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MADAGASCAR CONSERVATION & DEVELOPMENT

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

IN THIS ISSUE

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Tartuffe's Madagascar: conservation hypocrisy

THE INTERNATIONAL DONOR COMMUNITY'S UNSHAKEABLE INTEREST

In this editorial, we would like to review some of the significant events that affected Madagascar in 2017. Madagascar has been featured in the global media in connection with both conservation and development-related activities. For example, every two to three months, Malagasy rosewood is written about in the local or international press. On this subject, a new term has emerged in articles, blogs and reports: the word "palisander". It is used ostensibly to draw the French distinction between precious rosewood (*Dalbergia* spp.) and less precious rosewood-like wood (*Dalbergia* spp.) The main distinction is based on criteria which are very much subjective and biased towards private interests.

Regularly, when the rosewood topic comes up in and outside of Madagascar, people are quick to accuse public officials or elected representatives of complicity in its trafficking. Fighting against the trafficking of precious timber became a poster child of a sad, harsh reality that has increasingly confronted Malagasy people after the 2009 political coup d'état, when a minority annexed wealth, while the majority slid deeper into poverty (Randrianja 2012). Timber trafficking is observed often—it is reported in the local press, sometimes even internationally. However, reported statistics should be taken with a pinch of salt as information can in most cases, not be verified. While the official Madagascar 2017 report to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2017a) focuses heavily on the northeast, citing Marojejy and Masoala national parks as the focal areas of rosewood traffic (from sourcing to stocks), many more forests are affected in reality, by these continuing, illegal activities. The latest article published in a local newspaper (Léonard 2017) reported the seizure of a truck laden with rosewood logs originating in the Menabe, along the west coast of the island. The World Bank entered into the arena with a study designed to inventory timber stocks and to find a way to manage the resource. In 2017, these stocks became a nightmare for the World Bank—which, then simply wanted to get rid of them. It called for the covering up the stock, which it can't bear to confront, appearing more than ever like Tartuffe, Molière's hypocrite. In contrast to the World Bank, the 69th meeting of the standing committee of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), rejected the sale of Madagascar's stocks of precious wood (CITES 2017b). The stocks were shown to be variable in number, weight and volume (Moore Gerety 2017); the CITES decision does not look particularly strong and seems more of a call for slightly increased effort with regards to management and declaration of the stocks. As recent past has demonstrated, sooner rather than later, the ports may be opened officially to formalize the draining of these rich natural resources that no one appears able to contain.

Other projects, that also have involvement of the World Bank are less concerned with measures of intervention to stop illegal activities, and are seemingly more scientifically based, purporting to have some degree of hope attached to achievement of tangible positive results. There is the kind of project to which a blizzard of positive buzzwords is attached; these could be connected with 'recipes' for sustainable development interventions, of course with substantial funding. One such project is "PADAP": *Projet Agriculture Durable par une Approche Paysage*, which translates to Sustainable Agriculture Project using a Landscape Approach[1]. This agroforestry-based project aims to restore a forested landscape by engaging closely with farmers. It is to commence in 2018. Here, we want focus attention to the numbers, not the buzzwords: this project will engage 38 thousand people (mostly farmers) including 40% women, 140 km² of irrigated perimeters and 70 km² of forests under restoration—this translates to less than 0.2% of the rural population of Madagascar and some 0.02% of the total area of the island when it comes to irrigated perimeters. The project budget is of 107 million US$, of which 91.6 million US$ (85.6%) is to be repaid to the World Bank (65 million US$) and the French Development Agency (26.6 million US$). The project thus represents some 340 billion Ariary for 38,000 beneficiaries, which comes to more than nine million Ariary per beneficiary. As a baseline, the latest poverty indices show that 80% of farmers in Madagascar have access to less than US$ 1.25 a day, most of them surviving on less than one million Ariary a year.

The intentions of this project are commendable. However we do question its feasibility and would ask for a reality check: how are the beneficiaries of this project (the farmers) supposed to pay back the money that they receive? Or, how are they going to produce enough to supply local markets and create further employment vacancies? The PADAP is just one of its kind—the main challenge is that lots of funding in very short time periods all too often has little positive effect where it is most needed. It adds to complexity—and often rigidity—of governance, by creating the need for revised or new administrative structures. Donors believe that it is possible to maintain the ever-growing GDP, increase debts and all the while, produce more and more to shovel increasing amounts of money in the pockets of rich nations (but do refer to some interesting information here https://goo.gl/uwGUKP and https://goo.gl/rcCgst).

The two examples presented don't illustrate anything new in terms of governance and conservation, but they remind us that patience towards duration of such projects, or interventions, may be overwhelming even for the most committed of practitioners and activists. The struggle for conservation and sustainable development is unequal and oftentimes in-transparent. Money—or decisions based on funding and related mechanisms—will eventually win out and CITES, or committed NGOs, will sooner or later be forced to give way to a general state of oblivion imposed by the "global Tartuffes".

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1. <http://documents.worldbank.org/curated/en/866291485410927510/pdf/PIDISDS-APR-Print-P154698-01-26-2017-1485410921485.pdf>

SOME ARE MORE EQUAL THAN OTHERS

Forests remain a central focus of conservation activities since they host famously high levels of biodiversity. Deforestation continues unabated and at a high pace (e.g., Global Forest Watch 2017) despite great efforts being implemented (Waeber et al. 2016) to safeguard the lemurs and other 'flagship' forest-dwellers. A recent study published in PloS ONE by Bamford et al. (2017) based on a rapid assessment of 37 sites across Madagascar, showed that anthropogenic activities have reduced more than 80% of Madagascar's wetlands, mostly for agricultural production (rice). In a country where rice still constitutes the main staple food, and where fertility rates rank still among the highest, globally (current population "estimates" report of some 23 Million inhabitants—though the last official General Population and Housing Census dates back to August 1993!), wetlands remain extremely vulnerable to further, more substantial changes. Therefore, protection measures need to be strictly adhered to and any kind of infractions of park boundaries should be followed up in official accounts.

Allow us to illustrate here with an incidence that we suspect to be just one of several similar cases across the country. Lake Alaotra is a new protected area (NPA) known for its endemic lemur *Hapalemur alaotrensis*. In the first half of June 2017, a member of parliament—henceforth the VIP—since naming names under the current lack of a communication law can be challenging (but, do refer to https://goo.gl/Y9g7UE)—has been reported hunting ducks within the core zone of the NPA, right at Park Bandro in Andreba Gare (Razafy 2017a,b). The conservation officer was forced to delete his images and to amend the story, in such a way as to place the VIP hunter outside of the NAP. Other local NGOs were contacted by the higher political echelons and instructed to approach the press with an alternative story (very Trump-like). The VIP hunter assured that he was not aware of infringing the park boundaries. Ironically, however, it was the VIP hunter who was the then member of the Committee for Environment, Ecology, and Forest at the National Assembly, who signed the decree for the NPA Alaotra in April 2015! The VIP hunter was since reported to return with guards and guns to the same place—or to villages just south of it—for more recreational hunting. And the consequences? Not one. Now this has several implications. Firstly, it serves to illustrate very clearly that the law does not apply equally for everybody: VIPs do appear to enjoy political immunity. Secondly, NGOs risk trouble if they dare to report on the 'wrong' person. Thirdly, and arguably the most striking implication: such incidences and their (non-)treatment by the officials, send out wrong messages to the resident communities, i.e., it 'seems acceptable and safe to disrespect park boundaries and to hunt protected species within parks'. These factors in combination increase pressure on the Alaotra wetlands. Additionally, conversion of the marshes into rice fields is often instigated by forces stemming from outside the Alaotra system (cf. Waeber and Wilmé 2013).

THE GOOD, THE BAD, AND THE UGLY OF PEER-REVIEWED PUBLISHING

In 2017, some noteworthy articles came to our attention. They are totally independent, but, seen from the Southwestern Indian Ocean, appear to point towards Madagascar, because our visions are necessarily 'altered' depending on where our feet are standing on the Earth. On the other side of the globe, in the Galápagos, researchers have shown that evolution took a considerable shortcut, producing in only three generations what reproductive isolation would have developed over hundreds of generations (Lamichhaney et al. 2017). Undoubtedly, this discovery will force us to rethink many of Madagascar's endemic taxa, even if the Galápagos are composed of small, isolated islands compared with the massive Gondwana Madagascar. The islands of the Northeastern Pacific were never discovered by Austronesian navigators, having been colonized by humans more recently (e.g., Froyd et al. 2010). In this regard, papers published in 2017 serve to furnish us with more information on the origin of the Malagasy. The archaeologist Jean-Aimé Rakotoarisoa and his collaborators showed us that all Malagasy share a common Bantu and Austronesian descendant, with origins in Borneo (explaining at least a quarter), and Southern Africa (explaining at least another quarter). But these two portions of the origins of the Malagasy still do not convey the entire story of the origins of the Vazimbas and we are still far from understanding it (Pierron et al. 2017). We will probably never know when the first people set foot on the island. This is for an obvious reason: they arrived by boat, but there is no proof that they settled at the time. They could just as easily have left, or, died on the island without leaving any trace for archaeologists. Until proven otherwise, the dates proposed by scientists remains the earliest.

Another question has long preoccupied ecologists and biologists in Madagascar: how can one explain the absence of an extended, frugivorous animal population? Most lemurs have a mixed diet, including leaves, gums and insects. Few rely solely on fruits. The same applies to birds and most other mammals, with the exception of fruit bats. At the end of last October, Giuseppe Donati and collaborators proposed that the low levels of nitrogen found in Malagasy fruits were what drove the evolution of Madagascar's lemur communities (Donati et al. 2017). Another, unrelated story, reports that people are smaller in poorer countries than they are in rich countries. And that this difference can be explained by low nitrogen and phosphorus levels (Peñuelas et al. 2017). These recent discoveries will certainly inspire further research to be conducted in Madagascar, which has high potential to guide or inspire development interventions, so we look forward to receiving articles and notes by researchers who are addressing these issues in the region.

We end this editorial with a note on open access publishing, since peer-reviewed journals are providing the material, concepts, ideas and data for conservation practitioners and others. Therefore, journals are an important source of information and a platform of exchange. While the major publishing companies are offering more and more online open access journals, (Springer Nature included), some are locking up their prestigious journals behind pay walls, which very few African—and no Malagasy institutions—can afford. Until a few years ago, beneficiaries of the Online Access to Research in the Environment (OARE http://web.unep.org/oare/) system, could read the journal Nature. However, Nature has not been available—nor proposed under this formula—for over a year. But the articles are fortunately accessible thanks to Science Hub (Sci-Hub is a website with millions of articles available for direct download). Some two million scientific articles are published every year; the journal Madagascar Conservation & Development is but a drop in this growing ocean. Nonetheless, we are proud to publish a twelfth volume; to have several special issues "in the making" and that some articles will

be published at the beginning 2018. You may have noticed a slight change in our publishing frequency: instead of publishing two regular issues a year, we have adopted a proactive formula. Starting in 2017, we publish the articles as they are processed and we include the so-called regular articles into an annual volume.

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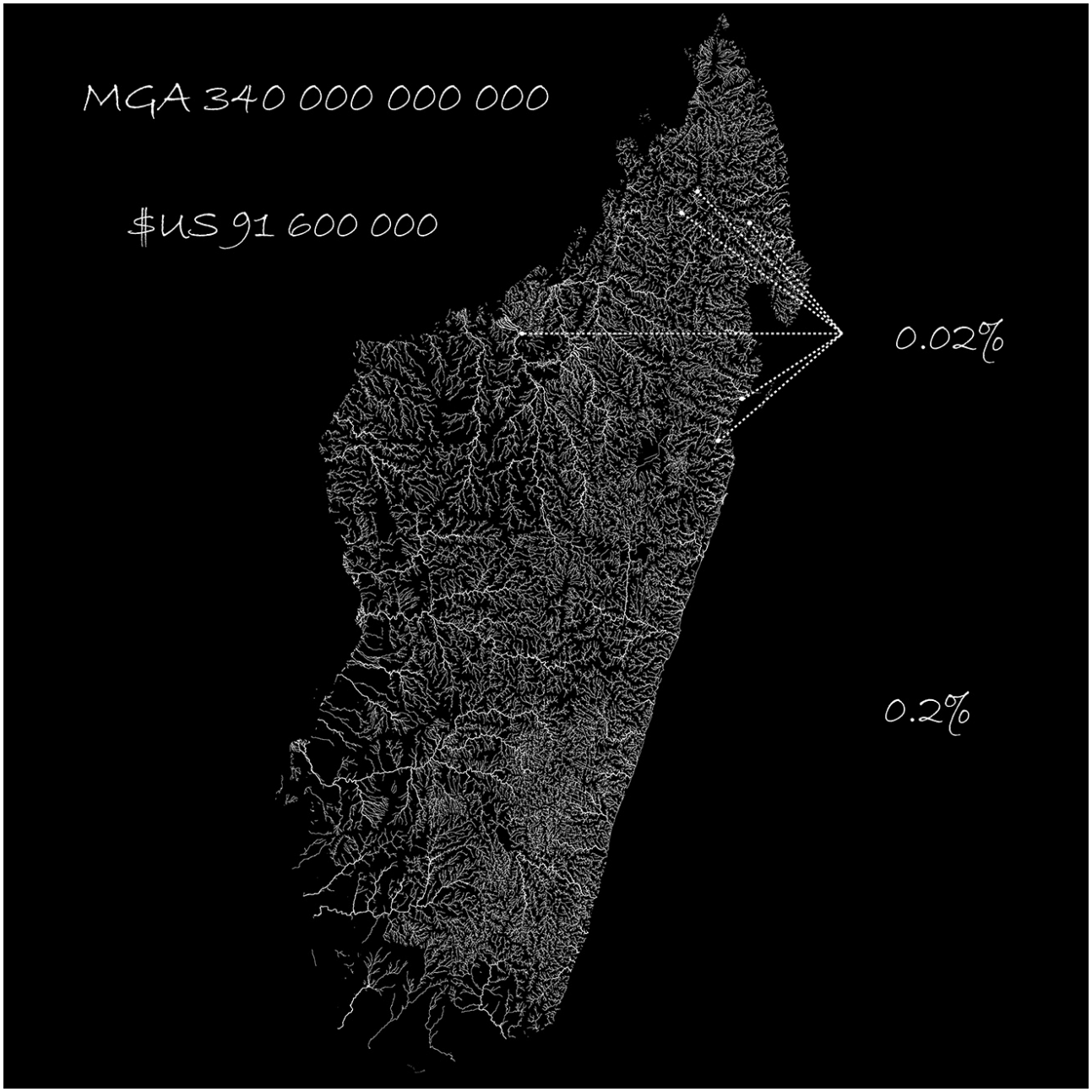

A question of scale: large funding, increased debt, few beneficiaries, small geographic area.

ARTICLE

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Effets de la production de charbon de bois sur les fourrés xérophiles, cas du plateau de Belomotse, Madagascar

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ABSTRACT

Woody charcoal production is the main cause of dry forest degradation in the southwestern Madagascar. This paper analyses the effects of this practice on the diversity, represented by species richness, structure, species composition and regeneration of the xerophytic thickets on the Belomotse Plateau, Toliara II District. Eleven 400 m^2 plots were randomly sampled in woody charcoal production sites and 10 in control sites. Woody charcoal production has reduced xerophytic thickets mean height, density and mean diameter at breast height. It has also affected species composition while it has not affected xerophytic thicket diversity or its regeneration. However, its regeneration rate is low on both woody charcoal production and control sites. Decline of pollinator insect communities or exogenous causes such as increasing climate aridification or escalation of rainfall variability may explain this low regeneration rate. Woody charcoal production in semi arid region is an unsustainable activity.

RÉSUMÉ

La production de charbon de bois est l'une des causes de la dégradation des forêts sèches du Sud-Ouest malgache. Cet article analyse les effets de cette pratique sur (i) la diversité biologique représentée par la richesse spécifique, (ii) la structure et (iii) la composition floristique des fourrés xérophiles du plateau de Belomotse, Toliara II. Onze placeaux de 400 m^2 ont été sélectionnés de manière aléatoire dans des sites de production de charbon de bois et 10 dans des sites témoins. La production de charbon de bois affecte la composition floristique des fourrés xérophiles. De plus, elle réduit leur hauteur, densité et diamètre moyen à hauteur de poitrine (dhp). En revanche, elle n'affecte pas la richesse spécifique ni la régénération naturelle. Les taux de régénération sont cependant faibles, indiquant un mauvais recrutement au sein des peuplements végétaux qui occupent les fourrés xérophiles. Le dépérissement des insectes pollinisateurs, ou des causes exogènes telles que l'aridification croissante et/ou l'accentuation de la variabilité interannuelle des précipitations peuvent expliquer cette mauvaise régénération. La production de charbon de bois en zone semi-aride n'est pas une activité durable.

INTRODUCTION

Le charbon de bois est une source d'énergie utilisée essentiellement pour la cuisson en Afrique et pour des usages industriels en Amérique latine (Chidumayo et Gumbo 2013). Son caractère accessible et le coût prohibitif des autres sources d'énergie (ex. gaz, électricité) contribuent au maintien de son usage dans les pays pauvres. Les études sur le charbon de bois se focalisent essentiellement sur l'aspect socio-économique de sa production (Zulu 2010, Minten et al. 2013, Sander et al. 2013). L'analyse des effets de cette activité sur le fonctionnement des écosystèmes forestiers est rare (Chidumayo et Gumbo 2013). Cette activité réduit la densité forestière et la biomasse (Kouami et al. 2009, Chidumayo et Gumbo 2013).

Une grande partie des forêts sèches malgaches a été détruite et peu de grands blocs subsistent (Seddon et al. 2000, Blanc-Pamard et al. 2005). L'agriculture itinérante sur brûlis et la fabrication de charbon de bois sont les principales causes de cette déforestation et/ou dégradation des forêts (Casse et al. 2004, Blanc-Pamard et al. 2005). La production de charbon de bois touche particulièrement les fourrés xérophiles qui occupent la partie côtière du Sud-Ouest malgache (Raoliarivelo et al. 2010), la zone la plus aride de Madagascar. En effet, ces fourrés xérophiles fournissent la quasi totalité des bois exploités pour la production

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de charbon de bois consommé dans la ville de Toliara. La demande de cette ville en charbon de bois augmente avec sa population (Gardner et al. 2015) et accentue davantage encore les pressions exercées sur les fourrés xérophiles des alentours dans un rayon de 40 km (Masezamana et al. 2013, Rabeniala et al. 2013). Ces fourrés xérophiles sont des formations arbustives caractérisées par la dominance de *Didieraceae* et *Euphobiaceae* et présentent un taux d'endémisme floristique élevé (Koechlin et al. 1997).

Les interactions entre la production de charbon de bois et le pâturage caprin, d'une part, et les fourrés xérophiles du Sud-Ouest malgache, d'autre part, ont déjà été analysées (Rabeniala et al. 2009, Raoliarivelo et al. 2010, Randriamalala et al. 2016). Il a notamment été montré que la combinaison de ces pratiques (charbon et pâturage caprin) réduit la biomasse ligneuse et modifie la composition floristique des fourrés xérophiles sur sable roux (Randriamalala et al. 2016). En revanche, le pâturage caprin seul n'affecte ni la diversité ni la structure des fourrés sur dalle calcaire même si cette formation végétale se régénère mal (Randriamalala et al. 2016) et a une faible productivité en biomasse (Randriamalala et al. 2015). On en sait donc peu sur les effets de la production de charbon de bois sur les fourrés xérophiles sur dalle calcaire, le type de sols prédominants dans les plateaux Mahafaly et de Belomotse du Sud-Ouest malgache.

