantial economic growth is needed just to match that growth in population, let alone to improve living standards, and the impact of such large numbers of people on natural resources is considerable. It is of crucial importance that the Malagasy government is able to make good progress towards its target of reducing the average size of families to 3-4 children from the present figure of 5.4.

I would like to mention the issue of funding, and to finish with a request for some assistance. The running costs of the journal are remarkably low: the articles that are submitted are done so freely; the editors contribute their time for no charge; and the fact that the journal is distributed online keeps publishing costs down. However, there are still lay-out charges that amount to several thousand Euros. The editors would also like, with good reason, to be able to distribute the journal more widely in Madagascar itself and they believe that they can best achieve this by offering there a paper as well as an electronic version, which would entail printing costs of a similar amount. If you are able to contribute in any way, or if you have any suggestions on the raising of funds, then please do get in touch with the editors.

Sir Mervyn Brown, Former British Ambassador to Madagascar; Member of the Academie Malgache

FOREWORD BY LUCIENNE WILME

Elles ne sont pas tombées de la dernière pluie!

Lors d'une conversation avec Chris Birkinshaw, nous nous sommes aperçus que malgré l'accumulation d'expériences, nous revenions régulièrement vers une de nos lectures classiques: Humbert 1965 et sa description des types de végétation de Madagascar. À chacune de nos relectures, nous redécouvrions des aspects que nous avions alors survolés ou qui ne prenaient formes qu'avec nos nouvelles visions de la biodiversité malgache. Nombreux auront été ceux à défaire le schéma du Professeur, à tenter de l'adapter à divers groupes d'animaux et de plantes et même à proposer de nouveaux schémas mais maintes fois ont avoué que Humbert reste indémodable, le classique qui reste tellement moderne. Car Humbert a bâti son ouvrage sur une extraordinaire expérience de terrain, et lorsque le Professeur nous parle des forêts de Madagascar, il fait parler les forêts car il les aura écouté et cette expérience accumulée sur les montagnes de Madagascar est irremplaçable et n'aurait su se contenter de travaux de laboratoire.

Réduire les forêts de Madagascar aux quelques catégories retenues par les uns et les autres sur la base des espèces qu'elles abritent, des caractéristiques climatiques, géologiques et autres pour les modéliser minutieusement avec des pixels informatisés sont autant d'outils basés sur d'importants travaux et qui sont destinés à mieux comprendre les milieux naturels de Madagascar dans le dessein de les protéger. L'accumulation des informations obtenues au cours des dernières années sur l'histoire naturelle de Madagascar requiert des outils de plus en plus sophistiqués car nous en savons encore bien trop peu, mais ce n'est pas pour cette raison que les écrits du Professeur ont pu rester d'actualité.

Il est au moins une chose qui n'a guère changé depuis plus d'un demi siècle: les explorations sur le terrain, les anciennes 'tournées' sont juste devenues les nouvelles 'expéditions'. À quelques gadgets près, comme le GPS qui a remplacé la boussole, l'équipement de base est le même et nos destinations sont restées sylvestres. Et surtout, nous faisons appel aux interprètes. Les interprètes sont ces villageois qui ont grandi à côté des forêts, qui n'ont pas de formation scientifique, mais une connaissance fine du milieu forestier, qui comprennent les signes, en résumé les écologistes de la région. Dans le Marojejy par exemple, ces écologistes nous intègrent généralement dans leur village, font appel à la bienveillance de nos ancêtres afin qu'ils nous protègent avant de nous guider à travers les montagnes. Et le professeur a découvert cette montagne avec Tsibohina comme l'avait fait le capitaine Aragon avant lui en 1937. Quelques 50 ans après, je découvrais le Marojejy avec Jolaza, Erik Patel est redevable à Rabary Desire et Nestor Jean Randrianasy ... et ces écologistes nous ont appris à nous émerveiller dans les forêts qui sont les leurs et celles de leurs ancêtres et qui auront valu cette superbe phrase du Professeur en page 7 de son ouvrage de 1955 sur le Marojejy: « le massif le plus prestigieux de l'île entière à la fois par son aspect grandiose, par sa richesse floristique et, surtout, par son caractère de nature inviolée sur la presque totalité de son étendue et sur le plus grande partie des avant-monts, c'est le Marojejy! »

Il n'est de forêt à Madagascar qui ressemble à une autre. Elles sont plus ou moins différentes, se ressemblent parfois mais ne sont jamais identiques. Vous espérez devenir plus intimes avec elles après quelques années, mais la réalité s'impose rapidement d'elle-même: les forêts de Madagascar ne sont pas tombées de la dernière pluie et se sont remises de plus d'un cyclone. Elles sont vieilles, très vieilles et il nous faut regarder dans les temps anciens, les temps géologiques, bien avant l'arrivée des hommes sur Madagascar, pour tenter de leur arracher quelques uns de leurs secrets.

Humbert est resté moderne car il a fait bien plus qu'étudier la forêt de Madagascar, il l'a écoutée. Rien ne remplacera jamais le terrain, et si l'avenir de la Science à Madagascar passe certainement par Internet et l'emploi d'outils de plus en plus sophistiqués, les forêts de Madagascar ne pourront être sauvées que si nous sommes nombreux à les adopter et les écouter. Les premiers ambassadeurs de ces forêts sont les Tsibohina et les riverains de toutes les forêts de Madagascar, et les jeunes étudiants et les chercheurs de Madagascar l'ont bien compris car ils les remercient sincèrement dans les publications de leurs travaux. Nous avons tous une dette envers ces guides, assistants de terrain, ces écologistes riverains et ce journal peut prendre le relais pour être le porte parole des forêts de Madagascar, mais ne blâmons ni les bûcherons ni les forces de la nature, essayons de comprendre et d'écouter pour trouver la meilleure solution. Depuis plus de cent ans, il y a urgence à sauver la forêt de Madagascar. Le fourré épineux du sud n'est plus que peau de chagrin, les forêts sèches de l'ouest avec ses gigantesques baobabs sont menacées comme elles ne l'ont jamais été et reculent tous les ans devant les flammes. Quelques forêts sèches mais aussi de belles forêts humides reculent depuis quelques années devant un phénomène qui a pris de l'ampleur: l'exploitation des ressources minières. Mais qui blâmerait un pays de mettre sa forêt sur le billot pour lutter contre la pauvreté de ses habitants? Les alternatives ne tombent pas forcément sous le sens mais les sacrifices devront être dûment pesés même si la forêt de Madagascar est inestimable; elle se meure en bien des endroits mais puisse-t-elle devenir la meilleure alliée des générations futures, que les Malgaches ne fassent pas les erreurs des pays développés en sacrifiant ses richesses naturelles mais qu'ils écoutent leurs ambassadeurs qui ont ouvert leurs sens à sa vieille alliée: la forêt !

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FOREST MANAGEMENT

Forest Management in Madagascar: An Historical Overview

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ABSTRACT

Madagascar is regarded as one of the most important areas for biodiversity on Earth, and this biodiversity is found mainly in Madagascar's forests. Rural Malagasy people struggle to meet their daily food needs and often turn to the forest for new agricultural land. Efforts to curb deforestation and conserve threatened and endangered species undertaken by the Malagasy government and by international conservation and development organizations have been shaped by the history of forest management in the country. This paper traces the evolution of forest management in Madagascar from pre-colonial times to the present in an effort to contextualize current efforts to create new protected areas and transfer forest management responsibilities from the central government to local communities. In addition, the history of forest management is critically examined with respect to the assumptions about the role of government and the governed, as well as the dominant narrative that drove policy, providing context for understanding the approach currently underway in Madagascar.

INTRODUCTION

Madagascar is regarded as one of the most important areas for biodiversity on Earth. The island is a global priority for conservation (Goodman and Benstead 2003; Myers et al. 2000) because its biodiversity faces a wide variety of threats, including habitat loss and fragmentation, and overexploitation of commercially valuable species of plants and animals.

Changes in human activity on the island have resulted in an alarming rate of deforestation in Madagascar (Nelson and Horning 1993), putting both biodiversity and local livelihoods at risk (Donohoe 2003; UNDP et al. 2000). It is estimated that although deforestation rates have decreased from 0.82 % per year between 1990 and 2005 to 0.55 % per year between 2000 and 2005 (Conservation International et al. 2007), they remain high, resulting in negative impacts on biodiversity, hydrology, and carbon cycles. Global deforestation has been linked to a variety of direct and indirect factors, including the introduction of coffee cash cropping (Jarosz 1993), population growth (Green and Sussman 1990), timber export (UNDP et al. 2000), and local, national, and global political and economic factors (Kull 2000; Moser 2006). In addition to such global factors, major domestic threats to forests in Madagascar include clearing for subsistence agriculture (tavy), charcoal, timber, and mining (Ganzhorn et al. 1997). Although the practice of tavy may be a low-input, labor-efficient agricultural technique, it has negative impacts such as increased soil compaction and erosion (Erdmann 2003). However, other factors such as political resistance to restrictive policies have also been identified as contributing to current rates of deforestation (Klein 2002; Jarosz 1993).

Madagascar is also among the poorest countries in the world with per capita GDP at US$ 290 in 2005, an infant mortality rate of 76 / 1000 births, and only 45 % primary school completion rate (The World Bank 2007). The country is stricken by frequent natural disasters such as cyclones, flooding, and drought. Food security is an issue as only 0.1 % of the national surface area is under agricultural cultivation (estimate in 2000) because of poor soils, and people struggle to meet their daily food needs (The World Bank 2007). Thus, the pressure to eke out food production from the land leads to forest clearing.

Efforts to curb deforestation and conserve threatened and endangered species undertaken by the Malagasy government and by international conservation and development organizations have been shaped by the history of forest management in the country. This paper traces the evolution of forest management in Madagascar from pre-colonial times to the present in an effort to contextualize current efforts to create new protected areas and transfer forest management responsibilities from the central government to local communities. In addition, the history of forest management is critically examined with respect to the assumptions about the role of government and the governed, as well as the dominant narrative that drove policy, providing context for understanding the approach currently underway in Madagascar.

PRE-COLONIAL FOREST POLICIES AND PRACTICES

Forest conservation and management in Madagascar has a long history that dates back to pre-colonial times (Table 1). James Sibree, a British missionary who spent 50 years on the island attributed deforestation to shifting agriculture and timber concessions: [Madagascar is] being diminished every year by the wholesale destruction of the forest in burning it for rice-planting, and it is grievous to see how recklessly it is cut down and destroyed for this and other more trivial reasons. The large concessions of forest land to European companies for timber-cutting and plantations also tend in the same direction, and unless some plan of forest conservation is soon effected, the

TABLE 1. Summary of the evolutions of forest policy in Madagascar

PERIOD		DOMINANT NARRATIVE	POLICY	ROLE OF GOVERNMENT	ROLE OF GOVERNED
Pre-Colonial (through 1896)		Madagascar was once fully forested	Cutting live firewood forbidden	Create and enforce repressive forest policy (through banning deforestation)	Abide by centrally-created laws
		Deforestation resulted from human activity	Burning and settling in forests forbidden	Ensure forests (i.e., royal property) are preserved for the use of royals	
			Clearing the land for agriculture forbidden		
Colonial (1896-1961)		Madagascar's forest resources are for French use and to enrich France	Reforestation of fast growing species	Create and enforce repressive forest policy (through establishing conservation areas or banning deforestation)	Abide by centrally-created laws
		Malagasy are unable to manage forests	Hunting lemurs forbidden	Manage forests unilaterally	Resist centrally-created laws by continuing tavy as a cultural practice
		Reforestation is needed for human consumption and development	Forest fires and deforestation forbidden		
			Logging concessions established		
Post-Colonial (1962-Present)	Early Independence (1962-1991)	The State is the only legal manager of forest resources	Deforestation forbidden	Create and enforce repressive forest policy	Abide by centrally-created laws
		Deforestation resulted from human activity	Hunting of several species forbidden	Manage forests unilaterally	Resist centrally-created laws by continuing tavy and burning as cultural practices
			Reforestation mandatory		
	NEAP Era (1992-Present)	Conservation is needed to save Malagasy biodiversity	Integrated conservation and development projects	Create protected areas	Stop destructive forest practices
		Standardized models are appropriate	Fences and fines	Enforce laws	Use economic development activities as an alternative to resource extraction
				Provide economic development opportunities	
	Community-based Forest Management	Local people can manage and conserve forests	Decentralization of forest management	Transfer management rights and responsibilities to local people	Conserve and manage forests for long-term sustainability
		The state is ill-equipped to manage forests effectively everywhere	Empowerment of local forest users to make decisions regarding forests	Monitor and oversee local-level management decisions	Adhere to principles established by the government or third-party NGOs

beautiful woods, with most of their flora and fauna, will eventually disappear (Sibree 1896 : 363).

Sibree's and others' observations regarding forest destruction reflect the attitudes of the time, which informed traditional forest conservation in Madagascar – top-down and repressive policy enforcement. Records dating as far back as the early nineteenth century document this approach to forest management. At that time, King Andrianampoinimerina (1745-1810) of Madagascar banned the cutting of live firewood and declared all forests in his kingdom as royal property. It is reported that he declared, "...it is forbidden for people to come to forge clandestinely arms in the forest because they can prepare a rebellion" (Ratovoson 1979:22). Similarly, Prime Minister Rainilaiarivony declared that anyone caught cutting pristine forest would be chained in irons (Sibree 1881).

Two definitive pieces of legislation appeared in the mid-nineteenth century: The Code of 101 Articles in 1868 and the Code of 305 Articles in 1881 (Henkels 2001). Both concerned civil law, criminal law, and procedure (Ratovoson 1979). Article numbers 101-106 forbade burning of forests and settling of people in the forest. Article 105 forbade the practice of tavy: "One may not clear the forest by fire with the goal of cultivating rice fields, corn or other crops. One who clears by fire a new terrain or expands those which exist already, that person will be put in irons" (Ratovoson 1979 as translated by Henkels 2001-2002: 2). Early legislation such as this fueled the argument that Madagascar was once completely covered by forest and human activity alone had resulted in dramatic forest cover loss (Sibree 1896).

COLONIAL FOREST PRACTICES

Top-down approaches to forest management continued during the colonial period (1896-1961). Soon after the French took control in 1896 they established the Water and Forests Service and declared all forests to be under government control or in the public domain. The French also began an intense reforestation program on the central plateau and eastern escarpment of the island by establishing plantations of fast-growing, nonnative species such as eucalyptus and pine. They banned the killing of lemurs, and in 1927 established the first protected-areas system in the Africa region (Tyson 2000). In 1930, the French-led government passed Article 36, which prohibited all forest fires and other forms of deforestation (Montagne 2004). At this time, no distinction was made between forest fires started for the purposes of creating agricultural fields, and those associated with rejuvenating pasture land (Maldidier 2000). However, the French also contributed to deforestation in Madagascar. They planted much of the eastern lowlands with coffee, displacing many Malagasy farmers and clearing natural forest in the process (Tyson 2000). In fact, the beginning of massive deforestation is thought to be the direct result of coffee cash cropping (Jarosz 1993). Since local people no longer had access to lowlands, they began cultivating less fertile, higher slopes for slash-and-burn agriculture (tavy). French officials responded by prohibiting the clearing of forests for tavy.

The tavy ban backfired, leading to popular unrest and more deforestation. The Malagasy circumvented the prohibition where they could and resented the French for banning a practice that had been, and still is, a sustainable system in the tropics as long as population densities are low and fallow lengths are long, and representative of a means of subsistence inherited from the ancestors. The ban had the effect of elevating the tavy way of life to a ritual that symbolized resistance to colonial rule. As Jarosz (1993 : 374) notes, Resistance to the ban was more than pitting the right to subsistence over forest conservation; it embraced issues of power, labor control, and Malagasy identity. Not surprisingly, the French failed to eradicate the practice; likewise, the postcolonial state is beset with the same difficulties.

The French also directly contributed to deforestation in Madagascar by opening the state's forests to logging concessions. In their search for precious woods such as ebony, rosewood, and palissandre, concession owners clear-cut lands beyond the boundaries of their concessions. The Water and Forests Service was unable to enforce regulations due to a lack of labor, capital, and political will. Forest Service agents often allowed infractions to slip by because of their personal relationships with concession owners (Rapport du Service Forestier 1922).

The Colonial period is thus characterized by a palpable tension between the government and the governed. This tension focused on the practice of shifting cultivation as Colonists and local people struggled to advance their interests and impose their will on land use. Whereas for the Malagasy peasants, shifting cultivation was a cultural practice that affirmed their identity, linked them to the ancestors, and allowed them a means of resistance to state authority, the colonial authority saw shifting cultivation as a destructive practice that resulted in degraded grassland and hindered state-led forest extraction, labor control, and tax collection (Jarosz 1993).

POST-COLONIAL FOREST POLICIES AND PRACTICES

Madagascar gained its independence from France in 1961, but this had little effect on its forest management policy until very recently. In addition to the 1930 forest law that banned forest fires, other laws continued to be passed, including one that prohibited the hunting of several endangered species. In 1962, President Philibert Tsiranana declared that all men had to plant 100 seedlings a year or suffer a tax (Tyson 2000). This string of legislation reinforced the state as the only legitimate manager of forest resources in Madagascar, and contributed to a repressive relationship between the forest service and local people (Montagne 2004).

Nonetheless, despite decades of forest conservation laws, the decrease in Madagascar's forests throughout most of the twentieth century has been attributed to corruption among forest service employees, lack of motivation to adhere to forest policies among poor rural people, and the government's inability to monitor the forest and enforce policies because of a lack of resources, bad roads, and difficult terrain (Ganzhorn et al. 1997). Forest practices in Madagascar since 1930 can be characterized as open access, where individuals and groups exploiting forest resources were both uncontrolled and uncontrollable by the government. The result was a paradoxical conflict between illegal local-level forest exploitation regarded as legitimate by local people, and the legally-sanctioned forestry policies regarded as illegitimate by local people (Bertrand and Razafindrabe 1997; Montagne 2004). This pattern of behavior and interaction between the government and the governed continued through the 1960s and 1970s.

THE NEAP ERA

In the mid-1980s, Madagascar's political climate began to change as it moved from an insular, quasi-communist political system closely tied to the Soviet Union, to a socialist democracy open to foreigners and foreign ideas. Due to this change, international biologists and ecologists began coming to Madagascar. Madagascar's reputation as a refuge for unique biodiversity was well known from its biogeography and from early Portuguese, British, and French records, but with modern methods and techniques, scientists were able to identify and classify many new organisms.

The move toward more open policy and increased interaction with foreigners also affected Madagascar's development agenda. The early 1990s met with a flurry of conservation and development activity. Bi-lateral and multi-lateral donor agencies such as the United States Agency for International Development (USAID) and the World Bank increased their involvement and funding levels. Policies and programs were developed, including Africa's first National Environmental Action Plan (NEAP). This plan was designed to include three five-year phases. Phase I (1992-1997) responded to the increasing consensus about the importance of Madagascar's unique biodiversity, and focused on the creation of protected areas and the institutional and organizational structures necessary for their management. This initial period was characterized by Integrated Conservation and Development Projects (ICDPs) in peripheral zones of protected areas, which were meant to compensate local people with micro-development projects as mitigation of restrictions on access to resources imposed by new protected areas.

Despite millions of dollars of investment, Phase I had mixed results (e.g., Barrett and Arcese 1995; Peters 1998). The policy of standardized projects made up of four main components (i.e., protected areas, buffer zones, compensation, and economic development), grew out of a deep-seated development discourse (Brechin et al. 2002). This discourse views development as a linear trajectory from less developed to developed, that should be followed by all nations regardless of culture, resource availability, or history. Similarly, the discourse advocates standardized approaches to achieving development from site to site (Scott 1998; Peet and Hartwick 1999). Results of this discourse and policy were that protected areas were disjointed from the economic development activities in peripheral zones meant to serve as alternatives to destructive environmental practices. Providing health centers or schools did not dissuade local people from practicing tavy, and the link between conservation and development was not made. Thus, the government, along with conservation and development donors and implementing organizations, imposed a model of development ill-suited to the local context in many ways, and local people struggled to navigate the new webs of relationships and institutions created by ICDPs.

Evaluations of Phase I activities indicated that the creation of a few dozen protected areas was not a viable approach to long-term sustainable management of Madagascar's natural resources (Montagne 2004). In addition, the ICDP model was deemed too centralized and standardized across sites to respond to local-level specificities. As a result, the Malagasy government and other actors interested in sustainable forest management began to look for new legal structures and institutional arrangements for forest governance. This trend reflects a global move toward more bottom-up, democratic, and participatory methods for designing and implementing natural resource-related policies and programs in developing countries (Durbin and Ralambo 1994; Peters 1998; Brechin et al. 1991; Chambers 1997).

COMMUNITY-BASED FOREST MANAGEMENT

In the 1990s, faced with high rates of deforestation and inefficient forestry practices, the Malagasy government, with support from international conservation and development organizations, pushed for a new community-based natural resources management policy (Bertrand 1994; Rajaonson et al. 1995; Kull 2002). This policy, known as GELOSE, is applicable to forests, pastures, wildlife, and water. It aims to promote better resource management through local-level management, rule-setting, and enforcement, leading to better environment stewardship. GELOSE was signed into law on September 10, 1996 (law No. 96-025), and in 1997, the law was incorporated into the new national forestry policy (Law 97-107 and Decree 97-1200).

The GELOSE law allows for the creation of tripartite negotiated contracts among the state (represented by the forest service), the municipality (i.e., mayor's office), and a voluntary association of community residents created for the purpose of this contract (i.e., Communauté de Base or COBA). The law does not stipulate how this association should be constituted – it may be constituted through some form of representation or include all village residents. However, no local resident can be excluded from the COBA association. Under GELOSE contracts, communities regulate resource use through dina, a locally-developed social agreement whose form pre-dates state-sanctioned rules (Henkels 2001; Marcus 2000). Contract negotiations are coordinated by an "environmental mediator" and the process for establishing a GELOSE contract, which is described in legislation, includes 22 steps (Kull 2002).

Only in 2000 did the GELOSE law receive the first two installments of its decrees (décrets d'application). Because implementation of GELOSE was viewed as complex and cumbersome, a piece of enabling legislation specific for forests was defined under order No. 2001-122. This policy, Contractual Forest Management (Gestion Contractualisée des Forêts or GCF), simplifies the process for transferring forest management rights to communities by eliminating the need for an environmental mediator and reducing the contract signatories to two: the state (represented by the regional office of the Ministry of Environment, Water, and Forests), and the COBA (Kull 2002; Antona et al. 2004).

The move toward community-based natural resources management gained momentum during the second of three five-year phases of the NEAP. Phase II (1998-2003) activities emphasized a landscape approach to natural resources management outside protected areas and included participatory approaches to conservation and development (Montagne 2004). GELOSE and GCF contracts were a major component of Phase II activities, and currently over 400 GELOSE and GCF contracts exist throughout Madagascar.

Law 96-025 allowed for local populations to take part in decision making and actions related to local natural resource management, but it did not specify the institutional mechanisms by which this should occur (i.e., representation by election, volunteer membership, etc.). GELOSE and GCF were mainly an experiment to transfer the management of local forest resources for subsistence use as well as conservation (Randrianasolo 2000); a small number of contracts attempted to generate economic benefits via the harvest of forest products, including timber. Subsistence use in this case included harvesting of timber products for domestic consumption such as home construction and firewood.

Phase III of the NEAP (2004-2008) aims to mainstream the environmental agenda and also includes a major initiative to expand the protected area network. In 2003, the President of Madagascar, Marc Ravalomanana, declared his "Durban Vision" to expand the surface area of protected areas from 1.7 million hectares to 6 million hectares by 2012. This will put Madagascar within IUCN's recommended standard of having 10 % of the country's land area under some form of protection. The protected area network, which will include both pre-existing and new protected areas, is now known as the System of Protected Areas of Madagascar (Système des Aires Protegées de Madagascar, or SAPM). Under SAPM, the majority of new protected areas are likely to be co-managed, and one vision for this co-management is that local communities will partner with government through COBA structures set up via GELOSE and GCF contracts.

GELOSE and GCF arrangements, whether or not associated with protected areas, can have a strong conservation component. Despite rhetoric of local empowerment to make decisions about forest management, these governance arrangements are substantially controlled. COBA are given management responsibilities for an initial period of three years, renewable for ten years. They are not granted land tenure (though under GELOSE there is an option for enhanced tenure security). In addition, third parties such as conservation and development NGOs play a strong role in orienting management plans and zoning of these areas. Their field agents often initiate community-level discussions regarding resource management and their agendas are often reflected in the management plans or zoning systems developed for community-managed areas (e.g., Antona et al. 2004). Thus, the effort to decentralize forest management in Madagascar has transferred some powers to local people while maintaining a certain level of centralized control.

CONCLUSION

Forest management in Madagascar has evolved over the last century from top-down, centralized legislation that aimed to restrict access to forest resources to more decentralized governance forms that attempt to put local people at the center of decision making. Although by tracing legislation this trend is clearly apparent, implementing truly decentralized governance is a complex process that involves institutional structure and power dynamics that are difficult to modify. In Madagascar, decentralized governance arrangements are changing the web of interactions among actors such as government, international agencies, and local communities in an attempt to shape power dynamics. Nevertheless, it is still unclear the extents to which local communities are able to capture the opportunity these changes represent and ensure their interests are represented. Understanding how these dynamics are evolving is a crucial step for monitoring the implementation of these policies and improving upon them over time. Additional research is needed to assess how these institutional changes are affecting principles of good governance such as participation, accountability, and transparency in decision making.

ACKNOWLEDGEMENTS

Funding for this work was provided by the National Science Foundation Graduate Research Fellowship, the Mario Einaudi Center for International Studies International Research Travel Grant, and the Cornell University Center for the Environment Student Environmental Research Grant. We are grateful to residents of the communities, forest agency staff, and NGO personnel who participated in this study.

REFERENCES

Antona, M., Bienabe, E. M., Salles, J., Pechard, G., Aubert, S., and Ratsimbarison, R. 2004. R*ights transfers in Madagascar biodiversity policies: achievements and significance.* Environment and Development Economics 9: 825-847.

Bertrand, A. 1994. *Revue documentaire prealable a l'elaboration d'une politique et d'une strategie de gestion des feux de vegetation a Madagascar.* CIRAD November.

Bertrand, A., and Razafindrabe, M. 1997. *Lever l'insécurité foncière: une des premières clefs du développement de Madagascar.* Paper read at Colloque International Politiques des Structures et Action Foncière, 24-26 November, at La Réunion.

Brechin, S. R., West, P. C., Harmon, D., and Kutay, K. 1991. *Resident peoples and protected areas: a framework for inquiry.* In: Resident peoples and national parks: social dilemmas and strategies in international conservation, P. C. West and S. R. Brechin (eds.), pp 5-28. University of Arizona, Tuscon.

Brechin, S. R., Wilshusen, P. R., Fortwangler, C. L. and West, P. C. 2002. *Beyond the square wheel: Toward a more comprehensive understanding of biodiversity conservation as social and political process.* Society & Natural Resources 15, 1: 41-64.

Chambers, R. 1997. *Whose Reality Counts? Putting the First Last.* Intermediate Technology, London.

Conservation International, IRG, Ministere de l'Environnement des Eaux et Forets, and USAID. 2007. *Change in Natural Forest Cover Madagascar 1990-2000-2005.* Conservation International, Washington, DC.

Donohoe, M. 2003. *Causes and health consequences of environmental degradation and social injustice.* Social Science & Medicine 56, 2003: 573-587.

Dufils, J. M. 2003. *Remaining forest cover.* In: The Natural History of Madagascar, S. M. Goodman and J. P. Benstead (eds.), pp 88-96. University of Chicago, Chicago.

Durbin, J. C., and Ralambo, J. A. 1994. *The role of local people in the successful maintenance of protected areas in Madagascar.* Environmental Conservation 21, 2: 115-120.

Erdmann, T. K. 2003. *The dilemma of reducing shifting cultivation.* In: The Natural History of Madagascar, S. M. Goodman and J. P. Benstead (eds.), pp 134-139. University of Chicago Press, Chicago.

Ganzhorn, J. U., Langrand, O., Wright, P. C., O'Connor, S., Rakotosamimanana, B., Feistner, A. T. C. and Rumpler, Y. 1997. *The state of lemur conservation in Madagascar.* Primate Conservation 17: 70-86.

Goodman, S. M., and Benstead, J. P. (eds.). 2003. *The Natural History of Madagascar.* University of Chicago, Chicago.

Green, G. M., and Sussman, R. W. 1990. *Deforestation history of the eastern rain forests of Madagascar from satellite images.* Science 248, 4952: 212-215.

Henkels, D. 2001. *A close up of Malagasy environmental law.* Vermont Journal of Environmental Law 3: 1-16.

Jarosz, L. 1993. *Defining and explaining tropical deforestation: Shifting cultivation and population growth in colonial Madagascar (1896-1940).* Economic Geography 69, 4: 366-379.

Klein, J. 2002. *Deforestation in the Madagascar Highlands - Established ‚truth' and scientific uncertainty.* GeoJournal 56: 191-199.

Kull, C. A. 2000. *Deforestation, erosion, and fire: Degradation myths in the environmental history of Madagascar.* Environment and History 6: 423-450.

Kull, C.A. 2002. *Empowering pyromaniacs in Madagascar: Ideology and legitimacy in community-based natural resource management.* Development and Change 33, 1: 57-78.

Maldidier, C. 2000. Note de lecture des quatre rapports d'évaluation externe du PAE. ONE - SCAC, Antananarivo.

Marcus, R. R. 2000. *Cultivating Democracy on Fragile Grounds: Environmental Institutions and Non-Elite Perceptions of Demogracy in Madagascar and Uganda.* Unpubl. Ph.D. thesis, University of Florida.

Montagne, P. 2004. *Analyse rétrospective du transfert de gestion à Madagascar et aperçu comparatif des axes méthodologiques des tranfserts de gestion sous loi 96-025 et sous décret 2001-122.* Consortium RESOLVE - PCP - IRD, Antananarivo.

Moser, C. M. 2006. *A selection correction for cloud cover in satellite images in an analysis of deforestation in Madagascar.* In: Working Paper: University of Western Michigan.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A. B. and Kent, J. 2000. *Biodiversity hotspots for conservation priorities.* Nature 403: 853-858.

Nelson, R., and Horning, N. 1993. *AVHRR-LAC estimates of forest area in Madagascar, 1990.* International Journal of Remote Sensing 14: 1463-1475.

Peet, R., and Hartwick, E. 1999. *Theories of Development.* The Guilford Press, New York.

Peters, J. 1998. *Transforming the integrated conservation and development project (ICDP) approach: Observations from the Ranomafana National*

Park Project, Madagascar. Journal of Agricultural and Environmental Ethics 11: 17-47.

Rajaonson, B., Randriamarolaza, L. P., Randrianaivo, D., Ratsimbazafy, E., Rejo Tsiresy, V. and Bertrand, A. 1995. *Elaboration d'une politique et d'une strategie de gestion des feux de vegetation a Madagascar.* Office National de l'Environnement, Antananarivo.

Randrianasolo, J. 2000. *Capitalisation des Experiences en Gestions Contractualisées de Forets à Madagascar: Fichiers d'Experiences.* Intercooperation Suisse, Antananarivo.