Ce papier analyse les effets de la fabrication de charbon de bois sur la diversité, la structure et la régénération naturelle des fourrés xérophiles sur dalle calcaire du Sud-Ouest malgache.

MATÉRIELS ET MÉTHODES

SITE D'ÉTUDE. Le site d'étude est localisé sur le plateau de Belomotse (communes d'Andranohinaly, d'Ambohimaha-velona, de Mihary et de Behompy, District de Toliara II, Figure 1). Le climat est semi-aride avec des précipitations annuelles moyennes de 418 mm pour la station de Toliara (Rabeniala et al. 2009). La végétation naturelle est formée par des fourrés xérophiles à Didieraceae et à *Euphorbia* spp. (Radosy 2013). Les deux principaux types de sol sont des dalles calcaires et des sables roux (Rabeniala et al. 2013). Les principales activités des populations locales sont l'agriculture qui se concentre dans les plaines alluviales des fleuves Fiherenana au nord et Onilahy au sud (Figure 1), l'élevage de petits ruminants et la fabrication de charbon de bois qui supplée à l'insuffisance des revenus agricoles et d'élevage (Masezamana et al. 2013). L'agriculture sur brûlis est également pratiquée dans les fourrés xérophiles sur le plateau (Rabeniala et al. 2013).

ACTIVITÉ DE PRODUCTION DE CHARBON DE BOIS SUR LE PLATEAU DE BELOMOTSE. Les sites de production de charbon de bois se concentrent autour de villages tels qu'Ankiliberengy, Ampamata, Ankazomena et Ambohimahavelona et autour de campements permanents tels que celui de Betsinefo (Figure 1). Ces campements sont occupés par des gens marginaux qui ont fait de la prison à Toliara ou qui ne possèdent pas de terrain dans les plaines fertiles alluviales depuis environ huit ans (Rabeniala et al. 2013). Les activités principales des occupants de tels campements sont la production de charbon de bois et la collecte de bois de feu. Les techniques de production de charbon de bois y sont les mêmes que celles décrites par Randriamalala et al. (2016). La différence réside dans le fait que les fours à charbon sur le plateau de Belomotse sont essentiellement creusés dans des sols calcaires rocailleux (dalle calcaire) contrairement à ce qui

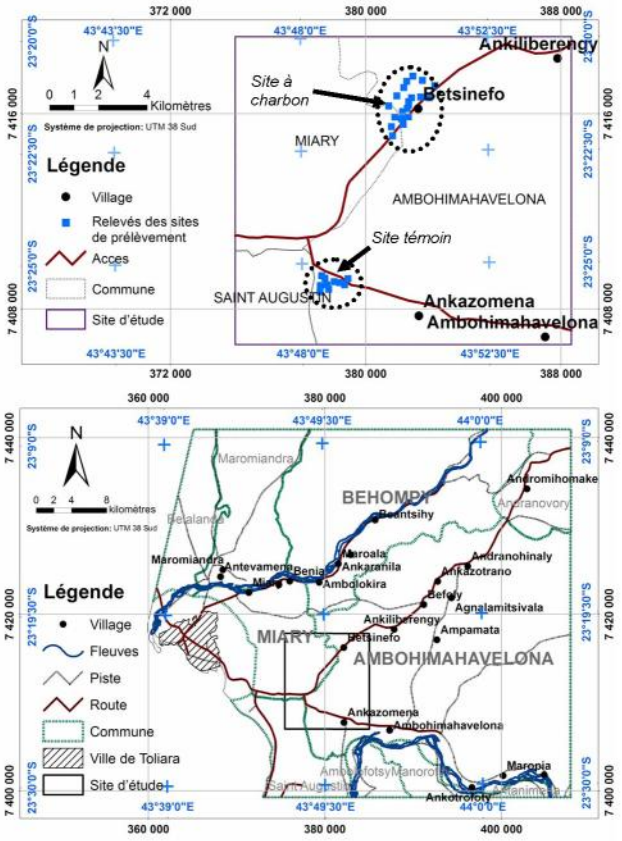

Figure 1. Localisation des sites d'étude.

se passe à Soalara Sud, où les fours à charbon sont exclusivement installés sur sable roux (Randriamalala et al. 2016). Les roches calcaires de taille inférieure (<20–30 cm) sont mises de côté et le four à charbon est creusé dans les sols meubles sous-jacents et entre les dalles calcaires. Les sols à sables roux sont généralement exploités pour l'agriculture (Rabeniala et al. 2013, Randriarimalala 2016).

La quasi-totalité de la production de charbon de bois est vendue à des intermédiaires qui les transportent par camion vers la ville de Toliara (Masezamana et al. 2013) même si une faible proportion est transportée par bicyclette vers la même ville par les producteurs eux même (Obs. pers.).

RELEVÉS FLORISTIQUES. Onze placeaux de 400 m^2 ont été sélectionnés aléatoirement dans les sites de production proches du campement permanent de Betsinefo, appelés sites à charbon de bois et 10 l'ont été dans des sites, plus au sud, à plus de 3 km à vol d'oiseau de tout village et/ou campement permanent (Figure 1). Ces derniers se trouvent dans des sites moins perturbés, qualifiés de témoins. En effet, les principaux villages le long de la Route Nationale 7 se trouvent au nord, du village d'Ankiliberengy et du campement de Betsinefo (Befoly, Ankazotrano, Andranohinaly, et Andranovory, Figure 1). Les autres villages importants se trouvent au sud-est (vers la route d'Ambohimahavelona, Figure 1). Les sites actuels de production de charbon de bois se trouvent essentiellement entre les villages d'Ambohimahavelona et d'Ankiliberengy (au nord-est des sites témoins, Rabeniala et al. 2013). Par conséquent, les sites les moins perturbés se trouvent plus au sud (Figure 1). Peu de fours à charbon abandonnés ont été observés dans ces sites témoins contrairement aux sites proches de Betsinefo où la densité de tels fours

est plus importante. Tous les placeaux sélectionnés se trouvent sur dalle calcaire, le type de sol prédominant.

Les sites à charbon de bois et les sites témoins ne sont pas pâturés par des caprins, ni par des zébus. Le site d'étude est un campement permanent et ses occupants sont des gens marginaux qui exploitent les fourrés xérophiles pour le bois (bois de feu, gaulette et surtout charbon de bois) et accessoirement pour l'agriculture (*hatsake*). Les éleveurs les plus proches se trouvent dans le village d'Ankiliberengy, à plus de 5 km à vol d'oiseau. Or il a été montré dans des cas similaires (à Soalara-Sud) que les pâturages caprins s'étendaient rarement à plus de 4 km autour des enclos (Rabeniala et al. 2009, Randriamalala 2014, Randriamalala et al. 2016).

Les arbres et arbustes de plus de 1,3 m de hauteur appartenant à la strate supérieure ont été inventoriés dans la surface de 400 m² partagée en quatre placettes de 100 m². Ensuite, une des placettes de 100 m² a été choisie au hasard pour l'étude de la régénération consistant à inventorier tous les individus de moins de 1,3 m, qui appartiennent à la strate inférieure. Les paramètres de relevé dans le placeau ont permis de calculer les indices de diversité et de structure suivants : la richesse spécifique de la strate supérieure, qui est le nombre d'espèces dans le placeau de 400 m², la densité d'arbustes dans la strate supérieure, le dhp moyen des individus appartenant à la strate supérieure (le diamètre de la plus grosse tige a été mesuré si l'arbuste considéré présente des ramifications à moins de 1,3 m du sol), la hauteur maximale de la strate supérieure, la richesse spécifique de la strate inférieure qui est le nombre d'espèces dans la placette de 100 m² et la densité d'arbustes dans la strate inférieure. Les taux de régénération (TR) des espèces arbustives ont également été calculés comme suit : $TR_{ij}=n_{ij}/N_{ij}$, avec TR_{ij} taux de régénération de l'espèce i dans le placeau j de 400 m², n_{ij}, nombre d'individus appartenant à la strate inférieure (<1,3 m de haut) et à l'espèce i dans le carré de 100 m² du placeau j, N_{ij}, nombre d'individus de l'espèce i appartenant à la strate supérieure (≥1,3 m de haut) dans le même carré de 100 m². La moyenne des taux de régénération par traitement a également été calculée : $TR=\sum(a_i/A) \times TR_{i\ (i=1\ à\ N)}$, avec a_i, répétition de l'espèce i dans le traitement considéré, A, nombre d'espèces dans le même traitement, TR_i, taux de régénération moyen de l'espèce i dans le même traitement.

ANALYSE DES DONNÉES. Des analyses factorielles des correspondances (AFC, Xlstat 6.03, Addinsoft 1995–2008) ont été appliquées aux données portant sur les espèces des placeaux de 400 m² pour analyser les effets de la production de charbon de bois sur la composition floristique de la strate supérieure des fourrés xérophiles. Des tests de comparaisons de moyennes (Xlstat 6.03) ont également été appliqués sur les variables de diversité et de structure pour analyser leurs variations par rapport aux perturbations liées au charbon de bois.

Des tests en deux parties (two-part tests, TPT, Lachenbruch 2001) ont été effectués pour analyser les variations du taux de régénération par rapport aux perturbations liées au charbon de bois. En effet, la moyenne n'est pas une synthèse satisfaisante des données relatives au taux de régénération puisqu'elles présentent beaucoup de zéros (45–59 %). Le TPT est une combinaison de tests qui prend en compte le fait que la somme de deux statistiques suivant une distribution χ^2 suit une distribution χ^2 avec un degré de liberté (ddl) égale à la somme des ddl des deux statistiques considérées (Delucchi et Bostrom 2004). L'hypothèse nulle est l'égalité des proportions de zéros dans les k échantillons (k≥2) et celle des moyennes des parties non nulles des k échantillons. Pour nos données, un test de fréquences pour deux échantillons (TPZ, Xlstat 6.03) avec un ddl a été utilisé pour comparer les proportions de zéros et un test de Kolmogorov-Smirnov (KS, Xlstat 6.03) a été utilisé pour comparer les moyennes des valeurs non nulles (Lachenbruch 2001, Delucchi et Bostrom 2004). La statistique du TPT est donnée par la relation : $TPS=Z^2+W^2$, Z est la statistique du TPZ et W celle de KS et TPS suit une loi du χ^2 avec deux ddl.

RÉSULTATS

COMPOSITION FLORISTIQUE. Le premier axe de l'AFC (18,69 % de l'inertie totale, Figure 2) ne correspond à aucun gradient particulier. Le second axe (14,84 %) sépare les placeaux des sites à charbon de bois des sites témoins (Figure 2). La végétation des sites témoins est caractérisée par *Chadsia grevei* (6 % de la valeur propre du second axe factoriel), *Commiphora lamii* (5,6 %), *Euphorbia leucodendron* (4 %), *Ruellia albopurpurea* (3,5 %), *Tetrapterocarpon geayi* (3,4 %), *Bauhinia grandidieri* (1 %), *Commiphora* sp. (3 %), *Operculicarya* sp. (2,8 %), *Dicraeopetalum mahafaliense* (0,9 %). Des arbustes à bois dur tels que *C. lamii*, *R. albopurpurea*, *B. grandidier* et *D. mahafaliense* caractérisent le site témoin. La végétation des sites à charbon de bois est caractérisée par *Grewia tulearensis* (9,3 %), *Cassia meridionalis* (4,6 %), *Mimosa delicatula* (3,7 %), *Ruellia* sp. (3,7 %), *Vaughania interrupta* (3,3 %), *Dichrostachys alluaudiana* (2,6 %), *Commiphora marchandii* (2,1 %), *Pristimera bojeri* (1,8 %), *Euphorbia dutso* (1,7 %), *Paederia grandidieri* (1,4 %), *Cynanchum* sp. (1,2 %), *Grewia calvata* (1,2 %), *Ormocarpum bernierianum* (1,1 %) et *Croton geayi* (1,1 %). Le site à charbon est essentiellement caractérisé par des lianes (*P. grandidieri* et *Cynanchum* sp.) ainsi que par des arbustes de

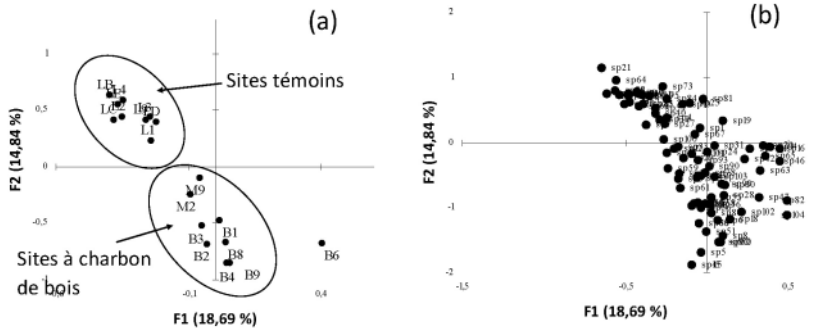

Figure 2. Projections des placeaux (a) et des espèces des strates supérieures (≥1,3 m ; b) dans le premier plan factoriel de l'AFC.

petite taille (<2 m de haut, *O. bernierianum* et *C. geayi*) et par des arbustes à bois relativement tendre (*G. tulearensis*, *C. meridionali et C. marchandii*). Des espèces à bois dur telles que *Diospyros manampetsae* H. Perrier, *Neobeguea mahafalensis* Leroy, *Securinega perrieri* Leandri et *Cedrelopsis grevei* Baillon sont communes aux deux sites. La production de charbon de bois affecte la composition floristique des fourrés xérophiles.

DIVERSITÉ, STRUCTURE. Les richesses spécifiques moyennes associées à la strate supérieure des fourrés xérophiles ne varient pas significativement avec les sites considérés (t=0,497, p>0,05, Tableau 1). En revanche, les moyennes des hauteurs maximales, des diamètres moyens et celles des densités varient significativement (p<0,05, Tableau 1). La production de charbon de bois n'affecte pas la richesse spécifique des fourrés xérophiles mais affecte leurs structures : cette activité engendre une baisse significative de la hauteur, du diamètre et de la densité. En ce qui concerne la strate inférieure, une variation significative de la richesse spécifique moyenne a été constatée par rapport aux sites à charbon de bois (t=3,484, p<0,01, Tableau 1). En moyenne, la strate inférieure des fourrés xérophiles dans les sites à charbon de bois présente une richesse spécifique plus importante que celles des fourrés xérophiles dans les sites témoins. En revanche, les moyennes des densités d'arbustes n'ont pas varié de façon significative avec les sites (t=0,520, p>0,05, Tableau 1). Les taux de régénérations moyens ne varient pas significativement avec les sites considérés (χ^2=2,214, p>0,05, Tableau 1). Les activités de fabrication de charbon de bois n'affectent pas la régénération naturelle des fourrés xérophiles. En revanche, cette régénération est mauvaise car la moitié des espèces arbustives recensées ont des taux de régénération de moins de 10 % (Tableau 1).

DISCUSSION

LA PRODUCTION DE CHARBON DE BOIS AFFECTE LA COMPOSITION FLORISTIQUE DES FOURRÉS XÉROPHILES. L'AFC effectué sur les individus de la strate supérieure a permis de séparer la composition floristique des sites de production de celle des sites témoins. Ces résultats confirment ceux de Randriamalala et al. (2016) qui ont montré que la production de charbon de bois affectait la composition floristique de fourrés xérophiles sur sable roux à Soalara-Sud, à une cinquantaine de kilomètres au sud du site d'étude. Ces résultats sont également en accord avec ceux de Colón et Lugo (2006), dans une zone semi-aride du Costa Rica avec des précipitations moyennes annuelles de 860 mm. Ces chercheurs ont montré, en comparant des indices de similarité, que la différence entre la composition floristique d'anciens sites de production de charbon de bois et celle de forêts matures adjacentes persiste plusieurs années après l'abandon de cette activité. La production de charbon de bois marque les fourrés xérophiles par le prélèvement des espèces à bois dure et épargne les espèces à bois tendre (Raoliarivelo et al. 2010, Ramaroson 2014).

Tableau 1. Variations des paramètres de diversité et de structure. n : Répétitions ; S : Richesse spécifique de la strate supérieure (.400 m^{-2}) ; Hm : Hauteur moyenne (m) ; DHPm : Diamètre moyen à 1,3 m (cm) ; D : Densité d'arbustes de la strate supérieure (.400 m^{-2}) ; S' : Richesse spécifique de la strate inférieure (.100 m^{-2}) ; D' : Densité d'arbustes de la strate inférieure (.100 m^{-2}) ; TR : Taux de régénération moyen par traitement (%), nombres entre parenthèses représentent respectivement : premier quartile ; médiane ; troisième quartile, en % ; p : Degré de signification des tests de comparaison de moyennes.

Sites	Sites à charbon de bois	Sites témoins	p
n	11	10	
S	34.73	36.1	>0,05
Hm	1.89	2.23	<0,01
DHPm	1.36	2.18	<0,01
D	207.18	269.1	<0,05
S'	12.82	8.1	<0,01
D'	43.91	39.5	>0,05
TR	59 (0 ; 9 ; 55)	63 (0 ; 0 ; 48)	>0,05

LA PRODUCTION DE CHARBON DE BOIS N'AFFECTE PAS LA DIVERSITÉ DES FOURRÉS XÉROPHILES. La diversité qui est représentée par la richesse spécifique n'est pas affectée par la production de charbon de bois. En effet, la variation, au cours du temps, de la richesse spécifique d'une formation végétale est le produit de (i) l'arrivée de nouvelles espèces par la germination de graines de (ii) la mortalité d'individus appartenant aux espèces résidente. La combinaison (i) de la variation de la composition floristique et (ii) de l'absence d'une différence significative entre les richesses spécifiques moyennes par rapport à la production de charbon de bois semble montrer que cette activité favorise la mortalité d'espèces à bois dure et l'émergence de nouvelles espèces que cette même activité épargne. Ces dernières peuvent être des arbustes de petite taille tels que *O. bernierianum* et *C. geayi*. A termes, la production de charbon de bois risque de mener à une extinction localisée (dans les sites de production) des espèces à bois dure. De plus, la variation de la composition floristique et la constance de variables telles que la richesse spécifique et la productivité sont souvent observées quand un écosystème subit des perturbations (Briske et al. 2003). Il a même été supposé que cette fluctuation d'espèces (bilan quasi-nul entre perte et gain) est un mécanisme de compensation qui contribue à la stabilité de l'écosystème (homéostasie, Ernest et Brown 2001).

Nos résultats sont en accord avec ceux de Randriamalala et al. (2016) qui ont montré que la production de charbon de bois et le pâturage caprin n'affectent pas la richesse spécifique des fourrés xérophiles sur sable roux à Soalara-Sud. Ces résultats sont par contre en désaccord avec ceux de Kouami et al. (2009) au Togo (P=800-1500 mm an^{-1}) qui ont montré que la production de charbon de bois occasionne généralement une baisse significative du nombre d'espèces ligneuses. Par contre, Colon et Lugo (2006) ont montré qu'au Costa-Rica (P=860 mm an^{-1}), les recrus se développant sur d'anciens sites de production de charbon de bois sont plus riches en espèces ligneuses que les forêts matures et les recrus post-agricoles adjacents. La régénération des sites de production de charbon de bois est donc possible. L'interaction richesse spécifique de la végétation-production de charbon de bois ne semble pas obéir à des schémas uniformes. Les pratiques de la production de charbon de bois, c'est à dire le caractère sélectif ou non (Chudimayo et Gumbo 2013) et l'intensité des prélèvements de bois peuvent expliquer ces différences. Ces pratiques peuvent perturber à des degrés différents les potentiels de régénération des forêts concernées (souches en place, germination de graines provenant de la banque et/ou de la pluie de graines) qui s'expriment différemment.

LA PRODUCTION DE CHARBON DE BOIS AFFECTE LA STRUCTURE DES FOURRÉS. La production de charbon de bois réduit la hauteur maximale, la densité des arbustes et le dhp des fourrés xérophiles. Ces résultats confirment ceux de Randriamalala et al. (2016) qui ont montré que le pâturage caprin et la production de charbon de bois réduisent les hauteurs moyennes, la densité d'arbustes et la biomasse aérienne des fourrés xérophiles sur sable roux à Soalara-Sud. De même, Kouami et al. (2009) au Togo ont trouvé que les végétations des sites exploités

pour le charbon de bois présentent généralement des hauteurs moyennes, des densités et des dhp plus faibles que celles des sites intacts.

La baisse de la densité et du dhp semble indiquer que la productivité en biomasse ligneuse des fourrés xérophiles serait inférieure au prélèvement de bois occasionné par la production de charbon de bois. En effet, la biomasse aérienne des formations arbustives est en général, positivement corrélée avec le dhp (Navar et al. 2004, Ali et al. 2015). Cette activité n'est donc pas durable et peut aboutir à termes à une extinction localisée des espèces à bois dure, propices à la fabrication de charbon de bois (Ramaroson 2014). En effet, la lenteur de la croissance des espèces arbustives des fourrés xérophiles est telle qu'il faut une rotation de plus de 55 ans pour produire la biomasse actuelle (Randriamalala et al. 2015).

UNE MAUVAISE RÉGÉNÉRATION DES FOURRÉS XÉROPHILES.

La production de charbon de bois favorise la diversité de la végétation de la strate inférieure, mais n'affecte pas de façon significative leurs densités, même si celle des sites à charbon semble être plus importante. Ces résultats vont en partie à l'encontre de ceux de Randriamalala et al. (2016) qui ont trouvé que la production de charbon de bois et le pâturage caprin n'affectaient pas la richesse spécifique de la strate inférieure des fourrés xérophiles sur sable roux à Soalara-Sud. La production de charbon de bois contribue à créer des trouées qui sont des moteurs de dynamiques forestières en zones humides mais dont l'importance pour la régénération des forêts sèches reste à démontrer (Quesada et al. 2009). Quoiqu'il en soit, il a été constaté que la régénération des forêts sèches ayant été exploité pour le charbon de bois est possible (Colón et Lugo 2006) et la diversité de la strate inférieure des végétations des sites exploités est cohérente avec cette théorie.

Les fourrés xérophiles se régénèrent cependant mal. Les taux de régénération des espèces qui s'y trouvent dépassent rarement les 100 %; c'est-à-dire que l'abondance des individus de régénération d'une espèce donnée est rarement plus importante que celle des individus matures semenciers appartenant à la même espèce. Le peuplement végétal dans les fourrés xérophiles est vieillissant : il n'y a pas suffisamment d'individus de régénération pour remplacer ceux qui sont matures quand ces derniers meurent. Cette mauvaise régénération a également été observée dans les fourrés xérophiles du plateau Mahafaly à une cinquantaine de kilomètres au sud du site d'étude (taux moyen de régénération de 44–235 %, Randriamalala et al., 2016). Cette mauvaise régénération n'est pas imputable à la production de charbon de bois puisqu'elle s'observe même dans les sites plus intacts et peut être due à une aridification du climat. En effet, le Sud-Ouest malgache a subi une aridification importante à la fin de l'Holocène, ce qui a causé l'extinction de nombreuses espèces animales et une modification importante de la végétation (Goodman et Jungers 2011). Il est possible que cette aridification du climat se poursuive et cause une diminution de la densité des arbustes comme cela a été le cas à Ferlo, au Sénégal (Vincke et al. 2010). De plus, une sécheresse prolongée affecte en premier lieu les individus de régénération, qui périssent (Suresh et al. 2010). Des observations répétées (diversité, structure et régénération) sur au moins deux années différentes doivent être menées pour mettre en évidence les effets de la variabilité interannuelle des précipitations (Randriamalala et al. 2016). En parallèle une analyse de la tendance à long terme (40-50 ans) des précipitations et de leur variabilité interannuelle doit être faite pour démontrer une éventuelle aridification du climat (Randriamalala et al. 2016).

L'inhibition de la reproduction végétale par l'extinction progressive et/ou la baisse de la densité des insectes pollinisateurs peut également être avancée pour expliquer cette mauvaise régénération des fourrés xérophiles. En effet, le site d'étude est une zone de densation des criquets migrateurs (Duranton et al. 2009). De ce fait, une quantité importante d'insecticides y a été déversée au cours des dernières années. Ces insecticides ont également pu tuer les insectes pollinisateurs (Devine et Furlong 2007), d'où une baisse de pollinisation des plantes entomophiles et une production réduite et une faible régénération par germination de graines. Des comparaisons entre (i) les régénérations naturelles et (ii) la diversité et la densité des communautés d'insectes de sites infectés par les insecticides (le site d'étude) et de sites témoins peuvent être faites pour tester cette thèse. Le site témoin pourrait être un site du parc national de Tsimanampesotse, à environ 100 km au sud du site d'étude. En effet, il est interdit d'épandre des insecticides dans les aires protégées.

CONCLUSION

La production de charbon de bois affecte négativement les fourrés xérophiles et n'est, par conséquent, pas une pratique durable. Cette dernière réduit leur densité, biomasse ligneuse (dhp) et leur hauteur maximale et affecte la composition floristique. Une disparition localisée, dans les sites de production de charbon de bois, des espèces à bois dur propice à la fabrication de charbon de bois peut survenir dans un futur proche (<20 ans, Ramaroson 2014). De plus, les fourrés xérophiles se régénèrent mal, même si cela n'est pas imputable au charbon de bois. L'aridification du climat et l'usage d'insecticide peuvent être à l'origine de cette mauvaise régénération. Des observations pluriannuelles, l'analyse de la distribution des précipitations au cours des 40–50 dernières années et la comparaison des potentiels de régénération des fourrés xérophiles dans des sites contaminés par des insecticides et dans des site témoins doivent être menées pour identifier les origines de la mauvaise régénération de cette formation végétale exceptionnelle.

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Understanding the role of organizational legitimacy within the realm of the community-based conservation approach

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ABSTRACT

Many organizations throughout the world utilize community based conservation (CBC) strategies to incorporate rural communities into conservation efforts. One key component to the success of these strategies is to gain trust within the communities which reside in the vicinity of the targeted areas for conservation. The research reported here introduces the concept of organizational legitimacy into the realm of CBC strategy by proposing how dimensions of legitimacy (pragmatic, moral, and cognitive) are related to community trust and attitudes. Employing institutional theory, this paper proposes that (i) pragmatic and moral legitimacy produce trust, (ii) trust positively influences cognitive legitimacy, and (iii) cognitive legitimacy influences attitudes. The Missouri Botanical Garden's (MBG) CBC efforts in Madagascar's Ambalabe and Mahabo communities served to empirically examine these propositions. The survey yielded 101 usable responses from community members in Mahabo and Ambalabe. A structural model was estimated to test the propositions and the results provided support for the premise that organizational legitimacy is needed to gain trust and influence favorable attitudes toward the organization. Since CBC strategies rely on trust between organizations and communities, the findings of this research provide implications for organizations seeking to implement CBC strategies. The findings do so by implying that in order to build trust with communities, organizations should first establish legitimacy, which not only helps build trust, but also indirectly affects attitudes toward the organization and its activities.

RÉSUMÉ

De nombreuses organisations à travers le monde utilisent les stratégies de la conservation communautaire pour intégrer les communautés rurales dans les efforts de conservation. Un élément clé du succès de ces stratégies est de gagner la confiance des communautés qui résident dans les zones ciblées. La présente recherche introduit le concept de légitimité organisationnelle dans le domaine de la stratégie de conservation communautaire en indiquant comment les dimensions de la légitimité (pragmatique, morale et cognitive) influencent la confiance et les attitudes de la communauté. Utilisant la théorie institutionnelle, ce document propose que (i) la légitimité pragmatique et morale entraîne la confiance, (ii) la confiance influence positivement la légitimité cognitive, et (iii) la légitimité cognitive prédit les attitudes. Afin d'examiner empiriquement ces propositions, les efforts déployés par le Missouri Botanical Garden dans les communes d'Ambalabe et de Mahabo à Madagascar ont été utilisés pour collecter les données. Cette technique d'échantillonnage a donné 101 réponses utilisables venant des membres des communautés des deux communes. Un modèle structurel a été estimé pour tester les propositions et les résultats obtenus et soutient l'hypothèse selon laquelle la légitimité organisationnelle est nécessaire pour gagner la confiance et susciter des attitudes favorables à l'égard de l'organisation. Puisque les stratégies de conservation communautaire s'appuient sur une relation basée sur la confiance entre les organisations et les communautés, les résultats de cette recherche montrent que si des organisations cherchent à mettre en œuvre des stratégies de conservation communautaire, elles doivent d'abord établir leur légitimité afin de gagner la confiance des communautés respectives.

INTRODUCTION

For the past several decades, conservation research has highlighted the importance of community based conservation (CBC) (Parker 1983, Owen-Smith 1993, Western and Wright 1994, Hackel 1999, Berkes 2004, Fritz-Vietta et al. 2009, Brooks et al. 2013). CBC is a strategy utilized by organizations around the world to conserve environments by actively working with local people in the targeted areas of conservation (Hackel 1999, Waylen et al. 2010). This approach allows the organization to not only incorporate the interests of the local people, but also engage the people into an integrated conservation strategy. In other words, the main idea

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behind CBC is that both conservation and development can be simultaneously attained, which serves the interests of both the community and the organization (Berkes 2004). For example, in 2003, Blue Ventures, a U.K.-based conservation organization, had interests in conserving marine life in southwestern Madagascar, a region where coral reefs were deteriorating due to factors such as the exacerbated commercialisation of traditional fisheries by exporters and climate change (Harris 2007, 2011). To satisfy this interest, Blue Ventures has worked with local fishermen in establishing a 'no take zone', where fishing restrictions were put in place to improve the sustainability of reef octopus (Harris 2007). In this case, Blue Venture's sustainable community-based system not only satisfied the interests of local people in terms of higher fishing profits and sustainable fishing practices, but also involved fishermen into an integrated marine life conservation strategy. CBC strategies thus rely on the integration of local communities into conservation strategies in order to satisfy the interests of both the organization and the local communities.

This method has been utilized in numerous conservation projects, and conservation research has discussed the positive effects of gaining trust through the CBC method (e.g., Mehta and Heinen 2001, Goldman 2003, Waylen et al. 2010). However, this extant research has relatively ignored the question of how to gain this trust. Researchers have depicted the attitudinal and behavioural effects of the CBC method (e.g., Mehta and Heinen 2001, Waylen et al. 2010), however, the question of what predicts the success of CBC efforts remains unanswered. In this current paper, we aim for a better understanding of the requirements of CBC success by proposing the role which organizational legitimacy plays in this dynamic. Since CBC is driven by the interest of local people as well as an organization's conservation targets (Campbell and Vainio-Mattila 2003), we envision CBC success to be the strategy's effectiveness in achieving such objectives. We thus define CBC success to be the fulfilment of community interests as well as the attainment of the organization's conservation goals through a collaborative relationship between the organization and the community. Here we seek to better understand the role of organizational legitimacy in contributing to CBC success by investigating its role for the organization in gaining trust and favourable attitudes from local people.

Furthermore, in spite of the rise in CBC implementation around the world, relatively little research has been conducted to investigate the cognitive network of constructs relevant to CBC strategies from the perspective of local community members. To address this concern, researchers like Waylen et al. (2010) have taken a perspective focused on local cultural contexts to examine how local attitudinal and behavioural dispositions indicate the outcomes of CBC efforts. In an effort to build on this previous research, we introduce the concept of organizational legitimacy into the realm of CBC strategies and its attitudinal outcomes within local cultural contexts. Organizational legitimacy has to be considered within the local cultural context, as local institutions provide the norms of what is socially acceptable and what is not acceptable to the community. Within this current paper, we utilize the term *institution* to refer to the "regulative, normative, and cognitive structures and activities that provide stability and meaning to social behaviour" (Scott 1995: 33). Institutions are the informal norms as well as the formal laws which provide structure to an environment (Peng et al. 2009). They are the formal and informal constraints that shape human interaction (Berkes 2004). Similarly, we utilize the term *community* to describe a group of people who are socially interdependent, share practices, and exist in an environment in which people interact in a cohesive manner (Bellah et al. 1985, Rovai 2002). We use the term *organization* to refer to a formal entity within an environment that has a specific purpose. This definition of organization is derived from the perspective of strategic management research (e.g. Mintzberg 1987). Finally, we use the term *institutional environment* to refer to the environment in which community members and organizations coexist and are governed by institutions (Scott 1995). For an organization to achieve its purpose, it must first gain legitimacy, or acceptance, within its institutional environment (Kostova and Zaheer 1999).

Since legitimacy is defined as the social acceptance of an organization within its local institutional environment (DiMaggio and Powell 1983, Suchman 1995), we envision this construct to play a pivotal role in the conceptual and strategic understanding of how organizations gain trust through CBC strategies and influence attitudes. Thus, we propose and empirically examine a conceptual framework that incorporates 'legitimacy', 'trust', and 'attitudes'.

Utilizing the context of Missouri Botanical Garden's (MBG) CBC efforts in Madagascar, we examine how levels of organizational legitimacy influence trust for the MBG (the organization) within the rural communities of Ambalabe and Mahabo in Madagascar, two of the twelve MBG conservation sites where CBC has been implemented. The impact of this study touches on the strategic implication of how organizations can gain trust within communities they are interested in collaborating with. Since trust is an important component in establishing CBC strategies, as mentioned by Berkes (2007), the results of this research are thus relevant to organizations seeking to implement the CBC method. In other words, by gaining an understanding of how organizational legitimacy influences trust and attitudes, organizations will be better prepared to implement legitimacy-seeking strategies when entering new areas of conservation. This study thus has two objectives: (i) to theoretically propose a model that incorporates the relationships between trust, legitimacy, and attitudes; and (ii) to empirically test this model in the context of an organization that has implemented the CBC method. In order to achieve these two objectives, we utilize two sites where MBG has implemented CBC efforts in Madagascar to measure legitimacy, trust, and attitudes; and then test the relationships between these constructs in a structural model. The following sections, first, review the background literature on CBC, organizational legitimacy, attitudes, and trust; and, then, empirically examine a structural model of these relevant constructs.

BACKGROUND AND THEORY

Gaining trust within communities is a fundamental task that organizations seeking to implement conservation activities in rural areas face (Dolch et al. 2015). Within the past decades, many organizations have taken the approach to involve rural community members in sustainable resource planning and management, or CBC, to address this challenge. CBC typically has two main objectives as described by Campbell and Vainio-Mattila (2003): to enhance biodiversity conservation and to provide incentives, which are often economic, to local people. The premise of the CBC method states that in order to effectively carry out conservation-related activities, organizations must build trust with local communities (Berkes 2007). We propose that organizational legitimacy is a crucial component in building trust within local communities.

ORGANIZATIONAL LEGITIMACY. Organizational legitimacy is the social acceptance of an organization by its environment (Suchman 1995). It refers to the social justification of an actor or activity as well as addresses the normative and cognitive forces that construct and empower organizational factors, and it is the acceptance of the organization by the society in which it exists (Suchman 1995, Kostova and Zaheer 1999, Sandström et al. 2014). It thus reflects the cultural support for an organization (Meyer and Scott 1983, Johnson et al. 2006). Organizational legitimacy has been stated to have three dimensions: pragmatic, moral, and cognitive legitimacy (Suchman 1995, Johnson et al. 2006). Pragmatic legitimacy refers to the "self-interested calculations of an organization's most immediate audiences" (Suchman 1995: 578). This form of legitimacy refers to the constituent's actual evaluation of an organization's actions where organizational behaviour is scrutinized to determine the practical consequences of the actions to the constituent (Wood 1991, Garud et al. 2014). Pragmatic legitimacy concerns the immediate, direct, and practical benefits which appeal to the legitimizing actor (Suchman 1995). Unlike pragmatic legitimacy, moral legitimacy is a positive normative evaluation of the organization's activity (Suchman 1995). The issue is not concerned about whether the activity benefits the evaluator, but rather if the activity is the right thing to do. Moral legitimacy, thus, is a reflection of whether the activity promotes social welfare, as defined by the constituent's socially constructed value system in the given institutional context (Suchman 1995). Cognitive legitimacy involves either affirmative backing for an organization or the mere acceptance of the organization as necessary or inevitable. It refers to the constituent's acceptance of the organization as a permanent part of its society (Suchman 1995). These dimensions of legitimacy are important to organizations seeking to achieve their objectives in the given environments because gaining legitimacy from a society leads to decreases in costs associated with operating in a foreign environment, as well as favourable attitudes toward the organization (Campbell et al. 2012, Husted et al. 2016). Pragmatic and moral legitimacy may be gained relatively quickly, however, cognitive legitimacy may only be gained after the legitimacy-granting constituent grants trust to the organization, and thus accepts the organization as part of its society (Suchman 1995).

TRUST. Trust is a construct that has elements of expectation and it exists within environments characterized by uncertainty. It is positive and is situation-specific (Bhattacharya et al. 1998). From this view, we adopt the definition of trust from Bhattacharaya et al. (1998), which states that trust is "an expectancy of positive (or nonnegative) outcomes that one can receive based on the expected action of another party in an interaction characterized by uncertainty" (Bhattacharya et al. 1998: 462). From this definition, we posit that community trust for an organization is thus a community's expectation of positive outcomes that can be received from an organization. Developing trust between an organization and the local community is a necessary condition for the effective implementation of CBC methods (Frey and Berkes 2014). We propose that in order for organizations to gain this trust, they may need to first gain pragmatic and moral legitimacy in the environment. We employ institutional theory (Scott 2008) to propose the predictive nature of legitimacy on trust.

THEORETICAL CONCEPT OF DEVELOPING LEGITIMACY, TRUST, AND POSITIVE ATTITUDES TOWARD THE ORGANIZATION. Institutional theory states that within an organization's environment, there are institutions that govern appropriate behaviour (Scott 2008). Institutions are formal or informal rules and norms that govern the behaviour of individuals and organizations within an environment (Allard and Small 2013). For example, in their study of community-based natural resource management in Madagascar's Manambolomaty Lakes, Rabearivony et al. (2008) emphasize the importance of understanding informal institutional norms that can contribute to the achievement of conservation objectives. In other words, understanding the local institutional environment is crucial to reaching conservation objectives.

In order for an organization to persist and thrive within an institutional environment, it must first be granted legitimacy from members of the environment such as the local people (Meyer and Rowan 1977, DiMaggio and Powell 1983, Osei-Tutu et al. 2014). According to institutional theory, legitimacy is granted within the contexts of the governing institutions (Meyer and Rowan 1977, Osei-Tutu et al. 2014). From this theoretical perspective, we propose that in order for organizations to gain a community's expectation of positive outcomes that can be received from the organization in the institutional environment (trust), constituents within the environment must either recognize the practical benefits the organization provides to the environment (pragmatic legitimacy) or the constituent must recognize the organization as morally good (moral legitimacy). Thus, our first hypothesis H1 is that both pragmatic and moral legitimacy positively influence community trust in the organization.