Ratovoson, C. 1979. *Les problèmes du tavy sur la côte est Malagache.* Madagascar Review de Géographie 35, 148.

Scott, J. C. 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed.* Yale University, New Haven.

Sibree, J. 1881. *The Antananarivo Annual and Madagascar Magazine.* London Missionary Society Press, Antananarivo.

Sibree, J. 1896. *Madagascar Before the Conquest: The Island, the Country, and the People.* T. Fisher Unwin, London.

The World Bank. 2007. *Madagascar Data Profile.* The World Bank 2007 [cited January 4 2007]. Available from http://devdata.worldbank.org/external/CPProfile.asp?CCODE+MDG&PTYPE=CP.

Tyson, P. 2000. *Island of dreams.* In: The Eighth Continent: Life, Death, and Discovery in the Lost World of Madagascar. HarperCollins, New York.

UNDP, UNEP, World Bank, and World Resources Institute. 2000. *World Resources 2000-2001: People and Ecosystems: The Fraying Web of Life.* In: World Resources Series. United Nations, Washington, DC.

LOGGING

Logging of Rare Rosewood and Palisandre (*Dalbergia spp.*) within Marojejy National Park, Madagascar

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ABSTRACT

Illegal logging of precious wood has emerged as one of the most severe threats to Madagascar's northeastern rainforests. Thousands of logs, worth millions of dollars, have recently been confiscated at ports of Vohémar, Antalaha, and Toamasina. This report details the logging of rare, endemic rosewood and palisandre (*Dalbergia baronii*, *D. louveli*, and *D. madagascariensis*) within the eastern and northeastern portions of Marojejy National Park, Madagascar. Harvesting these heavy hardwoods is a labor intensive activity requiring coordination between local residents who manually cut the trees, but receive little profit, and a criminal network of exporters, domestic transporters, and corrupt officials who initiate the process and reap most of the profits. Structured interviews of residents identified three major perceived causes: decline in value of the local vanilla cash crop, extremely high value of rosewood, and local poverty. The impacts of such selective logging include violating local taboos as well as ecological consequences such as increased likehood of fire, invasive species, impaired habitat, and loss in genetic diversity. Recommendations include listing *D. louveli* under CITES Appendix III, increasing the involvement of the judicial system, no future authorizations for the gathering of precious wood, reforestation, and extensive monitoring along strategic roadways.

INTRODUCTION

Within the past few years, logging of endemic precious wood such as rosewood, palisandre and ebonies, has emerged as one of the most extensive forms of habitat disturbance within Madagascar's northeastern rainforests. Quantities of rosewood, worth millions of dollars and representing thousands of trees have recently been confiscated at the northern ports of Vohémar, Antalaha, and Toamasina (Raoel 2005; Alphonse 2007). Numerous reports have accumulated of precious wood logging within protected areas near these ports, such as Masoala National Park (Rubel et al. 2003), Marojejy National Park (Rasarely et al. 2005), and to a lesser extent Betampona Special Reserve (Kett 2005). The aim of this report is to review the conservation status of these precious woods and provide further details as to how, where, and why such logging has occurred within Marojejy National Park, a newly inaugurated World Heritage Site (IUCN 2007) where I have been working periodically since 2001. The potential long-term ecological and social consequences of such logging are discussed. Finally, recommendations are presented for discouraging this important threat to some of Madagascar's most pristine rainforests.

NATURAL HISTORY

Marojejy National Park is a conservation priority since it is known to be one of the most biologically diverse regions in Madagascar due its large elevational range; while also possessing some of the few remaining large tracts of intact lowland rainforest. The Marojejy and Andringitra massifs also possess the most well preserved montane habitats (Goodman 2000; Garreau and Manantsara 2003). Eminent botanist Dr. Henri Humbert, the first to study Marojejy's flora, considered this reserve the most impressive range in Madagascar. His 1955 book about Marojejy, entitled "A Marvel of Nature", extols the rich flora, grandeur, and pristine natural state of this park. For example, Marojejy may contain more species of forest-dwelling birds (Goodman et al. 2000), reptiles and amphibians (Raselimanana et al. 2000), as well as pteridophytes (ferns) (Rakotondrainibe 2000) than any other reserve in Madagascar. With 11 species of lemurs, including the critically endangered silky sifaka (*Propithecus candidus*), primate diversity is profound as well (Sterling and McFadden 2003; Duckworth et al. 1995). Several types of rare rosewood and palisandre, members of the family Leguminosae, are also found within Marojejy.

The family Leguminosae, with 80 % endemism and 667 species, is amongst the largest and most unique plant families in Madagascar. It is a "large, cosmopolitan family containing many useful species, which range from major agricultural food and fodder crops, to resources of medicinal compounds and high quality hardwoods" (Du Puy 2002). Of the 100 genera of Leguminosae found in Madagascar, seven genera contain trees harvested for high quality hardwood: *Albizia*, Cordyla, *Cynometra, Dalbergia, Dialium, Intsia*, and *Phylloxylon* (Labat and Moat 2003). Among these, *Dalbergia* is perhaps the most well known and most prized as this genus contains the "rosewoods" and "palisandre" (Labat and Moat 2003; Du Puy 2002).

In Madagascar, the Tribe Dalbergieae is comprised of 43 species of *Dalbergia* and 2 species of *Pterocarpus*. All but one of the *Dalbergia* species (97.7 %) are endemic to Madagascar. *Dalbergia* species are found in all environments in Madagascar, except at high elevations above 1,600 m. In Madagascar, most *Dalbergia* species are shrubs though some are small to large trees (Du Puy 2002).

Twenty-five of the Malagasy Dalbergia species are characterized by high quality, strong, and durable wood often used in expensive furniture and carpentry, but also for making oxcarts and spears. It burns well, and is therefore also a preferred wood for making charcoal and cooking. As a result of overexploitation, 9 species are now endangered (Du Puy 2002).

A recent survey and GIS analysis of Malagasy Papilionoideae (large Leguminosae subfamily) assigned IUCN Red List categories to the three *Dalbergia* species found within Marojejy National Park in the northeast of Madagascar (Labat and Moat 2003). Listed as "vulnerable", *D. baronii* and *D. madagascariensis* were seldom found within 5 km of a protected area, and the authors note that large specimens are rare due to overexploitation. Even rarer, *D. louveli* is classified as "endangered" since no trees whatsoever were found within 5 km of a protected area, and "populations of this rare rosewood are now severely fragmented, and it is selectively felled for the export market" (Labat and Moat 2003).

All three tree species provide precious hardwood and are harvested for furniture construction overseas, and to a far lesser degree in Madagascar. The wood of *D. baronii* and *D. louveli* is lustrous deep red and referred to as "rosewood" or "bois de rose" in French or locally in Malagasy as "Andramena" which translates to "red-trunk". *D. madagascariensis* is one example of palisandre, a precious *Dalbergia* hardwood without the vibrant red coloration (Du Puy 2002). Recently, details have become available about the illegal harvesting of palisandre and rosewood from Marojejy National Park.

LOGGING

Soon after cyclone Gafilo struck the SAVA (Sambava, Andapa, Vohémar, Antalaha) region of northeastern Madagascar in March 2004, the Ministry for the Environment, Water, and Forests (MINENVEF) issued temporary permits, valid only until the end of March, only for the collection of wood that had been toppled by recent cyclones outside of protected areas. However, these restrictions were difficult to enforce because of the remote locations of the wood and because MINENVEF agents are seldom in the field. Sylvain Velomera, former Director of Marojejy National Park, questions the justification for these initial temporary permits: "It's only a justification to allow cutting of rosewood, since cyclones do not blow over rosewood, only papaya and coconut and other small vulnerable trees, not rosewood" (pers. comm.). During this time of economic stress, post-cyclone with the price of vanilla very low, exporters encouraged local farmers to harvest rosewood, palisandre, and ebonies anywhere they could find it, including protected areas. Numerous reports of illegal precious wood logging ensued (Raoel 2005; Rasarely et al. 2005).

In response, a regional decree (n° 001 2005 REG / SAV) was issued on March 25, 2005 mobilizing inspection brigades and prohibiting the traffic and transport of rosewood and ebony. Subsequently, 106 persons were arrested in northeastern Madagascar in 2005 for illegal harvesting or transport of precious wood (Rasarely et al. 2005). At Marojejy alone, in 2005 over 20 separate incidents of illegal rosewood logging are known to have occurred (Sylvain Velomora, former Director of Marojejy National Park, pers. comm.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.). On June 1, 2005 Malagasy police confiscated 165 tons (4,884 logs) of ebony and 340 tons (2,630 logs) of rosewood from two major ports in the northeast of Madagascar, Vohémar and Antalaha (Raoel 2005). More recently, in January 2007, 14 large crates of rosewood valued at about 1.5 million dollars were apprehended in Vohémar. Also, in June 2007, 800 pieces of hidden rosewood were confiscated from the premises of a prominent Antalaha businessman (Nivo 2007). The wood was apparently on its way to Singapore or China which is the world's largest consumer of tropical wood (Musa 2007). SAVA regional head Paulin explained that "We do not know the companies nor the people (involved), but we can see from the documents obtained by customs officials that (it) is destined for China" (Cocks 2005).

Several lines of evidence strongly suggest that most of this confiscated wood was logged within the two largest protected areas in the region, Marojejy National Park and Masoala National Park. First of all, very little primary forest remains outside of these protected areas (IUCN 2007). It is common knowledge in the region that all precious wood outside of the protected areas has already been logged (J.C. Nadal, Mayor of Sambava. pers. comm.). Secondly, according to forest surveys by the Masoala National Park staff, 70 % of locally logged rosewood occurs within Masoala National Park (Rasarely et al. 2005). Cut stumps and small stacks of cut rosewood are routinely encountered within both national parks (Rasarely et al. 2005; Sylvain Velomora, former Director of Marojejy National Park, pers. comm.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.). Finally, numerous arrests, eyewitness accounts, and the questionnaire described in this report confirm precious wood logging within these protected areas.

From April 25 to May 15, 2005, I returned to Marojejy National Park to obtain some further information as to where, how, and why such large quantities of precious wood were harvested within this protected area. Figure 1 displays known locations of illegal rosewood and palisandre logging within the park during 2005, and was based on field reports and eyewitness sightings of actual palisandre (*D. madagascariensis*) and rosewood (*D. baronii, D. louveli*) removal as well as recently cut stumps. The data for this map were provided by the Andapa office of Marojejy National Park. As seen in Figure 1, harvested rosewood tends to occur near large rivers at low elevations, which reflects the preference of *Dalbergia* for this habitat (Labat and Moat 2003) as well as the need for a waterway to transport the extremely heavy logs. Rosewood trees are known to be amongst the tallest and heaviest trees within Marojejy National Park and must be cut into pieces before transport. Figure 2 shows a small stack of cut rosewood logs near the village of Mandena, only one km from Marojejy National Park. Figure 3, taken just four km from Marojejy National Park, shows illegally cut rosewood in the act of being transferred from the Manantenina River to ground transportation. It is highly likely that these logs came out of Marojejy National Park, probably from the area called Antsahabe. There is very little, if any, rosewood growing anywhere else in the area outside the park, especially in the quantity that was being loaded on the trucks there near Manantenina (Paul Atkinson, former Marojejy National Park Peace Corps Volunteer, pers. comm.).

Illegal harvesting of precious wood within Marojejy National Park appears to be a time consuming and labor intensive activity that requires an organized labor force (Rubel et al. 2003). Since these trees are relatively rare and not used by the local farmers, the location and identification of the tree requires the assistance of a specialized "kotoala", a local resident living adjacent to the forest who is intimately familiar with the local flora and fauna,

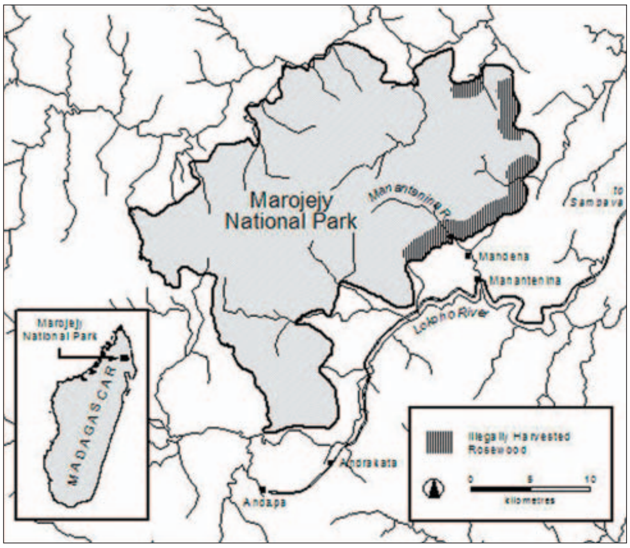

FIGURE 1. Map illustrating locations of logged rosewood within Marojejy National Park.

TABLE 1. Answers to „Why do you think there has been logging of precious wood with Parc National de Marojejy?"

ANSWERS	PERCENTAGE OF RESPONDENTS
Decline in the Value of the Cash Crop Vanilla (fell from 230 USD / kg in 2003 to 25 USD / kg in 2005)[1]	28% (14/50)
High Value of Rosewood (Worth 7 USD / kg or 70 - 140 USD per tree)[2]	22% (11/50)
Poverty	20% (10/50)
Time of Year: Hunger Period (January to March during cyclone season)	8% (4/50)
Foreign Market	8% (4/50)
Government Corruption	8% (4/50)
Not Enough Staff to Patrol Park	6% (3/50)

[1] Calvert, S. (2005). [2] Rasarely et al. (2005)

having harvested forest products since childhood. A recent World Bank Report has detailed the process of logging precious wood in Marojejy (Rasarely et al. 2005). Once a tree is found, it takes 1-2 hours to manually fell the tree by ax, after which it is cut into 1-2 meter lengths called "bola-bolas" that can weigh from 100 kg to 200 kg (pers. obs.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.). One end is usually carved out in a circular fashion creating a groove around which liana are wrapped so that the wood can be dragged to a waterway (see Figure 1). Local residents are then paid only 1,000 AR per trunk (about 50 to 100 times less than retail value) to manually drag each piece out of the forest. Once all the pieces arrive at a river, they are tied together in huge bundles and floated down these waterways to ground transport (see Figure 3), and then driven to one of the major shipping ports in the region such as Vohémar and Antalaha (Sylvain Velomora, former Director of Marojejy National Park, pers. comm.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.).

The true villains are the network of exporters, domestic transporters, and corrupt officials that organize, initiate, and greedily profit from the whole process (Rasarely et al. 2005; Rubel et al. 2003; Alphonse 2004, 2007; J.R. 2006). Most identities are unknown. But some details have come to light in the national press. One major exporter is believed to be a hotel owner in Sambava, who may be working for an Antalaha exporter. This Antalaha exporter is known to be close to an elected member of the majority party. A senator from the majority party is known to have tried to intervene to exonerate his brother who was involved in illegal rosewood exportation in SAVA (Alphonse 2007). Some customs officers and a high ranking MINENVEF official have also been implicated. In one well known example, false customs declarations were made in which a shipment of rosewood was instead declared as raffia (Alphonse 2004).

LOCAL PERCEPTION OF PRECIOUS WOOD HARVESTING

To assess local residents' perceptions of the cause of this precious wood logging within Marojejy National Park, anonymous structured interviews with a single adult member of 54 different households were conducted in the villages of Mandena (n = 29) and Manantenina (n = 25), adjacent to Marojejy National Park. Households right next to one-another were never both sampled. In total, seventy-four households were actually visited, but nine declined to participate, while in eleven other cases, no adults were available. All interviews were conducted in Malagasy. Subjects were first asked a yes / no question: "Do you think there has been logging of precious wood within Marojejy National Park?" 92.6 % (50 / 54) of households responded "Yes" and were then asked a second open-ended question: "Why do you think there has been logging of precious wood within Marojejy National Park?" If subjects provided more than one reason, we asked them to choose the "most important reason for logging of precious wood with Marojejy National Park". Six different responses provided by residents are displayed in Table 1. Statistically significant differences were found in the frequencies of answer categories ($\chi^2 = 13.74$; $p < 0.018$). A total of 70 % of the respondents identified one of three major explanations: decline in value of the local vanilla cash crop (28 %), extremely high value of rosewood (22 %), and local poverty (20 %).

ECOLOGICAL AND SOCIAL IMPACTS

In addition to depriving the government of Madagascar of millions of dollars of taxable revenue, illegal logging of precious wood can also have severe impacts on both the forest and indigenous peoples. Although selective logging results in less absolute forest loss than clearcutting, it is often accompanied by substantial peripheral damage such as decreases in genetic diversity (Gillies 1999) and increases in the susceptibility of the impacted areas to burning (Cochrane and Schultze 1998; Cowlishaw and Dunbar 2000). Elsewhere in Madagascar, some long-term ecological consequences have been documented from polycyclic selective logging, such as the precious wood logging described in this report. Such long-term impacts include invasion of persistent, dominant non-native plant species (Brown and Gurevitch 2004), impaired faunal habitat (Ganzhorn et al. 1990), and a diminution of endemic mammalian species richness (Stephenson 1993). Dr. Frank Hawkins, Technical Director of Conservation International in Madagascar, concludes that "The secondary impacts of [precious wood] logging are much

FIGURE 2. Rosewood logs cached near Mandena, 1 km from Marojejy National Park, anonymous.

FIGURE 3. 4 km from Marojejy National Park, illegally logged rosewood being transferred from the Manantenina River to ground transport in broad daylight. March 30, 2005. 16:46, anonymous.

more important than the logging...the forest dries out and is vulnerable to fire. People come in and hunt the animals. Very often the forest ends up disappearing completely" (Cocks 2005). Although slight habitat disturbance within Marojejy National Park has been described before (Goodman 2000; Duckworth et al. 1995), the extent of habitat disturbance due to precious wood logging described in this report far exceeds that described in these previous reports.

Precious wood logging also has angered local communities by trampling on the beliefs and taboos of local people. In traditional Sakalava culture, ebony is a sacred wood only cut by priests who conduct traditional ceremonies with ebony staffs. The chief of Ankalontany, a Sakalava Malagasy village in the northeast, explains that in 2005 "Some strangers from outside our village came here. They started cutting ebony and they clearly had no right. We asked for their authorization but they said they didn't have to show us papers. They said they had police clearance and we can't stop them." Laurent Tutu, president of the forest association of Ankalontany, remarked "It hurts us to see our trees cut like this. The forest loses its personality." (Cocks 2005).

RECOMMENDATIONS AND CONCLUSIONS

Illegal logging of precious wood continues to be a persistent source of habitat disturbance within Madagascar's northeastern rainforests. Unlike fuel-wood logging or slash-and-burn agriculture ("*tavy*"), the logging of precious wood is not primarily motivated by the subsistence requirements of local people. It is considered an organized criminal activity in which participating local residents receive but a tiny fraction of the profit made by the exporters, intermediaries and corrupt officials that initiate this entire process (Rasarely et al. 2005; Rubel et al. 2003; Alphonse 2004, 2007; J.R. 2006). Dr. Frank Hawkins emphasizes that "... The local people who are employed earn little money. 90 % of the revenue doesn't stay in the community" (Cocks 2005). When local residents were asked about the causes of rosewood logging within Marojejy, they primarily offered economic explanations such as the high value of rosewood and local poverty. In a nation where per capita annual income averages only 255 US dollars (US AID 2005), even a very small wage, e.g. 1,000 AR per log, can be significant, particularly during a time of low vanilla prices.

Extensive international, national, and local reforms will be required to discourage future logging. As reported by respondents in this survey, the high demand and value of rosewood is at the root of this problem. Imposing international trade regulations on Malagasy precious wood could reduce demand. Currently, no Malagasy rosewood is regulated under the Convention on International Trade in Endangered Species (CITES). Brazilian rosewood (*D. nigra*), listed as "vulnerable" by the IUCN, is the only type of rosewood that is protected under CITES. Although *D. louveli*, found in Marojejy National Park, is even more endangered, it has not yet been included in the CITES Appendices. However, a 1997 CITES Tree Species Evaluation exercise did highlight *D. louveli* as meeting the criteria (unsustainability) for Appendix II (CITES 1997). Extending CITES Appendix II regulation to *D. louveli* would require exporting and importing nations to verify the timber was legally acquired and the logging not detrimental to species survival. Like big-leaf mahogany, the premier commercial timber species of Latin America, CITES may be the only way to reduce unsustainable exploitation of precious wood in Madagascar (Blundell 2004). However, also as in the case of big-leaf mahogany, enforcing these international regulations will be difficult and require a new multi-lateral, cost-effective system to determine if exported wood has met the non-detrimental and legal criteria (Blundell 2007).

Obtaining protection under CITES Appendix I or II can be a very lengthy process since it requires CITES parties to vote on a listing. It was not until 2003 that big-leaf mahogany received such protection. This was the first time in history a commonly traded timber species was voted into CITES Appendix I or II. Before big-leaf mahogany was voted into Appendix II, several nations, such as Costa Rica, Boliva, and Brazil, voluntarily listed this species under Appendix III; which can be an important precursor to gaining protection under Appendix I or II. Obtaining listing under Appendix III is a much quicker process since it is simply a voluntary act by a country. Appendix III only stipulates that a listing country show export permits verifying the legality of the shipment. Unlike Appendix I or II, it makes few demands of importers (Blundell 2004). If the government of Madagascar is truly devoted to halting illegal precious wood logging, they will list *D. louveli* on Appendix III.

Nationally, improving enforcement of existing laws as well as increasing the involvement of the judicial system could help discourage future precious wood logging. For violations at Masoala National Park, Rubel et al. (2003) emphasize that "Judicial involvement is very rare. When there is legal involvement, almost no convictions." When there are convictions, the fines for seized wood in the SAVA region are very low (152 AR / kg) (Rasarely et al. 2005). Stiffer fines may not be enough. According to Alphonse (2007), the person who has the real power to dissuade future logging and increase punitive measures against the organizers is Koto Bernard, Minister of Environment, Water and Forests.

The continued assistance of local residents in reporting new incidents is crucial. It was only with the help of local people that authorities were able to apprehend a massive shipment of rosewood in Vohémar earlier this year (Alphonse 2007). Even within the newly inaugurated World Heritage Sites of Marojejy National Park and Masoala National Park, only a small staff is available to monitor these large forests (IUCN 2007). Of the 32 employees for both Marojejy National Park (60,050 ha) and Anjanaharibe - Sud Special Reserve (32,100 ha), only 14 go into the field, each for a few days each month (Gerard Bakharzafy, former Ecotourism Chief, Marojejy National Park, pers. comm.). Several Marojejy park agents have explained that they are responsible for too much territory, which makes it difficult for them to effectively monitor their region (Tila Augustin, Conservation Agent, Marojejy National Park, pers. comm.; Miandrasoa Simon, Conservation Agent, Marojejy National Park, pers. comm.). Rasarely et al. (2005) concur that "There is a crucial lack of personnel and budget in the local forestry service".

The most in-depth analysis of precious wood logging in the SAVA region was Rasarely et al.'s (2005) joint World Bank investigation. Three key recommendations were made. First, no future authorizations for the gathering of precious wood following cyclone damage should be issued. Second, reforestation should be promoted in all areas where logging occurred. Finally, new patrols should be established at strategic roadways, such the road between Manantenina and the entrance to Marojejy National Park, where much precious wood is known to have been transported (Sylvain Velomora, former Director of Marojejy

National Park, pers. comm.; Wul Frank, Conservation Agent, Marojejy National Park, pers. comm.). The recent completion of two new bridges over the Manantenina River in 2007 has made motorized transportation along this road even easier. Additional patrols will also be needed along logging 'hotspots' in the more remote northern and eastern portions of the park (see Figure 1).

Preventing further precious wood logging within Marojejy National Park will be extremely difficult since it has been organized by high ranking officials and prominent businessmen who are able to act above the law (Alphonse 2004, 2007; J.R. 2006; Raserely et al. 2005). Nevertheless, there are a few rays of hope. Many, but not all Marojejy park employees implicated in rosewood logging have been terminated or transferred. According to a recent IUCN (2007) document, old clearings seem to be showing some regeneration and there has been little new agricultural encroachment. Park management is evaluated in the same document as well established, organized, and professional. Masoala National Park faces far more managerial challenges given all of its waterways and the difficulty of accessing the eastern boundary. However, land cleared for marijuana plots has recently been observed within the remote northern sector a few kilometers from the park boundary (pers. obs.). Let us hope that World Heritage status will foster the extreme vigilance required to prevent further illegal logging of precious wood. As one of the most biologically diverse and unique national parks in Madagascar (Goodman 2000), Marojejy National Park deserves our attention and respect.

ACKNOWLEDGEMENTS

I am grateful for the assistance of Paul Atkinson, Rabary Désiré, and Nestor Jean Randrianasy, without whom this work would not have been possible. I thank the staff of Marojejy National Park, particularly former Director Sylvain Vélomora, for their cooperation. Thanks are also due to several anonymous reviewers who made numerous constructive comments that improved this manuscript.

REFERENCES

Alphonse, M. 2004. *Article sur l'exportation illicite de bois de rose : Rolly Mercia, convoqué à la gendarmerie.* Madagascar Tribune July 9 2004

Alphonse, M. 2007. *Exportation Illicite de bois de Rose.* Madagascar Tribune N° 5472. Jan 29

Blundell, A.G. 2004. *A review of the CITES listing of big-leaf mahogany.* Oryx, 38: 84-90.

Blundell, A.G. 2007. *Implementing CITES regulations for timber.* Ecological Applications, 17: 323-330.

Brown, K.A. and Gurevitch, J. 2004. *Long-term impacts of logging on forest diversity in Madagascar*. Proceedings of the National Academy of Sciences, 101: 6045-6049.

Calvert, S. 2005. *Vanilla's rise and fall takes Madagascar's growers for a ride.* Baltimore Sun. December 10.

CITES. 1997. *Tree species evaluation using the new CITES listing criteria.* www.cites.org/eng/prog/criteria/1st_meetng/trees.shtml

Cochrane, M.A. and Schulze, M.D. 1998. *Forest fires in the Brazilian Amazon.* Conservation Biology, 12: 948-950.

Cocks, T. 2005. *Loggers cut madagascan rainforest with impunity.* Reuters. July 4.

Cowlishaw, G. and Dunbar, R. 2000. *Primate Conservation Biology.* The University of Chicago Press, Chicago, USA.

Du Puy, D.J. 2002. *The Leguminosae of Madagascar.* Royal Botanic Gardens, Kew, UK.

Duckworth, J.W., Evans, M.I., Hawkins, A.F.A., Safford, R.J., and Wilkinson, R.J. 1995. *The lemurs of Marojejy Strict Nature Reserve, Madagascar: A status overview with notes on ecology and threats.* International Journal of Primatology, 16: 545-559.

Ganzhorn, J.U., Ganzhorn, A.W., Abraham, J.P., Andriamanarivo, L., and Ramananjatovo, A. 1990. *The impact of selective logging on forest structure and tenrec populations in western Madagascar.* Oecologia, 84: 126-133.

Garreau, J.M. and Manantsara, A. 2003. *The protected-area complex of the Parc National de Marojejy and the Reserve Speciale d'Anjanaharibe-Sud.* In: The Natural History of Madagascar, S.M. Goodman and J.P. Benstead (eds.), 1451-1458. University of Chicago Press, Chicago, USA.

Gillies, A.C.M. 1999. *Genetic diversity in Mesoamerican populations of mahogany (Swietenia macrophylla), assessed using RAPDs.* Heredity, 83: 722-732.

Goodman, S.M. 2000. *Description of the Parc National de Marojejy, Madagascar, and the 1996 Biological Inventory of the Reserve.* Fieldiana Zoology, 97: 1-18.

Goodman, S.M., Hawkins, A.F.A., and Razafimahaimodison, J.C. 2000. *Birds of the Parc National de Marojejy, Madagascar: With reference to elevational distribution.* Fieldiana Zoology, 97: 175-200.

Humbert, H. 1955. *Une merveille de la Nature à Madagascar.* Première exploration botanique du massif du Marojejy et de ses satellites. Mémoires de l'Institut Scientific de Madagascar, série b, 6: 1-210.

IUCN, 2007. *World heritage nomination. IUCN technical evaluation. Rainforests of the Atsinanana (Madagascar).* IUCN Evaluation Report. ID No. 1257.

J.R. 2006. *Trafic de bois de rose: Des dizaines de milliards en jeu.* La Gazety. December 6, 2006.

Kett, G. 2005. *Checking the reserve. Monthly from Madagascar.* March. Madagascar Fauna Group.

Labat, J.N. and Moat, J. 2003. *Leguminosae (Fabaceae).* In: The Natural History of Madagascar, S.M. Goodman and J.P. Benstead (eds.), 346-373. University of Chicago Press, Chicago, USA.

Martin, T. 2005. *Ressources forestières - Le bois de rose interdit d'exportation.* L'Express de Madagascar. February 21.

Musa, T. 2007. *Chinese demand drives global deforestation.* Reuters. June 10.

Nivo, T.A. 2007. *Bois de rose : 800 isa no tratra tao amin'ny mpandraharaha iray.* Madagascar Tribune. June 22.

Rakotondrainibe, F. 2000. *Pteridophyte diversity patterns along an elevational gradient in the Parc National de Marojejy.* Fieldiana Zoology, 97: 19-28.

Raoel, 2005. *Trafic illicite de bois précieux.* Madagascar Tribune. June 1.

Rasarely, E., Ramiandrarivo, L., Bettencourt, S., Bidani, B., Rajaonson, B., Rambeloarisoa, G. 2005. *Mission report in the SAVA of November 21 to 24, 2005.* World Bank Document.

Raselimanana, A.P., Raxworthy, C.J., and Nussbaum, R.A. et al. 2000. *Herpetofaunal species diversity and elevational distribution within the Parc National de Marojejy, Madagascar.* Fieldiana Zoology, 97: 157-174.

Rubel, A., Hatchwell, M., Mackinnon, J., and Ketterer, P. 2003. *Masoala – L'oeil de la Forêt.* Zoo Zurich.

Stephenson, P.J. 1993. *The small mammal fauna of Reserve Speciale d'Analamazaotra, Madagascar: the effects of human disturbance on endemic species diversity.* Biodiversity and Conservation, 2: 603-615.

US AID. 2005. Madagascar Annual Report FY 2005. June 16.

EDITORIAL NOTE

The author of this contribution could not fully satisfy the reviewers request to implement more witnesses of illegal logging, since it is very difficult to find people going on record.

Paul Atkinson, a Peace Corps Volunteer, received death threats after witnessing illegal logging activities in Marojejy National Park. As a result, the American Embassy decided to evacuate him in March 2006. Mr. Atkinson's Peace Corps tenure was due to end on April 7, 2006.