In this current paper, we do not propose cognitive legitimacy to constitute trust, but instead propose that trust predicts cognitive legitimacy. Specifically, we propose that once organizations meet a community's expectation of positive outcomes, i.e., are trusted, the community can begin to view the organization as a long-term or permanent part of their environment. Before a community can accept the organization as a permanent part of their environment, they must first develop trust for the organization. Thus, our second hypothesis H2 is that trust positively influences cognitive legitimacy.

Having cognitive legitimacy within a community is crucial for the organization in order to influence positive evaluations of the organization by the community. From this theoretical stance, we propose that a community's acceptance of the organization as a permanent part of their society, or cognitive legitimacy, influences positive attitudes toward the organization. The theoretical logic here is that since attitudes are the "summary evaluations of objects, issues, or people based on behavioural, cognitive and affective information or experiences" (Pirsch et al. 2007: 131), we propose that a community's acceptance of an organization's permanence within its environment, or cognitive legitimacy, contributes to the cognitive information concerning the organization, and in turn positively influences attitudes toward the organization. Thus, our final hypothesis H3 is that cognitive legitimacy positively influences attitudes toward the organization.

Understanding attitude formation within a community is crucial to organizational success because attitudes are a pre-disposition to behaviour (Bagozzi 1992). Consistent with this perspective, psychology research states that there is a hierarchical nature between attitudes and behaviour through the theory of reasoned action (e.g., Ajzen and Fishbein 1980, Smetana and Adler 1980).

The theory of reasoned action states that attitudes influence behaviours and behavioural intentions (Ajzen and Madden 1986). Thus, understanding the constructs that influence attitudes would provide organizational guidance in predicting behavioural reactions to an organization's strategies in their respective community. From the theoretical premise of institutional theory and the theory of reasoned action, we propose a model of legitimacy, trust, and attitudes.

In summary, our conceptual framework incorporates four elements: (i) we adopt a multidimensional perspective of legitimacy, (ii) we propose that two dimensions of legitimacy (pragmatic and moral) influence trust, (iii) we propose that trust influences cognitive legitimacy, and (iv) we propose that cognitive legitimacy influences attitudes. This framework is important to the implementation of the CBC method since attitudes and trust constitute two components to CBC success, as mentioned by previous research (i.e., Salafsky et al. 2001, Lepp and Holland 2006). Thus, this theoretical framework allows for an increased understanding of trust-building and attitude formation by proposing the role of legitimacy in this network of constructs; a perspective that can be useful for organizations seeking to implement CBC strategies. An example of an organization that has implemented the CBC strategy and gained legitimacy from local environments is the Missouri Botanical Garden (MBG), as discussed in the following section.

MBG IN MADAGASCAR: AMBALABE AND MAHABO CONSERVATION SITES

MBG is a private, not-for-profit scientific institution based in St. Louis, Missouri, USA. It was founded in 1859 by Henry Shaw (1800–1889) to provide recreational and aesthetic benefits of nature to the city's residents, and to contribute to expanding and applying knowledge about the natural world. Currently, MBG's activities span a wide range including horticultural displays, public instruction and outreach, plant conservation, and botanical research (MBG 2017). In keeping with its mission statement, "To discover and share knowledge about plants and their environment in order to preserve and enrich life", MBG's conservation and research programs are international in scope, with activities across every continent. The Garden's herbarium is now among the largest in the world, with over 6.6 million specimens (MBG 2017). One country that has been of particular interest to the MBG's conservation efforts is Madagascar. Madagascar is one of the most ecologically diverse islands in the world, with numerous endangered and endemic species of flora and fauna (Lowry et al. 1997, Rakotomanana et al. 2013).

MBG has operated a multi-faceted program in Madagascar for more than three decades. Initially, it focused on documenting this island's remarkable plant diversity (e.g. Waeber et al. 2016), taxonomic research, and in-country capacity building, with special emphasis on training. In the early 2000s, MBG became directly involved in promoting the conservation of Madagascar's native plants due to the severity of the island's plant species decline. This involvement encompasses several elements: (i) the analyses of botanical information to assist in conservation planning and decision-making; (ii) the improvement of advocacy for the conservation of Malagasy plants; (iii) the species-focused conservation of plants on the brink of extinction; and (iv) the establishment of CBC activities at priority areas for plant conservation that have led to the establishment of a dozen new, officially recognized protected areas. Two of these recognized protected areas are the Ambalabe and Mahabo forests, as discussed below.

AMBALABE SITE. The Ambalabe Forest (known locally as the Vohibe forest) is located in the Ambalabe commune, District of Vatomandry, in the eastern part of Madagascar (Figure 1). This Forest has an area of 3,117 ha composed of mid and low elevation tropical rainforests with scattered patches of secondary forest and wooded grassland located in Madagascar's eastern escarpment. The Ambalabe Forest is home to 11 species of lemur, from which three species (*Varecia v. variegata*, *Propithecus diadema*, and *Indri indri*) are Critically Endangered (IUCN 2016). This forest also contains countless endemic plant species including species that are threatened (e.g., *Dypsis faneva* Beentje (Arecaceae), *Dalbergia pupurascens* Baill. (Fabaceae) according to IUCN Red List (IUCN 2016). MBG began working with the people of the overall Ambalabe Commune, which includes all *fokontany* in the commune, in 2005, a time when the forest had not yet been scientifically explored, but was under a steady threat of human actions such as the traditional agriculture practice of slash and burn for rice farming. Part of the Ambalabe forest is classified as eastern lowland forest, a highly degraded ecosystem mainly due to slash and burn practices for rice cultivation in the eastern region of the island. To save the Ambalabe forest from destruction, as well as to contribute to the conservation of Madagascar lowland rainforest and the biodiversity it contains, MBG set up the CBC initiative in the Ambalabe Commune with the permission of the local authority and the members of the community.

MAHABO SITE. The Mahabo Forest (known locally as Ag nalazaha forest) is located at the Mahabo-Mananivo commune, District of Farafangana, in the southeastern region of Madagascar. The Mahabo forest has an area of 1,565 ha composed primarily of an evergreen humid forest on sand mixed with marshland and grassland vegetation. It is one of the best remaining Malagasy forest patches of the eastern littoral forests (Figure 2) with an approximate 5–38 m above sea level. The Mahabo forest is home to many endemic plant species such as *Asteropeia micraster* Hallier f. and *Leptolaena multiflora* Thouars, respectively members of the endemic plant family Asteropeiaceae and Sar-

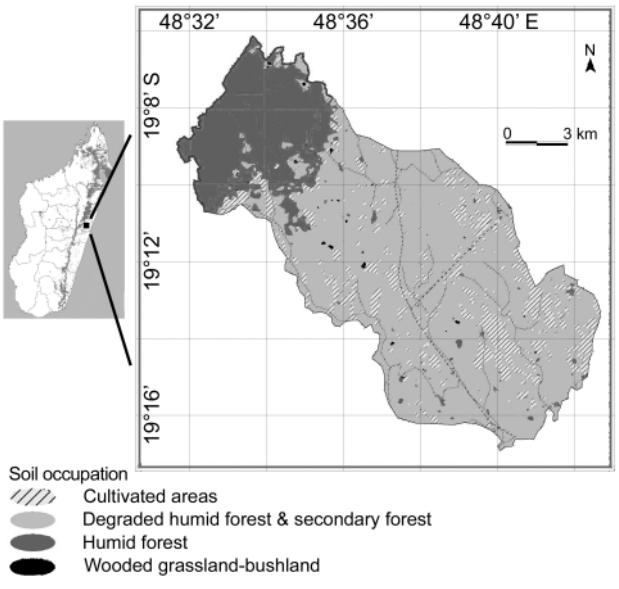

Figure 1. Ambalabe Forest.

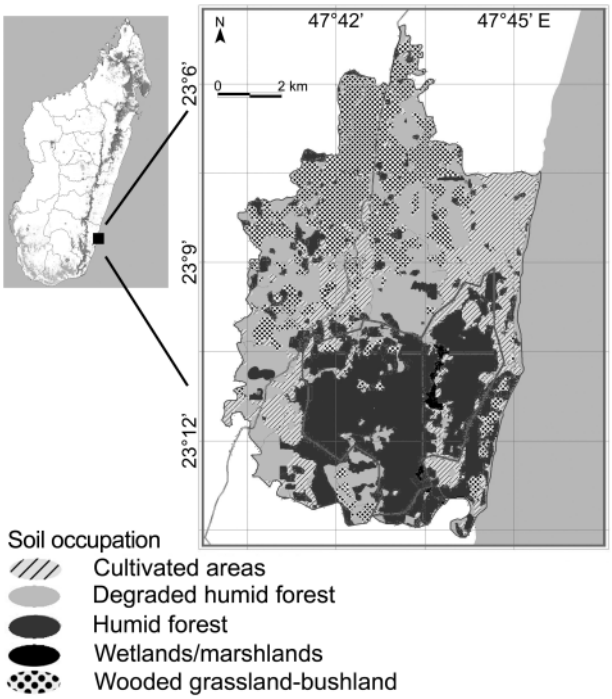

Figure 2. Mahabo Forest.

colaenanceae. These two species among several other species like *Dalbergia louvelii* R. Vig. (Fabaceae), *Dypsis utilis* (Jum.) Beentje & J. Dransf. (Arecaceae), are threatened according to the IUCN Red List (IUCN 2016). This forest is also home to the Critically Endangered White-collared Brown Lemur (*Eulemur cinereiceps*) (Andriaholinirina et al. 2014) and other species of lemur such as *Avahi laniger* and *Cheirogalus major*. MBG began working with the overall Mahabo Commune, which includes all *fokontany* in Mahabo, in 2003 when the forest was highly threatened by unsustainable practices from the surrounding population (Andriamaharoa et al. 2010). The eastern littoral forest on sand is one of the most highly degraded and threatened ecosystems in Madagascar. This is due to its easy access by the surrounding population, which permanently alter the habitat through deforestation. A study by Consiglio et al. (2006) suggests that the eastern littoral forest habitats house approximately 13% of the estimated 12,000 Malagasy vascular plants.

In both the Mahabo and Ambalabe sites, the MBG has implemented the CBC strategy in an effort to conserve the remaining forests. The activities related to this strategy are discussed in the following sections.

CBC IN AMBALABE AND MAHABO. For MBG in Madagascar, it is customary practice when conducting either botanical/ ethnobotanical studies or conservation activities for the staff to initially conduct a courtesy visit with community/ village leaders in the area of interest. This must be done before carrying out any activity, and its purpose is to greet and explain the objectives of the visit to the community leaders. Through this conversation, the community leaders are asked if they can grant the MBG staff the permission to carry out their plans in the area. Gaining permission from community leaders minimizes the risks of any future misunderstandings. This approach was used in both Mahabo and Ambalabe.

After the initial meeting with community leaders at each site, a dialogue and consultation was conducted in the form of a workshop within the community in order to build a relationship with the community members as well as to obtain information about each community's way of life, beliefs, goals, and relationships with the environment. This process provided the MBG staff members with the opportunity to inform community members about the importance of their participation in all aspects of the collaboration. Concurrently, the MBG staff was able to gain a better understanding of the issues between local communities and their environment, and the community members' interests. The ultimate result of the workshops at each site was that the MBG staff was able to have a clear vision of which activities to prioritize, with respect to both community and MBG interests. As a result, activities that have a positive direct impact on both forest conservation as well as improving the community's quality of life were prioritized.

It was only after these initial introductions with community leaders and workshops with the community members that the MBG staff was able to fully implement CBC-centred activities in each site. These activities were divided in three interconnected categories: research, natural resource management, and socio-economic development. In research, MBG staff members have been able to conduct botanical inventories and surveys to increase and improve the knowledge of the biodiversity of the two forest sites. Furthermore, ethnobotanical surveys at the two sites were conducted to document the traditional knowledge of plant use. The information obtained from these surveys and inventories helped shape the activities aimed at conserving the biodiversity of the two forested sites.

In terms of natural resource management, nurseries were established to produce either native species seedlings or non-native fast-growing tree plant species. The native species seedlings propagation was aimed at restoring forest patches that had been destroyed, while the non-native fast growing tree seedlings were distributed to community members to grow in their fields. This allows for an alternative solution to the problem of community members cutting down the native trees from the natural forest for daily living. Community members at both sites have continually participated in the plantation of seedlings during the restoration process. Along with the establishment of nurseries, other activities related to natural resource management have also been carried out. These included environmental education and the establishment of a forest patrol program. In terms of environmental education, the MBG team has partnered with the school districts at both sites to incorporate environmental classes that educate students about their environment and the benefits of conserving it into the school program. In parallel, for adults, meetings were held at both sites that focused on increasing the awareness and importance of the sustainable use of natural resources. In the establishment of the forest patrol program, the MBG staff incorporated community members into caring and protecting the forest and its surroundings. The presence of forest agents around and inside the forest has been identified as a major contributor to the decrease in forest destruction at both sites.

With respect to socio-economic development, income-generating and healthcare-improving activities have been established. For example, at both sites, infrastructure such as wells and fountains aimed at fighting water borne disease were constructed. Community members were also educated about vegetable gardens, as well as agricultural techniques to improve annual yields in rice farming. This education has not only improved diets and income levels within the communities, but has also decreased parti-

cipation in activities that are detrimental to the forest. For example, in Ambalabe, participation in hill rice farming, a major contributor to deforestation, has decreased due to community education on alternative agricultural techniques. These activities were implemented to serve both the MBG's conservation efforts as well as the communities' economic interests by providing community members with alternative ways of making a living without compromising forest conservation. The positive results of these activities can be attributed to the CBC strategy's emphasis on the community's socio-economic concerns.

LEGITIMACY IN AMBALABE AND MAHABO. For organizations to build trust in their respective environments, constituents in those environments must first grant the organization moral and pragmatic legitimacy. This can only be done in the context of the local institutional norms of the environment. In the case of MBG in Mahabo and Ambalabe, moral legitimacy was granted after the MBG staff showed respect to the community leaders by greeting and explaining the objectives of MBG before implementing any activities. This is a norm within the local institutional environments of both sites, thus allowing community leaders to scrutinize MBG as morally acceptable and granting MBG moral legitimacy. Then, the previously discussed workshops conducted and subsequent activities helped to build MBG's pragmatic legitimacy within the communities. The workshops were a way to communicate the practical benefits of MBG's activities to the communities, thus allowing community members to scrutinize MBG as practically beneficial to the community. Once a relationship was established, MBG began to implement strategies that tackled the socio-economic concerns of the community (i.e., educational programs, nurseries, etc.). After receiving the benefits of MBG's activities, community members began to grant MBG pragmatic legitimacy. Increasing moral and pragmatic legitimacy allowed the MBG staff to build trust in the community. Specifically, after the initial conversations and workshops, MBG could build trust through the continuation of CBC-related activities. This contributed to the community's expectation of positive outcomes that could be received from MBG, therefore further building community trust. This trust ultimately leads to cognitive legitimacy.

After many months of observing MBG's activities in the communities, the spiritual and community leaders at each site granted their full acceptance of MBG as a part of their community, thus granting MBG cognitive legitimacy. This acceptance was declared in the form of a traditional ceremony or *fomban-drazana* in front of all community members and the spirits of the ancestors at both sites. The ceremonies at the sites were an indication that MBG has gained cognitive legitimacy because it symbolized MBG's full integration into the community.

Since CBC success is the effectiveness of a CBC strategy in meeting the interests of local people while simultaneously meeting the conservation goals of the implementing organization, it can be stated that MBG achieved CBC success in both Ambalabe and Mahabo. An example of this success is reflected in MBG's basket weaving activity in Mahabo. Weaving baskets is an activity that women in Mahabo partake in for extra income. The women weave baskets throughout the week and sell the baskets at the Mahabo market day on Saturdays. Between 2003 and 2007, the price of each basket was roughly between $US0.5–1. During this period, the price was controlled by distributors who purchased the baskets from the weavers to sell in larger markets, thus leaving the women at the mercy of the distributors' prices. Aware of this situation, the MBG team sought out to find a solution where women can directly sell their baskets to a larger market, and cut out the distributors. The solution was a partnership between the MBG and the Blessing Basket Project, an organization that specifically connects basket weavers from developing countries to buyers in developed countries (Blessing Basket Project 2017). With this partnership, the women of Mahabo created an association of weavers and were able to sell their baskets in the US market. This largely increased the profit margin for the baskets, and contributed to the improvement of the Mahabo community's living standards. As a result, the women's association established a rule for itself stating that if any relative of a weaver member of their association is caught destroying the forest, the weaver is banned from the association and her baskets are no longer to be sold through the Blessing Basket Project. In this example, it can be stated that MBG achieved some CBC success because the CBC strategy served to meet the economic interests of the local people as well as the conservation interests of MBG.

Overall, from the perspective of the first author (A.R.) who has been part of these projects from their inception, the MBG has gained legitimacy and influenced community attitudes by implementing CBC strategies in Ambalabe and Mahabo. These efforts have not only improved the community members' standards of living, but have also helped achieve some conservation success. For example, in Ambalabe, since the MBG's involvement in this community in 2005, the number of native species seedlings planted has considerably increased, the number of annual trees cut down have decreased, the number of lemur traps have decreased, the area of forest that is lost to shifting cultivation has decreased, and the area of restored forest has increased (Table 1).

The perspective of the first author, although valuable, however, cannot be discussed as empirical evidence to support the hypotheses. Therefore, we empirically test our hypotheses on the relationships between the dimensions of legitimacy, trust, and attitudes in these two sites, as discussed in the following section.

METHODS

DATA COLLECTION. In May 2016, we collected survey data and followed the ethical standards of the National Institute of Health's (NIH) ethical standards for human research. These standards include respect for persons by treating individuals as autonomous agents; beneficence by respecting individual decisions and protecting people from harm; and justice by selecting participants equitably (NIH 2008). It is important to note that an author of this paper has completed the CITI (Collaborative Institu-

Table 1. Conservation statistics in Ambalabe (2005–2016) according to MBG staff.

year	number of native species seedling planted	restored area (ha)	area of forest lost to shifting cultivation (ha)	number of lemur traps	number of trees cut
2005	no data	no data	10	20	100
2006	140	0.09	8	15	98
2007	1791	1.12	4	5	30
2008	7720	4.83	6	1	10
2009	10644	6.65	4.5	2	10
2010	3648	2.30	2	1	20
2011	5070	3.17	0	0	5
2012	3619	2.53	1	1	10
2013	5271	3.60	2.5	4	15
2014	12361	7.73	3	0	-
2015	4228	2.64	0	0	5
2016	6541	4.08	0	5	7

tional Training Initiative) Program's basic course in social/behavioural research for investigators and key personnel.

To adhere to the NIH's standards, we first discussed the scope of the data collection with MBG's field botanists and site facilitators at each site. It was recommended that we should recruit respectable members of each community to administer the surveys to ensure respect and beneficence for the respondents. Therefore, a local school director in Ambalabe and a university student who was home on vacation in Mahabo were recruited to administer the survey to community members. They were both compensated for their time and efforts. The survey administrators only took respondents who voluntarily agreed to participate in order to ensure the justice component of the NIH's ethical standards. Furthermore, no identifiable information was collected from any respondent in order to further ensure anonymity and confidentiality. Finally, the survey was placed in reverse causal order in order to reduce the threat of common methods bias (Lindell and Whitney 2001). These procedures not only ensured respect, anonymity, and justice for the respondents, but also reduced the risk of response biases in the survey responses.