NATURAL DISTURBANCES

The Effects of Cyclone Hudah on the Forest of Masoala Peninsula, Madagascar

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ABSTRACT
Cyclones regularly impact the east coast of Madagascar but almost nothing is known about their effects on Malagasy ecosystems. On 2 April 2000 the powerful winds of Cyclone Hudah struck the humid forests in the northern part of Masoala Peninsula. An analysis of satellite images revealed that 3 % of the forest here was severely damaged or 22 % when just the forest of the northeast was considered. In 2001 the vegetation in this area was studied using fifteen 0.1 ha plots located in differently impacted sites. The cyclone had caused tree death (up to 53 % of the trunks within a plot); a reduction in trunk basal area (to 64 %); uprooting (to 46 %); snapping of trunks (to 51 %); reduction of crown volume (to mean of 83 %); an increase in herbs, liana and woody pioneer species and decrease in saplings of primary forest species; an increase in vegetation in the "shrub" layer and decrease in vegetation in the "canopy" layer. Among a sample of 340 trees killed by the cyclone, 39 % were uprooted, 37 % snapped, and 24 % were still standing. Mortality was relatively low for trees with either small or large trunk diameter compared to trees with intermediate size. In 2003 the plots were re-examined. Six had been impacted by human activities (fire or timber exploitation). A comparison between the vegetation in 2001 and 2003 in 6 plots that had been moderately or seriously impacted by Cyclone Hudah but not impacted by human activity revealed a further decrease in trunk density, an increase in the frequency of herbs and woody pioneers, a decrease in the frequency of liana and saplings of primary forest trees in the "shrub layer", and an increase of vegetation in the "shrub layer" but decrease of vegetation in the "canopy layer". The lack of recovery of this vegetation towards its pre-cyclone state may be explained by the impact of Cyclone Ihary, in 2002. Recovery may yet occur provided the vegetation is not impacted by human activities, particularly burning, that can derail this process. It is recommended that following cyclones conservation managers prioritize fire control.

INTRODUCTION
The Masoala Peninsula in northeast Madagascar (15 30’S, 50 10’E) is one of the largest areas of low-elevation humid evergreen forest remaining in Madagascar. This forest is renowned for its high species diversity and high local endemism (Rabenantoandro 2001). Much of this forest is protected in the Masoala National Park, which covers 230,000 ha. The east coast of Madagascar is impacted by cyclones on average 1.4 times per year (Service de la Météorologie 2000), but Cyclone Hudah, that tore across the northern part of the Masoala Peninsula on 2 April 2000, was unusually powerful. Sustained winds of over 230 km / hr were recorded with gusts exceeding 300 km / hr. These winds and the associated heavy rains were reported to have killed 13 people, left 50,000 homeless and 100,000 without food or drinking water. Crops, including the economically important vanilla, were devastated and infrastructure (roads, health services and schools) seriously affected. The coastal town of Antalaha was 90 % destroyed (CNN 2000).

In this study we estimate the area of forest seriously damaged by this cyclone, describe the nature of this damage and describe the structure and composition of the damaged forest one year and three years after the cyclone. Although the high frequency of cyclones in Madagascar has been invoked as a possible cause for the relatively low canopy height and high trunk density of the country's humid forests compared with humid forests elsewhere in the world where cyclones are less frequent (Leigh 1988; Gouvenain and Silander 2003), their impacts on vegetation has been little described with the exception of Rasamimanana et al. (2000) who presented information showing differential damage between tree species following a violent storm at Berenty.

METHODS
The distribution of cyclone damage was studied by analyzing satellite images of the northern part of the peninsula taken in May 2000, one month after the cyclone. To distinguish between the spectral patterns produced by cyclone-damaged forest and other vegetation types (in particular land being managed by shifting cultivation) images prior to the cyclone were analyzed and ground-truthing was conducted.

The effect of the cyclone on the vegetation was investigated by describing the vegetation in a total of fifteen 0.1 ha (50 m x 20 m) plots. Twelve plots were established at four different sites in the low elevation humid forest of the Ianobe River Valley and three at one site in the littoral forest adjacent to Ambohitralanana (see Figure 1) The plots were first surveyed between February to June 2001 and then again in May 2003. These sites were chosen because they are relatively easily accessible and were within the zone seriously affected by the cyclone. At each site, in order to include the range of variation in cyclone-damage

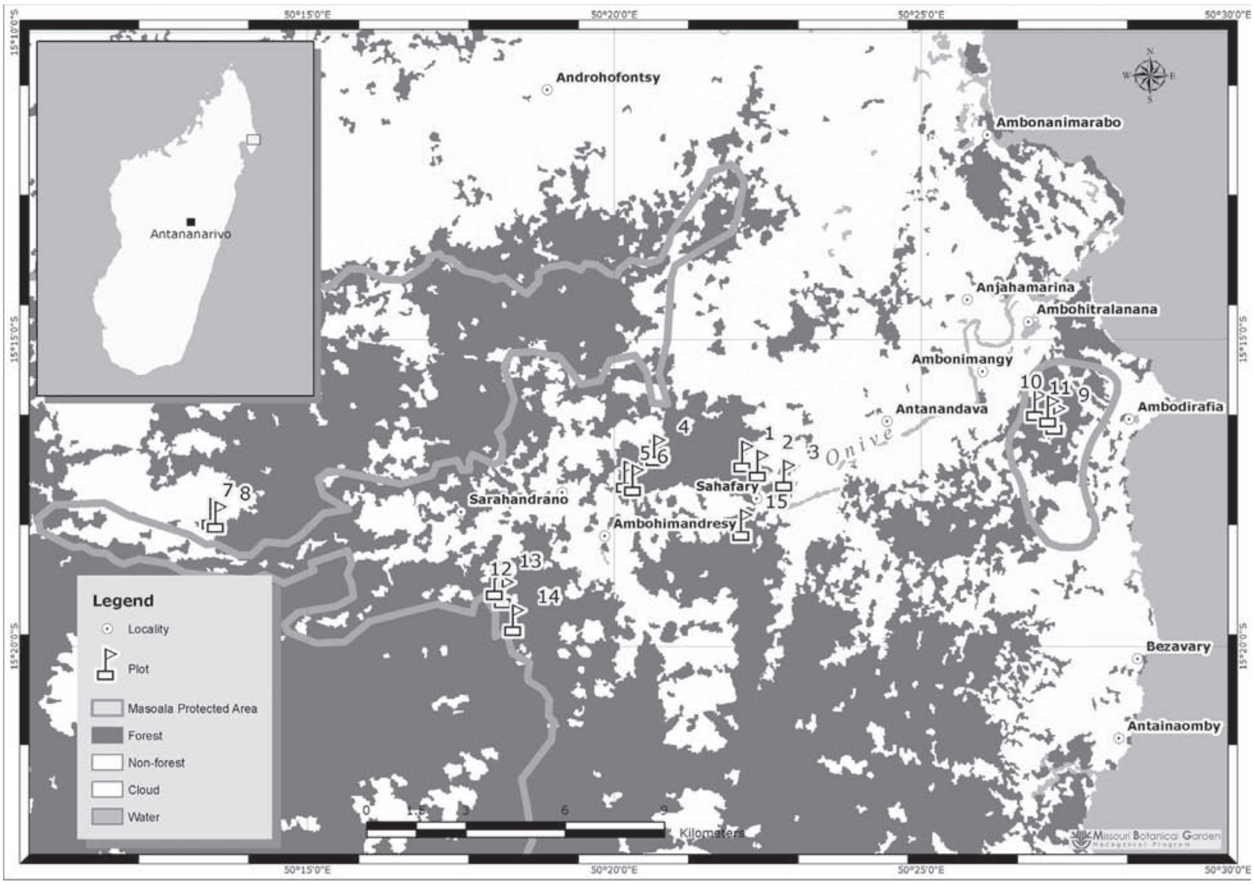

FIGURE 1. Location of plots.

to the forest, we endeavored to establish one plot in forest judged subjectively to be little damaged, one in moderately damaged forest, and one in severely damaged forest.

Within each plot, all trees with diameter at breast height (dbh) ≥ 10 cm, both alive and recently killed by the cyclone, were surveyed. For each tree we noted whether it was dead or alive, measured its dbh, and noted whether the tree was uprooted or whether the trunk had been snapped. In addition, for living trees, we estimated the proportion of crown volume that had been lost using five classes covering the range of loss in 20 % intervals.

The vertical structure of the forest within the plot and the frequency of various classes of plants (i.e. primary forest tree species, woody pioneer species, liana, or herb) were also described by noting points of contact between vegetation and a survey pole held vertically at 1 m intervals along a 50 m horizontal line bisecting the plot. The data were analyzed in terms of two zones: the zone between 0 to 6 m from the ground (or "shrub" layer) and the zone between 6 and 24 m from the ground (or "canopy" layer). The upper limit of the "canopy" layer was defined by the highest vegetation encountered during the study.

RESULTS AND DISCUSSION

Satellite photos show that Cyclone Hudah damaged the forest only in the northern part of the peninsula. In total, 3.2 % (4,627 ha out of the 143,236 ha) of forest in this area was classified as severely damaged. However, while damage occurred right across this zone (an east-west distance of 60 km), (east side of the summit of Ambatolaidama mountain) it was most extensive in the northeast where 22 % (1,946 ha out of 8,915 ha) of the forest was severely damaged. The most severely damaged forest was the littoral forest, and further inland, forest on east or southeast facing slopes (i.e. facing the direction of the cyclone) or adjacent to areas of cultivation. Damage generally diminished with distance from the coast.

Table 1 summarizes the effects of Cyclone Hudah on vegetation within forest subjectively classified as severely damaged, moderately damaged and undamaged by Cyclone Hudah. For each of the attributes considered there was a significant difference between the three forest types. The cyclone had caused: tree death (up to 53 % of the trunks within a plot); a reduction in trunk basal area (up to 64 % in a plot); uprooting (up to 46 %); snapping of trunks (up to 51 %); loss of branches leading to reduction of crown volume (up to a mean of 83 %); an increase in the frequency of herbs, liana and woody pioneer species; a small decrease in frequency of saplings of primary forest species and a small increase in the frequency of vegetation in the "shrub" layer and a large decrease in the frequency of vegetation in the "canopy" layer. Tree mortality in other tropical wet forests impacted by catastrophic winds is reported to be between 1 % to 25 % (Brokaw and Walker 1991; Bellingham et al. 1992; Zimmerman et al. 1994; Everham and Brokaw 1996) while reported values for snapping or uprooting range from 4.5 % to 80 % (Brokaw and Walker 1991; Everham and Brokaw 1996). However, it is difficult to make comparisons between studies because of differences in their experimental conditions.

Among the dead trees (N = 340), 39.4 % had been uprooted, 36.5 % had been snapped, and 24.1 % were still standing

TABLE 1. The effects of Cyclone Hudah in three types of forest differentially impacted by the cyclone.

	FOREST TYPE			SIGNIFICANCE: * $p<0.05$, *** $p<0.001$
	Intact (I)	Moderately damaged (M)	Severely damaged (S)	
No. plots	5	5	5	
Mean % trunks dead	0.2	19.9	45.6	χ^2 = 394***
Mean % basal area of trunks dead	0.6	23.5	51.5	I versus M, t = -20.9*** I versus S, t = -31.6*** M versus S, t = -14.5***
Mean % trunks uprooted	0.8	13.8	25.2	χ^2 = 163***
Mean % trunks broken	1.1	16.2	33.7	χ^2 = 222***
Mean % reduction of canopy per trunk	16	60.7	76.4	I versus M, t = -9.14*** I versus S, t = -11.24*** M versus S, t = -2.4*
Mean % frequency of herbs in zone 0-6 m	0.7	1.2	2.7	χ^2 = 229***
Mean % frequency of liana in zone 0-6 m	1.5	1.3	3	χ^2 = 142***
Mean % frequency of pioneer trees in zone 0-6 m	0	0.1	0.4	χ^2 = 74***
Mean % frequency of primary forest trees in zone 0-6 m	12.3	11.8	10.3	χ^2 = 34***
Mean total % frequency of vegetation in zone 0-6 m	14.4	14.5	16.4	χ^2 = 29***
Mean total % frequency of vegetation in zone 6-24 m	21.8	5.4	2.2	χ^2 = 2293***

(presumably dying because of the loss of branches and / or leaves). In addition, 14 % of the living trees (N = 1,438) were either uprooted or snapped.

Table 2 shows the proportion of trees in various dbh classes that were killed, uprooted or snapped. Death and damage were lowest in the 10 - 20 cm and > 50 cm dbh classes and highest in the intermediate classes. This is probably because trees with small dbh tend to be shorter than trees with larger dbh and therefore less exposed to the wind, while trees with dbh > 50 cm are a similar height to those with dbh 20 - 50 cm but their thicker trunks are stronger. The latter hypothesis is supported by the low percentage of trunks in the > 50 cm dbh class that were snapped (6.1 %) compared to trunks in smaller dbh classes (13.1 - 17.3 %). Alternatively, the largest trees could be more abundant in relatively unexposed sites (e.g. valleys (although valleys are not always protected sites (Everham and Brokaw 1996)) or tend to be species with high resistance to damage (e.g. because of their wood density or architecture). Rasamimanana et al. (2000) report that at Berenty tree species showed differential damage to a violent wind. The relatively low mortality of the largest trees seems to contradict the hypothesis proposed by Leigh (1988) and Gouvenain and Silander (2003) that the low canopy of Malagasy rainforest is due to high cyclone frequency. However, it may be that low canopy height is less the result of large trees being differentially removed from forests by cyclones in the present but rather the consequence of the application this selective pressure in the past resulting the evolution of trees that tend not to exceed average canopy height. The relatively high proportion of trees in the 10 - 20 cm dbh class that were snapped compared to the proportion that were uprooted was probably due to their susceptibility to snapping when impacted by a falling neighbour. Walker (1991) and Zimmerman et al. (1994) also report that when impacted by a powerful wind, large trees were more likely to uproot and small trees more likely to snap, but no such relationship was found by Bellingham et al. (1992).

In 2003, the vegetation in 6 of the 15 plots previously studied had suffered human impact: 3 had been affected by the extraction of timber and 3 had been burnt when a lumberman's cooking fire burnt out of control. Of the 9 plots where the vegetation had developed naturally, 3 had been classified as intact in 2001 and 6 as either moderately or severely damaged. Table 3 compares the vegetation in this latter group in 2001 and 2003. Between these two periods there had been a significant decrease in trunk density, a significant increase in the frequency of herbs and woody pioneers, a significant decrease in the frequency of liana and saplings of primary forest trees in the "shrub layer", a significant increase in the frequency of vegetation in the "shrub layer" and a significant decrease in the frequency of vegetation in the "canopy layer". Thus it would seem that the moderately and seriously cyclone - impacted vegetation was showing no signs of return to its pre - cyclone state. This is probably due to the occurrence of a second powerful cyclone (Cyclone Ihary) in this area in 2002. It would seem that this cyclone further degraded this already damaged forest and set back its recovery. Despite the increased abundance of herbs and woody pioneer species, seedlings and saplings of woody primary forest species remain present and ultimately these should affect recovery.

Within the three plots that had been burnt, the vegetation had been very seriously impacted. In particular, nearly all plants

TABLE 2. Percent of trees in various dbh classes that were killed, snapped, and uprooted by Cyclone Hudah.

Trunk dbh (cm)				N
	Dead	Snapped	Up-rooted	
> 10 – 20	16.2	14.8	9.3	1,124
> 20 – 30	25.5	13.1	18.7	396
> 30 – 40	22.2	17.3	10.5	162
> 40 – 50	25.4	15.9	12.7	63
> 50	15.2	6.1	12.1	33

of the primary forest had been killed, the layer of debris (fallen branches and trunks) had been lost and the plots had been invaded by the woody pioneer species Trema orientalis and Pteridium aquilinum. Here, recovery will require re-colonization by species from the primary forest – a process that will take a very long time and in reality, with ever increasing human pressure, is never likely to occur.

It would appear that following Cyclone Hudah the rural population, impoverished by its catastrophic winds and encouraged by a breakdown in regulatory structures, increased their exploitation of natural resources with the consequent derailing of forest recovery in many areas. Clearly a priority for conservation mangers in situations such as this should be to work with the Government and development NGO's to help local people to rebuild their lives without the abusive exploitation of natural resources. They should also understand that although cyclone-damaged forest can recover, until it does it will be highly vulnerable to burning because its fragmented canopy allows the understory, rich in cyclone debris, to dry out and also allows wind to enter the forest and fan flames. This vegetation will require intensive fire protection until the debris has rotted and the forest canopy reformed. This may require diverting limited resources away from less urgent activities: for example, following a cyclone, staff that previously worked in a tree nursery and restore a few hectares of forest each year may be better used in fire control that would reduce the risk of hundreds of hectares of cyclone-damaged forest from burning. Fire protection should be multifaceted and include awareness-raising among local stakeholders, fire patrols, creation and training of well-equipped and motivated fire-fighting teams, and the creation of fire breaks. These methods seem most effective when they fully implicate local stakeholders and, were possible, these activities should be designed to create employment in cyclone-impoverished communities. Those responsible for sites of conservation importance in cyclone-prone areas need to ready with contingency plans for the day when the inevitable happens. The donors too need to be ready with a special fund dedicated for emergency post-cyclone conservation actions that can be accessed rapidly. It is as yet unclear whether global warming is increasing frequency or power of cyclones (Young 2007), but if it is, then preparedness for cyclone-impact is even more imperative.

ACKNOWLEDGEMENTS

Thanks to Dr. Alain Randriamaherisoa for analysis of the satellite images, to Tantely Raminosoa for providing Figure 1 and to Solofo Rakotoarisoa, Patrice Antilahimena, Roger Bernard, Richard Razakamalala, Andriambolantsoa Rasolohery, and Faly Mbolatiana Randriantafika for their assistance with fieldwork. Financial support was provided by the National Geographic Society (Grant Number 6901-00). We also gratefully acknowledge courtesies extended by the Government of Madagascar (Direction Générale de la Gestion des Ressources Forestières) and by the Association Nationale pour la Gestion des Aires Protégées (ANGAP).

TABLE 3. Comparison between the vegetation in six plots classified as the moderately or seriously impacted by Cyclone Hudah, in 2001 and 2003.

	2001	2003	Significance
No. plots	6	6	*** p<0.001
Mean number of trees with dbh > 10 cm (± 95 % confidence limits) in 0.1 ha plot	64.0 ± 17.1	40.0 ± 8.0	t = 12.9***
Mean % frequency of herbs in zone 0-6 m	2.9	10.6	χ^2 = 865.7***
Mean % frequency of liana in zone 0-6 m	3.2	1.6	χ^2 = 107.4***
Mean % frequency of pioneer trees in zone 0-6 m	0.4	1.8	χ^2 = 160.1***
Mean % frequency of primary forest trees in zone 0-6 m	9.5	8.2	χ^2 = 18.0***
Mean total % frequency of vegetation in zone 0-6 m	16	22.2	χ^2 = 276.8***
Mean total % frequency of vegetation in zone 6-24 m	4	0.8	χ^2 = 246.6***

REFERENCES

Bellingham, P.J., Kapos, V., Varty, N., Healey, J.R., Tanner, E.V.J., Kelly, D.L., Dalling, J.W., Burns, L.S., Lee, D. and Sidrak, G. 1992. *Hurricanes need not cause high mortality: the effects of Hurricane Gilbert on forests in Jamaica.* Journal of Tropical Ecology 8: 217-223.

Brokaw, N.V.L. and Walker, L.R. 1991. *Summary of the effects of Caribbean Hurricanes on Vegetation.* Biotropica 23, 4a: 442-447.

CNN, 2000. http://edition.cnn.com/2000/WEATHER/04/04/mozambique.floods.02/index.html

Everham, E.M. and Brokaw, N.V.L. 1996. *Forest damage and recovery from catastrophic wind.* Botanical Review 62: 113-185.

Gouvenain de, R.C. and Silander, J.A. (2003). *Do tropical storm regimes influence the structure of tropical rain forests.* Biotropica 35(2): 166-180.

Rabenantoandro, J. 2001. *Analyse floristique, structurale et dendrometrique de la Forêt Dense Humide de Basse Altitude du Parc National Masoala sur le versant occidental selon la méthode de la parcelle permanente.* Unpubl. DEA Memoire, University of Antananarivo.

Rasamimanana, H., Ratovonirina, Jolly, A., Pride, E. 2000. *Storm damage at Berenty Reserve.* Lemur News 5: 7-8.

Service de la Météorologie 2000. *Perturbations cycloniques à Madagascar de 1961 à 2000.* Service de la Météorologie, Antananarivo.

Walker, L.R. 1991. *Tree damage and recovery from Hurricane Hugo in Luquillo Experimental Forest, Puerto Rico.* Biotropica 23: 379-385.

Young, E. 2007. *Climate Myths: Hurricane Katrina was caused by global warming.* NewScientist.com News Service. http://environment.newscientist.com/channel/earth/climate-change/dn11661.

Zimmerman, J.K., Everham III, E.M., Waide, R.B., Lodge, D.J., Taylor, C.M. and Brokaws, N.V.L. 1994. *Response of tropical tree species to hurricane winds in subtropical wet forest in Puerto Rico: implications for tropical tree life histories.* Journal of Ecology 82: 911-922.

LEMURIENS

Influences des Pressions Anthropiques sur les Lémuriens d'Anantaka, dans la Partie Est du Plateau de Makira, Maroantsetra, Madagascar

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RESUME
L'équipe de Groupe d'Etude et de Recherche sur les Primates de Madagascar (GERP), pour contribuer dans la protection, a prospecté et suivi 12 sites dans la forêt de Makira dont Anantaka pendant les mois de septembre et octobre 2005 et 2006. A l'aide des lignes-inventaire, la densité relative de la population de lémuriens a été obtenue par des observations directes tandis que les pressions humaines ont été inventoriées par l'évaluation des surfaces d'incidence des activités humaines. Des activités anthropiques sur les lémuriens ont été identifiées. Les influences de chaque type de pression sur les espèces de Lémuriens (trois diurnes strictes, une cathémérale et dix nocturnes) répertoriées à travers 12 sites ont été analysées à partir du coefficient de corrélation R de Spearman entre chaque facteur menaçant par rapport à chaque effectif de lémurien. Ainsi, d'une part, on a déduit que le site d'Anantaka, avec ses 14 espèces lémuriennes, est le plus riche en espèces de lémuriens. Et d'autre part, on a constaté que plus le nombre de village est abondant et plus leur distance par rapport à la forêt est rapprochée et que les impacts de pression sur l'écosystème forestier augmente avec des activités relatives comme la chasse, les coupes illicites, les défrichements de la forêt primaire, les défrichements des forêts secondaires et la transformation des forêts en tavy ou en kijana (prairie) ainsi que les exploitations minières illicites. A part cette dégradation de la biodiversité, la décadence de la moralité à la fois sur les notions du civisme et le concept du fady (tabou) en l'encontre des Aye aye par exemple, se trouve sur une situation bouleversante, puisque les gens ne considèrent plus ni les valeurs culturelles pour la conservation de la forêt ni les lois régissant la gestion forestière et les chasses des animaux sauvages. Ces critères classifient le site d'Anantaka dans la cible focale de conservation du fait que la couverture forestière d'Anantaka présente encore 75 % de forêt, 25 % est transformée en savoka et en prairie. C'est ainsi que l'indispensablement d'une priorité en matière de conservation des lémuriens pour conserver la niche écologique exceptionnelle d'Anantaka. La conservation de Makira serait optimale avec l'intégration de la population riveraine du site d'Anantaka dans la gestion rationnelle de leurs ressources naturelles et avec l'intervention de l'éducation environnementale dans quelques localités dont les Communautés de base (COBA) et avec l'appui technique émanant des associations dans l'élaboration d'un plan de développement touchant surtout l'agriculture et d'un projet qui assurera la surveillance et le contrôle du secteur par des missions de suivi-évaluation.

INTRODUCTION
Actuellement, les menaces influençant les écosystèmes forestiers de l'Est de Madagascar atteignent les forêts très reculées comme celles des forêts sur le plateau de Makira, à Maroantsetra, Madagascar. Ces forêts se situent dans la partie nord-est de Madagascar; elles constituent le plus grand bloc forestier contigu de la forêt dense humide sempervirente de la Grande Ile, avec ses 376,156 ha (Wildlife Conservation Society et Services des Eaux et Forêts 2004). Dans le but de mettre en place un plan de conservation des lémuriens dans ce bloc forestier, nous y avons exploré 12 différents sites (Figure 1). Parmi ces sites, Anantaka était prospecté et suivi pendant les mois de septembre et octobre 2005 et 2006. Anantaka est un écosystème forestier sur le flanc est du plateau de Makira (S: 15°25'52.7" EO: 49°27'16.0"), dans le fokontany d'Andongona, commune rurale d'Antsirabe-Sahatany, à 45 km à l'ouest de Maroantsetra, région d'Analanjirofo, province de Toamasina. Pendant nos observations, des faits marquaient les enjeux environnementaux du site. Les paysans détruisent délibérément leurs milieux en défrichant illégalement la forêt pour pratiquer la culture sur brûlis et pour délimiter leur territoire. Cette délimitation est amorcée par l'installation de pièges à lémuriens, ensuite par le défrichement de la surface à exploiter. La présente étude consiste à déterminer l'influence des menaces anthropiques sur les lémuriens, dans l'optique de mettre en oeuvre les priorités en matière de conservation de ces animaux et d'intégrer la population riveraine du site à être responsable de la gestion rationnelle de leurs ressources naturelles.

CARACTERISTIQUE DU SITE D'ANANTAKA
Le site d'Anantaka est une forêt dense humide sempervirente évoluant sur un plateau migmatitique Archéen, associé à des fractures tectoniques et des émanations magmatiques du Précambrien, du Crétacé supérieur et du Tertio-Quaternaire de Madagascar (Besairie 1972). Sa position géographique est située entre les coordonnées S15°24'35.0"; S15°25'52.7"et EO

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49°27’12.2” ; EO 49°27’16.0” (Figure 1); l’altitude varie entre 350 et 1,100 m. Le climat est de type tropical chaud et humide, avec une précipitation moyenne de 3,000 mm / an; les mois pluvieux vont de décembre en avril où la précipitation peut atteindre 2,500 mm et la saison sèche va du mois d’octobre à novembre où la précipitation varie de 80 à 120 mm ; la température oscille entre 15 et 35°C avec une moyenne de 24 °C; la forêt dans cette localité présente les caractéristiques de la zone éco-floristique orientale de basse à moyenne altitude, série à *Anthostema* et à Myristicaceae (Du Puy et Moat 1996; Humbert et Cours Darne 1965). Selon nos observations, les canopées forestières sont presque fermées et la plupart des hauteurs des arbres varient entre 20 et 30 m où leurs diamètres (dhp: diamètre hauteur de poitrine) sont souvent supérieurs à 30 cm tels que: Hazoambo ou *Xylopia* (Annonaceae), Notitrakoho ou (Aquafoliaceae), Vontro ou *Dypsis*, Rofilahy ou *Ravenea* (Arecaceae), Ramy ou *Canarium* (Burseraceae), Vongo ou *Mammea*, Vintanona ou *Calophyllum*, Azinina ou *Symphonia* (Clusiaceae), Fanjanabe ou *Cyathea* (Cyatheaceae), Hasimbe ou *Dracaena* (Dracaenaceae), Hazaomafana ou *Diospyros* (Ebenaceae), Vanana ou *Sloaena* (Elaeocarpaceae), Bakona ou *Anthostema*, Arina ou *Bredelia*, Paka ou *Uapacca* (Euphorbiaceae), Tanatanampotsy ou *Tisonia* (Flacourtiaceae), Tavolo ou *Ocotea*, Longotra ou *Potameia* (Lauraceae), Ambora ou *Tambourissa* (Monimiaceae), Ilondrara ou *Brochoneura* (Myristicaceae), Hompa ou *Eugenia* (Myrtaceae), Hetatra ou *Podocarpus* (Podocarpaceae), Hodopaso ou *Prunus africanum* (Rosaceae), Fatrena ou *Breonia*, Tifo ou *Enterospermum*, Taolanosy ou *Gaertnera* (Rubiaceae), Tamenapoza ou *Sarcolaena* (Sarcolaenaceae), Nanto ou *Manilkara* (Sapotaceae), Lombisy ou *Rhopalocarpus* (Sphaerosepalaceae).

METHODOLOGIE

RECENSEMENT PAR OBSERVATION DIRECTE DES LEMURIENS Trois ligne-inventaires ont été utilisées pour le recensement des espèces de lémuriens diurnes, cathémérales et nocturnes, rencontrées le long d’un trajet de 2 km préalablement choisi. L’observateur se déplace à une vitesse de 0.7 km par heure et à chaque fois il rencontre un groupe d’animal, il s’arrête et note: l’heure de rencontre, la position géographique de l’endroit, le nombre d’individus rencontrés ainsi que leurs âges relatifs (adulte, jeune, petit) et leurs sexes (mâle ou femelle), la distance, perpendiculaire au trajet, entre l’animal et l’observateur, puis il reprend le déplacement à la même vitesse (Altmann 1974; Ganzhorn 1994). Les observations pendant la nuit se font avec l’utilisation de lumières artificielles atténuées (lampe frontale). Les tapetum lucidium sur la rétine des animaux nocturnes reflètent ces lumières, ce qui facilite leurs repérages. L’observateur utilise ensuite des lumières plus puissantes, pendant quelques minutes, pour déterminer l’espèce.

MODE DE CALCUL DE DENSITE Les densités relatives de la population des lémuriens recensés pendant les périodes d’observations sont estimées à l’aide de la formule: d = N/2 x W x L (Avec d: densité estimée de la population, N: nombre d’animaux rencontrés, W: distance moyenne des animaux observés par rapport à la ligne-inventaire, L: longueur de la ligne-inventaire).

RECENSEMENT DES PRESSIONS HUMAINES Pour recenser les pressions humaines, nous avons procédé au comptage des traces d’activités humaines en suivant une ligne-inventaire et en quantifiant les produits exploités (comptage des arbres ou produits exploités dans la forêt) et puis en mesurant l’intensité des pressions anthropiques par l’évaluation des surfaces d’incidence des activités humaines à savoir les tavy rencontrés et les surfaces occupées.

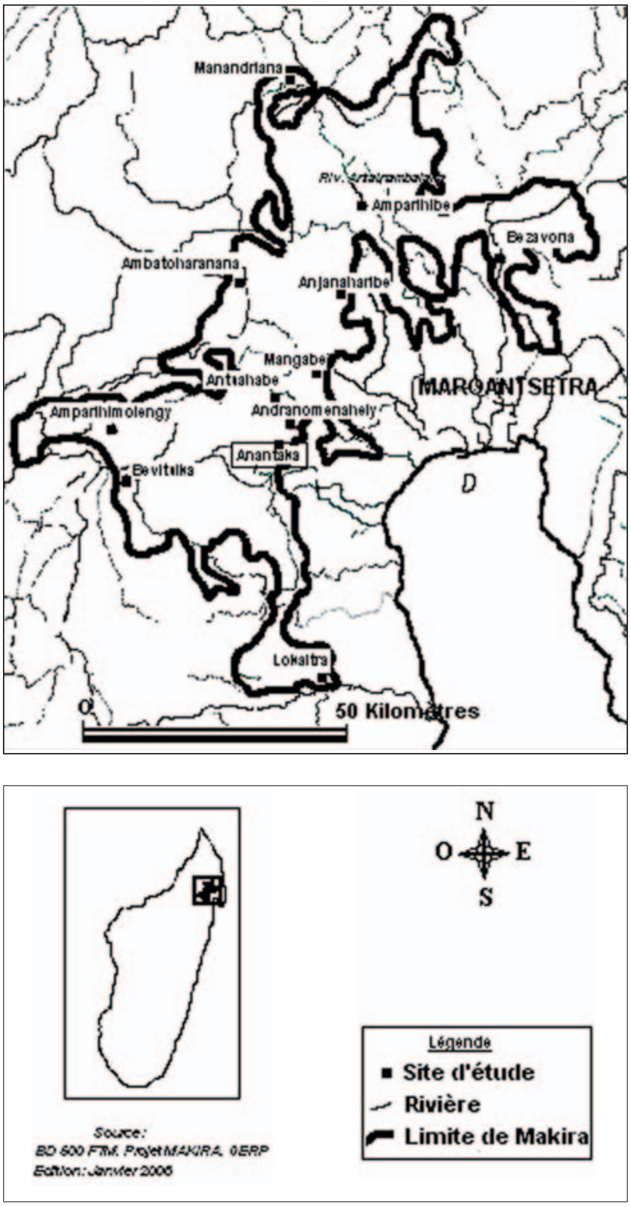

FIGURE 1. Localisation des sites d’études sur le site de conservation du plateau de Makira.