The paper survey questionnaire was constructed to measure the latent constructs within the two communities. To measure trust, a scale that was developed by Garbarino and Johnson (1999) was utilized. This scale had 4 statements and asks the respondent to rank their agreement on a likert type scale from 1 (strongly disagree) to 7 (strongly agree). This scale was selected because it aligns with the conceptual understanding of trust within the context of this current research. Specifically, Garbarino and Johnson's (1999) describe trust as a constituent having an expectation of positive outcomes that can be received from an organization; this includes the measurement items that ask the respondent if the organization meets their expectations, and if they can count on the organization to be good in order to measure this construct. Similarly, we used Wang et al.'s (2012) scale to measure attitudes because the measurement items in this scale reflect this paper's conceptual understanding that attitudes are summary evaluations of an organization. Both scales for trust and attitudes were implemented in the context of MBG. Table 2 displays the measurement items for each scale. The items for each dimension of legitimacy were derived from Suchman's (1995) theoretical description of each dimension. As pragmatic legitimacy concerns the tangible benefits to the individual constituent, the constituent's community, and the constituent's larger society, items for each of these elements were asked to measure the latent construct which represents pragmatic legitimacy. It is important to note that since legitimacy is an overall evaluation of the organization and the organization's activities, we do not frame the question items into the context of specific activities, but instead ask the respondents to provide their feedback on MBG's overall activities.

Moral legitimacy was measured with two items which ask the respondents if they felt whether MBG was honest and decent. Both are elements mentioned by Suchman (1995) to describe moral legitimacy. Finally, cognitive legitimacy was measured with three items which ask the respondents if they felt that MBG was a permanent part of their society, a necessary part of their society, and an inevitable part of their society. These items are all highlighted as elements of cognitive legitimacy by Suchman (1995). To make the questions more understandable by the local community, the survey questionnaire was translated to Malagasy by MBG staff members who speak both English and Malagasy. Specifically, the principal investigators in this research consulted with field botanists and site facilitators at each site to ensure that the conceptual understanding of the question items asked in the local dialect reflected the scientific meaning of each construct. The experienced field botanists and site facilitators consulted have been working within these communities in implementing CBC efforts of the MBG for five or more years. Community members administered the survey to respondents. The recruited individuals verbally asked each question item to individual community members and recorded their answers on a likert type scale ranging from 1 (strongly agree) to 7 (strongly disagree).

Although precautions were taken to ensure the survey responses were not distorted by the methods utilized, certain limitations still apply to this data collection method. First, even though the survey was structured in reverse causal order, the threat of common methods bias in never void is any survey questionnaire. Second, since the survey responses were collected from community members who voluntarily participated in the study, the sample is at risk of possibly under-representing some demographic groups within the communities; however, with this stated, anonymity and a willingness to participate in the survey was important to ensure the justice component of the NIH's standards.

DATA ANALYSIS. The analyses were conducted in four stages.

First, a measurement assessment of the items and constructs were conducted. Second, the relationships between the constructs were tested in a structural model by employing partial least squares (PLS), using SmartPLS 2.0 (Ringle et al. 2005). Third, the relationships were also tested in a hierarchical regression model conducted in SPSS 19 to provide further evidence for the model. Finally, a mediation analysis utilizing the Preacher and Hayes (2004) mediation test was conducted to provide evidence of the mediating role that cognitive legitimacy plays in the relationship between trust and attitudes.

In the first stage, we assessed the measurement model using SmartPLS 2.0 (Ringle et al. 2005). We examined factor loadings, composite reliability, and average variance extracted (AVE) estimates to assess the validity and reliability of the latent constructs. Carmines and Zeller (1979) suggest that factor loadings should be close to or above .70 to ensure construct validity; Anderson and Gerbing (1988) suggest that the composite reliability estimates should exceed .70 to ensure reliability; and Fornell and Larcker (1981) suggest that the AVE for all constructs should exceed .50 to ensure convergent validity. We utilized these thresholds to ensure the measurement model sufficiently reflected the latent constructs that were measured. Furthermore, we also examined the construct correlations, means, and standard deviations for each construct to ensure discriminant validity.

Similar to the measurement assessment, we tested the hypotheses utilizing PLS in SmartPLS 2.0 during the second stage of the analyses. We selected PLS as the appropriate method because PLS is similar to regression, but it also concurrently models the structural paths. Also, the PLS algorithm allows for each indicator item to independently load onto the latent construct, where regressions would assume equal weights for all indicators (Magnusson et al. 2013). Furthermore, PLS can effectively handle smaller sample sizes for structural models (Hair et al. 2013).

In the third stage of the analyses, a hierarchical multiple regression was conducted in SPSS 19 with attitudes toward MBG as the dependent variable. This method was chosen to demonstrate

the hierarchical nature of the model. Composite scores were calculated for each latent construct, and four regression models were conducted in this analysis.

In the final stage of the analyses, the Preacher and Hayes (2004) method of testing indirect effects was employed to test the mediating role that cognitive legitimacy plays in the relationship between trust and attitudes toward MBG. Where the PLS and regression analyses can show a hierarchical nature of the proposed relationships, this method tests for a specific mediating effect of cognitive legitimacy.

Table 2. Item loadings, composite reliability (CR), and average variance extracted (AVE); N=101 (the questions in Malagasy are italicized).

	CR/AVE	loadings
pragmatic legitimacy	.82/.60	
MBG's activities benefit me		0.83
Manome tombotsoa ahy ny asa ataon'i MBG		
MBG's activities benefit the Ambalabe Commune		0.80
Manome tombotsoa ny Commune Ambalabe ny asa ataon'i MBG		
MBG's activities benefit Madagascar		0.69
Manome tombotsoa an'i Madagascar ny asa ataon'i MBG		
moral legitimacy	.94/.88	
MBG is honest		0.93
MBG dia mendripitokisana		
MBG is decent		0.94
MBG dia hendry		
cognitive legitimacy	.88/.71	
MBG is a permanent part of Ambalabe		0.86
MBG dia rantsana na ampahany iray maharitra ao Ambalabe		
MBG is a necessary part of Ambalabe		0.86
Tena ilain'ny Commune Ambalabe i MBG		
MBG is an inevitable part of my community		0.80
MBG dia ampahany na rantsana tsy azo ialan'ny fiarahamoniko		
trust in MBG	.92/.75	
MBG always meets my expectations		0.83
MBG dia mitondra ireo zavatra mifanaraka amin'ny eritreretiko na antenaiko		
I can count on MBG to be good		0.67
Mahatoky zaho fa fikambanana na sehatr'asa tsara i MBG		
MBG is reliable		0.91
Azo hianteherana i MBG		
MBG can be trusted		0.85
Azo atokisana i MBG		
attitude towards MBG	.94/.84	
Supporting MBG is a Good Decision		0.89
Ny fanohanana an'i MBG dia fanaoahankevitra tsara		
MBG is a satisfactory organization		0.94
MBG dia fikambanana na sehetr'asa mahafapo		
I can get a lot of benefits from supporting MBG		0.92
hahazoako tombontsoa betsaka ny fanohanana an'i MBG		

Table 3. Construct correlations, means, and standard deviations of each construct. The values represent the strength of the correlation between the variables. Significance levels are represented by: *p<.05, **p<.01, ***p<.001.

	pragmatic legitimacy	moral legitimacy	cognitive legitimacy	trust	attitudes toward MBG
pragmatic legitimacy	1				
moral legitimacy	0.57***	1			
cognitive legitimacy	0.81***	0.71***	1		
trust	0.70***	0.81***	0.73***	1	
attitudes toward MBG	0.71***	0.77***	0.80***	0.84***	1
mean	5.95	5.39	5.65	5.63	5.58
standard deviation	1	1.26	1.09	1.19	1.31

RESULTS

The data collection method yielded 50 responses from Ambalabe community members and 51 responses from Mahabo for a total of 101 usable responses. The mean age for the sample was 31.4 years old, with a standard deviation of 8.66 years. The sample consisted of roughly 57% male and 43% female respondents.

Results from the first stage of the analysis (Table 2, Table 3) indicated that the measurement model displayed validity and reliability as all factor loadings were above .70, composite reliability estimates for each construct exceeded .70, and the AVE for each construct exceeded .50.

In the second stage, results from the PLS model estimation provided strong support for the hypotheses. In support of hypothesis H1, both moral (β=.61, p<.001) and pragmatic (β=.36, p<.001) legitimacy were found to positively influence community trust. In support of hypothesis H2, community trust (β=.75, p<.001) was found to significantly influence cognitive legitimacy. Finally, in support of hypothesis H3, cognitive legitimacy (β=.80, p<.001) was found to positively influence attitudes toward MBG (Figure 3).

In the third stage of the analyses, results from the regression models provide support for the statement that both organizational legitimacy and trust are significant for the development of positive attitudes toward the organization (Table 4). In Model 1, the control variables of age and gender were included as variables, and age (β=.17, p<.10) was found to marginally influence attitudes toward MBG while gender was not found to be significant. In Model 2, pragmatic (β=.40, p<.001) and moral (β=.54, p<.001) legitimacy were added as predictors along with the control variables and were both found to be significant predictors of attitudes, while the control variables were not significant. In Model 3, trust (β=.51, p<.001) was included and was found to highly influence attitudes. When trust was added, both pragmatic (β=.22, p<.01) and moral (β=.22, p<.05) decreased in significance and beta, while age (β=.10, p<.10) was marginally significant and gender was not sig-

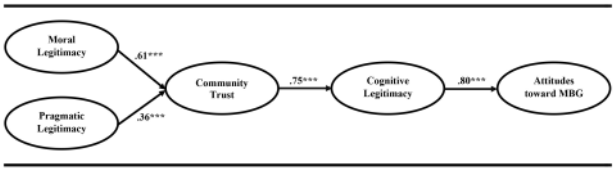

Figure 3. Structural model results for the partial least squares (PLS) estimation. Betas represent the variance in the dependent variable explained by the predictor variable. Significance levels are represented by: *p < .05, **p<.01, ***p<.001

Table 4. Results of hierarchical multiple regression analysis: the influence of legitimacy and trust on attitudes toward the organization. Model 1 shows the influence of the control variables only, model 2 includes pragmatic and moral legitimacy, model 3 includes trust, and model 4 includes cognitive legitimacy. Significance levels are represented by: †p<.10, *p < .05, **p<.01, ***p<.001.

	model 1		model 2		model 3		model 4	
	β	std. err.	β	std. err.	β	std. err.	β	std. err.
cognitive legitimacy	-	-	-	-	-	-	0.40***	0.11
trust	-	-	-	-	0.51***	0.11	0.49***	0.10
pragmatic legitimacy	-	-	0.40***	0.09	0.22**	0.09	-0.02	0.11
moral legitimacy	-	-	0.54***	0.07	0.22*	0.09	0.10	0.09
control variables								
age	0.17†	0.02	0.04	0.01	0.10†	0.01	0.09†	0.01
gender	0.06	0.27	0.00	0.15	-0.03	0.13	-0.08	0.13
adjusted R-square	0.01		0.70		0.76		0.80	
R-Square	0.03		0.71		0.77		0.81	
R-Square change	0.03		0.68***		0.06***		0.04***	

nificant. Finally, in Model 4, cognitive legitimacy (β=.40, p<.001) was included and was found to highly predict attitudes. Also, in Model 4, trust (β=.49, p<.001) had a decreased beta, neither pragmatic nor moral were significant, age was found to be marginally significant (β=.09, p<.10), and gender was found to not be significant. The overall hierarchical regression analysis yielded a significant model [F (1, 92) = 18.34, p<.001, R squared = .81, Adjusted R squared = .80].

The results of the hierarchical regression analysis provided evidence in support for the proposed model, as shown in Table 4. Specifically, when trust was included in Model 3, pragmatic and moral legitimacy became less significant and had smaller beta values; and when cognitive legitimacy was included in Model 4, not only were trust and cognitive legitimacy found to be highly significant, but pragmatic and moral legitimacy were no longer significant. This indicates the mediating roles of trust and cognitive legitimacy in the model.

Although the PLS and regression analyses provide some indication of the mediating role of cognitive legitimacy in the relationship between trust and attitudes, it cannot be stated with full confidence that cognitive legitimacy is a mediator from the results of these analyses. Specifically, in the regression analysis, attitudes toward MBG was the dependent variable, therefore, only the effects of the variables on this dependent variable was shown, which provides little evidence of mediation. Therefore, the Preacher and Hayes (2004) mediation test with 5000 bootstraps was conducted in SPSS 19 to test the mediating effect cognitive legitimacy. The results show that the indirect effect of trust on attitudes toward MBG with cognitive legitimacy as the mediator is significant with 99% confidence interval. Further, the relationship between trust and attitudes toward MBG was highly significant without the mediator (β=.66, p<.001), and marginally significant when the mediator was inserted (β=.16, p<.10) (Table 5). This provides evidence for the mediating role that cognitive legitimacy plays in the relationship between trust and attitudes toward MBG.

DISCUSSION

In this research, we find that (i) moral legitimacy influences community trust, (ii) pragmatic legitimacy influences community trust, (iii) community trust influences cognitive legitimacy, and (iv) cognitive legitimacy influences attitudes toward the organization (MBG). These findings emphasize the notion of Pretty and Smith (2004) that building social capital is important when organizations seek positive biodiversity outcomes. Thus, these findings provide strategic implications for organizations seeking to implement the CBC approach within their respective conservation sites.

By finding that both moral and pragmatic legitimacy influence trust, we imply that in order for organizations to gain trust within a community, it must first appeal to the community members as a morally good organization and/or must demonstrate the practical benefits it can provide to the community. Moral standards here are defined by the institutional environment, so the community scrutinizes what is morally acceptable. For example, in order for MBG to gain moral legitimacy in Mahabo and Ambalabe, the MBG staff met with community leaders to explain and discuss their interests and plans. This is a local institutional norm within these communities, and influenced moral legitimacy. In other words, the institutional environment includes informal norms of behaviour (Berkes 2004), and the communities of Ambalabe and Mahabo have specific norms which are considered by the community members to be appropriate behaviour for moral organizations. In MBG's case, to be considered a moral organization and increase moral legitimacy, the MBG staff followed the norm of first meeting with community leaders to discuss the MBG's interests.

Along with providing inference that moral and pragmatic legitimacy influence trust, the results from the PLS analyses also indicate that moral legitimacy has a stronger influence on trust than pragmatic legitimacy. This is an interesting result since trust is conceptualized as an expectation of positive outcomes (Bhattacharya et al. 1998), and pragmatic legitimacy is the constituent's perception that an organization can provide tangible benefits. However, moral legitimacy is a positive normative evaluation of an organization and may better influence an expectancy of positive outcomes than pragmatic legitimacy. This point, however, requires further research, and we encourage future researchers to further investigate this dynamic.

The practical implication of the finding that both pragmatic and moral legitimacy influence trust is valuable to organizations such as the MBG which rely on building trust through CBC strategies. Strategically, this finding implies initially gaining moral and pragmatic legitimacy is beneficial to organizations seeking to build trust with a community. Also, although both moral and pragmatic legitimacy can influence trust, the finding that moral legitimacy has a stronger influence on trust than pragmatic legitimacy implies that establishing moral legitimacy is a better trust-building strategy than establishing pragmatic legitimacy. The contribution of this finding to CBC research revolves around the notion that moral and pragmatic legitimacy can be added to elements of organizational trust-building. Previous research suggests that community engagement and interactions are crucial to building trust (Davenport et al. 2007). Our finding suggests that to build trust, community engagement and interactions should reflect the organization's practical and moral benefits to the community. Examples of these activities include recognizing and integrating community capabilities into activities, exchanging ideas with community members, and respecting community members as equals,

Table 5. The Preacher-Hayes mediation test results: the mediating effect of cognitive legitimacy on the relationship between trust and attitudes toward MBG. The indirect and direct effects with significance levels represented by: †p<.10, *p < .05, **p<.01, ***p<.001

				CI (95%)		CI (99%)	
	β	std. err.	t-value	lower	upper	lower	upper
direct and total effects							
trust -> cognitive legitimacy	0.67***	0.06	10.75				
cognitive legitimacy -> attitudes toward MBG	0.74***	0.09	8.31				
trust -> attitudes toward MBG (without mediator)	0.66***	0.07	9.07				
trust -> attitudes toward MBG (with mediator)	0.16†	0.08	1.91				
indirect effects							
trust -> cognitive legitimacy -> attitudes toward MBG				0.308	0.690	0.262	0.759

as the MBG has done in their respective communities. These activities should be conducted with the perspective that the community is a group of socially interdependent people who are governed by the institutions of the environment. For example, before any conservation activities were conducted, the MBG staff in Ambalabe and Mahabo held workshops in order to better understand the needs of the community as well as communicate MBG's goals and benefits to community members within the institutional environments.

The second finding of this current research is that community trust precedes cognitive legitimacy, which reinforces the crucial role that trust plays in CBC strategy success. This finding indicates that before organizations can be accepted by community members as a permanent and inevitable part of their environment, they must first build trust. Thus, trust plays a mediating role between pragmatic/moral legitimacy and cognitive legitimacy. As evidenced in MBG's case in Mahabo and Ambalabe, before gaining complete acceptance in the community (cognitive legitimacy), the MBG established relationships with the community members through workshops and CBC-related activities in order to build trust. By gaining this trust, MBG was able to be accepted as a permanent part of the environment.

The finding that cognitive legitimacy mediates the relationship between trust and attitudes toward the organization indicates that organizations could indirectly influence community attitudes by building trust and cognitive legitimacy. This finding is crucial to CBC strategy success because attitudes are pre-dispositions to behaviour (Bagozzi 1992). As previously mentioned, the theory of reasoned action emphasizes the hierarchical nature of the relationship between attitudes and behaviour (Ajzen and Madden 1986). Organizations seeking to influence behaviours that promote conservation must first influence attitudes, but in order to influence attitudes, cognitive legitimacy must be gained from the community. Since the successes of CBC strategies rely on conservation-promoting behaviours, this finding proves to be an important finding in conservation strategic management. This strategic implication was evidenced in MBG's success at reaching the conservation success through the CBC method, as gaining cognitive legitimacy influenced positive attitudes towards MBG's activities. This was evidenced through community participation in conservation initiatives such as forest patrolling, and the previously discussed women's weaving association's rule that the forest must not be cut.

In conclusion, we have introduced three dimensions of organizational legitimacy as important elements in understanding of trust and attitudes toward an organization. The findings provide support for a framework which states that pragmatic and moral legitimacy precede trust, trust influences cognitive legitimacy, which influences downstream attitudes. The findings of this research suggest that organizational legitimacy plays a key role in the success of CBC strategies, and we invite future research to further explore these relationships.

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The cost of making compensation payments to local forest populations in a REDD+ pilot project in Madagascar

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ABSTRACT

REDD+ is usually presented as an incentive-based mechanism that can provide payments to compensate for the costs induced by conservation restrictions. Yet in Madagascar REDD+ is implemented through a command-and-control approach with almost no or insufficient compensation. This paper challenges the financial feasibility of an individual cash or in-kind compensation scheme as part of a REDD+ project and assesses the cost of implementing a hypothetical individual compensation scheme for local populations living on the boundary of an ongoing REDD+ pilot project in southeastern Madagascar. In order to estimate a plausible level of compensation, we measured households' perceived economic losses arising from the project. We carried out this economic evaluation based on households' declarative statements about their agricultural production (before and after project implementation) and their perceptions of the causes of such changes. We then estimated the start-up and running costs of implementing conditional transfers to compensate for reported losses using first-hand project cost data from different conservation projects in Madagascar, including the one analysed in this paper. Comparing our estimated total cost to the current budget of the REDD+ project, we concluded that compensating households would cost seven times more than the budget initially devoted to field activities during the first phase of the project. Yet we discuss that individual compensation may increase the long-term environmental and social additionality (through greater legitimacy) of the REDD+ project, as it may play a role of safety nets and help farmers, especially the most vulnerable ones, to implement new agricultural techniques to adapt to land use restrictions.

RÉSUMÉ

REDD+ est généralement présenté comme un mécanisme incitatif basé sur la compensation des coûts induits par les mesures de conservation de la forêt. Cette vision de REDD+ tend toutefois à être remise en cause par la réalité des projets pilotes. À Madagascar par exemple, les projets pilotes sont mis en œuvre selon une logique contraignante voire coercitive, où les compensations pour les populations locales sont extrêmement réduites. Partant de l'hypothèse que l'un des facteurs explicatifs de l'absence de mécanisme de compensation directe est un coût trop élevé, ce papier évalue le coût de la mise en œuvre d'un système de compensations monétaires individuelles en parallèle des activités de conservation et de développement d'un projet pilote REDD+ situé au sud-est de Madagascar. Pour ce faire, nous estimons les pertes économiques induites par le projet telles que perçues par les ménages au moyen d'entretiens individuels. Ces entretiens nous ont permis de reconstituer la production des ménages avant et après la mise en œuvre du projet, et d'évaluer dans quelle mesure les changements opérés étaient ou non dus à l'implémentation du projet REDD+. Dans un second temps, nous estimons les coûts de transaction liés à la mise en œuvre du système de compensation en utilisant des données issues de différents projets de conservation et de développement à Madagascar. La confrontation de nos estimations avec le budget actuel du projet REDD+ montre que compenser les pertes individuelles des mé- nages est hors de la portée financière du projet, puisque cela représente sept fois le budget dédié aux activités de développement local pendant la première phase du projet. Dans la discussion, nous revenons sur l'intérêt d'associer des compensations individuelles aux programmes d'investissement agricole, dans la mesure où les compensations jouent un rôle de « filet de sécurité » pour les ménages, notamment les plus vulnérables, et les encouragent à expérimenter de nouvelles techniques agricoles leur permettant de s'adapter aux restrictions d'usage.

INTRODUCTION

Tropical forests play a major role in climate regulation, both for the regulation of hydrological and carbon cycles (IPCC 2007, Pan et al.

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2011) and as hosts of invaluable biological diversity (O'Connor 2008). The Reduction of Emissions from Deforestation and Degradation (REDD+) is an international initiative which seeks to channel funds with the support of the UNFCCC (United Nations Framework Convention on Climate Change) negotiations to encourage tropical countries to protect their forests. Socio-economic incentives and performance-based payments are one of the core principles of REDD+ (Karsenty and Ongolo 2012), which explains why the implementation of some REDD+ projects contains payments for environmental services as a separate but complementary tool (Ezzine-de-Blas et al. 2015). Madagascar has a record of implementing REDD+ strategies through command-and-control approaches using protected areas with almost no or insufficient compensation (Brimont and Karsenty 2015). In Madagascar, there are currently four ongoing REDD+ pilot projects being implemented by international environmental NGOs. All of them plan to create new protected areas, following the line of the pre-REDD+ national conservation strategy; in 2003, the Government of Madagascar decided to more than triple the size of the protected areas network (Corson 2011), which is planned to cover 40% of the remaining natural forest of the island (S. Desbureaux 2014, pers. comm.). When protected areas fall in populated areas within or along its boundary, the NGOs have traditionally supported the creation of management transfer contracts (*transferts de gestion*) from the state to the communities. The community—represented by an ad hoc legally recognized local institution called VOI (*Vondron'Olona Ifotony*)—is required to respect and enforce a management plan which defines zones with different degrees of protection—and therefore land use rights—depending on the type of land use found at the time of the management transfer. For example, forests in the buffer area of the protected area are usually classified as strict conservation zones. In the other zones, further from the edge of the protected area and where forests are more degraded, harvesting activities for timber and non-timber products are allowed through strict regulations enforced by the VOI and the protected area management organization (Madagascar National Parks, MNP), which oblige households to pay a harvesting fee. Slash-and-burn agriculture, which is the main component of households' livelihoods, is only permitted on dedicated fallows within a VOI's territory after the payment of the slash-and-burn agriculture or tavy fee (Antona et al. 2004, Hockley and Andriamarovololona 2007). Therefore, the REDD+ project entails strict (for undisturbed forests) or fee-mediated (for degraded areas) restriction for the use of significant areas that were traditionally used for tavy. Such conservation restriction rules are likely to entail a cost for local communities, since farmers can no longer clear forest to manage soil fertility (Styger et al. 2009).

In addition to management transfers, REDD+ projects can fund local development projects which are expected to compensate and help households adapt to the losses arising from conservation restrictions. Recent studies have shown that these development projects faced the typical difficulties of Integrated Conservation and Development Projects (ICDPs), which are related to (i) elite capture, (ii) exclusion of the most vulnerable households, (iii) concentration of support on the more accessible zones, and (iv) inadequacy of the means proposed compared to the needs (Brimont et al. 2015). Therefore, households living in the territories affected by REDD+ projects are de facto hardly compensated for the agricultural and livelihood losses resulting from conservation restrictions.

Some authors argue that individual direct transfers benefit local populations more than ICDPs (Ferraro and Kiss 2002). Some one-off cases have been tested in Madagascar with relative success (Sommerville et al. 2010). Other academics argue that compensation covering only the cost of losing access to forest land is not sufficient to decrease deforestation over the long term, mainly because it does not address the drivers of deforestation. Such compensation should be linked to development activities that support agronomic innovation or the creation of economic alternatives (Karsenty 2011, Brimont and Karsenty 2015). Lack of financial means is a recurring problem for environmental NGOs and tropical conservation, and the gap between current funding and

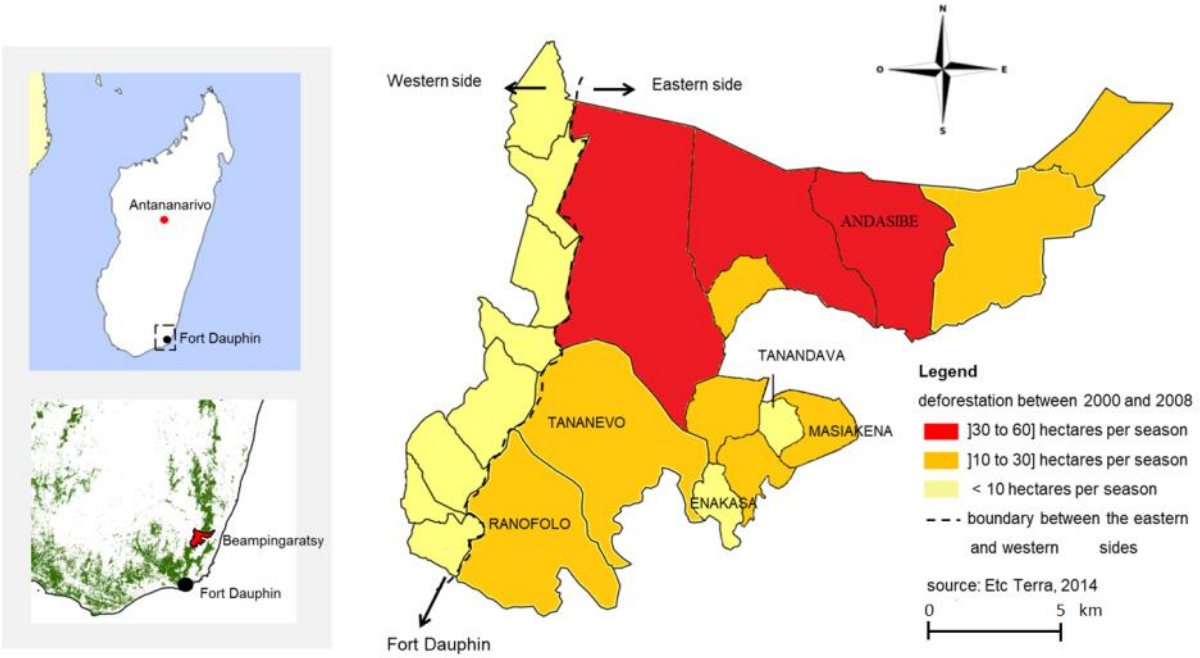

Figure 1. Study area with boundaries of the six participating VOIs.

budget needs is particularly large in very poor countries like Madagascar (Balmford and Whitten 2003). The purpose of this paper is therefore to discuss whether a direct payment scheme—in cash or in kind—would be an economically and socially viable option as part of the ongoing Beampingaratsy REDD+ pilot project, in southeastern Madagascar, by assessing the cost of its implementation. Although no direct conditional transfers are currently being implemented in our study area, we ask whether the implementation of an individual compensation scheme in parallel with existing conservation and development activities appears to be an economically viable and efficient option.

THE BEAMPINGARATSY FOREST AND THE REDD+ CONSERVATION PROJECT. The Beampingaratsy forest covers 38,250 hectares and is located 100 kilometres north of Fort-Dauphin, the largest town on the southeastern coast of Madagascar (Figure 1). More than 6500 households, i.e., about 30,000 people, live in this area (WWF 2011). The main driver of deforestation is tavy and the conversions of forest to pastureland on the western side of Beampingaratsy forest, while forest degradation is caused by collecting firewood (Laboratoire de Recherche Appliquée and WWF 2011).

The Beampingaratsy project started in 2009 as part of a nationwide REDD+ project called the Holistic Conservation Programme for Forests in Madagascar (HCPF), implemented by a French environmental association, Etc Terra (previously known as GoodPlanet), in partnership with the World Wide Fund for Nature (WWF). The project was funded by Air France, a French airline company. During the first implementation phase (2009–2012), the purpose of the HCPF REDD+ project was twofold: first, developing national carbon accounting methodologies to measure the reduction of emissions from deforestation and, secondly, implementing conservation activities in five forest areas of Madagascar, including Beampingaratsy. The overall budget of the Beampingaratsy project was about $US 150,000 (HCPF in litt., non-public accounting document). Functioning costs (salaries and office cost) amounted to 35% of the budget, while field activities accounted for 65%. During this first period, the project supported the implementation of 20 management transfers (VOIs) and initiated the legal and administrative process to create the protected area. While in other REDD+ projects VOI territories are mainly located in the buffer zones of protected areas, in Beampingaratsy the future protected area was made up of the conservation zones of VOIs (Figure 2). This was due to both the specific topographical and demographic conditions of the Beampingaratsy forest, and the social-ecological purpose of the protected area: Beampingaratsy was intended to be an IUCN category V protected landscape (IUCN 2016) where the interaction of people and nature is recognized and to be safeguarded. At the end of the first implementation phase, the project in the created VOIs fostered a variety of development and conservation activities, which consisted of a reforestation programme, support for improving agricultural yield, such as training in improved rice growing techniques, and activities aimed at diversifying household incomes, i.e., beekeeping, cash crops, tree nurseries or market gardening. The project also funded a literacy programme for adults, which was implemented in some VOIs. The second implementation phase (2013–2017) is pursuing those development and conservation activities.

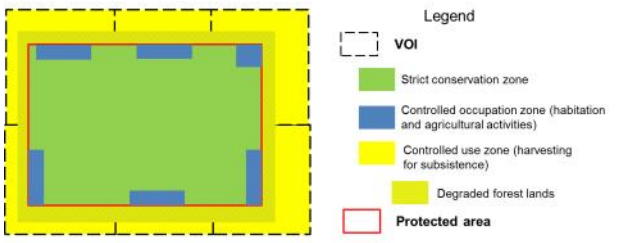

Figure 2. Zoning scheme of the Beampingaratsy REDD+ project.

During the first implementation phase, the deforestation rate decreased from an average of 1.44% per tavy season before the project began (2000–2008), to 0.81% per tavy season (C. Grinand 2013, pers. comm.). To provide a baseline for comparison, the deforestation rate at national level between 2000 and 2010 was 0.97% (Mayaux et al. 2013).

PAYMENTS FOR ENVIRONMENTAL SERVICES (PES). The payments for environmental services (PES) literature usually distinguishes between three types of costs: (i) opportunity costs, i.e., households' forgone revenues from the protection of ecosystems, (ii) transaction costs, which cover the start-up and running costs incurred by the implementation and functioning of PES, and (iii) the actual payments (Pirard 2012, Ezzine-de-Blas et al. 2016). Many studies have evaluated the opportunity costs of reducing deforestation (for Madagascar case studies, see Kramer et al. 1995, Shyamsundar and Kramer 1996, Kremen et al. 2000, Ferraro 2002), and the transaction costs of direct incentive schemes in tropical countries (Angelsen 2008, Börner and Wunder 2008, Grieg-Gran 2008, Wunder et al. 2008).

METHODS

In this article, we differentiate costs according to their economic (opportunity vs. transaction costs), and time-dependent (start-up vs. running costs) rationales. We identify three categories of costs: compensation costs, implementation costs, and operating and monitoring costs.

Compensation costs: Compensation costs are the losses experienced by local populations resulting from conservation restrictions. As previously explained, in Madagascar conservation restrictions usually entail a decrease in agricultural production because farmers can no longer clear primary forest to manage soil fertility. Previous research in Madagascar studying the costs of conservation for local populations has not assessed the impacts on livelihoods; it has used either a contingent valuation approach, such as the "willingness-to-accept" methodology (Kramer et al. 1995, Shyamsundar and Kramer 1996, Desbureaux and Brimont 2015), or the opportunity costs method, in which the authors assess the potential income derived from practising agriculture on newly deforested land (Kremen et al. 2000, Ferraro 2002). For the purpose of this article, we chose to estimate the loss of household income arising from the implementation of the Beampingaratsy REDD+ project, i.e., restrictions on the use of natural resources established by VOI management plans, as a way of estimating the de facto real conservation cost for local populations. In order to estimate these costs, we conducted two series of semi-structured interviews with the heads of household located in the VOIs on the eastern side of the Beampingaratsy forest at the end of 2011 and mid-2012. This research covered six out of 12 VOIs, representing 32,516 hectares of forest (Figure 2). In all, 100 households were interviewed. Because of the lack of any population census, we selected the householders who were at home when we visited the VOIs and who were willing to respond

to our questions. To minimize sampling bias due to this constraint, we visited 12 hamlets located in the buffer zone of the protected forest. The VOIs had been informed of our arrival prior to a meeting with local authorities on the weekly market day.

We used two proxies to measure the impact of the project on livelihoods: The change in the reported time allocated to the different agricultural activities of the household, and the change in the reported production associated with each of the agricultural activities. Changes in time were measured using the pebble distribution method developed by Colfer, Sheil and coworkers (Colfer et al. 1999, Sheil et al. 2001, Sheil et al. 2003). The pebble distribution method is a scoring procedure based on pictures which symbolize the outcomes to be scored: the counters should be attributed to outcomes according to their quantitative relationships or values. The participants are then asked to explain the final scores (Lynam et al. 2007). The pebble distribution method is appropriate in very poor areas where people are often illiterate. Pictures and physical counters help them to represent trends and serve as a basis for the discussion. As agricultural activities are likely to be impacted by conservation restrictions, we identified the different crops grown by farmers with the help of the project staff. We drew cards to represent each crop using two colours, one representing crops grown inside the forest, and the other crops grown outside the forest.

Tubers (cassava, yams, sweet potatoes) and rainfed rice were found to be the main crops in forest; fruits (banana, pineapple), coffee, tobacco and sugarcane were also grown in fields mixed with forest regeneration. In non-forest areas, irrigated rice was the main crop, with cassava and other semi-perennial tubers. There were also perennial crops such as fruit trees (litchi, mango or orange trees) mainly used for home consumption, and cash crop trees (coffee).

The interviews proceeded in two steps. First, participants were asked to distribute counters according to the time they had allocated to different crops before the project started, i.e. in 2008. We converted counters into an actual share of time by dividing the number of counters allocated to each crop by the total number of counters used (participants were free to choose the global quantity of counters they wanted to). Secondly, we asked for the quantity of production associated with each crop. For this step the counters were used as a basis for discussing agricultural production. We converted agricultural production into monetary equivalent using local market prices to calculate the income derived from each crop. We classed incomes in five groups: (i) perennial crops grown in the forest, (ii) annual crops grown in the forest, (iii) perennial crops grown outside the forest, (iv) annual crops grown outside the forest, and (v) off-farm activities.

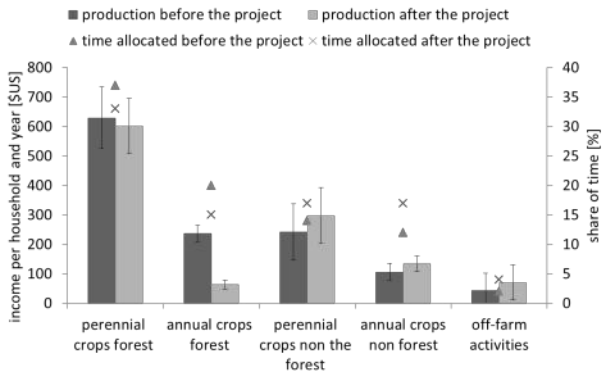

Figure 3. Changes in production value before and after implementation of the project in the affected and unaffected households (N=100, error bars indicate standard errors).

We repeated the same procedure for 2011. If changes had taken place between 2008 and 2011, we investigated causal relationships through semi-structured discussions with the participants to capture the net effect of the implementation of the protected area. We validated our identification of the households who had been affected by the implementation of the protected area with a census carried out by the team of the project that had identified the households most reliant on forest land. To estimate the net cost borne by the households affected by the project, we compared the stated changes in agricultural production between 2008 and 2011 for the two groups of households. Changes in production were calculated by subtracting production in 2008, i.e., before the implementation of the project, from production in 2011 for each household, i.e., after the implementation of the project (Figure 3). A positive income meant that production increased from 2008 to 2011, while a negative income meant production decreased from 2008 to 2011. In addition to crop cards, we added a card representing off-farm activities (small-scale mining, self-retailing, building work, basketry) and agricultural employment to measure the changes in time and income associated with off-farm activities. We also collected data on the main characteristics of the households we interviewed (e.g., family composition, age and level of education and origin of the head of family). Parametric statistics (Student's t-test) were performed with R software.

Operating and monitoring costs: Operating and monitoring costs were running transaction costs. We assumed that the direct payment scheme would be implemented in parallel with existing conservation and development activities while human resources remained constant. Our estimations referred to the costs incurred by implementing the individual compensation scheme only. Operating costs covered management costs which are administrative costs including the transportation and distribution of the compensation. As there are no bank services around the Beampingaratsy forests, we further assumed that the person in charge of the VOIs would go to the nearest town, Fort Dauphin, obtain the money, and then distribute it to the beneficiaries (one distribution event per year). Operating costs included (i) the commission of the bank in charge of the money deposit, and (ii) the transport, accommodation and expenses of people in charge of money withdrawal and distribution. The bank commission was estimated based on a former programme of direct payments to VOIs implemented by Conservation International (CI) in Didy, a rural town on the edge of the CAZ protected area (Ankeniheny-Zahamena Corridor). In this programme, the money was managed by a micro-credit institution which took a 2.5% commission. The other operating costs as well as monitoring costs were estimated using data from the accounting documents of the Beampingaratsy project at WWF regional office in Fort Dauphin. Monitoring would be undertaken on a yearly basis by the NGO in charge of project implementation to confirm that the compensation was distributed to each beneficiary, and collect forest and socio-economic data to assess changes.