ANALYSE DES DONNEES Dans cette étude, pour connaître l’influence de chaque menace sur les lémuriens, nous avons calculé le coefficient de corrélation R de Spearman qui existe entre chaque facteur menaçant par rapport à chaque effectif de lémurien.

RESULTATS ET INTERPRETATIONS

LES LEMURIENS DANS LE SITE D’ANANTAKA 14 espèces de lémuriens ont été inventoriées dans le site d’Anantaka. Parmi ces 14 espèces, trois sont diurnes strictes: Babakoto ou *Indri indri*, Varikandana ou *Varecia variegata subcincta* et Bokombolo ou *Hapalemur griseus*; une cathémérale: Varikosa ou *Eulemur fulvus albifrons* et dix nocturnes: Ampongy ou *Avahi laniger*, Tsitsihy ou *Lepilemur seali*, Hataka ou *Chei-*

TABLEAU 1. Tableau récapitulatif des espèces de lémuriens inventoriés dans le bloc forestier de Makira

Sites	MND	APB	BZV	ABH	AJB	MGB	ATB	ADM	ATK	APG	BVT	LKT	Statut IUCN (2006)
Coordonnées géographiques	S14°49'53.3" EO49°27'37.3"	S15°02'06.7" EO49°35'02.0"	S15°06'56.6" EO49°48'18.8"	S15°08'16.0" EO49°21'02.3"	S15°11'17.1" EO49°36'50.8"	S15°18'40.1" EO49°30'12.1"	S15°21'33.9" EO49°30'12.1"	S15°23'53.0" EO49°27'05.2"	S15°25'52.7" EO49°27'16.0"	S15°24'31.9" EO49°08'05.1"	S15°29'17.9" EO49°09'33.5"	S15°49'06.9" EO49°30'37.8"	
Diurne													
Indri indri	1	0	0	1	0	1	1	1	1	1	1	1	EN
Propithecus candidus	1	0	0	0	1	0	0	0	0	0	0	0	CR
Varecia variegata rubra	0	0	1	0	1	0	0	0	0	0	0	0	EN
Varecia variegata subcincta	0	0	0	1	0	1	1	1	1	1	1	1	CR
Hapalemur griseus griseus	0	1	1	0	1	1	1	1	1	1	1	1	VU
Cathémérale													
Eulemur rubriventer	1	0	0	1	1	0	1	1	0	1	1	1	VU
Eulemur fulvus albifrons	1	1	1	1	1	1	1	1	1	1	1	1	VU
Eulemur fulvus fulvus	0	0	0	0	0	0	0	0	0	1	0	1	VU
Nocturne													
Avahi laniger	0	1	1	1	1	1	1	1	1	1	1	1	LC
Lepilemur seali	1	0	1	1	1	1	1	1	1	1	1	1	DD
Lepilemur mustelinus	0	0	1	0	0	1	0	0	0	0	1	0	DD
Cheirogaleus major	1	0	1	1	1	1	1	1	1	1	0	1	DD
Cheirogaleus ravus	0	0	0	0	0	0	1	0	1	0	0	0	DD
Cheirogaleus crossleyi	0	0	0	1	0	0	0	0	0	1	0	0	DD
Cheirogaleus sibreei	0	0	0	1	0	0	0	0	1	0	0	0	DD
Microcebus mittermeieri	1	0	1	1	1	1	1	1	1	1	1	1	DD
Microcebus sp.	0	0	1	0	0	1	1	0	1	1	1	1	DD
Allocebus trichotis	0	0	0	0	0	0	1	1	1	0	0	1	DD
Phaner furcifer	0	0	0	0	0	1	0	1	1	0	0	0	DD
Daubentonia madagascariensis	0	0	0	0	*	1	0	*	1	0	0	0	VU
Nombre d'espèce par site	7	3	9	10	10	12	12	12	14	12	10	12	

Signification: MND: Manandriana, APB: Amparihibe, BZV: Bezavona, ABH: Ambatoharanana, AJB: Anjanabaribe, MGB: Mangabe, ATB: Antsahabe, ADM: Andranomenahely, ATK: Anantaka, APG: Amparihimolengy, BVT: Bevitsika, LKT: Lokaitra, 0: absence; 1: présence; *: traces d'activités récentes / statut IUCN CR: en danger critique, EN: en danger, VU: vulnérable; LC: (Least Concern) Moins concernée, DD: (Data Deficient) données insuffisantes et non évaluées.

TABLEAU 2. Tableau des pressions recensées au niveau des différents sites dans le bloc forestier de Makira

	PRINCIPAUX FACTEURS ANTHROPIQUES					
	Nombre de villages interactifs	Distance moyenne entre un village et le site forestier (km)	Piège (nombre / km^2)	Coupe illicite (nombre de bois de dhp>18 cm coupés / ha)	Surface sous forme de tavy ou prairie (kijana) dans le site (ha)	Exploitation minière (nombre de trous / ha)
SITES						
Manandriana	5	2	0	186	75	600
Amparihibe	6	20.65	0	0	0	0
Bezavona	5	5.64	0	94	350	0
Ambatoharanana	2	13.26	0	0	0	0
Anjanaharibe	6	4.1	0	0	450	0
Mangabe	5	9.26	0	255	30	0
Antsahabe	1	13.17	0	32	0	0
Andranomenahely	5	9.38	0	0	0	0
Anantaka	6	5.98	66.7	266	300	0
Amparihimolengy	6	15.98	0	0	500	0
Bevitsika	2	10.29	0	0	0	0
Lokaitra	7	9.95	7.81	54	200	232

rogaleus major, Tsitsiha ou *C. ravus*, Tsitsihy ou *C. sibreei*, Microcèbe de Mittermeier ou *Microcebus mittermeieri*, *Microcebus* sp (en cours de détermination), Tsidiala ou *Allocebus trichotis*, Tantana ou *Phaner furcifer* et Hay hay ou *Daubentonia madagascariensis*.

A part, le site d'Anantaka, nous avons exploré 11 autres sites dans le bloc forestier de Makira, du nord au sud: Manandriana, Amparihibe, Bezavona, Ambatoharanana-Anjiabe, Anjanaharibe, Mangabe, Antsahabe, Andranomenahely, Ambongabe Amparihimolengy, Maroankolany Bevitsika et Lokaitra. Le nombre d'espèces de lémuriens dans ces autres sites varie entre trois et 12. Le Tableau 1 suivant résume les nombres d'espèces recensées dans le bloc forestier de Makira, en fonction de leur rythme nycthéméral.

Les 12 sites visités au bloc forestier de Makira présentent 20 espèces de lémuriens; parmi les espèces recensées 60 % sont nocturnes, 25 % diurnes et 15 % cathémérales. La comparaison des 12 sites répertoriés permet de déduire que le site d'Anantaka est le plus riche en espèces de lémuriens où on y a recensé au total 14 espèces, suivi de Mangabe, Antsahabe, Andranomenahely, Ambongabe-Amparihimolengy et de Lokaitra avec 12 espèces, puis Ambatoharanana-Anjiabe, Anjanaharibe et Maroankolany-Bevitsika avec dix espèces; ensuite Bezavona avec neuf espèces, Manandriana avec sept espèces et en dernier Amparihibe qui n'abrite que trois espèces. Par rapport à l'orientation des sites d'études, la partie centrale et la partie sud du bloc forestier présentent une homogénéité d'espèces lémuriennes par rapport à la partie nord. Le site d'Anantaka, avec ses 14 espèces de lémuriens, présente donc une richesse très élevée en diversité spécifique lémurienne par rapport aux 11 sites que nous avons étudiés dans le bloc forestier du plateau de Makira et par rapport aux autres sites déjà explorés dans les forêts de Makira (Raharivololona et al. 2003) ainsi qu'aux aires protégées environnantes comme Anjanaharibe Sud, Marojejy et Masoala (Schimd et Smolker 1998; Sterling et Rakotoarison 1998; Sterling et McFadden 2000).

LES PRESSIONS HUMAINES Plusieurs facteurs anthropiquesmenacent l'écosystème forestier dans le plateau de Makira. Le Tableau 2 ci-dessous indique les pressions relatives à chaque site.

Le Tableau 2 présente les valeurs de pressions anthropiques recensées par site dans le bloc forestier de Makira. Nous constatons que plus le nombre de villages est abondant et plus leur distance par rapport à la forêt est rapprochée, les impacts de pression sur l'écosystème forestier augmente. La chasse, les coupes illicites, les défrichements de la forêt primaire, les défrichements des forêts secondaires et la transformation des forêts en 'tavy' ou en prairie 'kijana' ainsi que les exploitations minières illicites peuvent influer l'équilibre écologique forestier. Dans le bloc forestier de Makira, les sites de Manandriana, d'Anantaka et de Lokaitra sont les plus exposés aux menaces anthropiques par rapport aux neuf autres sites mais la spécificité du site d'Anantaka oriente notre étude sur l'influence des menaces anthropiques sur les lémuriens.

RELATION ENTRE LES PRESSIONS ANTHROPIQUES ET LES ESPECES DE LEMURIENS La chasse et le piégeage sont très courants à Anantaka pour satisfaire les besoins rationnels en protéine animale; les chasseurs pratiquent à la fois la chasse traditionnelle, en utilisant des pièges à lémuriens ('laly'), des frondes et parfois des fusils de chasse. Ces pratiques atteignent leurs paroxysmes aux environs des périodes de festivité, telles que la fête pascale, la fête nationale et les fêtes de la fin d'année. Elles sont également importantes pendant la période de labour de rizière pour valoriser les travaux effectués, sous forme d'entraide dans la société. Les résultats de nos enquêtes indiquent que les lémuriens les plus recherchés sont ceux de grande taille comme: *Indri indri*, *Varecia variegata subcincta* et *Eulemur fulvus albifrons* et si les pièges attrapent des *Daubentonia madagascariensis*, les chasseurs les ramènent et les mangent comme tous les proies. Après la chasse, au moins une personne ramène cinq à dix individus, d'une même ou de différentes espèces. Si la chasse est bonne, une partie est consacrée à la famille et les restes sont vendus aux clients

Tableau 3. Influence des pièges et des coupes d'abres sur les lémuriens dans le site d'Anantaka

ESPECES DE LEMURIENS	DENSITE DE LEMURIENS (INDIVIDU / KM²)	COEFFICIENT DE CORRELATION AVEC LE PIEGE	COEFFICIENT DE CORRELATION COUPE D'ARBRE
Indri indri	13	-0.35	-0.77
Varecia variegata subcincta	5	-0.61	-0.93
Hapalemur griseus griseus	1	0	0
Eulemur fulvus albifrons	57	-0.08	-0.46
Avahi laniger	65	-0.01	-0.43
Lepilemur seali	30	-0.02	-0.62
Cheirogaleus major	42	-0.12	-0.54
Cheirogaleus ravus	15	-0.32	-0.73
Cheirogaleus sibreei	7	-0.51	-0.9
Microcebus mittermeieri	40	-0.12	-0.56
Microcebus sp.	6	-0.63	-0.9
Allocebus trichotis	14	-0.32	-0.77
Phaner furcifer	5	-0.61	-0.93

habituels qui ont effectués leurs commandes au préalable. La pratique de chasse de lémuriens par l'installation des pièges sous formes de 'laly' et 'laly totoka' (système de piège où l'on essaie de cerner l'habitat d'un groupe de lémuriens en créant un passage forcé pour piéger un animal) menace directement ces animaux, car une telle installation défriche directement le domaine vital d'un groupe et qui provoque l'éclatement ou l'isolement d'un groupe. En effet, pour installer une piège, une surface de 815 m^2 de forêt est détruite et 14 arbres de dhp > 18 cm sont abattus. Le Tableau 3 ci-après rapporte les résultats des calculs de corrélations entre les pièges recensés au niveau du site d'Anantaka et la densité au km^2 de chaque espèce de lémuriens rencontrée lors des suivis des ligne-inventaires.

L'analyse de coefficient de Spearman donne $R < 0.5324$, $\alpha = 0.05$ avec $N = 12$ (nombre des sites), non significatif: c'est à dire, il n'y a pas de corrélation entre les facteurs humains et la densité relative des lémuriens. En outre, les coefficients de corrélation de chaque espèce de lémuriens avec le piège montrent une valeur négative telle que: plus le nombre de piège augmente, plus la densité de chaque espèce de lémuriens diminue, c'est-à-dire toutes les espèces de lémuriens à Anantaka sont influencées par les installations des pièges. Par rapport aux valeurs du coefficient de corrélation R, les espèces de lémuriens suivantes: *Varecia variegata subcincta*, *Cheirogaleus sibreei*, *Microcebus* sp, *Phaner furcifer* et *Daubentonia madagascariensis* ont des valeurs supérieures à 0.5324. Ces espèces sont donc influencées par les pièges. Par contre, les autres espèces: *Indri indri*, *Eulemur fulvus albifrons*, *Avahi laniger*, *Lepilemur seali*, *Cheirogaleus major*, *C. ravus*, *Microcebus mittermeieri* et *Allocebus trichotis* ne sont pas influencées aux pièges, car la valeur de leurs coefficients de corrélation R est inférieure à 0.5324. Donc, chaque espèce de Lémuriens peut être sensible ou non aux pièges sauf l'*Hapalemur griseus* qui présente une valeur de R égale à zéro. Mais cette espèce est vulnérable car sa densité est faible. Par rapport aux coupes d'arbres, les coefficients de corrélation de chaque espèce de lémuriens montrent une valeur négative. La corrélation négative indique que: plus le nombre de coupe d'arbres augmente, plus la densité de chaque espèce de lémuriens diminue, c'est-à-dire que toutes les espèces de lémuriens à Anantaka sont influencées par les coupes d'arbres. Par rapport aux valeurs du coefficient de corrélation R; les espèces de lémuriens suivantes: *Eulemur fulvus albifrons* et *Avahi laniger* ont des valeurs inférieures à 0.5324; c'est-à-dire que ces deux espèces sont insensibles aux coupes d'arbres. Par contre, la valeur du coefficient de corrélation R est supérieure à 0.5324 pour les espèces suivantes: *Indri indri*, *Varecia variegata subcincta*, *Lepilemur seali*, *Cheirogaleus major*, *C. ravus*, *C. sibreei*, *Microcebus mittermeieri*, *Microcebus* sp., *Allocebus trichotis*; *Phaner furcifer* et *Daubentonia madagascariensis*, lesquelles sont de ce fait sensibles aux coupes d'arbres. Donc, chaque espèce de lémuriens peut être sensible ou non aux coupes d'arbres sauf *Hapalemur griseus* qui, ayant une valeur de R égale à zéro, est vulnérable à cause de sa faible densité.

Dans le site d'Anantaka, 36 % des espèces de lémuriens sont sensibles aux pièges et 64 % en sont insensibles et par rapport aux coupes d'arbres, 85 % des espèces de lémuriens existantes sont sensibles et 15 % insensibles. Donc, les facteurs anthropiques les plus menaçants d'Anantaka sont les coupes d'arbres et l'installation de pièges. Les destructions de l'habitat conduisent au déséquilibre de l'écosystème forestier, à la décadence de la biodiversité et à la dégradation des différentes niches écologiques. A part cette dégradation de la biodiversité, la décadence de la moralité à la fois sur les notions du civisme et le concept du tabou ('fady') se trouve sur une situation bouleversante, puisque les gens ne considèrent plus ni les valeurs culturelles pour la conservation de la forêt ni les lois régissant la gestion forestière et les chasses des animaux sauvages.

RECOMMANDATION ET CONSERVATION

PRIORITE EN MATIERE DE CONSERVATION DES LEMURIENS SUR LES 90 espèces de lémuriens connues actuellement à Madagascar (Mittermeier et al. 2006), Anantaka, présente 14 espèces (15 %) regroupées dans les cinq familles de lémuriens actuelles. Avoir de tel nombre d'espèces lémuriennes dans un même site est rarissime. L'habitat d'Anantaka présente donc une niche écologique encore originelle convenable aux différentes espèces de lémuriens adaptées aux forêts denses humides de basse à moyenne altitude de l'est de Madagascar. Ces critères classifient ce site d'Anantaka dans la cible focale de conservation. Comme les lémuriens sont des animaux arboricoles, le défrichement de la forêt pour la culture sur brûlis (culture de riz, cultures vivrières) ou pour l'extension des propriétés foncières ainsi que l'installation des pièges à lémuriens menace leurs existences. Trois paramètres priorisent la conservation des espèces, à savoir, la superficie de l'habitat à conserver, la structure et les conditions écologiques de l'habitat et la relation de l'habitat à conserver avec l'habitat périphérique (SAPM / UICN 2005). La couverture forestière d'Anantaka présente encore 75 % de forêt, 25 % est transformée en 'savoka' et en prairie; Anantaka est un habitat exceptionnel pour les diversités lémuriennes qui nécessitent un système de conservation dans l'immédiat.

INTEGRATION DE LA POPULATION RIVERAINE DU SITE D'ANANTAKA À ÊTRE RESPONSABLE DE LA GESTION RATIONNELLE DE LEURS RESSOURCES NATURELLES

En 2004, la politique de gestion forestière GELOSE (Gestion locale sécurisée pour gérer les forêts communautaires) est appliquée dans la zone. Le projet émane du WCS / Projet Makira et le service de Cantonnement de Maroantsetra. Alors, on a crée les Communautés de base (COBA) à Anjiahely et à Antsirabe, villages aux alentours d'Andongona et d'Anantaka. L'impact de cette implantation semble immédiat car la pratique de la chasse, de culture sur brûlis et les défrichements illicites de forêt sont atténués pour ces villages car les communautés elles-mêmes gèrent leurs forêts. Par contre, cette initiative n'a pas d'impact dans le site d'Anantaka, car la chasse et le piégeage ainsi que le défrichement des forêts continuent toujours. Pendant nos observations en 2006, 20 pièges ont été repérés par comptage direct au niveau des ligne-inventaires du site d'Anantaka, dont la mise en place entraîne la destruction d'une espace forestière de 1,6257 m^2, où environ 266 arbres de dhp > 18 cm sont abattus. L'abondance des pièges accélère la destruction de la forêt et souvent les chasseurs n'arrivent plus à collecter les animaux piégés et les laissent pourrir sur place où ils deviennent des proies faciles pour les *Cryptoprocta ferox*, nous en étions des témoins oculaires dans le cas d'un *Tsitsiha* ou *Cheirogaleus ravus* (Figure 2).

L'intervention de l'éducation environnementale est indispensable dans le 'fokontany' d'Andongona et le village d'Anantaka pour sensibiliser les COBA et les populations sur l'importance et l'avantage des ressources forestières, pour qu'ils ne défrichent plus la forêt mais de restaurer plutôt les forêts détruites par les pratiques de cultures sur brûlis et l'installation des pièges à lémuriens. Les appuis techniques seront indispensables pour les associations à élaborer un plan de développement tenant compte de la nécessité de fournir à ses membres des services de qualité, de développer sa viabilité financière. L'application de politiques économiques relatives à satisfaire les besoins quotidiens de chaque membre de l'association est primordiale, c'est-à-dire faire un aménagement de terroir pour permettre les cultures vivrières et d'instaurer l'équilibre des circuits de production et de consommation dans un système économique adéquat. Ce système nécessite la création des conditions améliorant l'offre viable en produits et en services financiers, dans les zones rurales. Donc, ce système nécessite la création d'un projet qui assurera la surveillance et le contrôle du secteur par des missions de suivi-évaluation et tenir des rencontres de concertation pour des éventuels ajustements adaptés et afin de mieux sécuriser les différents appuis financiers et techniques.

FIGURE 2. *Cheirogaleus ravus* oublié par le chasseur et dévoré par le Fosa ou *Cryptoprocta ferox*

CONCLUSION

L'intensité des pressions humaines est très forte particulièrement dans le site d'Anantaka à cause des installations des pièges à lémuriens qui entraînent la fragmentation et la dégradation partielle de la forêt. Ces fragmentations amplifient la dégradation produite par la pratique de culture sur brûlis. Ces situations perturbent la biodiversité dans le site, en particulier celle des lémuriens, car les fragmentations de leurs habitats naturels diminuent les espaces de leurs domaines vitaux. Ces perturbations pourront entraîner par la suite la migration de l'espèce animale et même la disparition progressive des quatorze espèces existantes ainsi, Anantaka ne pourra plus être un site de conservation exceptionnelle pour les lémuriens. Le paradoxe de la pratique de culture sur brûlis comme dans toute la côte Est de Madagascar se fait sentir dans cette zone, car les besoins en rations alimentaires humaines riment avec la destruction des ressources naturelles à partir de laquelle le système de gestion et de conservation n'est plus respecté. Les influences des pressions anthropiques n'affectent pas seulement les lémuriens mais elles peuvent également avoir des conséquences sur la dégradation du biotope et sur le mode de vie de l'homme. En effet, une visualisation des appuis techniques sur l'agriculture et une activité génératrice de revenus sur les cultures vivrières pour satisfaire les besoins locaux sont indispensable dans l'immédiat pour nourrir les 2,300 habitants. Ensuite, il faut clarifier aux gens, l'importance des ressources naturelles, l'équilibre écologique et son impact dans la vie quotidienne, la nécessité de la gestion de ces ressources dans une vision durable, par le biais de l'éducation environnementale pour améliorer d'une manière stable leurs niveaux de vie.

REMERCIEMENTS

Nous adressons nos remerciements à la Fondation MacArthur qui a financé le présent projet et au projet Wildlife Conservation Society (WCS) Madagascar en particulier WCS / Projet Makira, Maroantsetra et à toutes ses équipes, dirigés par son Directeur

National Monsieur Jean Jacques Jaozandry et le Conseiller Technique Principal Monsieur Christophe Holmes pour leurs aimables collaborations, ainsi qu'à toutes Autorités administratives (Direction de la Préservation de la Biodiversité du Ministère de l'Environnement et des Eaux et Forêts, Direction des Eaux et Forêts de Toamasina et ses collaborateurs, les Circonscriptions des Eaux et Forêts d'Antsohihy, de Fénérive Est et d'Antalaha, les services de cantonnements forestiers de Maroantsetra, d'Andapa, d'Antalaha, de Mandritsara et de Befandriana, les Chefs de District de Maroantsetra, de Mandritsara et de Befandriana, les Maires dans les différentes communes), les autorités locales (Chefs de fokontany, Tangalamena et Sojabe) de Maroantsetra, Mandritsara et de Befandriana, les Communautés de base aux environs de nos sites d'interventions pour leurs appuis en ressources humaines (Guides et Porteurs), en matériels et logistiques et en particulier à tout le Staff de MCD, les Reviewers pour leurs précieux commentaires prodigués sur cet article.

REFERENCES

Altmann, J. 1974. *Observational study of behavior: Sampling methods.* Behavior 49: 227-267.

Besairie H. 1972. *Géologie de Madagascar*, Service Géologique de Madagascar. Tananarive.

Commission Communication SAPM (Système des Aires Protégées à Madagascar). 2005. Adhésion des cibles à différent niveau à la mise en place du SAPM (non publié).

Du Puy, M. 1996. *A refined classification of primary vegetation of Madagascar based on the underlying geology: using GIS to map its distribution and to cossets conservation status.* W.R Laurence (éds.). Proceedings of the international symposium on the biogeography of Madagascar: 205-218 + 3 maps. Edition de l'ORSTOM. Paris.

Fonds d'Intervention pour le Développement (FID). 2003. Plan Communal de Développement de la commune rurale d'Antsirabe Sahatany (non publié).

Ganzhorn, J. U. 1994. *Inventaires biologiques dans la forêt de Zombitse. Les Lémuriens.* Goodman S. M., Langrand, O. (éds.), Recherche pour le développement, Série Sciences biologiques, CIDST, Antananarivo, Madagascar, Numéro Spécial, pp. 70-72.

Humbert, H., Cours- Darne, G. 1965. *Description des types de végétation.* H. Humbert et G. Cours Darne (éds.), Notice de la carte de Madagascar - travaux de la section scientifique et technique de l'Institut français de Pondichéry, 6:46-78.

Ministère de l'Environnement, des Eaux et Forêts, WCS, 2003. *Site de Conservation de Makira:* Rapport d'atelier de planification technique et stratégique, février 2003. (non publié).

Mittermeier, R.A., Konstant W.R., Hawkins, F., Louis E.E., Langrand, O., Ratsimbazafy, H.J., Rasoloarison, R., Ganzhorn, J.U., Rajaobelina, S., Tattersall, I., Meyers, D.M. 2006. *Lemurs of Madagascar* (Second edition), Conservation International Tropical Field Guide Series, Washington, D.C. 520 p.

Raharivololona, B.M., Ratsisetraina, R.I., et Day, S.R. 2003. *Lémuriens des forêts humides du plateau de Makira, Maroantsetra, Madagascar.* 2003. Lemur News, 8:18-19.

Schmid, J. and Smolker, R. 1998. *Lemurs of the Reserve Spéciale d'Anjanaharibe-Sud, Madagascar*; Fieldiana Zoology 90:227-240.

Sterling, E.J. and McFadden, K. 2000. *Rapid census of lemur populations in Parc National de Marojejy, Madagascar.* S.M. Goodman (eds.), A floral and Faunal Inventory of the Parc National de Marojejy, Madagascar: With Reference to elevational variation. Fieldiana Zoology, New series 97: 265-274

Sterling, E.J. and Rakotoarison, N. 1998. *Rapid assessment of richness and density of primate species on the Masoala peninsula, eastern Madagascar.* Folia Primatologica, 69:109-116.

Wildlife Conservation Society. 2004. *Contexte environnemental du site de conservation de Makira* (Rapport pour le WCS, non publié).

MINING

Contested Spatial Coincidence of Conservation and Mining Efforts in Madagascar

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ABSTRACT

Mining appears to represent an important threat to conservation efforts in Madagascar. Expanding mining activities on the island have the potential to provide revenue for development and conservation efforts, but also pose a potential threat to conservation efforts on the island due to the spatial distribution and extent of mining concessions and the environmental impacts that mines often cause. By measuring the extent of overlap of permitted mining concessions with protected areas, potential protected areas, and mining-exclusion zones on the island, we assessed potential effects of mining on terrestrial conservation and evaluated the success of the governing institutions in limiting that impact. Permitted mining areas in 2006 overlapped with protected areas, potential protected areas, and mining-exclusion zones on the island. Mining concession areas overlapped with 33 % of surface area planned for protection in 2005, 21 % of surface area planned for protection in 2006, and 12 % of the surface area from which mining was to be legally excluded. Total permitted area and area of overlap with conservation areas increased between 2005 and 2006 despite efforts in 2004 to limit such overlap. Changes in the mining permitting and regulation could improve prospects for limiting the impact of mining on biodiversity conservation on the island.

INTRODUCTION

Mining has the potential to provide less industrially-developed countries (LDCs) with revenue that could promote development and reduce poverty, but expanded mining reforms are often unsuccessful in improving development indicators or national economic performance and lead to numerous harmful socio-economic and environmental impacts (Miranda et al. 2003; Bridge 2004a; Davis and Tilton 2005; Haselip and Hilson 2005).

Madagascar faces potential conflicts between conservation and mining management. Since 2003, the government's Durban Vision effort has sought to triple the surface area of protected areas in order to protect six million ha of terrestrial and marine areas (Norris 2006) on this threatened island biodiversity hotspot (Myers et al. 2000). The Government of Madagascar and international financial institutions (IFIs), in the past decade, have also sought to promote a liberalized mining sector (Duffy 2005, 2007; Sarrasin 2006). New laws liberalizing, promoting, and regulating mining on the island were enacted in 1999-2001, 2003, and 2005 (Rép. Mad. 1999, 2000a, 2001, 2003a, 2005; Colored Stone 2005; Weldon 2005; Sarrasin 2006) and these policy changes have led to an increase in mine permitting and activity on the island (Cope 2002; Rép. Mad. 2003b; Bridge 2004b; Mining Journal 2004). Noted effects of existing mining efforts have included socio-economic and health impacts of uranium mining during the mid-20th century (Hecht 2002), socio-economic and environmental impacts of gem mining rushes around Ambondromifehy / Ankarana and Ilakaka / Isalo (Walsh 2003, 2004; Cardiff and Befourouack 2003; Duffy 2005, 2007), and environmental impacts of certain industrial graphite and chromite mining operations (Rép. Mad. 2003b; Felena 2006).

The new mining regulations gave some consideration to environmental impacts of mining. The current mining policy requires that mining entities conduct environmental studies and plans according to the types of mining activity and permit requested (Table 1; Duffy 2007). The Ministère de l'Energie et des Mines (MEM) can also declare certain zones as reserved in order to protect conservation sites, sites with fossils, or other sites decided by the MEM (Rép. Mad. 1999, 2000a). Due to perceived problems with the mine permitting process (Rép. Mad. 2003b), permit granting in various conservation areas was even formally halted beginning in 2004 and extended through 2008 in order to designate mining-exclusion or "no-go" zones (Rép. Mad. 2004; Borrini-Feyerabend and Dudley 2005; Norris 2006; Duffy 2007; Rép. Mad. 2007). The mine-forests commission (Comité / Commission Interministériel des Mines et des Forêts), officially decreed in 2004, also began to work to resolve and prevent overlap of mining permits with conservation zones (Rép. Mad. 2007).

Although others have noted overlap of potential mining areas with areas of importance to conservation on the island (Rép. Mad. 2003b; Duffy 2005, 2007; F. Hawkins personal communication), a recent quantitative evaluation of the spatial intersection of actual permitted concessions with a complete set of types of conservation areas over time remains lacking.

We sought to conduct such an analysis and determine current evidence of conflict between mining and conservation objectives in Madagascar by evaluating spatial coincidence of

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TABLE 1. Regulatory characteristics of mining permits in Madagascar (Rép. Mad. 2000b; BPGRM 2002). Exploitation permits may allow for the most intensive environmental impacts, but their spatial extent is more limited than that of research permits. Plans d'Engagement Environnementales (PEE) represent less stringent environmental impact planning than Etudes d'Impactes Environnementales (EIE). New regulations are expected to change grid square size and other conditions in 2007.