Implementation costs: Implementation costs were one-off transaction costs which occurred before the start of the payments. They were composed of two activities: the identification of beneficiaries and the information and awareness campaign. The identification of beneficiaries, i.e., the households who were affected by the conservation project, would be done by Malagasy

consultants living in the Fort Dauphin area (meaning low transportation costs). We estimated these costs based on the accounting documents of the Beampingaratsy project. After identifying the beneficiaries, the implementer staff would explain the purpose of the compensation programme and present the criteria used to select the beneficiaries of the compensation. Beneficiary identification cards—which helped to identify beneficiaries as identity cards are uncommon in that place—were distributed to each individual beneficiary to inform him/her of his/her right to receive the compensation.

RESULTS

COSTS FOR LOCAL HOUSEHOLDS. Considering both changes in time allocation and in incomes, our results showed that 38 out of a total of 100 heads of household had not perceived any change in their activities, 47 stated a negative impact in their activities due to the implementation of the protected area, and 11 stated changes due to causes other than the implementation of the protected area, such as climate events, health problems, insect pests, etc. Lastly, four households reported positive changes due to the implementation of the conservation project. These farmers grew irrigated rice in the bottomlands, and they said that forest conservation had increased the water supply for their fields and improved their yields. These statements should be treated with caution, as a positive impact due to a reduction in deforestation on the water supply is yet to be confirmed and would, if such a causal relationship were to be confirmed, require time to happen (R. Vaudry 2014, pers. comm.). Instead, these perceptions can be interpreted as echoing the NGO's environmental discourse

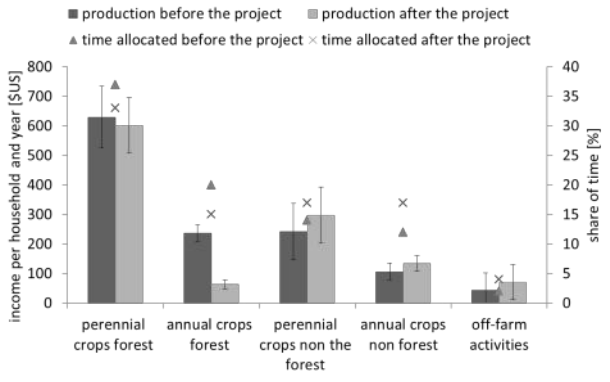

Figure 4. Perceived changes in agricultural production value (bars) and in share of time for different farming activities for affected households (N=47, error bars indicate standard errors).

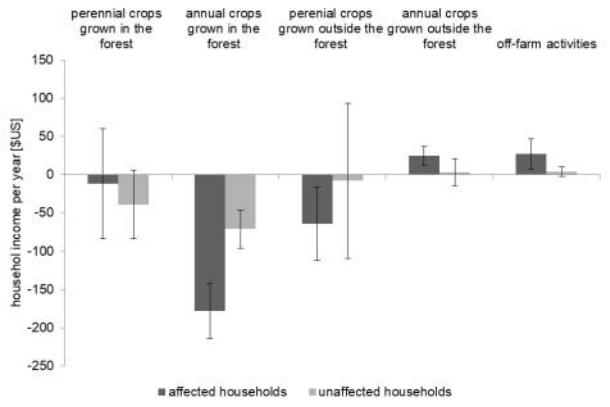

Figure 5. Perceived changes in agricultural production value (bars) and in share of time for households having stated no impact (N=53, error bars indicate standard errors).

about the link between water and forests. The 47 households who considered the changes in their activities due to the conservation project to be negative, henceforth referred to as the 'affected households' as opposed to the other 53 households, called 'unaffected households', mentioned decreasing yields as the main reason, since they were not allowed to clear undisturbed forest to access new fertile land for tavy activities. In order to adapt to this constraint, these farmers had to clear former fallow areas where fertility had been already exhausted. As a result, farmers chose to stop growing some of the crops usually grown in the forest—mainly rice—either because yield was too low, or because they preferred to set aside the land outside the forest in order to allow soil fertility to recover. Dependence on forests for this group of households appeared to be substantial (Figure 4) compared to unaffected households (Figure 5). These results showed that land use restrictions affected in particular the households who relied most on slash-and-burn agriculture.

We observed a significant decrease in the production of annual crops farmed on forest land by both affected and unaffected households. The average income from crops grown on forest land by affected households dropped from $US 238/yr to $US 64/yr (t-test, p=0.0001) and by unaffected households from $US 103/yr to $US 36/yr (t-test, p=0.04). This means that factors other than the conservation project impacted agricultural production homogeneously for both unaffected and affected households. According to our respondents, these factors were climate events, health problems of the head of household and insect pests. Conservation restrictions exacerbated such drops, since the decrease in agricultural production of the affected households was statistically greater than that of the unaffected households. The decrease in time allocation for annual forest crops fell from 20% to 15% for the affected households (t-test, p=0.05); this was not the case for unaffected households (t-test, p =0.21). The time devoted by affected households to annual non-forest crops, i.e., irrigated rice, increased from 12% to 17% (t-test, p=0.02), whereas it remained stable for the unaffected households (24% before the project and 23% after).

The difference between the affected and unaffected groups was only statistically significant for the annual crops in the forest. Affected households lost an average of $US 178/yr while unaffected households lost $US 71/yr (t-test, p=0.02); net losses due to the implementation of the conservation project were $US 107/yr per affected household. This loss amounted to around 11% of the average monetary equivalent of the total agricultural production per household.

DIRECT COMPENSATION SCHEME. In order to extrapolate such a figure to the overall east-side project implementation zone, we estimated 55% of households whose agricultural production had been affected by the project (55% is the average of our own estimation and the estimation of the census made by the project team to identify the households most reliant on forest land as previously mentioned). Thus, out of a total of 4400 households on the eastern side of Beampingaratsy some 2420 households were assumed to have been affected by the project. The overall economic agricultural cost experienced by forest populations on the eastern side of Beampingaratsy thus amounted to $US 258,940 per year.

Implementation costs included (i) the identification of beneficiaries among some 4400 households, and (ii) the information and

awareness campaign to inform beneficiaries of their right to receive the compensation. Identification of the beneficiaries would require a field survey. Assuming that a survey carried out 4 interviews per day, the survey needed 1100 man-days paid at $US 30 per day (80,000 ariary). We added $US 3000 for transport (from Fort Dauphin) and equipment (camping gear, paper forms, etc.), and we calculated that the total cost of the field survey would amount to $US 39,000 (including $US 3,000 for the design of the survey and the database).

We budgeted $US 7750 for data processing, i.e., computerization (220 man-days paid at $US 30) and the analysis of the database to draw up a list of selected beneficiaries (30 man-days paid at $US 30). We budgeted $US 2000 for the creation of beneficiary cards, and $US 2500 to organize a session to report back the results to local authorities, the people in charge of the VOIs, and the local population.

Operating costs covered compensation money management and annual withdrawal: We assumed that the bank commission would be 2.5% of the total deposit ($US 258,940), i.e., $US 6475. Regarding the cost of the withdrawal of money by the people in charge of the VOIs, we budgeted $US 80 per VOI per year for transport, accommodation and per diem i.e., $US 960 per year for all the VOIs. Monitoring costs covered the annual field survey made by the implementer staff to check that compensation had been distributed to each beneficiary, and collect forest and socio-economic data to assess changes. The cost of the annual field survey was the same as the initial field survey, which explains why the operating and monitoring costs were very similar to the implementation costs.

The estimated total cost of implementing direct compensation scheme to the households affected by the implementation of the project was $US 361,375 for the first year, and $US 310,125 in subsequent years. Related to the size of forest in VOIs located on the eastern side of the Beampingaratsy forest (32,516 hectares), the cost was around $US 11 per hectare the first year, and around $US 10 per hectare per year the subsequent years. Related to the number of households in these VOIs (4400 households), the cost was around $US 82 per household the first year, and $US 70 per household per year the subsequent years. If we added to our estimation the current operating budget of the project ($US 150,000 during the first implementation phase, i.e., $US 50,000 per year), the overall cost amounted to $US 411,375 the first year, and $US 360,125 in subsequent years (Tables 2 and 3). Related to the size of the forest in the study zone (32,516 hectares), the cost was around $US 13 per hectare the first year, and around $US 11 per hectare per year the subsequent years. Related to the number of households living in this area (4400 households), the cost was around $US 93 per household the first year, and $US 82 per household for the subsequent years.

DISCUSSION

This paper estimated the overall cost of implementing an individual compensation scheme as part of a REDD+ project in Madagascar. Assessing the impact of conservation restrictions on forest land use on local livelihoods, we found that about half of the 4400 households in the study area were affected by the project. The average loss was $US 107 per household per year, which amounted to about 11% of the average monetary equivalent of the total agricultural production per household. Our results showed that the time devoted by affected households to irrigated rice increased from 12% to 17%: the conservation project probably incited the affected households to reallocate their time from slash-and-burn agriculture to the cultivation of irrigated rice. However, we did not detect a statistically significant simultaneous increase in production for any of the two groups. This result might respond to two (non-exclusive) factors; first, the increase in labour input was too

Table 1. Yearly costs of implementing a direct compensation scheme.

Categories of costs	Details	Detailed budget [in $US]	Aggregate budget [in $US]
Compensation costs	$US107 per household (2,420 households)	258,940	258,940
Implementation costs (only the first year)	Methodology and database design	3000	
	Field survey	36,000	
	Survey analysis	7750	
	Beneficiaries' identification cards	2000	
	Reporting and distribution of beneficiaries' cards	2500	
	Sub-total		51,250
Functioning and monitoring costs	Bank fees (in Fort Dauphin)	6475	
	Cash withdrawal	960	
	Field survey	36,000	
	Survey analysis	7750	
	Sub-total		51,185
Total for the first year			361,375
Total for subsequent years (without implementation costs)			310,125

Table 2. Summary of the cost estimates.

		Total per year [$US]	Per hectare per year [$US]	Per household per year [$US]
Direct payments scheme	Opportunity costs	258,940	8	59
	Transaction costs (first year)	102,435	3	23
	Transaction costs (subsequent years)	51,185	2	12
Subtotal (first year)		361,375	11	82
Subtotal (subsequent years)		310,125	10	70
Current operating budget	Investment costs	32,500	1	7
	Transaction costs	17,500	1	4
Subtotal		50,000	2	11
Total (first year)		411,375	13	93
Total (subsequent year)		360,125	11	82

small to be translated into higher production, particularly given that initiating irrigated agriculture requires a significant amount of work to build terraces and level the land—it then gradually requires less work and yields higher production—and second, inputs other than labour were required to improve agricultural yield, including soil fertility and agricultural techniques.

We then estimated the transaction costs of implementing a direct compensation scheme, and we obtained an overall cost of $US 361,375 for the first year and $US 310,125 in subsequent years because of start-up costs. Transaction costs accounted for a substantial share of the cost of implementing a PES scheme, a finding that was in line with what some other authors have highlighted (e.g., Norgaard 2010, Pirard 2012). Our study showed that transaction costs made up 29% of the overall costs the first year and 19% the subsequent years. The cost of compensating affected households was high compared to the current funding levels of the REDD+ project. The current budget devoted to field activities (e.g., community-based natural resource management, development activities, tree planting) in the eastern part of Beampingaratsy was about $US 50,000 in the last budgeted year of the project, which is more than seven times less than the budget required for implementing the compensation scheme. This article therefore confirms that compensating local populations entails significant costs, especially when poor populations (i.e., with a low opportunity cost) are concerned.

Funding tropical conservation has been difficult for many years, and the current financial crisis in industrialized countries has worsened it. The possibility of funding from the carbon voluntary market and the REDD+ mechanism was tangible at the time the project was conceived and its implementation started, but currently the voluntary carbon market is saturated, many projects are unable to sell their carbon credits, and REDD+ projects on a local scale are no longer supported by institutional donors such as the World Bank, which supports 'jurisdictional' programmes on a much larger scale (Seyller et al 2016). Balmford and Whitten (2003) concluded that the lack of funding was mainly due to political interests. This still holds true when we consider the amounts of money spent on REDD+ readiness programmes (expertise, workshops, negotiations, etc.) and the tiny share that actually goes to local populations (Bidaud 2012). Regarding the REDD+ national strategy, the budget estimated for Madagascar was $US 7.378 million, of which 65% was for scientific activities, such as carbon stock measurement (FCPF 2013). It is to be hoped that the financial commitments made by developed countries at the last Conference of the Parties (COP21) in Paris for mitigation and adaptation to climate change—$US 100 billion are expected for developing countries by 2020 to implement action for mitigation and adaptation to climate change—will breathe new life into the funding of conservation and development field activities.

Aside from the financial constraints, other factors may explain why some conservation NGOs and the Government of Madagascar do not implement direct compensation. First, legal arguments can be mentioned, as farmers have long been compelled by law to stop slash-and-burn agriculture in primary forest. During a research meeting at the University of Antananarivo in 2012, an NGO representative replied to criticisms about the absence of compensation for the costs borne by local peasants saying that NGOs and the State are not obliged to pay compensation for stopping primary forest clearance as it is in any case against the law. This means the customary rights of local populations on natural resources are not actually recognized in spite of the management transfers. Second, we cannot exclude the possibility that compensating households can create perverse effects, especially by attracting new migrants from neighbouring areas (even though the control of new migration can be part of the PES contracts proposed to communities). Other consequences may be related to the nature of the compensation. Compensating with cash can entail a loss of intrinsic motivation, rendering future conservation actions more expensive and difficult to fit in with the local population. Aligning in-kind compensation with local motivation might be a strategy for minimizing such risks (Rode et al., 2015). Third, in a context of limited financial means and uncertainty about the future of carbon funding, conservation NGOs may prefer to concentrate their money on development activities rather than combining them with direct compensation, in the hope that benefits from investments in rural development would continue even after the project ends.

Our study showed that the perceived changes in livelihoods from conservation restrictions pointed in the direction of a major disruption to the local populations' agricultural subsistence practices. Aware of such a situation, and after numerous exchanges with the authors of this study, Etc Terra decided to increase the project's investment in agricultural innovation to improve irrigated rice yields through better growing techniques, slash-and-burn fertility improvement through agro-ecological techniques, and support for the development of cash crops (Etc Terra 2015). Such a turn in the REDD+ project implementation strategy is in line with the numerous informal discussions we had with local farmers on their need for agricultural support, in particular for the construction and maintenance of water infrastructure for irrigated rice. By implementing individual compensation until the new agricultural systems become operational and in parallel with agricultural investments, affected households would more likely experiment with innovative techniques and increase the project take-up and overall legitimacy. Individual compensation would thus be part of a mix of conservation and development instruments including protected areas, management transfers and agricultural investments. They may play the role of safety nets and help farmers, especially the most vulnerable ones, to test innovative agricultural techniques.

In this paper we adapted the pebbles distribution method to capture households' declarative statements about the changes in their agricultural production before and after the project. This method was based on reconstructed and stated data, and was therefore sensitive to the interviewee's subjectivity. Nevertheless, the pebble distribution method has proved reliable in numerous research activities to capture consistent data trends (Colfer et al. 1999, Sheil et al. 2001, Sheil et al. 2003). A systematic flaw in the reported perceptions would have prevented our analysis from capturing statistically significant differences between affected and unaffected households. In addition, we confirmed our categorization between affected and unaffected households by double-checking with the WWF local team household field census. Lastly, our estimated economic compensation provided the most up-to-date figures when compared to available studies: Shyamsundar and Kramer (1996) found that households would accept 185 kilograms of rice per year to stop using forest located within the conservation zone of the Mantadia protected area, while in our case study, $US 107 amounted to 284 kg of rice, and Ferraro (2002) estimated that stopping deforestation costs would range from $US

59 to 216 per household and per year in the Ranomafana corridor (we updated Ferraro's estimate taking into account the inflation rate since 2002 (INSTAT 2015)).

Individual compensation would be part of a mix of conservation and development instruments to increase both the long-term environmental and social efficacy of the REDD+ projects in Madagascar. They could also increase the legitimacy of the projects, on local, national, and even international scales. Much criticism has surfaced in Madagascar and abroad since the Government decision to increase the size of the protected area network: conservation NGOs are blamed for "economically displacing" some of the poorest people on the planet. The Madagascar Environmental Justice Network is representative of this movement which brings together scholars, activists and professionals to denounce the social impacts of the natural resources policy in Madagascar[1]. By adequately compensating the local population, individual compensation may facilitate the political acceptance of conservation policies.

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ARTICLE

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Grass survey of the Itremo Massif records endemic central highland grasses

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ABSTRACT

Despite the substantial area covered by grasslands in Madagascar (65%), the taxonomy of the grasses (Poaceae), which represent the main plant component of these vegetation types, is still understudied. Inventories and detailed specimen identification work from 12 localities in the Itremo Massif Protected Area allowed us to compile a list of grasses present in the area. In total, members of eight subfamilies, 56 genera, and 99 species have been recorded from the Itremo Massif. Grasslands cover 75% of the Itremo Massif Protected Area and are dominated by Panicoideae (65%) and by C_4 plants. The genera *Eragrostis* and *Panicum*, with nine and eight species respectively, are the best represented genera in Itremo. *Eragrostis betsileensis* and *Tristachya betsileensis* are the two species known to be local endemics. Twenty species are endemic to the central highlands, and a further 14 species are restricted to Madagascar. Five ecological groups of grasses were identified in the Itremo Massif: shade species in gallery forests, open wet area species, fire grasses, anthropogenic disturbance associated grasses and rock-dwelling grasses. Grasslands of the Itremo Massif are likely to be at least partly natural as shown by their richness in terms of endemic and native grass species. Conservation of such grasslands is thus an important issue, not only for grasses but for all species that inhabit these open canopy habitats.

RÉSUMÉ

Malgré la superficie importante occupée par les formations herbeuses de Madagascar (65%), la taxonomie des graminées (Poaceae) dominant ces écosystèmes reste mal connue. Les inventaires effectués dans 12 localités de l'Aire Protégée (AP) du Massif d'Itremo et les travaux d'identification nous ont permis de dresser une liste des espèces de Poaceae de la région. Au total, la liste établie est composée de huit sous-familles, 56 genres et 99 espèces dont la sous-famille des Panicoideae (65 %) et des espèces à photosynthèse en C_4 sont les taxons dominants. Les genres *Eragrostis* et *Panicum*, avec respectivement neuf et huit espèces, sont les mieux représentés. *Eragrostis betsileensis* et *Tristachya betsileensis* sont les seules espèces localement endémiques, tandis que 20 espèces sont endémiques des hautes terres du centre, et 14 sont endémiques de Madagascar. Cinq groupements de Poaceae qui correspondent à des milieux différents ont été identifiés au sein de l'AP : les espèces ombrophiles des forêts galeries, les espèces de milieux humides ouverts, les espèces associées au feu, les espèces rupicoles et les espèces anthropiques. Les formations herbeuses de l'Itremo seraient au moins en partie d'origine naturelle et ancienne, comme le suggère leur richesse en espèces endémiques et indigènes, et méritent donc d'être conservées, non seulement pour les Poaceae mais pour toutes les autres espèces qui y cohabitent.