NAME OF PERMIT TYPE (ABBREVIATION)	SPATIAL EXTENT ALLOWED	MAXIMUM DURATION	PROSPECTING ALLOWED?	RESEARCH ALLOWED?	EXTRACTION ALLOWED?	TECHNOLOGY ALLOWED	ENVIRONMENTAL PLANS REQUIRED	SALE OF SUBSTANCES ALLOWED?
Authorisation Exclusive de Réservation de Périmètre (AERP)	2,400 grid squares	3 mo	yes	no	no	undefined	none PEE; EIE[1]	no
Permis Réservé aux petits Exploitants (PRE)	16 grid squares (4 per block)	8 yrs + 4 yrs extensions	yes	yes	yes	manual	PEE; EIE[1]	yes
Permis de Recherche (R)	1,600 grid squares	10 yrs + 5 yrs extensions	yes	yes	no	mechanized	PEE; EIE[2]	no
Permis d'Exploitation (E)	160 grid squares	40 yrs + 20 yrs extensions	yes	yes	yes	mechanized	EIE	yes

[1] Regulations require PRE permits to file EIE if in areas with high concentrations of miners (>20 within 500m radius)

[2] Regulations require R permits to file EIE if in sensitive areas, if demanded by a prior PEE, or if being transformed to an E permit

areas with the various mining permits issued by MEM (Table 1) and current and potential protected areas and mining-exclusion ("no-go") zones. We also assessed temporal change in potential conflict between conservation and mining objectives, and examined how new temporarily protected areas corresponded with previous protection plans.

METHODS

To establish the locations of mining permits, we acquired the database of mining permits of 9 June 2006 from the Bureau du Cadastre Minier de Madagascar (BCMM) of the Ministère de l'Energie et des Mines of the Government of Madagascar. We also obtained that database from 3 May 2005 and the database of mining-excluded grid squares (2.5 x 2.5 km "carrés") from 3 May 2005 from ANGAP (Association Nationale pour la Gestion des Aires Protégées / Parcs Nationaux de Madagascar).

We used several different geographic coverages to represent areas of conservation importance on the island. We obtained a geographic database consisting of the locations of protected areas established prior to 2005 and new protected areas that were to have been created in 2005 and 2006 and projected to be created in 2007-2008 in accordance with the planned Système d'Aires Protégées de Madagascar (SAPM; Durban Vision unpublished data). The 2007-2008 zones represented remaining forest that could potentially become protected area rather than distinct planned protected areas; many of these areas may have become degraded since the original categorization of the forest lands. We also examined classified forests (forêts classées) and forest reserves (réserves forestières) managed by the Ministère de l'Environnement, des Eaux et Forêts. Some of these latter forest areas, some SAPM areas, and some mining-exclusion areas coincided with one another. We also used a geographic database containing spatial information on new, temporarily protected areas established in 2005-2006 to compare with previous SAPM protection plans.

We measured the extent of overlap of areas with mining permits with areas of potential conservation importance using ArcGIS 8.3 (ESRI, Redlands, California). We approximated a Laborde projection using a standard Hotine Oblique Mercator projection for all shapefiles. Intersected area measured was the area in common between mining grid squares and conservation area and assumed the shape of the intersection regardless of grid square boundary shape. We measured overlap of permitted mining grid squares from 2006 with SAPM areas, with classified forests and forest reserves, and with mining-exclusion areas listed in 2005. To better understand the potential impacts of permitting practices, we also analyzed characteristics of permits (type of permit, permitted substance, permit dates, and types of overlapped mining exclusion zones) granted for overlapped conservation areas. Some permits did not have starting permit dates in the databases; 3 % of permitted grid squares in 2005 and, after filling in missing dates where possible from matching permits from the 2005 database, 8 % of permitted grid squares in 2006 did not have starting permit dates. We also included in our analyses permits, representing 5 % of the permitted grid squares listed in 2006, that ought to have expired within a year prior to the database date because their continued presence in the database may have implications for mining activity in the field.

Possible differences in digitizing practices or projections between agencies represented a minor potential source of error in the analysis. As an indication of the small magnitude of this error, however, discrepancy between grid square surface areas for overlapping permitted grid squares listed in 2005 with those of 2006 and permitted grid squares from 2006 with overlapping exclusion zone grid squares averaged only 0.02 % (± 0.001 % SE) and 0.02 % (± 0.004 % SE) per grid square for those respective comparisons. For our analyses we also assumed that official boundaries in spatial databases for SAPM areas were accurate, but official limits for some existing protected areas may also have differed from border markers and acknowledged limits on the ground (e.g., Cardiff and Befourouack in press), and so overlap of permitted mining zones with current SAPM areas in the field may differ slightly from what we measured.

In order to evaluate the pace of mining activity on the island and the change in its relevance to conservation efforts, we measured the change in number of grid squares with mining permits between our permit lists from 2005 and 2006, the number of grid squares granted new permits in several consecutive years, and the change in area of overlap with all pre-2007 existing and planned SAPM areas over several years. Finally, we measured the proportion of the total mining concession surface area that overlapped with SAPM zones, and measured surface area of the total remaining new and potential SAPM area that remained free of mining permits.

RESULTS

Mining areas with permits in 2006 overlapped with several categories of protected, potentially protected, forested, and mining-exclusion zones (Figure 1; Table 2). Greatest area of overlap occurred with mining-exclusion zones, and greatest proportional overlap occurred with 2005 SAPM areas (Table 2).

The greatest surface area of overlap for all 2006-listed permitted grid squares with SAPM 2005-6 zones occurred in the North (Makira and Daraina), the Southwest (Mikea) and the center-east (Ranomafana-Andringitra; Table 3). Less overlap of mining concessions occurred with a few pre-2005 protected areas (Table 3). Overall area of overlap of mining concessions of all permit types with SAPM 2005-6 areas increased between 2005 and 2006; overlap of small exploitation (PRE) and exploitation (E) permits with those SAPM areas increased between 2003 and 2005 before decreasing (Table 3). Between 16 and 67 % of the 2006-listed grid squares that overlapped with SAPM areas of different years started after the decree stopping permitting in conservation zones from mid-October 2004 (Table 2). Gold or ilmenite featured as the most commonly permitted primary substance for several categories of conservation areas (Table 2). Most of the permitted surface area overlapping with SAPM areas was under research permits (R; Table 2). Surface area of overlap of mining concessions with the combined SAPM areas represented only 6 % of the total area in the country with 2006-listed mining permits.

Most of the mining-exclusion zone surface area with overlapping 2006-listed permits was also under research permits (R; Table 2). Approximately half of that overlapped area consisted of zones that were excluded because they were conservation sites (Table 4), and these overlapped conservation exclusion zones represented 16.8 % of all conservation exclusion zones by surface area (Table 2). A total of 68 % of mining-excluded conservation site surface area with mining permits coincided spatially with SAPM areas from 2005 to 2008. Most of the permitted yet officially mining-excluded grid squares with starting dates had starting dates after the date of the permit halt decree of 2004 (Table 2).

Surface area with mining permits increased between May 2005 and June 2006, with 12,735 grid squares having permits in both years, 1,813 grid squares losing permits between 2005 and 2006, and 15,417 grid squares receiving new permits. The majority of the newly permitted grid squares between May 2005 and June 2006 were AERP permits. Ignoring AERP permits, the total number of permitted mining grid squares also increased between 2000-2002 and 2003, and between 2003 and 2004 (Figure 2).

The sum of the surface area of pre-2005 protected areas added to the area of 2005-2008 planned, potentially protected areas that did not also have mining permits was 7.4 million ha.

Although time lags and differences in size and shape occurred, all planned 2005 SAPM protected areas received temporary protection by 2007 (Figure 3; Table 3). Most planned

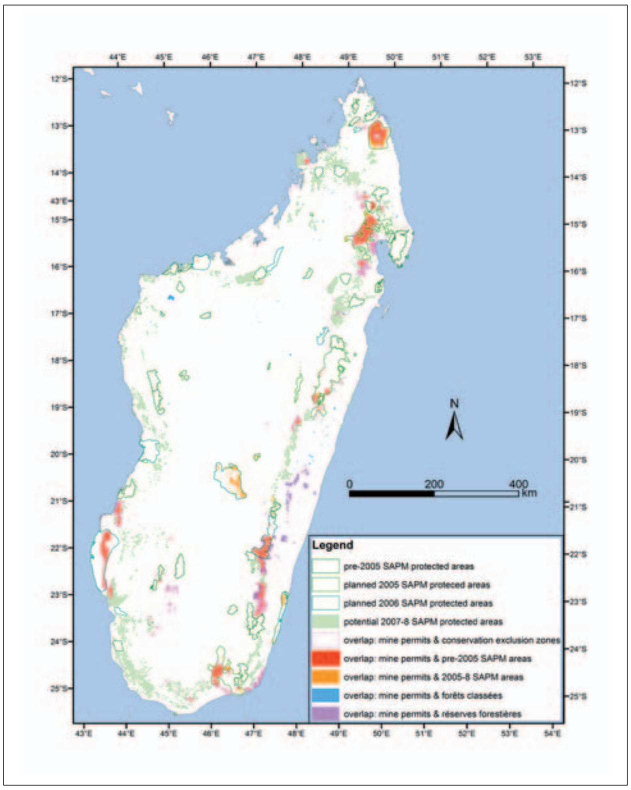

FIGURE 1. Map illustrating overlap of mining permits on list from 09 June 2006 with all areas of conservation importance that we assessed. The map shows permit overlap with forêts classées and réserves forestières only where overlap does not also correspond with permit overlap with SAPM areas. We did not illustrate the overlap of permits with exclusions zones other than conservation exclusion zones (see Table 4) and did not illustrate the post-2004 SAPM areas that have received temporary protection. Overlap with pre-2005 SAPM areas is enlarged for visibility.

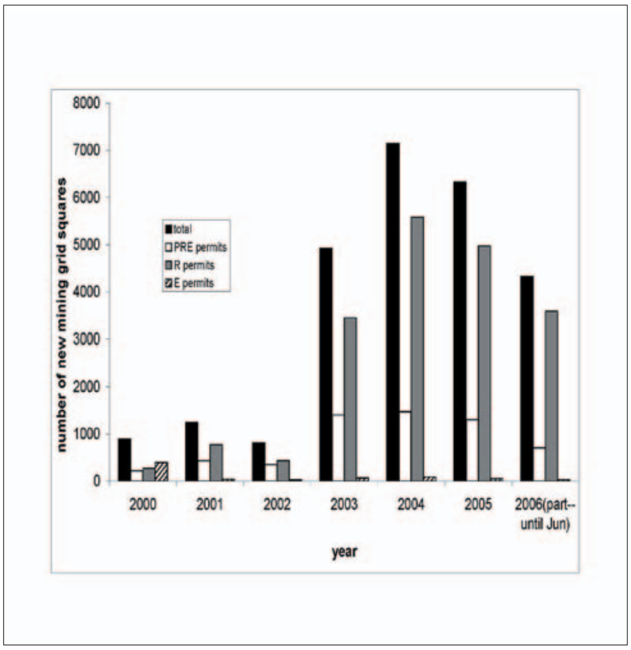

FIGURE 2. Number of mining grid squares granted small exploitation (PRE), research (R), and exploitation (E) permits in 2000-2003 (Mining Journal, 2004), 2004 (based on permit dates from list of May 2005), 2005, and June 2006 (latter two based on permit dates from list of June 2006). Counts for 2004 and 2005 may not include some permits that were obtained during those years but expired before the date of the database that we used to generate the count. Proportions of the permitted grid squares also lacked start dates in the 2005 (0.05 %) and 2006 (12 %) databases. Total = PRE + R + E.

TABLE 2. Mining permits listed in June 2006 overlapped with all types of categories of areas of conservation importance examined. Permits for all overlapped areas had expiration dates ranging until at least 2039 and substances sought included gold for almost all categories. SAPM = Système d'Aires Protégées de Madagascar. Percentage of permits since decree represents the percentage of mining grid squares with starting dates occurring after the date of application of the 2004 decree halting permitting in conservation exclusion zones.

OVERLAPPING PERMIT CHARACTERISTIC	PRE-2005 SAPM AREAS	2005 SAPM ADDITIONS	2006 SAPM ADDITIONS	2007-8 SAPM ADDITIONS	FORÊTS CLASSÉES	RÉSERVES FORESTIÈRES	MINING EXCLUSION ZONES (AND CONSERVTION SITE EXCLUSION ONLY)
surface area (ha) by permit type							
AERP	0	7,397	47,681	3,639	5,270	14,532	137,446
PRE	294	41,527	38,515	12,880	8,190	23,566	213,035
R	546	450,080	252,739	203,799	41,789	193,382	1,992,797
E	92	7,789	5,609	5,385	8,240	1,379	83,868
total	932	506,794	344,544	225,704	63,489	232,858	2,427,146
percentage of total area for category	0.05	32.6	20.9	6.3	2.7	23.0	12.1 (16.8)
median starting date	2005	2003	2003	2003	2004	2004	2004 (2004)
median expiration dates	2015	2014	2011	2014	2014	2013	2014 (2014)
starting dates range	1995-2006 [1]	1991-2006 [2]	1991-2006	1992-2006	1935-2006	1994-2006	1913-2006 (1992-2006)
expiration dates range	66.7	34.3	2006-2041	2006-2044	2006-2043	2006-2041	2005-2046 (2006-2046)
percentage of permits since decree	2011-2039	2006-2043	41.1	16.3	29.8	52.6	52.5 (60.7)
minerals with greatest permited area, % of area	gold-diamond, 58	gold-other, 65	ilmenite-other, 40	corundum-other, 34 ilmenite-other, 28 gold-other, 19	gold-other, 36 copper-other, 24	corundum-other, 57 gold-other, 27	gold-other, 36 (gold-other 31)

[1] A permit for mica mining in Andohahela Parcelle III dated from 1965

[2] A permit for mica mining in the Atsimo area dated from 1965

TABLE 3. Change in surface area between 2003 and 2006 of overlap of zones with mining permits with different SAPM (Système d'Aires Protégées de Madagascar) areas. Recorded 2003 overlap (Rép. Mad. 2003b) only represented exploitation (E) and small exploitation (PRE) permits. We did not include planned 2007-8 SAPM areas in this analysis.

SAPM YEAR	NAME OF AREA	SURFACE AREA (HA) OVERLAPPED BY PRE AND E PERMITS IN 2003	SURFACE AREA (HA) OVERLAPPED BY PRE AND E PERMITS IN 2005	SURFACE AREA (HA) OVERLAPPED BY PRE AND E PERMITS IN 2006	SURFACE AREA (HA) OVERLAPPED BY ALL PERMITS IN 2005	SURFACE AREA (HA) OVERLAPPED BY ALL PERMITS IN 2006	PROPORTION OF SAPM AREA OVERLAPPED BY PERMITS IN 2006	YEAR TEMPORARY PROTECTION GRANTED
pre-2005	Andohahela (parcelle 3)	0	28	28	28	28		
	Anjanaharibe-Sud	< 1,250 [1]	238	277	238	823	8.5	
	Mantadia	< 1,250 [1]	64	64	64	64	2.6	
	Vohibasia	0	0	17	0	17	0.6	
2005	Anjozorobe[2]	0	26	26	26	26	0.1	2005
	Atsimo[2,3]	6,875 [4]	22,725	16,636	95,196	99,108	0.1	2006
	Daraina[2,3]	12,500 [4]	15,114	13,850	177,358	183,240	28.0	2005
	Makira[2]	10,000 [4]	1,666	0	182,142	187,569	70.3	2005
	Zahamena - Mantadia[2,3]	11,250 [4]	25,841	18,804	50,867	36,851	51.5	2005
2006	Alaotra[2]	1,250 [4]	1,031	887	1,031	887	6.9	2006
	Andavakoera	0	0	251	0	721	2.0	
	Farafangana	0	0	0	19,679	24,862	5.4	
	Ibity	< 3,750 [1]	4,566	6,473	5,092	9,200	21.6	
	Itremo	44,375	31,685	26,327	38,755	83,072	70.2	
	Mahavavy - Kinkony[2]	0	0	0	13,863	2,492	23.6	2006
	Mikea	0 [5]	0	0	151,088	115,665	2.0	
	Ranomafana-Andringitra[2,3]	5,000	10,163	10,186	107,638	107,644	22.0	2006
							55.6	
TOTAL		97,500 [1]	113,147	93,826	843,065	852,270		

[1] overestimate because individual mining grid squares only partially overlapped with SAPM areas; [2] corresponding temporarily protected area differed in shape and surface area (smaller or larger) from this original SAPM listing; [3] corresponding temporarily protected area(s) differed in name(s) from this original SAPM name listing; [4] counted grid squares as per SAPM 2005 delimitation not as per map in Rép. Mad. (2003b); [5] overlap mentioned in text but not shown (possibly R or AERP permit overlap)

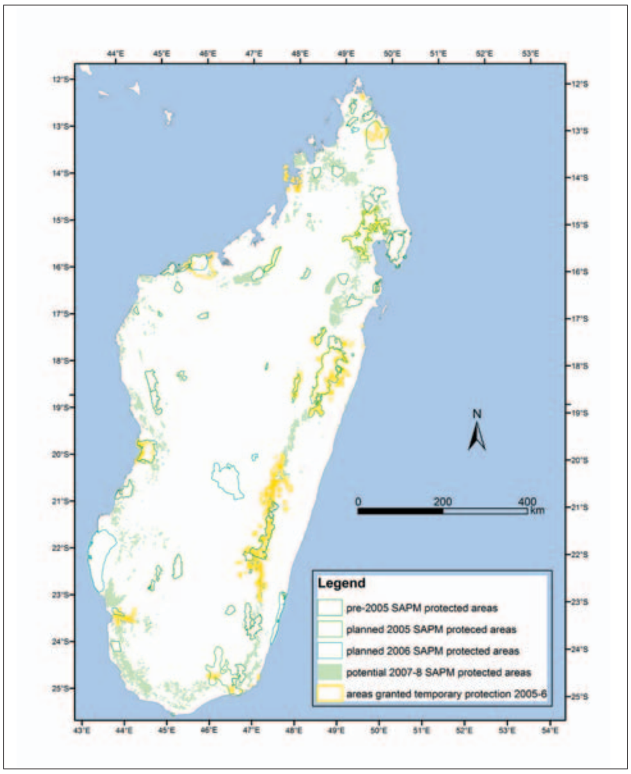

FIGURE 3. Geographic correspondence between planned SAPM protected areas for 2005-2006 and areas actually temporarily protected in 2005-2006. Temporary protection zones differed in size and shape from SAPM plans for 2005 and 2006, and most planned 2006 areas, which had extensive mining permit overlap, remained unprotected by early 2007. Names and mining permit overlap proportions of planned areas are in Table 3.

2006 SAPM protected areas, however, had yet to receive temporary protection by 2007 (Figure 3; Table 3).

DISCUSSION

The area of overlap of actual mining concessions with areas that were listed as mining-exclusion zones and current and potential SAPM protected areas suggests that current regulation of the mining industry in Madagascar may be insufficient to conserve areas with important biodiversity. This appears to validate concerns that institutional changes associated with mining liberalization and structural adjustment may prevent the government from properly managing an expanding mining industry (Rép. Mad. 2003b; Ramamonjisoa 2004; Sarrasin 2006; Duffy 2007). Mining interests in Madagascar may displace or alter planned conservation efforts as they have in countries such as Australia (Pouliquen-Young 1997), Guyana (Funk et al. 1999), and French Guiana (Thiollay 2002).

OTHER EXPLANATIONS? The difference in database dates for the permit list (2006) and the exclusion zone list (2005) might have influenced measured overlap with exclusion zones. The overlap could actually have reflected a reduction in the list of exclusion-zone areas between those years, as suggested by the title of an ordinance from 2005 (Rép. Mad. 2007), or the unrecorded suspension of mining permits once new exclusion zones were put in place. Examination of a printed map of the Daraina region from BCMM from June 2006, however, confirmed the presence of official overlap between exclusion sites and permitted mining grid squares (SGC unpublished data). Most of the overlapped exclusion zones were also excluded

TABLE 4. Conservation sites (Site de conservation) were the mining exclusion zone sub-category with the greatest surface area of overlap by mine permits listed in June 2006, but overlap occurred for other sub-categories as well.

CATEGORY OF EXCLUSION ZONE	SUB-CATEGORY OF EXCLUSION ZONE	OVERLAP SURFACE AREA (HA)	PERCENTAGE OF TOTAL OVERLAPPED EXCLUSION ZONES REPRESENTED BY EXCLUSION SUB-CATEGORY (%)
Forêts classées	Forêts classées	70,519	2.8
Parcs nationaux	Parcs nationaux	1,874	0.1
Zones Fossiliferes	Zones Fossiliferes	230,054	9.3
Zones réservées	Site de conservation	1,222,603	49.2
	Zone d'étude géologique	695,765	28.0
	OMNIS	136,288	5.5
Zones Tampon	„ASS_OR"	70,519	2.8
	„Zones réservées"	31,270	1.3
	„Z_QMM"	22,473	0.9
	Zones Tampon	5,005	0.2

for conservation reasons and the overlap may be of conservation importance even if the exclusion were removed. Many of the overlapping permits were also granted in 2006 and were therefore too recent to have been unofficially suspended by the institution of the exclusion zones from 2005.

CONSERVATION COMPATIBILITY? The approval of temporary or permanent protection for several SAPM areas with mining overlap in recent years, the larger size than originally planned for some of those areas, and the subsequent decrease in permits in some of those areas might suggest that resolution of potential conflicts favors conservation outcomes. Indeed, the mines-forests interministerial commission is intended to prevent conflict between conservation and mining interests and has generally facilitated limiting mining permits on new temporarily-protected areas (J. MacKinnon personal communication), but old permits remained on several of those new temporarily-protected areas and permits granted since temporary protection appeared to overlap slightly with those areas at Anjozorobe and Ankeniheny Zahamena (SGC unpublished data). Remaining potential SAPM surface area without mining permits was theoretically sufficient to cover the goals of the Durban Vision. Many forest areas considered potential SAPM areas, however, may have become degraded since the drafting of the initial SAPM plans that were based on earlier forest cover information, and further mine permitting may threaten remaining forest area.

CAUSES FOR CONCERN Several observations indicate that current mining plans and conservation goals may not be compatible:

- Mining permits overlapped with all categories of conservation areas and covered up to 33 % of the surface area of a given conservation category.
- Permit-granting appeared to have continued in mining-exclusion zones and SAPM areas in spite of government efforts to halt such overlap in 2004 and 2006 (Rép. Mad. 2004, 2007).
- The duration of permits granted in areas of conservation concern and the potential high value of the gold to be extracted suggest that granting those permits may not have been a temporary mistake.

- The number of grid squares with permits also tended to increase since 2002 and the number of non-AERP permits granted in the first half of 2006 also suggests an increasing rate of permitting. Overlap of mining concessions with SAPM areas appears to have increased at least between 2003 and 2005 as well. Although many of the overlapping permits are research permits that may lead to less intensive but more extensive impacts, small (PRE) and large (E) exploitation permits also overlapped frequently with conservation areas.
- The temporary protection granted to some new SAPM areas may expire prior to granting of permanent protection (USAID unpublished report) and the extension of the ban on permitting in the exclusion zones will expire in 2008 (Rép. Mad. 2007).
- Some new temporarily-protected areas are smaller than originally planned, and five of the areas that were originally scheduled to receive protection in 2006, and that had overlapping mining permits, had yet to receive even temporary protection.
- Granting of exploitation permits may exclude conservation efforts in potential SAPM 2007-8 areas where conservation plans are not sufficiently advanced to establish temporary protection. Additional work ought to examine how potential competition for certain areas by conservation and mining interests may have influenced temporal and spatial distribution of granting of official SAPM protection and granting of mining permits.
- The "governance state," consisting of a combination of the authority of the state, IFIs, development agencies, private corporations, and NGOs (Duffy 2006), has failed to adequately manage and limit impacts of existing artisanal mining efforts, which can accompany or follow large-scale mining (Hilson 2002), at several locations in Madagascar over the past decade (Walsh 2003; Rép. Mad. 2003b; Cardiff and Befourouack 2003; Duffy 2005, 2007). We did not assess the impact of small-scale artisanal mining but this sector may expand in conjunction with the expansion of the overall mining sector and have significant conservation impacts.
- We did not consider overlap with protected area buffer zones or locally-protected areas in our analysis, but such overlap could threaten conservation around and within those areas.
- Freshwater aquatic biodiversity on the island may suffer from mining activities given that Madagascar is classified as a country that is very highly vulnerable and predisposed to water quality problems from mining and that water pollution and over-use are common consequences of mining (Miranda et al. 2003).
- The expanding off-shore and on-shore petroleum extraction industry in Madagascar (Yager 2004) will most likely affect Malagasy marine and terrestrial conservation.

CONCLUSIONS

Mining in Madagascar may have the potential to provide revenue for projects that support conservation and development goals. Mining in degraded savannah may have relatively limited negative impact on biodiversity conservation on the island, although such mines could still cause local socio-economic problems, adversely affect soil and water conservation and quality, and contribute to larger economic processes with additional severe global environmental impacts such as climate change (Bridge 2004a). Given the large proportion of mining-permitted area that was outside of areas of conservation importance (94 % outside of SAPM planned areas), restricting mining to areas away from forested conservation zones seems feasible even if many mineral resources occur below remaining forested areas. Restriction of mining to savannah would help prevent fragmentation of areas that can still contribute to the goals of the Durban Vision and biodiversity conservation and would help protect the availability of forest products for people who depend on them.

Management of the mining industry as of July 2006, however, appears to provide inadequate protection to forested areas and terrestrial areas of conservation concern on the island. Reversing permitting and expanding and enforcing a ban on mine permitting in areas of conservation importance would most likely improve prospects for biodiversity conservation on the island. Increased direct foreign aid for sustainable development such as health and education programs could potentially provide desired development outcomes without the negative environmental and socioeconomic impacts likely to accompany mining sector expansion.

ACKNOWLEDGEMENTS

We would like to thank Tsiory Razafindrazaka, ANGAP, and Frank Hawkins for providing or advising on use of spatial information. We also acknowledge the Ministère de l'Energie et des Mines and the Bureau du Cadastre Minier de Madagascar for selling us the database of mining permits. This material is based upon work supported under a National Science Foundation Graduate Research Fellowship. Steven M. Goodman, James MacKinnon, Jade Sasser, Andrew Walsh, Lucienne Wilmé, and two anonymous reviewers kindly provided valuable comments on a previous version of this manuscript. We also thank Martin Nicoll for his assistance with mining policy references. Carlos Ivan Zambrana Flores and Lucienne Wilmé graciously assisted with GIS analysis.

REFERENCES

Borrini-Feyerabend, G., and Dudley, N. 2005. *Elan Durban.* Nouvelles perspectives pour les Aires Protégées de Madagascar. http://www.pnae.mg/chm-cbd/implementation/doc/sapm/les_ap_mcar_elan_durban.pdf

BPGRM. 2002. *Base de Données Pour la Gouvernance des Ressources Minérales.* Guide pour les opérateurs miniers à l'usage du cadastre minier. http://www2.gaf.de/bpgrm/pdf/law-mining/guide.pdf

Bridge, G. 2004a. *Contested terrain: mining and the environment.* Annual Review of Environment and Resources 29:205-259.

Bridge, G. 2004b. *Mapping the bonanza: geographies of mining investment in an era of neoliberal reform.* The Professional Geographer 56:406-421.

Cardiff, S. and Befourouack, J. 2003. *The Réserve Spéciale d'Ankarana.* In: The Natural History of Madagascar, S.M. Goodman and J.P. Benstead (eds.), pp 1501–1507. University of Chicago Press, Chicago.

Cardiff, S., and Befourouack, J. In press. *La Réserve Spéciale d'Ankarana.* In: Paysages naturels et biodiversité à Madagascar, ed. S.M. Goodman. Muséum national d'Histoire naturelle, Paris.

Colored Stone. 2005. *Madagascar opens to foreign buyers.* Colored Stone January/February 2005. http://www.colored-stone.com/stories/jan05/madagascar.cfm

Cope, L.W. 2002. *Madagascar mining – open for business.* Engineering and Mining Journal 203:24-28.

Davis, G.A. and Tilton, J.E. 2005. *The resource curse.* Natural Resources Forum 29:233-242.

Duffy, R. 2005. *Global environmental governance and the challenge of shadow states: the impact of illicit sapphire mining in Madagascar.* Development and Change 36:825-843.

Duffy, R. 2006. *Non-governmental organisations and governance states: the impact of transnational environmental management networks in Madagascar.* Environmental Politics 15:731-749.

Duffy, R. 2007. *Gemstone mining in Madagascar: transnational networks, criminalisation and global integration.* Journal of Modern African Studies 45:1-22.

Felena. 2006. *Un audit environnemental est préconisé.* Le Quotidien 1033, 30 septembre 2006. http://www.lequotidien.mg/article.php?art=11914&date=2006-09-30

Funk, V.A., Fernanda Zermoglio, M. and Nasir, N. 1999. *Testing the use of specimen collection data and GIS in biodiversity exploration and conservation decision making in Guyana.* Biodiversity and Conservation 8:727-751.

Haselip, J. and Hilson, G. 2005. *Winners and losers from industry reforms in the developing world: experiences from the electricity and mining sectors.* Resources Policy 30:87-100.

Hilson, G. 2002. *Land use competition between small- and large-scale miners: a case study of Ghana.* Land Use Policy 19:149-156.

Hecht, G. 2002. *Rupture-talk in the nuclear age: conjugating colonial power in Africa.* Social Studies of Science 32:691-727.

Mining Journal. 2004. *Madagascar.* Mining Journal Special Publication. Mining Communications, London. 12pp.

Miranda, M., P. Burris, J. F. Bingcang, P. Shearman, J. O. Briones, A. L. Viña and Menard, S. 2003. *Mining and critical ecosystems: mapping the risks.* World Resources Institute, Washington, D.C.

Myers, N. Mittermeier, R. A., Mittermeier, C. G., da Foncesca, G. A. B. and Kent, J. 2000. *Biodiversity hotspots for conservation priorities.* Nature 403:853-858.

Norris, S. 2006. *Madagascar defiant.* BioScience 56:960-965.

Pouliquen-Young, O. 1997. *Evolution of the system of protected areas in Western Australia.* Environmental Conservation 24:168-181.

Ramamonjisoa, B.S. 2004. *Origines et impacts des politiques de gestion des ressources naturelles à Madagascar.* Schweizerische Zeitschrift für Forstwesen 155(11):2-10.

Raoel. 2007. *Et une protection de plus pour l'Alaotra!* Tribune de Madagascar 5465 (20 January 2007).

Rép. Mad., République de Madagascar. 1999. Loi No. 99-022 portant Code Minier. http://www2.gaf.de/bpgrm/pdf/law-mining/loi99_022.pdf

Rép. Mad. 2000a. Decrêt No. 2000-170 fixant les conditions d'application de la Loi no. 99-022 du 19 Août 1999 portant Code Minier. http://www2.gaf.de/bpgrm/pdf/law-mining/decret2000_170.pdf

Rép. Mad. 2000b. Arrêté interministériel No. 12032/2000 sur la réglementation du secteur minier en matière de protection de l'environnement. http://www2.gaf.de/bpgrm/pdf/law-mining/DSTM.pdf

Rép. Mad. 2001. Loi No. 020/2001 Etablissant Régime Spécial pour les Grands Investissements dans le Secteur Minier Malagasy. http://www2.gaf.de/bpgrm/pdf/law-mining/decret2003_784.pdf

Rép. Mad. 2003a. Décrêt No. 2003-784 fixant les condition d'application de la Loi no. 2001-031 du 08 octobre 2002 établissant Régime Spécial pour les Grands Investissements dans le Secteur Minier Malagasy. http://www2.gaf.de/bpgrm/pdf/law-mining/decret2003_784.pdf

Rép. Mad. 2003b. *Evaluation environnementale sectorielle des mines.* Tecsult International, Montréal. 300pp.

Rép. Mad. 2004. Arrêté interministériel N° 19560/2004 Portant suspension de l'octroi de permis minier et de permis forestier dans les zones réservées comme „sites de conservation". http://www.droit-afrique.com/images/textes/Madagascar/

Rép. Mad. 2005. Arrêté Interministeriel No. 5371/2005 MEFB-MEM fixant le taux et les modalités d'assiette et de recouvrement du Droit Spécial sur les Transactions Minières (DSTM). http://www2.gaf.de/bpgrm/pdf/law-mining/DSTM.pdf

Rép. Mad. 2007. Actualisation du plan de gestion environnemental du projet de gouvernance des ressources minérales. http://www.pgrm.mg/index.php?option=com_docman&task=cat_view&gid=14&Itemid=18

Sarrasin, B. 2006. *The mining industry and the regulatory framework in Madagascar: some developmental and environmental issues.* Journal of Cleaner Production 14:388-396.

Thiollay, J.-M. 2002. *Bird diversity and selection of protected areas in a large neotropical forest tract.* Biodiversity and Conservation 11:1377-1395.

Walsh, A. 2003. *„Hot money" and daring consumption in a northern Malagasy sapphire-mining town.* American Ethnologist 30:290-305.

Walsh, A. 2004. *In the wake of things: speculating in and about sapphires in northern Madagascar.* American Anthropologist 106:225-237.

Weldon, R.G.G. 2005. *Madagascar liberalizes gem trade.* Professional Jeweler 23FEB2005. http://www.professionaljeweler.com/archives/news/2005/022305story.html

Yager, T.R. 2004. *The mineral industry of Madagascar.* U.S. Geological Survey minerals yearbook – 2004 26:1-6.

ZONE HUMIDES

Concept de Modèle Ecologique pour la Zone Humide Alaotra

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ABSTRACT
The wet zone Alaotra consists of the largest lake of Madagascar with about 20,000 ha of open-water and up to 23,000 ha of marshes. This wet zone is unique by the presence of an endemic fauna, and its marshes consist of a monospecific vegetation. The local communities directly depend on this wet zone with fishing and agriculture being an integral part of the region's economy. Consequently, various anthropological pressures such as burning of the vegetation, over-fishing, pollution of the lake by the use of weed-killers, and sedimentation of the watersheds due to heavy erosions of the surrounding hills, negatively impact on this ecosystem. The wet zone Alaotra has been classified as an official Ramsar wetland site since 2003 and also as a SAPM protected area in January 2007 because of its ecological importance and its various threats to this ecosystem.

The objective of this article is to present and describe the ecological model, which consists of the identification of the various ecological entities as well as their interdependence, in order to justify the wetlands classification as both a Ramsar and a New Protected Area site. The model has been adopted from Ogden (2005), and its ecological entities integrated in the conceptual model are derived from various research works conducted on the wet zone Alaotra. The model will be critically important in convincing the local authorities as well as the local communities to work together with the researchers, in order to implement the best conservation practices and ensure the sustainable management of the wet zone Alaotra.

RESUME
La zone humide d'Alaotra comprend le plus grand lac de Madagascar qui a une superficie de 20,000 ha ainsi qu'un marais d'une superficie de 23,000 ha. Elle est unique au monde par l'existence d'une faune endémique dont l'habitat est un marais composé d'une végétation mono-spécifique. La vie de la population dépend de cette zone humide, si on ne prend en compte que la pêche, l'agriculture, et l'économie de la région. Cependant, différentes pressions anthropiques affectent cet écosystème telles que la mise à feu du marais et la surpêche, la pollution du lac par l'utilisation des herbicides et la sédimentation à cause d'une forte érosion des bassins versants. Ces pressions causent des impacts sur la faune et la flore de la zone humide d'Alaotra. Cela entraîne un changement environnemental de l'Alaotra, comme la fragmentation du marais, constatée depuis plus de dix ans, et un danger pour la vie de la population aussi bien dans le présent que dans le futur. L'importance de cette zone humide ainsi que les différentes menaces dont elle est la cible, ont conduit a sa classification en tant que site Ramsar en 2003 et fait partie du Système Aire Protégée en janvier 2007.

Cet article a pour objectif de décrire le concept de modèle écologique, qui consiste à identifier les différentes entités écologiques ainsi que leur interdépendance, afin de justifier son classement dans le site Ramsar et en Nouvelle Aire Protégée. Ces entités résultent des différents travaux de recherche effectués sur la zone humide Alaotra. Le modèle adopté est celui d'Ogden (2005). Le modèle écologique présent est une de clé principales de la restauration qui devrait permettre de convaincre les autorités locales ainsi que les villageois à assurer ensemble avec les chercheurs la meilleure conservation et la gestion durable de la zone humide Alaotra.

GENERALITES
La zone humide Alaotra est située à 170 km au NE de la capitale de Madagascar. C'est une zone très productive car elle est le premier grenier rizicole du pays. Elle est composée d'un lac et d'un marais. C'est une zone humide unique dans le monde, en raison de la faune endémique unique dont l'habitat est un immense marais. Les principales espèces végétales caractéristiques sont *Cyperus madagascariensis*, *Cyperus latifolius*, abritant des espèces de faune endémique telles que *Hapalemur alaotrensis*, *Microcebus rufus*, *Salanoia* sp. 72 espèces d'oiseaux dépendent de cette zone humide comme habitat permanent ou saisonnier (Pidgeon 1996). La zone humide Alaotra abrite 50 oiseaux en permanence, dont huit endémiques Malagasy (Langrand 1995). 11 espèces de poissons y ont été recensées dont six endémiques et une endémique de la région Alaotra. Il s'agit du *Rheocles alaotrensis* (Bedotidae) (Pidgeon 1996). La zone humide Alaotra souffre de différentes pressions humaines. Deux espèces d'oiseaux endémiques sont en extinction (*Tachybaptus rufolavatus* et *Aythya innotata*). De nombreuses recherches ont été entreprises sur la diversité et l'écologie de la faune et de la flore Alaotra. Pour freiner la chasse aux lémuriens et aux oiseaux: l'éducation environnementale ainsi que la sensibilisation ont été employées dans la région (distribution de posters, des articles, du T-shirts sur l'environnement) (Pidgeon 1996). En 2001, une coopération entre les villageois et les autorités

locales existait pour la préservation du marais, mais sans application des lois. « Si les autorités locales sont sincères sur l'application des lois, la conservation est induite à Alaotra » (Mutschler 2003). Un contrat renouvelable de trois ans a été accordé par l'état, aux villageois aux alentours de la zone humide Alaotra. Ce contrat était pour objet d'un transfert local de la gestion de la zone humide (plus de 35 % de la superficie du marais). Un programme de sensibilisation et éducation villageoise a été engagée par Durrell Wildlife depuis 2001, dans le but de gérer la zone humide Alaotra de manière durable, et afin de démontrer l'importance de la biodiversité dans la zone humide Alaotra. Par ailleurs, les associations villageoises ont crée le Dina, pour qu'il y ait une bonne gestion de la zone humide en respectant les lois existantes. Une régénération de la végétation du marais est constatée si on fait une comparaison de son état (en 2005) par rapport à celui de 1997. Cette zone humide est accordée comme étant un site Ramsar en 2003 (Andrianandrasana et al. 2005). En janvier 2007, la zone humide Alaotra est classée officiellement dans le site Ramsar, en Nouvelle Aire Protégée dans le cadre du Système d'Aire Protégée de Madagascar.

Cet article a pour objectif d'établir un concept de modèle écologique pour la zone humide Alaotra. Il s'agit d'un plan qui identifie les pressions anthropogéniques majeures, les impacts, ainsi que les attributs biologiques ou les indicateurs des réponses écologiques d'un milieu (Ogden 2005). Compte tenu du degré d'endémisme local de ladite zone humide et la pression humaine qui y pèse, avec une fragmentation du marais non négligeable constatée depuis longtemps, sa préservation est prioritaire, vu l'importance économique aussi bien l'agriculture que l'aquaculture.

SITE D'ETUDE La zone humide Alaotra est située à une altitude de 750 m, à 170 km au Nord Est de la capitale (Figure 1) (Minenvef et al. 2005). C'est une zone humide composée d'un lac, qui est le plus grand lac malagasy avec une superficie de 20,000 ha et d'un marais avec une surface de 23,000 ha (Andrianandrasana et al. 2005). Elle est alimentée par trois principales rivières qui sont l'Anony, la Sahamoloto et la Sahabe (Aldegheri 1972).

Selon Ferry et al. (1999), son pH varie de 5.5 à 8.1, et sa conductivité est relativement basse, variant de 45.6 µS / cm à 64.7 µS / cm. De 1987 à 1995, la teneur en anions et en cations diminue de 0.575 meq / l à 0.161 meq / l tandis que celle de la silice augmente de 0.500 mg / l à 4.700 mg / l.

La zone humide Alaotra est influencée par deux saisons: la saison sèche et la saison humide. La température moyenne maximale de 28.4 °C est enregistrée en Janvier tandis que la température moyenne minimale est de 22.8 °C en Juillet.

METHODOLOGIE

Elle consiste à (1) rassembler tous les résultats de travaux effectués dans la zone humide Alaotra par la recherche bibliographique d'une part et notre recherche personnelle sur la végétation de la zone humide Alaotra d'autre part; la flore et la faune de la zone humide sont identifiées; l'état de dégradation de l'habitat de la faune endémique est présenté: une fragmentation non négligeable du marais Alaotra constatée depuis plus de dix ans démontrée par la carte de végétation du marais Alaotra (établie en Juillet-Août 1997), permettrait d'avoir une réflexion et une justification de la conservation

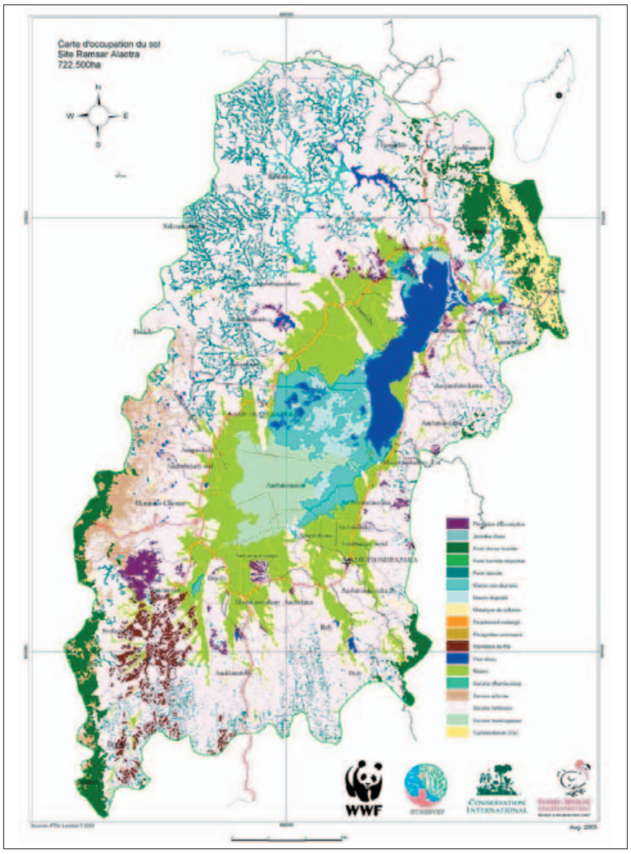

FIGURE 1. La zone humide Alaotra (modifiée d'après la carte d'occupation des sols site Ramsar Alaotra Août 2005, source FTM Landsat 7 2000).

en site Ramsar de la zone humide Alaotra, en comparant cet écosystème à la situation la plus récente; (2) identifier les rôles que peuvent prendre les différentes entités écologiques. Un diagramme est dressé pour montrer leur interdépendance, afin que l'homme soit persuadé de l'importance de cette zone humide. Le modèle adopté est celui d'Ogden (2005). Cette méthode consiste à grouper les attributs.

- Les *attributs* ou *indicateurs* sont composés de flore et faune qui participent au fonctionnement de l'écosystème.
- Les *influences anthropogéniques* sont toutes pressions qui induisent un changement néfaste sur la zone humide Alaotra.
- Les *impacts écologiques* sont tous changements physiques, chimiques ou biologiques induits par les pressions anthropogéniques.
- Les *réponses écologiques* sont considérées comme étant toutes réactions causées par les influences anthropogéniques.

Le concept de modèle écologique ainsi que la carte de végétation montrant la fragmentation du marais Alaotra sont des outils pour justifier les intérêts du classement de la zone humide Alaotra dans le site Ramsar (en août 2003). Elle était classée officiellement dans le site Ramsar de Madagascar et en nouvelle aire protégée en janvier 2007.

RESULTATS

Les résultats suivants présentent le diagramme du concept de modèle écologique pour la zone humide Alaotra (Figure 2).

LES ATTRIBUTS OU INDICATEURS ECOLOGIQUES

Flore: 35 espèces végétales ont été recensées dans le marais tandis que 52 espèces sont présentes dans le lac Alaotra (Ranarijaona, 1998). Parmi ces plantes, trois sont endémiques, citons *Melanthera scandens subsp. madagascariensis*, *Cynosorchis gracilis* et *Utricularia perpusilla*. Le marais est composé de deux principales espèces qui sont: *Cyperus madagascariensis* (Photo 1) et *Cyperus latifolius*, formant chacune un peuplement monospécifique (Figure 3). *Typhonodorum lindleyanum* (Photo 2) forme également un peuplement mono-spécifique mais avec une superficie beaucoup plus petite par rapport aux deux autres espèces (Figure 3). La zone à *Typhonodorum* est toujours une zone en eau, dans laquelle il est difficile de mettre le feu par rapport aux deux autres zones. *Phragmites mauritianus* (Photo 3) est l'espèce la plus commune qui colonise facilement le milieu dégradé plus ou moins asséché. C'est une espèce qui s'adapte plus facilement aussi bien en eau qu'en milieu asséché. Ces espèces servent d'habitat et de nourriture pour la faune; *Typhonodorum lindleyanum*, *Eichhornia crassipes* sont mangés par les porcs et les zébus, tandis que *Potamogeton octandrus*, *Ceratophyllum demersum*, les *Utricularia*, rencontrées dans des zones en eau temporaire servent de nourriture pour les oiseaux et les poissons. Cependant, elles sont en compétition avec les espèces envahissantes. D'autres espèces telles que *Cyperus madagascariensis*, *Cyperus latifolius*, *Phragmites mauritianus*, sont utilisées comme matériaux de constructions et artisanaux (fabrication des paniers et de nattes). Les plantes aquatiques sont également importantes pour la population locale par le fait qu'elles sont employées dans la médecine traditionnelle. Au point de vue écologique, *Pychnostachys caerulea*, *Echinochloa stagnina*, *Aeschynomene elaphroxylon*, *Salvinia hastata* et *Eichhornia crassipes* prédominent en général dans le lac. Cependant, des espèces envahissantes flottantes telles que *Salvinia hastata* et *Eichhornia crassipes* colonisent l'eau libre d'une zone de marais ayant subi la pression humaine; tandis que des espèces herbacées telles que *Polygonum wellensi*, *P. tomentosum* colonisent les milieux inondés en permanence.

Faune: Poissons: Six espèces sont endémiques dans la zone humide Alaotra. Citons quelques exemples: *Paratilapia polleni* (Cichlidae), *Rheocles alaotrensis* (Astherinidae), *Ratsirakia legendrei* (Eleotridae). Beaucoup d'espèces sont introduites telles que *Tilapia zillii*, *Oreochromis macrochir*, *O. niloticus* et *O. mossambicus*, *Ophiocephalus striatus* (Fibata), *Gambusia holbrooki*, *Cyprinus carpio* et *Carassius auratus*. Les tilapia représentent 84.02 % de la population des poissons dans le lac Alaotra. Ils sont très remarqués aussi bien par leur densité que par leur poids moyen (Pidgeon 1996).

Oiseaux: 72 espèces d'oiseau en permanence ou en visite temporaire ont été recensées dans la zone humide Alaotra. 50 espèces sont présentes en permanence dans le lac dont deux en extinction. Les espèces les plus communes sont *Anas melleri*, *A. hottentota*, *A. erythrorhyncha* (Mutschler 2001).

Mammifères: Selon Pidgeon (1996), neuf mammifères ont été identifiés dans le marais Alaotra. Citons les primates tels que l'espèce *Hapalemur alaotrensis* (endémique de la région), *Microcebus rufus*, *Salanoia concolor*; les carnivores qui sont *Viverricula indica* et *Salanoia concolor*. Les rongeurs sont *Brachyuromys betsileonsis* et *Rattus rattus*, et les insectivores sont *Suncus marinus* et *Microgalus cowani*.

PHOTO 1. *Cyperus madagascariensis* (Wild.) Roem&Schult (Cyperaceae)

PHOTO 2. *Typhonodorum lindleyanum* Schott (Araceae)

PHOTO 3. *Phragmites mauritianus* Kunth (Poaceae)

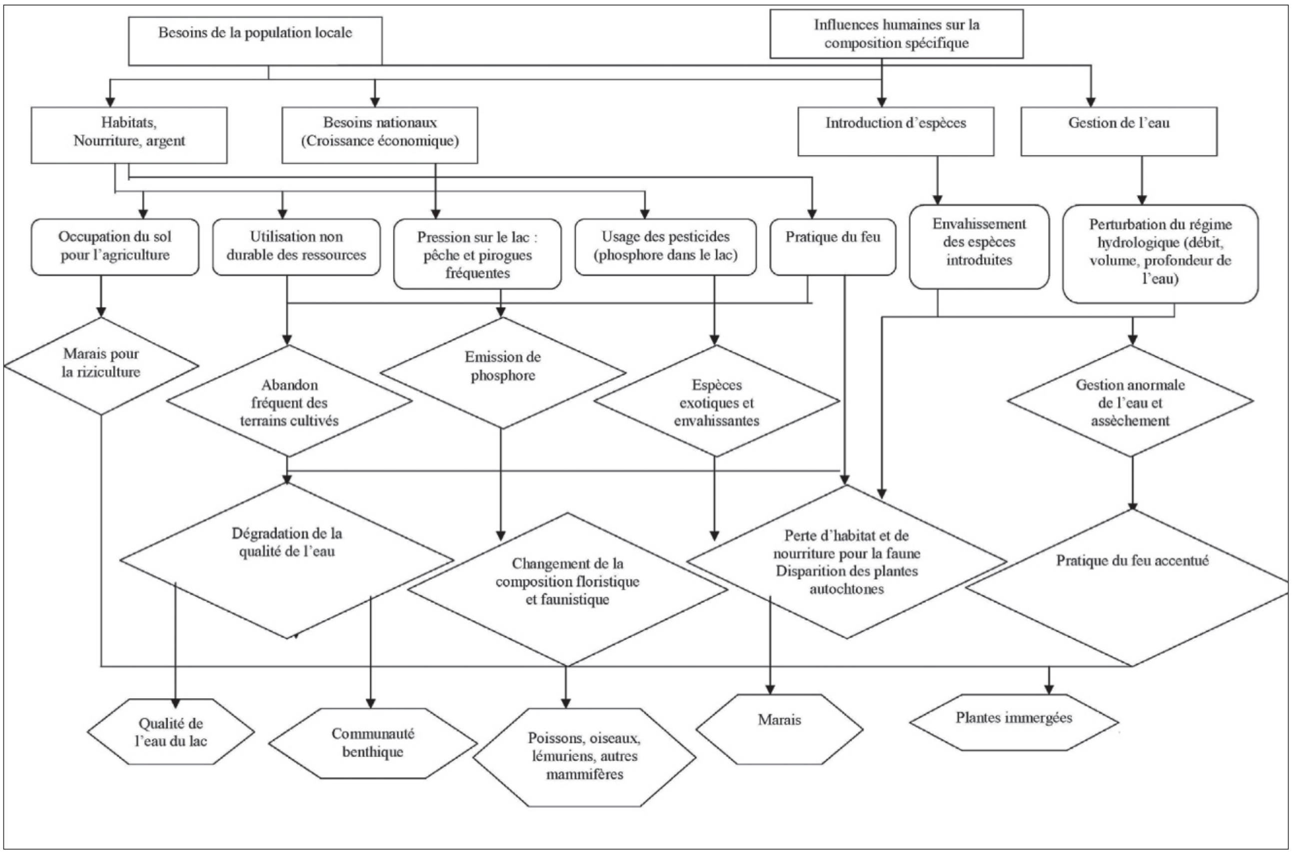

FIGURE 2. Diagramme de concept écologique.
Pressions anthropogéniques; Réponses écologiques; Impacts écologiques; Attributs ou indicateurs

LES INFLUENCES ANTHROPOGENIQUES ET LES REPONSES ECOLOGIQUE Trois sources majeures de réactions anthropiques ont été identifiées dans la zone humide Alaotra, pour subvenir aux besoins de la population. Il s'agit (1) des principaux besoins qui sont l'agriculture, la pisciculture; (2) l'introduction des espèces exotiques telles que les poissons; (3) et la gestion de l'eau.

La faune endémique de l'Alaotra est menacée par le changement de l'environnement: par la dégradation de l'habitat, la surpêche et la chasse excessive; la compétition par introduction des espèces de poissons, la sédimentation due à l'érosion, la pollution humaine par l'utilisation des pesticides et l'invasion des plantes envahissantes (Andrianandrasana et al. 2005).

Agriculture: La zone humide Alaotra est le premier grenier à riz de Madagascar, avec une production annuelle de 250,000 tonnes de riz (Rakotonierana 2004). La population locale dépend de la production rizicole. Pour avoir une meilleure production, divers aménagements ont été effectués par la compagnie Somalac en 1961 (irrigation, élargissement ou diversion des rivières comme la Sahabe, la Sahamaloto, l'Anony, le canal de Mahakary et d'Ampilahoana). Ces aménagements entraînent une diminution de la superficie de l'habitat naturel de la faune (Figure 3). L'emploi des divers engrais et pesticides entraîne un changement de la composition physico-chimique de l'eau et cause un impact négatif sur la présence des espèces aussi bien floristique que faunistique.

La déforestation des bassins versants entraîne l'érosion qui accélère l'ensablement des canaux d'irrigation. Par conséquent, une diminution presque de moitié de la production rizicole a été constatée. Les villageois ne cessent de réclamer de nouvelles aires du marais intact pour l'agriculture, entraînant la formation de mosaïque de végétation aquatique (Figure 3). La surface de marais brûlée varie de 7,300 ha (31,7 %) à 2,500 ha (> 10 %) en 2003 pour être transformée en rizières (Andrianandrasana et al. 2005).

Changement du régime hydrologique: La dégradation du système d'aménagements pèse sur la zone humide Alaotra, ce qui entraîne un changement dans le temps et dans l'espace du régime hydrologique (débit, volume, profondeur de l'eau) (Moreau 1987). L'eau du lac et du marais est mal gérée à cause de la sédimentation. Des rizières (ancien marais) ont été abandonnées à cause du manque d'eau ou d'une inondation excessive; d'autres endroits du marais avec de l'eau ou mieux irrigués sont brûlés pour être transformées en rizières. Une grande superficie de rizières a été détruite. Le problème en eau devient de plus en plus sérieux; une partie du marais est asséchée et abandonnée (Figure 3). La gestion de l'eau entraîne un changement du milieu naturel tant au niveau de la profondeur de l'eau, qu'au niveau de la biologie et l'écologie des attributs de la zone humide (Ogden et al. 2005).

Influence de la pêche: Le lac Alaotra est une source exclusive pour la population. En 1963, environ 1,000 pêcheurs ont été identifiés (Kiener 1963). Ils utilisaient un système de barrages fait avec de la boue ou servent des hameçons ainsi que d'autres matériaux pour capturer les poissons. A cette époque, plus de 150 pêcheurs ont servi de filets et plus de 30,000 pêches en ligne ont été recensées (Un pêcheur peut avoir plusieurs matériels de pêche en ligne). D'autres pêcheurs ont utilisé du « harato », qui est un système de panier qu'on laisse traîner ou déposer dans des endroits choisis, pendant un certain temps voulu pour piéger les poissons. La production annuelle en poissons décline de 4,000 tonnes (en 1960) à 2,000 tonnes en 2004 (Razanadrakoto 2004). Le nombre de pêcheurs augmente de 1,000 à 4,000 en 2003 (Razanadrakoto 2004). La consommation de poissons est de 5.33 kg par personne en 2001 dans les cinq sites suivis par Durrell Wildlife à 7.21 kg par personne dans les 16 sites en 2003 (Andrianandrasana et al. 2005).

Actuellement, l'affluence accentuée a été toujours constatée dans la zone humide Alaotra. Le nombre de la population de la région Alaotra augmente de 109,000 (Pigeon 1996) à 550,000 à ce jour (PRD 2003, selon Andrianandrasana 2005). Cette augmentation a une influence sur l'habitat naturel de la faune dans le lac et le marais (la mise à feu, l'aménagement) mais aussi sur la faune abritée dans cette zone humide (la surpêche, la disparition des poissons autochtones).

Pratique du feu pendant la saison sèche: Le feu est périodique dans le marais, quand le niveau de l'eau baisse et que le milieu s'assèche. La mise à feu est pratiquée pour chasser les lémuriens et les poissons *Ophiocephalus striatus*, mais également pour l'agriculture afin d'augmenter la fertilité du sol selon la population locale. Depuis 2001, les feux sont également pratiqués en vue de créer des étangs artificiels pour la pêche car près de 70 % des étangs naturels dans le marais sont envahis par les espèces exotiques (Andrianandrasana et al. 2005).

Influence des pesticides sur la qualité de l'eau: L'usage des pesticides est libre dans la région Alaotra. Dans le lac, une forte teneur en phosphore et faible teneur en nitrogène ont été détectées (Pidgeon 1996). 34 sortes de pesticides sont en vente dans la région (Pidgeon 1996). Entraînés par l'eau, les éléments tels que le phosphore et le nitrogène peuvent causer une prolifération des phytoplanctons ainsi qu'une végétation en macrophytes rabougrie. Ce qui présente un impact sur la faune qu'il abrite.

Influence de l'homme sur la composition spécifique:

Flore: Le feu induit une répartition en mosaïque de la végétation. En plus, celui-ci entraîne un effet néfaste en dévastant certaines zones du marais (Figure 3). Ce qui favorise l'installation des espèces exotiques.

Faune: Depuis 1926, plus de dix poissons ont été introduits accidentellement ou volontairement par la Direction des Eaux et Forêts, afin d'améliorer la qualité et quantité nutritionnelle dans le lac Alaotra (Kiener 1962, Moreau 1979), mais également pour contrôler et éradiquer les moustiques (introduction volontaire de *Gambusia holdrooki* en 1940 ainsi que *Ophiocephalus striatus* en 1980 pour la pisciculture).

La chasse entraîne la disparition de deux oiseaux endémiques qui sont *Aythya innotata* et *Tachybaptus rufolavatus* (Mutschler 2003). Selon Andrianandrasana et al. (2005), 5,600 oiseaux ont été chassés en 2003 selon les enquêtes effectuées par Durrell Wildlife dans 16 villages aux alentours de la zone humide Alaotra. Ce nombre a diminué de 4,800 en 2002. Les oiseaux résidents dans la zone humide sont chassés. Citons *Dendrocygna viduata*, *Sarkidiornis melanotos*, *Anas melleri*. Trois lémuriens ont été chassés en 2003 s'ils étaient quatre en 2002.

Envahissement des espèces exotiques:

Flore: Les principales espèces exotiques envahissantes de la zone humide Alaotra sont la jacinthe d'eau *Eichhornia crassipes* et la fougère d'eau *Salvinia hastata*. Leur installation est favorisée par la dégradation de la qualité de l'eau du lac.

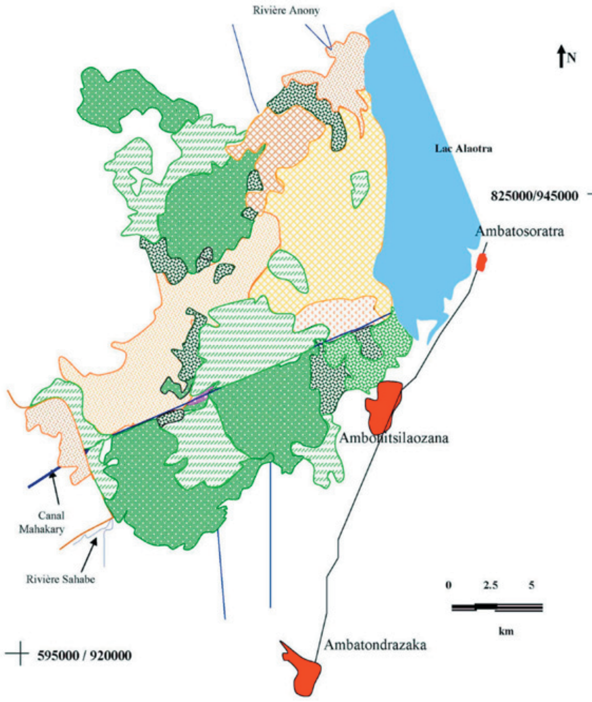

FIGURE 3. Fragmentation du marais Alaotra (carte de végétation établie en Juillet-Août 1997).

- *Cyperus latifolius* associée à des espèces herbacées
- *Cyperus madagascariensis*
- Zone dégradée avec des îlots de *Cyperus madagascariensis*
- *Typhonodorum lindleyanum* ou *T. lindleyanum* associée à *Cyperus madagascariensis*
- Zone dégradée avec *Cyperus madagascariensis* associée aux *Phragmites*, des espèces herbacées et des espèces flottantes telles que *Eichhornia crassipes*, *Salvinia hastata*
- Zone dégradée avec *Cyperus madagascariensis* à espèces herbacées
- Rizières abandonnées avec des îlots de *Cyperus madagascariensis* et *Phragmites*
- *Phragmites mauritianus*

Faune: Les poissons endémiques sus-cités sont devenus rares à cause de l'introduction des espèces exotiques, qui sont majoritaires dans le lac. Il s'agit de *Osphronemus goramy*, *Carassius auratus* (introduits en 1900), *Cyprinus carpio* (en 1926), *Salmo indicus*, *S. fario*; les Cychlidae tels que *Tilapia melanopleura* (en 1955), *T. rendalli* (en 1955), *T. zillii* (en 1955). Il y a aussi d'autres espèces introduites tels que *Oreochromis macrochir* et *O. mossambicus* (en 1960), *O. striatus* (en 1980), qui possèdent une importante biomasse dans le lac Alaotra (Pidgeon 1996).

IMPACTS ECOLOGIQUES Les impacts induits par différents facteurs dans la zone humide Alaotra sont: la fragmentation de l'habitat (Figure 3), le changement du régime hydrologique, la dégradation de la qualité de l'eau, la dévastation de certaines zones par le feu, la disparition des espèces, de l'habitat et de la nourriture de la faune autochtone, la disparition des ressources naturelles de la population.

Fragmentation de l'écosystème: Les espèces telles que *Salvinia hastata* et *Eichhornia crassipes* colonisent la surface libre de l'eau après la mise à feu. Ce qui entraîne un changement tangible de l'habitat. D'autres espèces végétales envahissantes deviennent très communes et colonisent l'habitat (Andrianandrasana 2002). Elles sont associées à la principale espèce qui compose la végétation climacique. Les espèces herbacées sont surtout caractérisées par *Polygonum tomentosum*, *Polygonum wellensi*, *Salvinia hastata*, *Eichhornia crassipes*, et *Aeschynomene elaphroxylon*. Ce changement de l'habitat naturel entraîne une forte perturbation de la vie de la faune qui colonise le milieu auparavant. Des espèces de lémuriens se déplacent pour trouver l'habitat approprié. Dans le lac, le peuplement de *Phragmites mauritianus* se disperse en îlots ou alignés. La répartition en îlots est due, d'une part à la dispersion des graines de *Phragmites* par les oiseaux *Acrocephalus* et d'autre part à l'usage des fragments de leur tige pour piéger les poissons, dans les zones temporairement inondées ou non. Ces fragments peuvent être transportés par l'eau et le vent, ils poussent quand les conditions leurs sont favorables. Les fragments utilisés comme piquets pour le piégeage des poissons repoussent et se répartissent de façon alignée (Ranarijaona 1995).

Dégradation de la qualité de l'eau: Une quantité importante de sable et de sédiments envahit les rizières, les terrains de culture ainsi que les canaux d'irrigation et le fond du lac, à cause de la sédimentation. La transparence de l'eau du lac est faible (0.50 m) (Ranarijaona 1995). Un symptôme d'eutrophisation serait probable pour le lac Alaotra si la sédimentation continue. L'utilisation des herbicides ou pesticides entraîne la pollution de l'eau. Ce qui favorise l'installation des plantes envahissantes telles que *Eichhornia crassipes* et *Salvinia hastata*, entraînant la disparition de la faune qui y abrite. Une supposition a été évoquée que le changement de la composition chimique de l'eau du lac aurait pu provoquer la mort de quelques poissons trouvés flottés à la surface de l'eau (Pidgeon 1996). Les engrais chimiques utilisés pour l'agriculture affectent l'eau du lac ainsi que la faune et la flore. Certaines hydrophytes sont sensibles aux herbicides. La disparition des hydrophytes pose un problème à la nourriture aux poissons. Ainsi, l'usage des pesticides aux alentours du lac Alaotra entraîne une dégradation de la composition chimique de l'eau et favorise le développement des espèces envahissantes qui rendent asphyxiées la faune.

Disparition de la flore autochtone, habitat et nourriture: L'installation des espèces introduites telles que *Polygonum wellensi*, *Cyperus prolifer*, *Echinochloa crusgalli*, *Aeschynomene elaphroxylon*, *Leersia hexandra*, *Ludwigia leptocarpa* est favorisée à cause de la dégradation de l'écosystème. Ce qui provoque la formation de mosaïque de marais. Sachant que 39 espèces de plantes aquatiques servent de nourriture pour les oiseaux appartenant au tribu des *Aythyini* (Pidgeon 1996), elles risquent de disparaître à cause de la dégradation de la qualité de l'eau, de la sédimentation ainsi que l'envahissement des espèces exotiques. L'installation des espèces introduites peuvent également induire un changement de la composition floristique du lac par compétition interspécifique, ainsi qu'une disparition des espèces immergées telles que *Potamogeton octandrus*, *Utricularia stellaris*, *ceratophyllum demersum*. Ce qui entraîne un déséquilibre dans l'écosystème.

Disparition de la faune autochtone: La faune telle que *Hapalemur alaotrensis* ainsi que d'autres mammifères et oiseaux sont menacés par la dégradation de leur habitat et de la disparition de leur nourriture. Deux espèces endémiques d'oiseaux sont actuellement en extinction à cause de l'influence humaine. Il s'agit de *Aythya innotata* et T*achybaptus rufolavatus* (Mutschler et al. 1995). Pendant les cinq dernières années, la population des lémuriens a été déclinée de 30 %; si la population d'*Hapalemur alaotrensis* était de 10,000 en 1995, ce nombre diminue de 1,000 à 3,000 lémuriens par an (Mutschler et al. 2001). Les espèces de poissons autochtones telles que *Paratilapia polleni* sont disparues par l'introduction de *Gambusia holbrooki* (Mutschler 2003). Les poissons autochtones telles que *Rheocles* ne représentent que seulement 0.27 % de la population (Pidgeon 1996). Les espèces benthiques qui servent de nourriture pour les poissons et les oiseaux sont disparues également à cause de la sédimentation. Les espèces endémiques telles que *Anguilla mosambica* et *Anguilla marmorata* se sont déplacées et devenues rares à cause de la pression humaine.

CONCLUSION

Cet article essaie d'examiner et de rassembler toutes les recherches effectuées sur la zone humide Alaotra, ainsi que la végétation du marais Alaotra et l'impact de la dégradation sur la faune et la flore. Ces différentes recherches n'ont qu'un seul objectif commun: gestion durable et conservation. Ces résultats de recherche ne sont pas exhaustives, mais peuvent résumer à quel degré d'importance possède la zone humide Alaotra; ils permettent de justifier le classement de la zone humide Alaotra dans le site Ramsar et en Nouvelle Aire protégée en Janvier 2007. Elle est très particulière par sa richesse en faune endémique unique au monde mais aussi par ses ressources naturelles. De nombreuses vies dépendent de cette zone humide aussi bien sur le plan écologique que socio-économique. Cependant, des influences anthropogéniques ont été constatées dans cette zone humide, malgré les différentes sensibilisations et éducations environnementales offertes aux villageois. La superficie du marais ne cesse de diminuer par la mise à feu pour le transformer en rizières. La végétation climacique du marais est détruite ou dégradée, la surface libre laissée par la mise à feu est recolonisée par des espèces flottantes envahissantes ou du *Phragmites*. Des rizières issues de l'ancien marais sont abandonnées à cause du problème en eau. Cependant, la sensibilisation des villageois est fructueuse car une régénération de la végétation du marais est constatée et que les villageois sont conscients de la gestion durable et de la conservation du marais.

Le présent travail offre le concept de modèle écologique, en décrivant l'interdépendance entre les différentes entités écologiques. Ce modèle pourrait persuader les autorités locales ainsi que les villageois d'élaborer ensemble avec les chercheurs un programme de restauration dans le futur. Dans tout les cas, le reboisement aux alentours de la région Alaotra, la conservation durable des forêts existantes, ainsi que l'application des lois dans la conservation de la zone humide Alaotra sont les clés pour sa restauration, afin d'aboutir à une meilleure conservation durable.

SUGGESTIONS DE RECHERCHE

La Figure 3 nous a permis de savoir l'état de dégradation du marais 10 ans passés. Si on fait une comparaison avec la carte du marais « occupation des sols site Ramsar » en 2005 (Figure 1), une évolution promettant est remarquée au niveau de la régénération de la végétation du marais. Ce qui est également constatée en regardant une diminution tangible de la superficie des marais brûlée de l'an 2000 (de l'ordre de 7,000 ha) à 2003 (sur une superficie de 2,500 ha (Andrianandrasana et al. 2005).

Celle-ci est sans doute due à la sensibilisation des villageois faite par Durrell Wildlife ainsi que les différentes entités. Les villageois ont apprécié la sensibilisation malgré les différentes lois imposées pour la gestion durable et la conservation de la zone humide Alaotra. Cette sensibilisation a créé un contact ainsi qu'une collaboration entre les villageois et le gouvernement (Andrianandrasana et al. 2005). C'est bien l'un des objectifs du programme du gouvernement actuel dans le MAP (Madagascar Action Plan): « fampandrosoana miainga avy eny amin'ny vahoaka ifotony ». Cette dégradation n'aurait cessé de s'accentuer si aucune mesure n'avait été prise pour la conservation de la zone humide Alaotra. C'est la raison pour laquelle l'objectif concernant la conservation de la zone humide Alaotra en site Ramsar et en Nouvelle Aire protégée est atteint. Il se trouve d'après les cartes site Ramsar qu'une grande partie du marais est devenue 'zone sensible', un site de conservation de la faune menacée existe déjà, un site de patrimoine culturel est identifié dans la zone humide Alaotra; pour les préserver, l'application des règlements communautaires agréés par tous les villageois ou 'dina', est une des issues pour contrôler la pêche et maintenir le marais (Durbin 2003).

Des recherches multidisciplinaires seront encore nécessaires pour conserver et mieux gérer la ressource de manière durable. Voici quelques suggestions de recherche: Pour convaincre le monde concerné à la zone humide Alaotra, il est nécessaire de faire connaître l'existence du présent concept de modèle écologique. Des recherches méritent d'être lancées:

- Flore: Etude de l'état actuel du marais par photosatellite la plus récente; écologie et dynamisme de croissance de marais dans le but de sa restauration; la diversité et l'écologie des phytoplanctons du lac Alaotra afin de confirmer l'état du lac s'il y a eutrophisation ou non.
- Faune: Etude des impacts majeurs de l'absence des deux oiseaux endémiques en extinction; essai de multiplication des principales espèces survivantes.
- Hydrologie: Analyse du régime hydrologique et de la qualité de l'eau du lac, causés par les pressions anthropogéniques. Etude de la qualité de l'eau des rivières et du lac à l'aide des macrophytes, par l'utilisation de l'Indice Biologique des Macrophytes des Rivières (IBMR).
- Agriculture: Approche participative: persuader la population locale que « sans marais = sans lac = sans vie »; sensibilisation de la population locale d'appliquer des techniques modernes (usage des variétés améliorées, respect de calendrier cultural) pour la production rizicole ainsi que d'autres cultures pour éviter la réclamation sans cesse du marais et le problème d'épuisement du sol.

Conservation: Le classement de la zone humide Alaotra dans le site Ramsar et en nouvelle aire protégée est une décision incontournable et très méritante, vu sa richesse en faune et sa flore d'une part et les ressources naturelles et les différents intérêts qu'elle apporte à la population locale et nationale d'autre part. La création de nouvelles aires protégées pour certaines zones cibles dans les bassins versants Alaotra est une clé pour lutter contre l'érosion. Cette érosion a une influence néfaste sur la zone humide Alaotra.

La réalisation d'une étude d'impact environnemental et socio-économique suite à la création de la Nouvelle Aire Protégée est vivement souhaitable.

REMERCIEMENTS

Je tiens à remercier très chaleureusement Dr. Jonah Ratsimbazafy pour ses précieuses collaborations à l'élaboration du concept de modèle écologique de la zone humide Alaotra. Mes reconnaissances s'adressent à Dr. Ferry L. (IRD) et Dr. Robison L. (CNRE) ainsi que toute l'équipe de l'IRD, à l'IRD et au BRL de m'avoir financée et m'aidée à la réalisation des différents travaux de terrain. Je réitère mes remerciements à Dr. Razafimandimbison S. pour la traduction en anglais du résumé.

REFERENCES BIBLIOGRAPHIQUES

Aldegheri, M. 1972. *Rivers and streams on Madagascar.* In: Battistini R. & G. Richard-Vindard. 1972. Biogeography and ecology in Madagascar, pp 261-267. Dr. W. Junk B.V., The Hague.

Andrianandrasana T.H. 2002. *Etude de la régénération du marais Alaotra, habitat naturel du Hapalemur griseus alaotrensis.* Durrell Wildlife Conservation Trust – Madagascar Programme. Antananarivo, Madagascar.

Andrianandrasana, H.T., Randriamahefasoa, J., Durbin, J., Lewis, R.E., and Ratsimbazafy, J.H. 2005. *Participatory ecological monitoring of the Alaotra wetlands in Madagascar.* Biodiversity and Conservation Journal, 14:2757-2774.

Durbin, J., Rakotoniaina, L.J., Randriamahefasoa, J. 2003. *Project Alaotra: using endangered species as flagships for community based wetland conservation.* In: The natural history of Madagascar, M.Goodman and J.P. Benstead (eds.), pp. 1551-1555. The university of Chicago press, Chicago and London.

Ferry, L., Robison, L., Ranarijaona, H., Gasse, F. 1999. *Les lacs de Madagascar: présentation et typologie.* IRD, Montpellier (unpublished).

Ogden, J.C., Davis, S.M., Kimberly, J., Barnes, J.T., Fling. H.E. 2005. *The use of conceptual Ecologicals Models to Guide Ecosystem Restoration in South Florida*. Journal of the Society of Wetland Scientists, USA, 25, 4:795-809.

Kiener, A. 1962. *Evolution de la pisciculture et de la pêche dans les eaux intérieures de Madagascar depuis 1950.* Bulletin de Madagascar. 1033-1044.

Kiener, A. 1963. *Poissons, pêche et pisciculture à Madagascar.* Centre technique Forestier Tropical, 24, Nogent sur Marne. 404.

Langrand, O. 1995. *Guide des oiseaux de Madagascar.* Delachaux et Niestlé, Lausanne, Switzerland. In: Participatory ecological monitoring of the Alaotra wetlands in Madagascar Andrianandrasana, H.T., Randriamahefasoa, J., Durbin, J., Lewis, R.E., and Ratsimbazafy, J.H. (2005). Biodiversity and Conservation Journal, 14:2757-2774.

Minenvef, WWF, Conservation International, Durell Wildlife Conservation Trust 2005. Cartes de grandes fonctions, Site Ramsar Alaotra 722.500 ha.

Moreau, J. 1987. *Madagascar.* In: M. Burgis and J.J. Symoens (eds) African wetlands and shallow water bodies, pp 595-606. Orstom, Paris.

Mutschler, T., Feistner, A.T.C. 1995. *Conservation status and distribution of the Alaotran gentle lemur Hapalemur alaotrensis.* Oryx, 29: 267-274.

Mutschler, T. Nievergelt, C., Feistner, A.T.C. 1995. *Human induced loss of habitat at lac Alaotra and its effects on the Alaotran gentle lemur.* In: Environmental change in Madagascar, Petterson B.D., S.M., Goodman, J.L., Sedlock (eds.), pp 35-36. Field Museum, Chicago.

Mutschler, T., Randrianarisoa, A.J., Feistner, T.C. 2001. *Population status of the Alaotran gentle lemur Hapalemur alaotrensis.* Oryx, 35:152-57.

Mutschler, T. 2003. *Lac Alaotra.* In: The natural history of Madagascar, S.M. Goodman, J.P., Benstead (eds.), pp 1530-1534. The university of Chicago press, Chicago and London.

Odgen, C.J. 2005. *Everglades ridge and slough conceptual ecological model.* Journal of the society of Wetland Scientists, USA, 25, 4:810-820.

Pidgeon, M. 1996. *An ecological survey of lake Alaotra and selected wetlands of central and eastern Madagascar in analysing the demise of Madagascar pochard Aythya innotata*. Lucienne Wilmé edition, WWF, Antananarivo.

Rakotonierana. D. 2004. Rapport Annuel 2003 CIRAGRI. *Circonscription d'Agriculture.* Ambatondrazaka, Madagascar.

Ranarijaona, H.L.T. 1994. *Méthode d'approche pour l'étude de la végétation aquatique de Madagascar.* Rapport LRSAE Hydrobiol (unpublished).

Ranarijaona, H.L.T. 1995. *Etude préliminaire de la végétation aquatique du lac Alaotra.* Rapport LRSAE Hydrobiol (unpublished).

Ranarijaona, H.L.T.1998. *Etude de la végétation du marais Alaotra.* Rapp. LRSAE Hydrobiol (unpublished).

Ranarijaona, H.L.T. 1999. *La flore des milieux lentiques malgaches (lacs, marais, étangs): essai de typologie.* Unpubl. Doctorat du 3ème cycle. Université d'Antananarivo, Madagascar.

Razafindrakoto, D. 2004. Rapport Annuel 2003 CIRPRH. *Circonscription de la Pêche et des Ressources Halieutiques, Ambatondrazaka, Madagascar. In: Participatory ecological monitoring of the Alaotra wetlands in Madagascar.* Andrianandrasana, H.T., Randriamahefasoa, J., Durbin, J., Lewis, R.E., and Ratsimbazafy, J.H. (2005). Biodiversity and Conservation Journal, 14:2757-2774.

COMMUNITY

"To live with the Sea" Development of the Velondriake Community-Managed Protected Area Network, Southwest Madagascar

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ABSTRACT

Madagascar's southwest coast supports some of the largest coral reef systems in the western Indian Ocean. These reefs not only provide critical habitat to thousands of marine species but also are essential to the survival of the indigenous Vezo people who rely on healthy marine resources for food, transport, cultural identity and income. However, coastal populations are growing rapidly and international fisheries companies have begun exploiting the region's waters through a sophisticated collection network to supply an expanding export market. In recent years local fishers have begun reporting declines in the size and number of their catches.

Building on the success of a pilot marine no take zone launched three years ago in the remote fishing village of Andavadoaka, Blue Ventures Conservation (BV), Madagascar's Institute of Marine Sciences (Institut Halieutique et des Sciences Marines – IHSM) and the Wildlife Conservation Society (WCS) are now working with 21 neighbouring villages, and fisheries collection and export companies to develop a network of community-run marine and coastal protected areas that will span more than 800 km^2, aiming to benefit more than 10,000 people and protect coral reefs, mangroves, seagrass beds and other threatened habitats along Madagascar's southwest coast. The villages, grouped into three constituent geographic regions, have established a management committee which serves as a liaison between conservation scientists and community members, providing input and insight into all phases of conservation planning, from research activities to implementation of management plans. The management committee also selected a unifying name for the network: *Velondriake*, which means "to live with the Sea."

Along with protecting biodiversity and livelihoods, the network is working to increase environmental awareness among communities, expand local and national capacity for biodiversity conservation and serve as a model for other community conservation, economic development, and governance initiatives across Madagascar and elsewhere. Velondriake aims to benefit villages within the network by empowering members of the local communities as managers of their own natural resources, enabling communities to contribute directly to the development of sustainable resource management systems to support local culture and livelihoods. Additional benefits are being brought to local partner organisations and institutions through the capacity building resulting from involvement of their staff in the project and the improved availability of data, lessons learned and best practice guidelines.

BACKGROUND

Southwest Madagascar exhibits one of the largest and most biologically diverse coral reef systems in the western Indian Ocean (Cooke et al. 2000). These reefs not only provide critical biodiversity habitats but are also essential to the survival of the semi-nomadic Vezo communities, who are completely dependent on the region's marine environments for food, transport, income and cultural identity. Vezo communities in the region of Andavadoaka, a remote village of 1,200 people located on the southwest coast of Madagascar (Figure 1), some 50 km south of Morombe, have subsisted from traditional and artisanal fishing activities for generations. Census data collected by Blue Ventures during household surveys in Andavadoaka in 2005 show that fishing is the primary income-generating activity for 71 % of the population (Langley et al. 2006).

Despite their enormous biological, social and economic importance, the region's marine environments are facing severe threats from climate change and direct anthropogenic impacts. Over the last decade many shallow coral reefs in southern Madagascar have suffered widespread degradation following the mass coral bleaching and mortality event attributed to the El Nino event of 1998 (Cooke 2003). Bleaching events have continued in recent years as a result of periods of anomalous warming of sea surface temperature. Marine surveys have revealed that following bleaching-related mortality, many of the reefs in the region have undergone a general phase shift from coral to algal-dominated habitats (Harding et al. 2006).

These broad-scale climatic stresses have coincided with a dramatic increase in fishing activities in recent years. Coastal population growth, and the concomitant increasing need for marine resources, has been rapid, exacerbated by high levels of migration towards coastal zones. The agricultural productivity of inland farming areas in southwest Madagascar is severely restricted on account of the region's aridity, and the rich marine resources of coastal areas in the region have long attracted people from inland farming communities on account of the presence of supplementary dietary proteins and relatively lucrative income sources.
Census data reflect this trend. The population of the Toliara region grew by 324 % between 1975 and 1993 (Cooke et al.

FIGURE 1. Location of the Andavadoaka region, southwest Madagascar (Imagery ESRI).

2000). Limited employment opportunities, combined with low agricultural productivity, resulted in a five-fold increase in the fishing population in a period of 17 years leading up to the early 1990ties, causing an overexploitation of marine resources, especially near urban centres such as Toliara (Gabrié et al. 2000). Laroche et al. (1997) provide evidence that over-fishing in the Toliara region has led fishers to target lower value fish in an effort to sustain yields in the face of reduced stocks of large piscivorous species. At the beginning of the new century, over 50 % of the artisanal fishing in Madagascar was estimated to occur along the reef systems of the southwest (Cooke et al. 2000). The village of Andavadoaka, at the geographical centre of this project area, has seen a doubling of population input rate (births and immigration arrivals per year) in the 10 years leading up to 2003, with over 50 % of the population being aged 14 or under. Fishing is the primary economic activity for 71 % of villagers (Langley et al. 2006).

Alongside population growth, fishing pressure has also been considerably exacerbated by commercialisation of traditional fisheries. In recent years international seafood collection companies have developed a new and highly lucrative fisheries market for a wide range of seafood products throughout the region. Commercial collectors and exporters first arrived in villages in the project area in 2003, bringing a more easily accessible and higher paying market for fresh octopus and large reef and pelagic fish species (L'Haridon 2006).

Although fishing methods are still traditional, the recent introduction of market exports for fresh seafood products, as opposed to the traditional dried and salted fish market, has led to an increase in the value and exploitation of target species. This increase has been accompanied by a change in recent years from a largely barter and subsistence economy to a fisheries-dependent cash-based economy. The dramatic increase in fishing intensity seen in recent years has raised concerns amongst local communities and conservation groups of direct reef damage and overexploitation.

Working in partnership with the University of Toliara's Institut Halieutique et des Sciences Marines (IHSM), UK-based NGO Blue Ventures Conservation commenced monitoring the region's marine environment in 2003, with the establishment of a field research station in the village of Andavadoaka.

PROGRESS TOWARDS COMMUNITY MANAGEMENT

Vezo communities in Andavadoaka and surrounding villages understand that the livelihoods and economic security of community members are inextricably linked to the health of local marine ecosystems. Local fishers have reported observing marked declines in catches over the last decade, and since 2003 discussions have taken place between the Andavadoaka community and Blue Ventures regarding the development of a marine protected area in the region. When engaging the community in discussions of this nature it has been critically important to avoid the proliferation of misconceptions amongst local fishers of the function and benefits of protected areas. Furthermore, it has been important during all discussions regarding marine conservation issues to avoid the alienation of fisheries collection and export companies, which represent the largest economic force in the region.

Considering the economic needs of the village, it was considered of paramount importance that management approaches began with a pilot protected area scheme that had the potential to offer relatively immediate economic rewards in order to provide potential incentives for establishing further protected area trials. A management scheme for the octopus fishery, aiming to provide both economic and ecological benefits, was therefore selected as the most appropriate starting point for conservation planning, since octopus is currently the most important marine resource for the economy of many fishing communities in the region, accounting for over 70 % of marine produce purchased by commercial fisheries collectors in Andavadoaka (L'Haridon 2006).

Between October 2003 and October 2004 meetings were held with both female and male fishers in Andavadoaka to discuss fisheries data, community perceptions of the state of fisheries and marine resources, and options for management. In October 2004 a Dina, or local law, was decided upon by the village, agreeing to the closure of the reef flat around the sand cay of Nosy Fasy, a 200 ha barrier island located seven km offshore due west of the village, for a period of seven months commencing November 1, 2004 (Figure 2). The fishing restriction applied only to all forms of octopus fishing; fishing for other species, such as reef fish, was allowed to continue. Although a popular fishing site for octopus before the closure, the loss of the Nosy Fasy site to octopus fishers during the closure period represented an estimated reduction of only approximately 15 % of local fishing grounds. A guardian was employed by the village fisheries cooperative to prevent poaching. Fishers worked together with village elders and representatives of Blue Ventures, the Wildlife Conservation Society (WCS), fisheries collection company Copefrito, and the IHSM to produce the Dina.

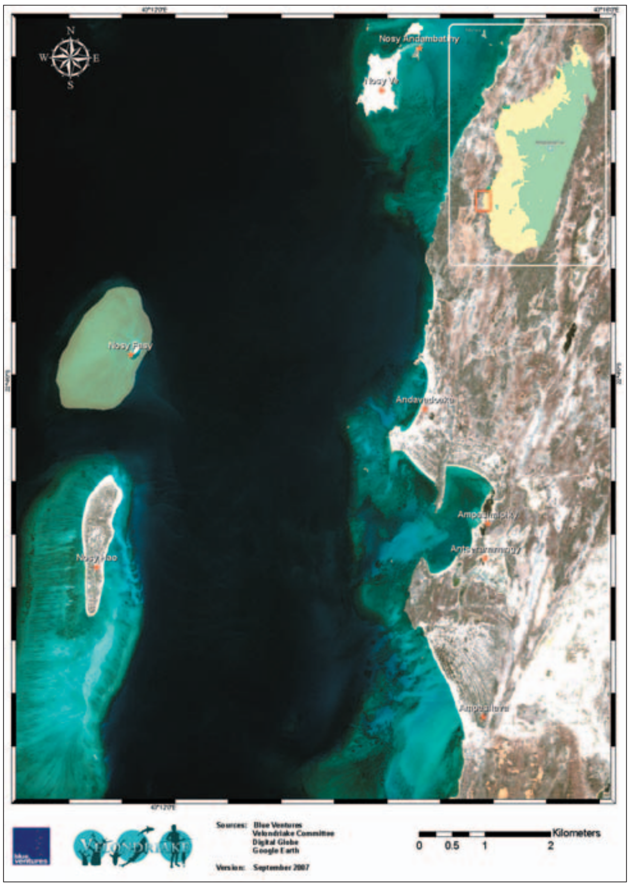

FIGURE 2. Location of the trial octopus no take zone at Nosy Fasy (Imagery Digital Globe).

The primary goal of the no take zone (NTZ) was to trial a conservation intervention that might serve to improve the sustainability of reef octopus *Octopus cyanea*, the village's most important commodity. Village elders and local fishers combined their traditional knowledge of fishing activities with fisheries data collected by Blue Ventures to implement a seasonal fishing ban aiming to allow octopus to grow in size and number, in order to produce greater yields for local fishers when the ban was lifted. Results from the first experimental closure, implemented between November 2004 and June 2005, showed that the number and average weight of octopus caught by villagers was significantly greater after the closure and when compared to control sites (Humber et al. 2006). In addition the Ministry of Fisheries consulted project results in creating new fisheries legislation for an annual six-week closed season for octopus fishing across the southwest of Madagascar country starting in December 2005.

Despite the positive fisheries effects of the trial NTZ, catch per unit effort did not increase as expected after this trial closure; an unanticipated outcome attributed to intense over-harvesting of octopus by visiting migrant fishers ("freeriders") on the days following the NTZ's reopening. Notwithstanding this issue, following presentation of the results of the programme to communities throughout the Andavadoaka region, Andavadoaka and neighbouring villages requested support in adopting this model for octopus fisheries management in order to pursue further NTZs as a means of restoring stocks and providing some protection for the shallow water reef habitats upon which much the region's economy depends. By early 2006 a series of three short-term octopus NTZs had been implemented, including a re-closure of the first trial NTZ at Nosy Fasy. This groundswell of community interest in developing marine conservation programmes led to an unprecedented opportunity for villagers to work together to develop a broader network of marine and coastal protected areas.

Between July and October 2006, representatives of 23 coastal villages, from Bevato in the north to the Baie de Fanemotra in the south, along with facilitators from Blue Ventures and WCS, came together in Andavadoaka to propose a series of maps of suggested protected areas and other conservation reserves aimed at protecting local marine and coastal ecosystems and promoting sustainable resource use (Figure 3). In total, communities proposed eight marine zones encompassing lagoon patch and fringing reefs for permanent closure as marine protected areas (MPAs); 16 reef flat zones for temporary closure as octopus NTZs; three mangrove protected areas; one intertidal lagoon zone with restrictions on seine fishing for protection of seagrass habitat; one special management area for aquaculture trials near Andavadoaka; one special management area for ecotourism in Andavadoaka; and three terrestrial areas for protection of baobab trees *Adansonia grandidieri* within selected areas of dry forest habitat. It was agreed that an approximately rectangular envelope, encompassing all of these special zones, would comprise the management boundary, within which additional regulations governing resource use and access would apply. The network was named '*Velondriake*', which means 'to live with the Sea'.

The proposed Velondriake management envelope containing all individual proposed protected and managed habitats equals 823 km^2 in size, covering over 40 km of coast (see Figure 1). Within this area, 20.06 km^2 (2.44 % of the total management area) comprise specific protected or special management areas. Of this, 12.56 km^2 (approximately 15.61 % of the total 80.47 km^2 of reef flat located within the management envelope) constitute proposed seasonal NTZs for octopus fishing; 3.75 km^2 constitute proposed permanent coral reef marine protected areas; 2.67 km^2 constitute proposed permanent mangrove protected areas; 0.55 km^2 constitute proposed permanent terrestrial forest protected areas; and 0.23 km^2 and 0.27 km^2 constitute proposed special management areas for marine aquaculture and ecotourism development respectively.

In August 2006 meetings took place in Andavadoaka to discuss the creation of a management committee to include representatives from surrounding regions to oversee the protected area planning process. The committee was to be supported and elected by members of three regional subcommittees (Vondrona), split geographically between the northern, central and southern regions of the protected area network. It was agreed that one or more representatives from all villages within the Velondriake network would be members of the Vondrona subcommittees, representatives being chosen by election in their respective villages. The northern group, Vezo Milagnoriake, comprises nine villages from two administrative regions, or Fokontany, from Andavadoaka to Bevato. The central group, Milasoa, comprises five villages from two Fokontany in the region surrounding Andavadoaka. The southern group, Fagnemotse, comprises nine villages from four Fokontany in the region between Andavadoaka and the Baie des Assassins.

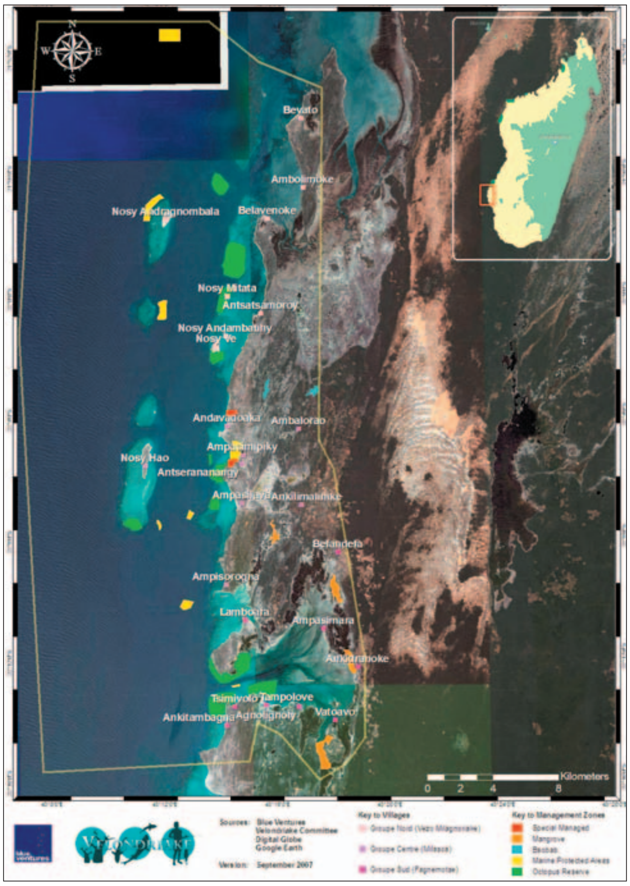

FIGURE 3. Location of protected areas and special management zones within the Velondriake network, September 2007 (Imagery Digital Globe and Google Earth)

The Velondriake and Vondrona committees' status was formalised at a series of meetings in Andavadoaka in October 2006 with the election of committee members, approval of the Velondriake Dina, and development of a preliminary action and management plan for the protected area network, identifying the overall goal and specific objectives of the initiative. The committee now serves as a liaison between communities, scientists and representatives of conservation NGOs, providing input into all phases of the conservation work, from research activities to the implementation of management plans.

AIMS AND OBJECTIVES

The primary goal of the Velondriake network, as stated in the preliminary management plan, is to protect marine and coastal biodiversity while improving livelihood sustainability in the Velondriake region.

Within this goal a number of specific objectives have been identified associated with the development of the protected area network. These include: developing the capacity of Velondriake's local and regional management committees for self-management; promoting communication, solidarity and coordinated environmental management planning between villages; and diversifying local economies through the promotion of ecotourism and the development of mariculture as an alternative income source in Velondriake villages.

Crucially, the management plan focuses on empowering local communities as managers of their own marine resources, able to contribute directly to resource management plans aiming to support local culture and livelihoods.

MONITORING AND ASSESSMENT

Community members are receiving training and support from partner conservation organisations to monitor the network to ensure that conservation strategies are being implemented, raise awareness amongst fellow community members about the potential economic and environmental benefits of biodiversity conservation, and gather data on species health and socioeconomic indicators to measure conservation success.

FISHERIES MONITORING

Monitoring of fisheries within the Velondriake region is critical to developing understanding of the impact of no take zones and fisheries management plans on local stocks. Monitoring of octopus and fin-fish fisheries in the region commenced in 2004, and in 2006 this was expanded to include landings by local shark and marine turtle fisheries. Local women and fisheries collectors are trained and employed by Blue Ventures to carry out surveys of landings and catches throughout the year, recording additional fisheries data including gear types and catch locations. The continuous monitoring of the fisheries over time will provide greater understanding of the impacts of the industry on the local marine resources, and ultimately allow for more specific and effective management techniques to be employed.

ECOLOGICAL MONITORING

Velondriake's partnership with established conservation groups is helping gather critical information on local marine species and habitat status. A long-term regional coral reef research programme, monitoring changes in the status and biodiversity of reef sites, has been developed in the region since 2003, incorporating reef habitats both within and outside protected area zones. Data gathered are shared with the IHSM and international marine research networks to assist in marine research and conservation efforts. Additional ecological monitoring is carried out at seagrass and mangrove habitats, as well as within the deciduous dry 'spiny' forest habitats. Since October 2006, project partners have been in the process of monitoring proposed sites to finalise the location and zoning plans for the protected areas within final management plan for Velondriake.

SOCIOECONOMIC MONITORING

Since 2005 socioeconomic research has been carried out in Andavadoaka and the two neighbouring villages of Ampasilava and Lamboara, in partnership with a regional Western Indian Ocean coastal socioeconomic monitoring programme coordinated by the CORDIO network (Coral Reef Degradation in the Indian Ocean). Following a training workshop in Andavadoaka in 2006 to involve local communities in the monitoring programme, this programme has been expanded to cover 10 of the total 21 villages within the Velondriake network. Communities within the Velondriake region vary widely in terms of size, ethnicity, and environmental locality; the latter category comprising villages situated on offshore islands, inshore coastal habitats, sheltered deltaic mangrove environments and inland dry forest habitats. Fishing practices, target species and market access all vary widely between villages. The main objectives set out by the Velondriake socioeconomic study are to establish an understanding of the current socioeconomic status as a reference for future change, and to understand community attitudes to management methods, and the perceived impacts that these measures have on communities. Knowledge gained from this monitoring programme will enable future marine resource management plans to be tailored to local situations, whilst aiding the development of effective environmental education programmes.

RESULTS AND LESSONS LEARNED

The experimental NTZs piloted in Andavadoaka showed that short-term closures of reef flats to octopus fishing can lead to an increase in the number of octopuses fished once a closed area is reopened. The observed increase in mean weight brought about by the closures means that fishers, who are paid by the kilogram of wet weight of octopus, increased their earnings. Furthermore, increasing the average size of the octopus population is likely to also increase its reproductive output. Results have confirmed that decreasing fishing intensity on the opening days can increase the duration of fisheries benefits from the NTZs (Humber et al. 2006).

Perhaps more importantly than their direct impact on fisheries, the development of pilot NTZs in Andavadoaka, targeting a single species in one specific shallow marine habitat, has served as a highly effective learning experience for conservation practitioners and communities throughout the Velondriake region. Through the trial NTZs, local fishers have been able to see how conservation activities can improve octopus populations and lead to greater fishing yields. Consequently less than two years after it was first implemented the pilot NTZ project has precipitated broad-scale community support for the proliferation of NTZs for fisheries management across a much wider region. Moreover, increased awareness of the potential benefits that can be derived from conservation tools such as the NTZs, brought about by efforts to communicate and share results from the first trial NTZs, has given rise to community support for the development of other broader-scope management interventions, including permanent protected areas covering a range of marine, coastal and terrestrial habitats.

In line with requests from all communities within the Velondriake network, partners must now focus on the development of a coordinated environmental education and awareness-raising programme, aimed at all ages of society, in order to provide local stakeholders with the tools, training and institutional capacity needed to monitor and manage natural resources.

Support for Velondriake across the wider region has been borne out of the development of long-term working relationships between conservation groups, communities and other stakeholders, based on perseverance, commitment and transparency between parties. The readiness of fisheries collection company Copefrito to be fully involved in conservation planning, in particular supporting the trialling of NTZs and sharing company fisheries data, has led to the evolution of a highly effective multi-stakeholder partnership through the course of the project. This, along with the permanent presence since 2003 of Blue Ventures' field research station in the region, has undoubtedly been instrumental in developing mutual understanding and trust between conservation groups, community leaders and fisheries companies, in turn strengthening the credibility of proposed conservation interventions. The successful continuation of these partnerships depends on maintaining regular communication and dialogue between all parties.

The bottom-up approach to marine and coastal conservation adopted by the Velondriake project to date has so far worked effectively in producing a community-endorsed blueprint for the first network of marine and coastal protected areas in southern Madagascar. Whilst the precise circumstances of this project may not be replicable directly beyond the semi-nomadic Vezo communities of the Andavadoaka region, the community-management and partnership processes employed in the project's development will provide Madagascar's first potentially replicable model for community-centred marine and coastal conservation planning. In doing so this initiative is expanding national capacity for biodiversity conservation, and improving the availability of data, lessons learned and best practice guidelines. Throughout the Velondriake project technical reports and policy briefs are made available to local and national government, research groups and NGOs, as well as relevant international networks, to raise awareness of the initiative wherever appropriate.

It remains to be seen what the long-term ecological and fisheries effects of the octopus NTZs will be, since both the short- and long-term effects of the permanent protected areas and other managed zones within the expanded Velondriake network remain unknown. Although encouraging, the rapid growth in the number, area and nature of the reserves incorporated within the network has meant that the detailed, rigorous monitoring, community liaison and feedback that were prioritised throughout the first experimental NTZs cannot be continued at the same focused level across the broader Velondriake region, due to fundamental limitations of human and financial resources available for the project. Although members of the management committees and partner organisations contribute considerable time freely to the initiative, unavoidable core management, communication, monitoring and travel costs, as well as salaries of collectors involved in monitoring catch landings, constitute significant financial overheads to the project in its current form.

If Velondriake's objective of promoting long-term sustainable management of marine and coastal resources is to be realised in the medium to long-term, communities must be empowered with skills and resources to manage and monitor resources without direct NGO leadership and donor financial support. There is currently no financial model in place to enable Velondriake communities to independently meet the costs of capacity building, monitoring and management of the Velondriake network. Consequently the project depends on external support from partners. This dependency poses a fundamental limitation to the financial sustainability of the network. Without the development of a management fund, supported and maintained by communities, local cooperatives and / or fisheries collectors, and fairly administered by the Velondriake management committees, Velondriake's continued success will remain at risk to the withdrawal of partner aid.

During the Velondriake zoning meetings held in Andavadoaka, communities recognised the importance of incorporating marine, coastal and terrestrial areas that have the potential to attract tourists to the region. Ecotourism does not have the potential to offer as reliable or potentially as great a source of income to local villagers as fisheries products. However, it represents a potentially more sustainable non-extractive use of reef resources that could deliver sufficient income to promote the management of protected areas. Vezo communities in the Velondriake region have few resources other than the sea that they can utilise to generate income, and at this point in time have

FIGURE 4. Fishers landing catch of Octopus cyanea following reopening of Nosy Fasy no take zone, 2006.

only extractive options for resource utilisation. With a growing market of tourists arriving in Andavadoaka the potential exists to incorporate local villagers into this expanding service industry and for local communities to obtain substantial economic gain in doing so. By demonstrating to local villages that coral reef and other marine and terrestrial resources can be used to generate income from non-extractive activities, whilst also simultaneously achieving conservation and fishery benefits, protected areas have the potential to provide a greater appreciation for, and understanding of, natural resources within the region. The need to develop Velondriake's capacity to receive, host and guide ecotourists has led to the development of a community eco-guide training programme, and plans for construction of a community-run eco-lodge, which will be fully owned and managed by the village of Andavadoaka, and occupied in part by visitors brought to the region by Blue Ventures' existing ecotourism programmes, which currently account for over 7,000 tourist-nights to the village each year.

Notwithstanding the manifest benefits of community management within Velondriake, the project remains vulnerable to forces beyond local community control. Despite encouraging community support of, and adherence to, local management plans, villages have no assurance that the local laws established during the creation of Velondriake will be either known to, or respected by, outside or migrant resource users. Commercial fishing trawlers operate with increasing frequency within Velondriake's shallow waters, irrespective of fisheries restrictions that have been agreed by local resource users. Similarly, outside investors seeking to acquire and develop land within the Velondriake area are able to do so without consulting the Velondriake committees in their current form. Plans for major tourism developments within the Baie de Fanemotra are currently being proposed with negligible consultation of communities living within the bay. Such activities pose an insidious and potentially damaging threat to traditional livelihoods, as well as the health of local coral reefs and related marine ecosystems. As such there remains a critical need to communicate and strengthen local environmental governance structures and management plans at a regional and national level, in order that relevant governmental departments can play their role in supporting and safeguarding Velondriake, through reinforcement of the legislative status of this pioneering initiative.

For regular research reports and more information please visit: http://www.blueventures.org/research_update.htm

ACKNOWLEDGEMENTS

Special thanks to all staff and volunteers of Blue Ventures Conservation, Andavadoaka, and the Wildlife Conservation Society, Antananarivo.

REFERENCES

Cooke, A., Ratomahenina O. and Ranaivosoin E. 2000 *Madagascar.* In: Seas at the Millenium. C.R.C. Sheppard (eds.), pp 113-131. Elsevier Science Press

Cooke, A. 2003. *Marine and coastal ecosystems of Madagascar.* In: "The Natural History of Madagascar". S.M. Goodman and J.P. Benstead, (eds.), pp 179-209. University of Chicago Press.

Gabrié, C., Vasseur, P., Randriamiarana, H., Maharavo, J. and Mara, E. 2000. *The coral reefs of Madagascar.* In: Coral Reefs of the Indian Ocean, T. R.McClanahan, , Sheppard, C. & Obura, D. (Eds.) Oxford University Press, New York: 411-444

Harding, S., Randriamanantsoa, B., Hardy, T., Curd, A. 2006. *Coral Reef Monitoring and Biodiversity Assessment to support the planning of a proposed MPA at Andavadoaka, Madagascar.* Blue Ventures Conservation, London, and the Wildlife Conservation Society, Antananarivo. 100 pages.

Humber, F., Harris, A., Raberinary, D. and Nadon, M. 2006. *Seasonal Closures of No-Take Zones to promote a Sustainable Fishery for Octopus cyanea (Gray) in Southwest Madagascar.* Blue Ventures Conservation, London. 28 pages.

L'Haridon, L. 2006. *Evolution de la collecte de poulpe sur la côte Sud Ouest de Madagascar: elements de réflexion pour une meilleure gestion des resources.* Blue Ventures Conservation, London. 46 pages.

Langley, J., Harris, A. and Nihalani, A. 2006. *The 2004-2005 Census of Andavadoaka, South-West Madagascar.* Blue Ventures Conservation, London. 29 pages.

Laroche, J., Razanoelisoa, J., Faroux, E., and Rabenevanana, M.W. 1997. *The reef fisheries surrounding the south-west coastal cities of Madagascar.* Fisheries management and ecology, 4, 285-99.

EDITORIAL NOTE

International Year of the Reef
The United Nations has designated 2008 as the International Year of the Reef – a worldwide campaign to raise awareness about the role and importance of coral reefs and the threats they face.

Healthy coral reefs, often also referred to as 'rainforests of the oceans,' provide:

- Habitat to over one million aquatic species
- Food for people living near coral reefs
- Income: Billions of dollars and millions of jobs in over 100 countries around the world
- A natural barrier protecting coastal cities, commun ties and beaches

Blue Ventures is working with like-minded businesses, government leaders, non-profits and individuals to raise awareness for the need of reef conservation and push for policies and programs that will ensure these precious resources remain healthy and productive for generations to come.

Please visit www.iyor.org to get involved and learn more about this campaign.

MCD INTERVIEW

Three Women engaged in the Blue Ventures Conservation Velondriake Community Project

Volanirina RAMAHER
Eleonore
Christine

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1) INTERVIEW AVEC VOLANIRINA RAMAHERY RESEARCH SCIENTIST DE BLUE VENTURES CONSERVATION

Qui êtes-vous, quelle est votre fonction dans ce projet et depuis quand y participez-vous?

Je m'appelle Volanirina Ramahery et je suis Research Scientist de Blue Ventures Conservation dans le village d'Andavadoaka. Blue Ventures Conservation est une ONG britannique basée à Londres. Elle a commencé à travailler dans le village en 2003 pour le suivi écologique des récifs coralliens aux alentours et pour la promotion du tourisme écologique. Blue Ventures Conservation a reçu plusieurs prix internationaux en signe de reconnaissance pour ses efforts dans la conservation et la gestion durable des ressources naturelles. En 2005, Blue Ventures Conservation a initié la création de la réserve de poulpe de Nosy Fasy, située à l'ouest d'Andavadoaka. L'idée a gagné plusieurs autres villages qui ont créé leurs propres réserves de poulpe, de mangrove, d'herbiers et même de baobabs. Maintenant, tous les villages impliqués, 23 au total, se sont regroupés et ont formé l'Association Velondriake qui se traduit par „vivre grâce à la mer". L'Association Velondriake est le premier exemple au Madagascar d'une association communautaire responsable de la gestion d'une aire protégée.

Je suis arrivée à Andavadoaka en Septembre 2006 en tant que volontaire de Blue Ventures Conservation pendant six semaines. Puis, j'ai été engagé en tant que chercheuse en Novembre 2006. Je m'occupe de plusieurs activités de recherche et mon rôle au sein du projet Velondriake est de fournir l'appui technique nécessaire au comité de gestion qui, à son tour, va sensibiliser et éduquer les villageois pour la gestion durable de leurs ressources.

Ainsi, avec mes autres collègues, nous organisons des ateliers de formation sur l'éducation environnementale, l'écologie des zones côtières et marines, les activités anthropiques qui causent la dégradation des habitats marins ainsi que le déclin de la production de la pêche, le suivi écologique des récifs coraliens et l'évaluation de la diversité des poissons récifaux.

La principale source de revenu de la population côtière de Madagascar est la pêche. Pour la population Vezo du Sud Ouest, les produits de la mer constituent le seul revenu des ménages et la plus importante source de protéine animale. Il est donc essentiel de trouver une politique efficace pour gérer les ressources marines de la région. Les parcs marins constituent un des outils les plus avantageux pour une pêche durable à condition que les sites protégés soient bien choisis et que la communauté locale soutienne les efforts de gestion.

Quel sont les changements dans votre vie depuis que vous avez commencé à travailler dans ce projet?

Je me suis intéressée tôt à la conservation de la nature. J'ai réalisé que la nature à Madagascar est exceptionnelle et après le baccalauréat, j'ai décidé d'étudier les Sciences Naturelles à l'Université d'Antananarivo. J'ai été attirée par la conservation marine plus tard, lors de la préparation du Diplôme d'Etudes Approfondies en Biologie Animale et Conservation en 2001. J'ai remarqué que la conservation à Madagascar est principalement concentrée sur la faune et la flore terrestres et que les habitats marins sont très peu étudiés, alors qu'une grande partie de la population malagasy dépend des activités de pêche et que les resources halieutiques sont primordiales pour l'économie du pays. Maintenant, je pense que conservation doit aller avec développement socio-économique.

Après mes études aux Etats-Unis, où j'ai obtenu le Master en Gestion des Zones Côtières, je suis retournée au pays et j'ai décidé de travailler en milieu rural pour aider les gens à gérer leurs ressources et à développer leur région. Travailler pour le

Volanirina RAMAHERY

projet Velondriake m'a permis de me familiariser avec le processus de mise en place d'un parc marin géré par la communauté locale. Je suis aussi plus confiante en mes capacités de facilitateur, de leadership et de relations humaines. Je suis plutôt timide de nature mais maintenant, s'adresser au public n'est plus un problème pour moi. Les ateliers de formation pour le comité de Velondriake m'ont aussi permis de trouver un moyen simple pour transmettre mes connaissances à la communauté locale.

J'espère que mon travail à Andavadoaka a aidé les habitants à comprendre que développement et progrès ne sont pas impossible et peuvent même être réalisés en respectant la nature. Mais celà demande beaucoup d'efforts et du sérieux de la part de tous. J'encourage les gens à trouver d'autres sources de revenu, à développer d'autres talents pour réduire la pression sur les resources naturelles, à être plus confidents et avoir un esprit d'entreprise.

Pour les villages et les alentours du projet, qu'est-ce qui a, selon vous, changé par ce projet?

La mise en place du projet Velondriake a permis aux pêcheurs d'identifier les problèmes d'exploitation non durable des ressources côtière et marine ainsi que les causes de la destruction des écosystèmes marins. Les communautés de pêcheurs des 23 villages veulent s'engager d'avantage dans la gestion durable des ressources dont ils dépendent et dans l'amélioration de la productivité de la pêche. La communauté locale est plus sensible aux effets bénéfiques du tourisme. Actuellement, deux autres villages veulent s'associer avec les 23 villages de Velondriake et faire partie de la nouvelle aire marine protégée.

2) INTERVIEW AVEC ELEONORE, PECHEUR DE POULPE

Qui êtes-vous, quelle est votre fonction dans ce projet et depuis quand y participez-vous?

Je m'appelle Eléonore et je travaille dans la pêche aux poulpes. Je suis mariée à un pêcheur et nous avons 14 enfants. Je pêche les poulpes depuis mon enfance et la pêche est la principale source de revenu de ma famille.

J'ai approuvé, avec les autres villageois, la mis en place de la première réserve de poulpe à Andavadoaka (Nosy Fasy). Et je pense que c'est bien de créer d'autres réserves (mangroves et récifs coralliens) car elles vont permettre d'augmenter la production des pêcheurs.

Eleonore

Quels sont les changements dans votre vie depuis que vous avez commencé à travailler dans ce projet?

La création des réserves de Velondriake en 2005 a amélioré la production de poulpe. Avant, il y avait des jours où on n'arrivait pas à en trouver. Maintenant, la production est basse seulement en cas de mauvais temps. La taille des poulpes a aussi augmentée. Durant la marée basse des vives-eaux, je pêche avec mon mari, mes fils et mes filles, huit personnes au total, et souvent on ramène 10 à 15 kg de poulpe.

Pour les villages et les alentours du projet, qu'est-ce qui a, selon vous, changé par ce projet?

On va aussi pêcher dans les réserves aux alentours d'Andavadoaka et c'est la même chose. On peut toujours trouver des poulpes. Jusqu'à maintenant, je ne trouve pas de problèmes liés a la création de réserves dans la région d'Andavadoaka.

3) INTERVIEW AVEC CHRISTINE TRESORIERE DU COMITE MILASOA DE LA ZONE CENTRE DE VELONDRIAKE

Qui êtes-vous, quelle est votre fonction dans ce projet et depuis quand y participez-vous?

Je m'appelle Christine, je suis mariée a un pêcheur et nous avons sept enfants. Je suis la trésorière du Comité Milasoa de la zone centre de Velondriake depuis 2006. Je fais la pêche aux poulpes et la collecte pour Copefrito, une compagnie de pêche basée à Toliara.

Quels sont les changements dans votre vie depuis que vous avez commencé à travailler dans ce projet?

La sensibilisation des villageois pour la protection des récifs coralliens a amélioré l'état des récifs coralliens. Avant la création des réserves, les produits de la pêche ont diminué. Maintenant, il y a beaucoup plus de poissons et de poulpes pour notre consommation et pour envoyer à Toliara.

Pour les villages et les alentours du projet, qu'est-ce qui a, selon vous, changé par ce projet?

Les populations des autres villages sont aussi convaincues de la nécessité de préserver les ressources marines et ont également créés des réserves marines.

Christine

AROVAKO I MADAGASIKARA!

The EAZA Madagascar Campaign 2006 / 7

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EAZA CAMPAIGNS

EAZA, the European Association of Zoos and Aquaria, has for the past several years run annual conservation campaigns. This began in 2000 with the Bushmeat campaign and since then the topics have included focal species (rhinos, tigers and chelonians) and habitat areas (Atlantic Coastal Forest in Brazil). The 6th campaign focused upon Madagascar, the first time that an entire country has been the subject of an EAZA campaign.

The campaign was co-chaired by the Zoological Society of London and Zoo Zurich, ably supported by Durrell Wildlife Conservation. In addition, many different zoos, NGO's and private individuals provided support. The format followed that of the previous successful campaigns. The organising team produced an information pack which helped zoos implement the campaign within their own organisation. This pack was distributed at the 2006 EAZA Annual Conference in Madrid, where the campaign was officially launched on October 4th, appropriately enough, 'World Animal Day'. EAZA were delighted that Dr. Guy Suzon Ramangason, Director General of ANGAP and representing the government of Madagascar, could travel to Madrid to help launch the campaign on behalf of the President of Madagascar, Marc Ravalomanana. President Ravalomanana endorsed the campaign and provided a foreword to the campaign information pack. In addition the actor John Cleese provided support by agreeing to act as Patron to the campaign.

THE AIMS OF THE 2006 / 7 CAMPAIGN

- *Raise public awareness* of one of the most important reservoirs of natural history on the planet. Promoting the idea of biodiversity through the unique fauna and flora found on Madagascar.
- *Promote ecotourism* to Madagascar. For many biodiversity rich countries, responsible ecotourism can be a viable way to bolster their economy, whilst ensuring that the unique habitats and wildlife that visitors come to view are afforded greater protection by being recognised as an asset.
- *Raise funds* for specific conservation projects throughout the island. The fundraising target for the Madagascar Campaign has been set at 500,000 €.
- *Highlight ways in which the public can make positive contributions* to conservation through activities in their daily lives. If world conservation goals are to be achieved, sustainable use and recycling are messages that are particularly prevalent in the developed world, which uses a far greater share of the world's resources than the biodiversity rich developing world.
- *Alert EAZA collections to the diversity of Madagascar's wildlife* – it's not just lemurs! Promoting the responsible sourcing and keeping of conservation dependent species currently held in small numbers, or not at all, in EAZA collections. By disseminating information regarding threatened Malagasy species it is hoped that this will influence future collection planning decisions at EAZA institutions.
- *Promote the concept of 'twinning'* between EAZA members and National Parks and protected reserves.

PUBLIC OUTREACH

Whilst the EAZA Madagascar Campaign ran for one year, it is hoped that long-term interest in the island will be stimulated. The pan-EAZA active part of the campaign closed on September 12th 2007 at the annual EAZA conference, held in Warsaw, Poland.

The campaign has proved to be a great success since its official launch. In total 165 zoos across 23 countries have participated in the campaign. The participating zoos were innovative and enthusiastic, developing numerous different activities that informed Europeans about the amazing biodiversity of Madagascar, the threats to its future and how they could help through donations to the campaign. Activities in the various zoos included theatre shows with storylines telling the tale of Madagascar and its lemurs, its ancient pirates, extinct species such as elephant birds and other species on the island. Exhibitions of graphics about the island, video games made by local universities and short films, all spread the message. Competitions to name new zoo infants born, and children's games in zoos steadily raised the sums required to undertake the highlighted conservation work. An estimated 25 million + Europeans are likely to have seen the campaign this year, proving the reach of a zoo-led awareness campaign. Some zoos even took the campaign into their city centres, increasing the reach of the campaign to beyond the zoo-going public.

A preliminary 11 month fundraising total was able to be announced at the closing ceremony. An astounding 451,000 € had been raised with more money coming in every day – it seems likely that the campaign will reach and surpass its 500,000 € target by the end of 2007.

ASSISTANCE IN CYCLONE REPAIRS 2007

EAZA zoos were also able to assist with cyclone damage repairs following the devastating affects of one of the worst recorded cyclone seasons, with large areas of northeast Madagascar hit by the storms. EAZA was contacted by the Wildlife Conservation Society (WCS), working in the Masoala and Makira forest areas. Significant damage had been sustained both in the protected forests and to local villages, with both buildings and crops damaged and WCS required assistance to help repair the damage. The Madagascar Campaign group alerted EAZA members to the cyclone damage and made an emergency appeal for funds. Within 24 hours EAZA members and supporters had raised 25,000 € for cyclone damage repairs. To date the monies have been spent on a number of activities including

Masoala:

- Compensation (allowance) to Park staff based in Altalaha who lost property (houses) [completed]
- Repairs to park infrastructure (repairs to nine ranger posts) [ongoing]
- Repairs to tourism infrastructure (tent shelters and sign posts) [ongoing]
- Repairs to communications/radio network [ongoing]
- Creation of firebreaks in three detached parks [completed]
- Repairs to irrigation in communities [four sites ongoing]

Makira:

- Rehabilitation and new construction of irrigation system in the community resource management sites of Ambodivohangy. [ongoing with completion by end of 2007] Impact: 330 ha of rice field irrigated 2,140 community members benefit. The system will improve planting that will occur in December and harvest in May 2008.
- Installation of a well for potable water in the community resource management site of Marovovoana [ongoing]

RECIPIENTS OF THE CAMPAIGN 2006 / 7

The monies raised during the campaign year will be forwarded to 20 different conservation projects which were selected in a screening process in 2006. It is hoped that the monies can be distributed as soon as possible. The conservation projects are diverse, both in subject matter and in location around the island, and range from reforestation projects to provide buffer zones around protected areas, to education programmes around Lake Aloatra, to research projects to identify the conservation priorities in the Montagne de Francais in northern Madagascar. EAZA will be receiving updates from all the recipient projects next year and these will forwarded to all campaign participants, demonstrating how their funds have been spent. EAZA also hopes that this campaign and the updates from the projects will continue the interest of EAZA zoos in Madagascar.

When all 20 projects have been funded and including the monies already forwarded to the cyclone damage relief programme, EAZA will have a small remaining fund. EAZA is investigating how to best use this money for the greatest possible benefit to Madagascar. It is hoped it may be possible to utilise the funds to apply to various grant awarding bodies, using the EAZA campaign surplus funds as matched funding, to seek even greater sums of money. This will make the funds raised by zoos work that bit harder for Madagascar.

ACKNOWLEDGEMENTS

The EAZA Madagascar campaign 2006 / 7 has been fun, rewarding for participant zoos and most of all beneficial to the conservation of biodiversity on this remarkable island. The campaign team would like to thank all those who made the campaign possible; the contributors to the campaign pack, the President of Madagascar and John Cleese for lending their support, to the zoos that took part and for the general public for supporting these efforts.

Conserve Madagascar, Arovako i Madagasikara!

PICTURES

‚Pretty Pictures,' A Reason to Care?

Eric Matson

These white terns are nesting, they will incubate and hatch their egg on the unimproved branch. The chicks need to get their life in balance from day one.

‚PRETTY PICTURES,' A REASON TO CARE?

The key to conservation is understanding, the key to understanding is knowledge and all knowledge comes from experience and observation. Few of us are able to experience everything the world has to offer and fewer still have the skills to observe with true understanding. Yet many of us do understand, and much of our understanding is born not of our own experience but through the efforts of others who are driven to share their observations via the visual media.

Madagascar has few visitors, its remote location combined with its often rudimentary infrastructure make it both desirable to the few and inaccessible to the many. Those of us who are able to visit and experience and observe and start to understand are blessed but we are also tasked with sharing our knowledge with the many. Visual images can reveal beauty and rarity, make the uncommon commonplace, share the delight of discovery and sometimes provide a reason to care.

For me this is the role of my photographs, to illustrate or even become an argument for understanding, a step in the process of preservation and a voice for the silent. Conservation of biodiversity in Madagascar, like many other naturally rich but economically poor places is best linked to development through the people closest to the ground. My images are at their best when they couple the inseparable, the rich natural world and the needs of the people, to ignore either would be unfair to both.

This image appears to show Baobabs on fire but it is not so simple, the flames are from a hidden cane field being prepared for harvest, but still it speaks of the clash between old growth and new growth. It was taken near the avenue of baobabs Morondava.

The girls in this image are selling milk in the market at Tulear, in the background are bundles of bark to be sold as traditional medicine.

IMPRESSUM

Madagascar Conservation and Development is the journal of Madagascar Wildlife Conservation (MWC) and the Jane Goodall Institute (JGI Switzerland). It is owned by these two institutions and is produced in these institutions own responsibility.

COVER PICTURE: Summit of Marojejy by Eric Mathieu

DESIGN: Thomas Lehner [Hochschule für Gestaltung und Kunst Basel]

LAYOUT: Stephanie Züllig [Madagascar Wildlife Conservation Switzerland]

FUNDRAISING: Julian Cooke [Anglo-Malagasy Society, UK]

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BIC (Bank Identifier Code): POFICHBEXXX
Adress: Swiss Post - PostFinance
Nordring 8
3030 Bern, Switzerland
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IBAN: CH6509000000606846302

ISSN 1662-2510