INTRODUCTION

Grasses are members of the plant family Poaceae, and are primarily known for their critical role in food provision. Cultivated rice *Oryza sativa* L., maize *Zea mays* L., and sugar cane *Saccharum officinarum* L. are all members of this family. In 2015, 1.104 billion tonnes of these cereals were produced for human consumption (FAO 2015). The second critical role of grasses is their cornerstone function in many of the world's ecosystems. Grasslands as defined by the FAO cover about 26% of the land on Earth (FAOSTAT 2000), and 65% of Madagascar (Moat and Smith 2007). Open canopy vegetation types with a grassy understory have a history of being undervalued compared to closed canopy forest, even when they are known to represent ancient ecosystems (Bond and Parr 2010, Parr et al. 2014, Bond 2016). Many grassy biomes have only recently been recognised as natural and valuable ecosystems (e.g., Bond et al. 2008, Vorontsova et al. 2016). Multiple authors documenting the vegetation of Madagascar (e.g., Koechlin et al. 1974) have traditionally assumed that Malagasy grasslands are degraded formations resulting from the destruction of climax forests.

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Despite their critical role in the landscape, Malagasy grasses have been poorly studied taxonomically, causing a significant species knowledge gap not only in the flora of Madagascar but also in that of the world (Bond et al. 2008). The only comprehensive taxonomic reference published to date is that by Bosser (1969) in his book *Graminées des pâturages et des cultures à Madagascar*, which is limited to the central highlands and accounts for approximately half of the island's grass species diversity. Recent progress has been made in documenting Madagascar's bamboos, but much remains to be done (Dransfield 1998, 2000, 2003). Accurate grass identification requires careful microscope observation of the reproductive organs, in addition to high quality collection of reference specimens. The superficial similarity of unrelated taxa, the complexity and small size of the flowering structures, and the frequently incomplete specimens can make the identification process challenging, and this has previously discouraged collecting activity. In the national herbarium of the Parc Botanique et Zoologique de Tsimbazaza, Antananarivo (TAN), the majority of grass collections identified to species level are relatively old, largely collected between 1960 and 1970 by the French botanists Jean Bosser and Philippe Morat. This study is part of an ongoing project seeking to document grasses and grasslands of Madagascar, working towards a taxonomic revision of all Poaceae of Madagascar (Vorontsova et al. 2013, Vorontsova and Rakotoarisoa 2014), carried out by the Royal Botanic Gardens Kew and the Kew Madagascar Conservation Centre (KMCC).

This study evaluates the grass diversity in the Itremo Massif Protected Area. We establish a list of species, present an identification key, and survey ecological preferences of the species, building a knowledge platform to study the origin of grasslands in this area.

STUDY SITE

The Itremo Massif Protected Area (PA), managed jointly by the local community and KMCC, was chosen to study the grasses of the Malagasy central highlands. The Itremo Massif PA covers an area of 24 788 ha dominated by grassy biomes (70% of the land area). The choice was justified by an increasing knowledge base of Itremo's flora following ongoing study by the KMCC (Kew Madagascar Conservation Centre 2012). The Itremo Massif PA has been established as a protected area in 2015 (established by decree n° 2015-713 of the Ministry of Environment, Ecology, Sea and Forests), and is located in the southern part of the central highlands. The Itremo Massif is 117 km west of Ambositra, Ambatofinandrahana district, Amoron'i Mania Region, ex-Province of Fianarantsoa, between E046°38'10" and E046°14'35" longitude, and S20° 35' 40" and S20° 35' 36" latitude (Figure 1).

The Itremo Massif PA is surrounded by three villages and two rivers: Itremo village in the east, Amborompotsy and Mangataboahangy villages in the west, Mania river in the north and Matsiatra river in the south. The landscape is dominated by plains interspersed with rocky outcrops. These are composed of micaschistes (at lower elevation; ca. 500 m), quartzite (from 700 to 1500 m), dolomitic marbles (from 900 to 1000 m) and marbles at the summit (> 1500 m; Birkinshaw et al. 2008). Itremo Massif has a subhumid bioclimate, characterized by dry and rainy seasons, an annual average temperature of 19.5°C and an annual average rainfall of 1416 mm, with December, January and February being the wettest months of the year (Cornet 1974; Birkinshaw et al. 2008).

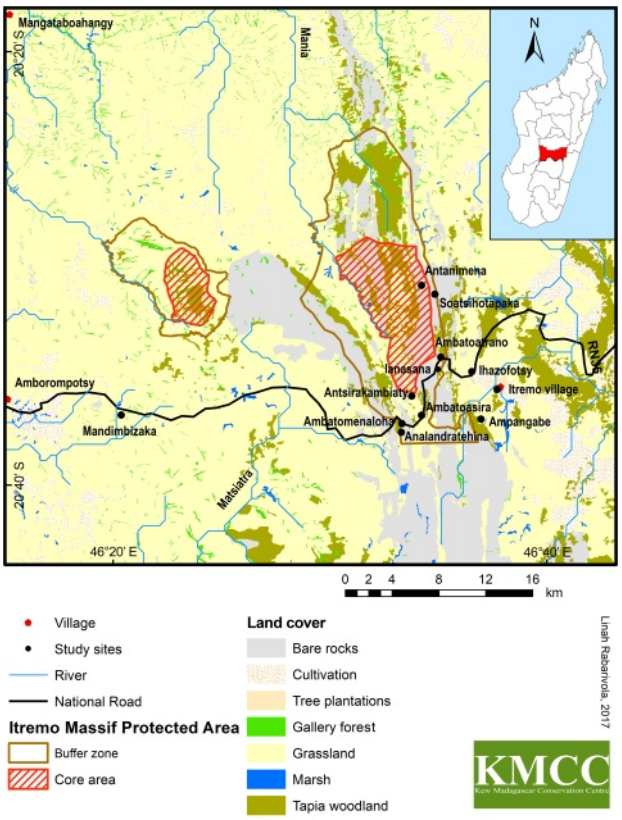

Figure 1. Vegetation map of the Itremo Massif Protected Area. (Map by Linah Rabarivola and the Kew Madagascar Conservation Centre. Study sites are marked with black circles; the checklist also includes older herbarium specimens collected throughout the area with no specific location data)

The Itremo Massif PA is home to 549 known species of plants in 278 genera and 99 families, with 77% of species endemic to Madagascar, and 30 local endemics (Kew Madagascar Conservation Centre 2012). The vegetation of Itremo Massif is composed of gallery forests, tapia forests, grasslands, swamps, and rock outcrops, as well as secondary vegetation types (Birkinshaw et al. 2008, Kew Madagascar Conservation Centre 2012).

METHODS

A field inventory of the grasses was carried out in all habitats of Itremo during repeated visits by the first author in March 2013, February 2014, and June 2014. Local sites surveyed include Ambatoatrano, Ambatoasira, Ambatomenaloha, Ampangabe, Analandratehina, Antanimena, Antsirakambiaty, Ianasana, Ihazafotsy, Itremo village, Mandimbizaka, Soatsihotapaka (Figure 1). Every fertile grass suspected of being a distinct species was collected to make herbarium vouchers distributed to Tsimbazaza (TAN), Kew (K) and Paris (P) herbaria (abbreviations fide Thiers 2015). Habitat metadata, photographs, and silica gel samples were collected, and data were recorded in a BRAHMS (2015) database. Images of all the genera are available online at <https://goo.gl/uqyCtJ>. Previous collections of grasses in Itremo made by M. S. Vorontsova and by KMCC were added to the dataset as well as all Itremo Poaceae specimens held at K and P herbaria. Occurrence records were used to compile a list of species characteristic of each habitat type.

Reliable species-level identification of the grasses requires dissection of the spikelet, as the spikelet contains almost all characters distinguishing genera and species. Spikelet structure was recorded, including the composition of glumes, florets, lemmas,

paleas, the number of veins and the placement of indumentum, and the size of all spikelet parts. Full drawings of the spikelet dissections were made for at least one member of each genus (example presented in Figure 2). Identification was carried out by reference to existing herbarium collections, and using keys in Bosser (1969), Clayton (1970), Clayton et al. (1974), Clayton and Renvoize (1982), Vorontsova et al. (2013) and Kellogg (2015). The keys were modified and adapted to create an identification key to Poaceae species of Itremo (Supplementary material). Species distribution data are from the World Checklist of Selected Plant Families (2017) and from taxonomic work by the authors. Data on the photosynthetic system is from Osborne et al. (2014) and Kellogg (2015).

RESULTS

POACEAE DIVERSITY. The grasses are a species-rich family represented in the Itremo Massif PA by 56 genera and 99 species (Table S1). These can be identified using the keys provided in the Supplementary Material. Grasses are the most diverse plant family in the Itremo Massif PA. Within the Poaceae these species belong predominantly to the tropical PACMAD clade (Panicoideae, Arundinoideae, Chloridoideae, Micraioideae, Aristidoideae, and Danthonioideae, 92%), with some also belonging to the temperate BEP clade (Bambusoideae, Ehrhartoideae, and Pooideae, 8%). They belong to eight subfamilies and 14 tribes within the Poaceae according to the classification by Kellogg (2015). With 64 species, the common tropical mesic environment group Panicoideae is the best represented subfamily, followed by the tropical arid subfamily Chloridoideae with 20 species. The temperate Pooideae and the bamboos (Bambusoideae) are represented by just five and three species, respectively. Aristidoideae, Arundinoideae and Micraioideae are represented by two species each. The rice relatives Ehrhartoideae are represented in the Itremo Massif PA by only one native species, *Leersia hexandra*. The genera *Eragrostis* and *Panicum sensu lato* are the most diverse with nine and eight species respectively. Common tropical grass genera of Africa including *Andropogon*, *Brachiaria* (note these have not been moved to the genus *Urochloa* due to their diverse phylogenetic placements not currently fully resolved), *Oplismenus*, *Setaria*, *Sporobolus*, *Digitaria* and *Hyparrhenia* are moderately diverse and represented by three to five species each. The remaining 47 genera are represented by a single species each. Species with the C_4 photosynthetic system predominate with 68 species, suggesting a flora adapted to open and seasonally dry habitats.

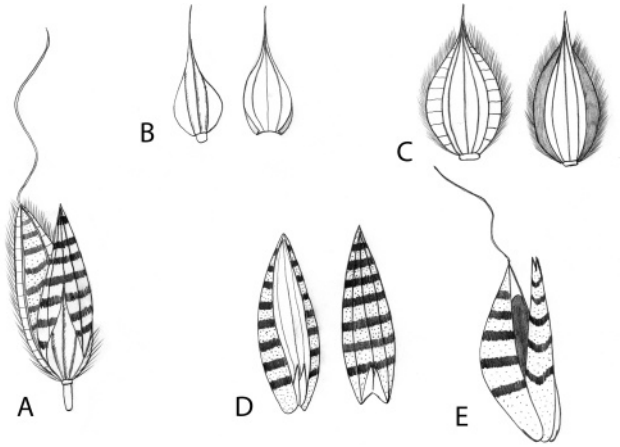

Figure 2. Spikelet dissection of *Alloteropsis semialata*, illustrating dissection work carried out in order to identify grasses through their spikelet structure. (A: spikelet (9 mm long including awn); B: lower glume, dorsal and ventral views (4.5 mm long); C: upper glume, dorsal and ventral views (6 mm long); D: lower floret, ventral and dorsal views (5 mm long); E: upper floret, the upper lemma with awn shown on the left hand side, the immature grain inside (9 mm long including awn). Drawing by Nanjarisoa Olinirina Prisca from *Nanjarisoa 23*, Ampangabe, collection made on 26 March 2013)

POACEAE BIOGEOGRAPHIC AFFINITIES. The ecological preferences and distribution ranges of the 99 species of Poaceae in the Itremo Massif PA are presented in Table S1 and Figure 3. Two of the species (2%) are narrow endemics only known from the Itremo Massif PA: *Eragrostis betsileensis* and *Tristachya betsileensis* (Figure 4). Despite the comparatively low local endemicity, 22 of the species recorded (22.2%) are restricted to the central highlands and a further 12 (12.1%) are endemic to Madagascar. Overall, 36 of the grass species (36.4%) are endemic to the island. The majority of the species (59 species, 59.6%) are thought to be native to Madagascar and also occur in other parts of the world, predominantly in tropical Africa. Only four species have been recorded as likely introduced, a figure which is highly uncertain due to poor records of species origins. The native versus introduced status of Madagascar's grasses is largely unknown and challenging to establish. We have tentatively assigned native status to the majority of African grasses following notes by Bosser (1969), long term taxonomic work by the last author, the authors' personal impression of similarity to African ecosystems, and limited data indicating significant genetic diversity within Malagasy *Aristida* (Besnard et al. 2014, Hackel et al. 2017).

POACEAE HABITAT PREFERENCES. The greatest diversity of grasses was recorded in fallow fields (41 species, 41.4%) and roadsides (37 species, 37.4%). Both of these habitats are rich in C_4 grasses, particularly from the subfamily Chloridoideae, which are adapted to arid conditions. The characteristic species of fallow fields and roadsides are those commonly observed in disturbed areas all over Madagascar: *Chloris pycnothrix*, *Cynodon dactylon*, *Eragrostis tenuifolia* and *Cenchrus polystachios* (Table 1). Environmental heterogeneity was noted as particularly high in the disturbed areas, likely indicating increased species turnover with

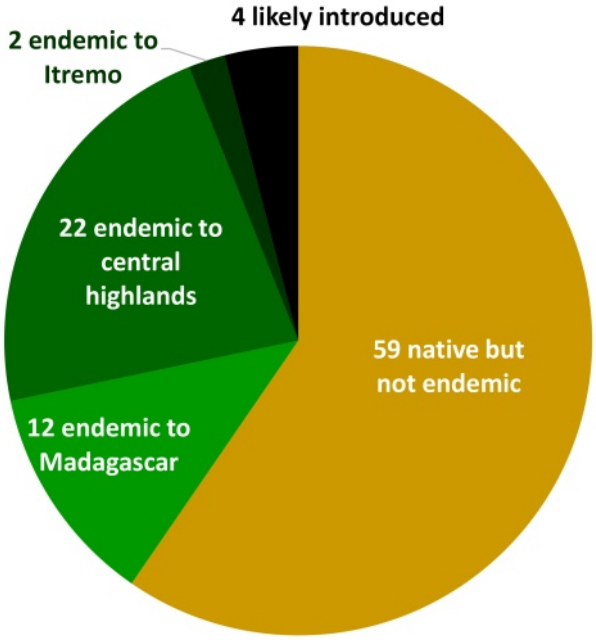

Figure 3. Distribution ranges and likely native/introduced status of the 99 grass species recorded in Itremo.

Figure 4. *Tristachya betsileensis*, locally endemic to Itremo. (Spikelets 12 mm long; live plant scanned using an Epson 10000XL scanner)

dispersal occurring along the road and associated with movement of zebu. The natural habitat with the greatest species diversity was the tapia forest (37 species) and the majority of its grasses were the same as those found in the grassland (34 species). Five species endemic to the highlands were reported in tapia and grasslands, these two habitats sharing a similar continuous grassy understory: *Andropogon ibityensis*, *A. itremoensis*, *Panicum cinctum*, *P. ibityense*, and *P. perrieri*. The highest endemicity was observed on the rocky outcrops. Almost all rocky outcrop grasses sampled are endemic to the central highlands. The Itremo endemic *Tristachya betsileensis* is restricted to these outcrops (Figure 4). One C_3 species (*Styppeiochloa hitchcockii*) highly tolerant of desiccation and able to recover rapidly was also reported in this habitat. The grass flora of gallery forests and marshes, swamps and streamsides (group I: high moisture habitats protected from fire) is clearly distinct from tapia, grassland, rocky outcrops, and disturbed places (group II: dry and sunny habitats with regular fire). Habitats associated with high moisture and no fire are home to a notably diverse Poaceae flora with 33 species recorded in the gallery forests and 32 species in open wet habitats. These are also home to the greatest diversity of subfamilies: Bambusoideae (bamboos) and Ehrhartoideae (rice relatives) have only been recorded in the high moisture and no fire habitats. Species judged to be characteristic of each habitat and their environmental correlates are presented in Table 1.

DISCUSSION

POACEAE DIVERSITY. The Itremo floristic data summary compiled by the Missouri Botanical Garden in 2008 listed 27 species of Poaceae (Birkinshaw et al. 2008). This study has increased threefold the number of grasses recorded, now reaching 99 species. Twenty of these species (including the three endemic bamboos) do not appear in the standard reference book of Madagascar grasses by Bosser (1969). The sharp increase in the number of recorded species has been achieved by our first ever targeted Poaceae survey of this area, which redressed a long-term bias against botanical collecting in similar grassland areas, previously assumed to be botanically depauperate (e.g., Lowry et al. 1997). Specialist skills of spikelet structure observation, working with Poaceae taxonomic reference literature, as well as the use of international herbaria have also made this possible, since some of the species were not represented or not correctly named at TAN. We demonstrate that specialist studies of grasses can reveal previously undocumented diversity. This study presents the first reference list of Itremo Poaceae species and their habitats, to be used in the management of the PA as well as for future diversity and ecosystem research. The subfamily and genus identification keys written during this study are the first for the Itremo Massif PA. We hope that with these keys, other botanists will be able to identify grasses from Itremo and other parts of the highlands.

The new total of 99 Poaceae species in Itremo PA is significantly higher than previous regional grass studies published for Madagascar. This likely reflects a lack of deliberate effort to record the grasses by Lewis et al. (1996) who listed only 18 species in Andringitra National Park, and Gautier (1997) who listed 42 species in the Manongarivo Reserve. The Poaceae specialist Morat (1973) lis-

Table 1. Poaceae species judged to be characteristic of Itremo's habitats.

Groups	Subgroups	Habitats	Characteristic species
Group I: Damp area grasses, require permanent soil moisture	**Subgroup 1:** Shade species, require significant shade, do not tolerate strong sunlight	Gallery forest	*Brachiaria epacridifolia, Brachypodium madagascariense, Isachne mauritiana, Hickelia madagascariensis, Oldeania itremoensis, Oplismenus hirtellus, Oplismenus flavicomus, Oplismenus compositus, Saccharum perrieri, Acroceras boivinii, Pseudobromus breviligulatus, Panicum mitopus*
	Subgroup 2: Open wet habitat	Marshes and swamps, streamsides	*Adenochloa hymeniochila, Calamagrostis emirnensis, Ischaemum polystachyum, Setaria sphacelata, Trichopteryx dregeana*
Group II: Dry area grasses, require prolonged exposure to sunlight	**Subgroup 3:** Anthropogenic grasses (highly tolerant to disturbance); i.e., ruderal species, weeds of cultivation and roadside	Roadsides, fields	*Chloris pycnothrix, Cynodon dactylon, Cenchrus polystachios*
	Subgroup 4: Fire grasses; tolerant of frequent burning or dependent on it	Tapia forest, grassland	*Andropogon ibityensis, Andropogon itremoensis, Ctenium concinnum, Digitaria ciliaris, Digitaria pseudodiagonalis, Panicum cinctum, Panicum ibityensis*
	Subgroup 5: Rock grasses	Rocky outcrops, schiste, quartzite, marble, basalt	*Andropogon ivohibensis, Oldeania ibityensis, Setaria bathiei, Styppeiochloa hitchcockii*

ted 43 species in Madagascar's southwestern grasslands (species list adjusted to modern taxonomic concepts), which is close to the 34 species we record in Itremo grassland and 37 in Itremo tapia forest. The overall species richness and subfamily composition of Madagascar's grass flora is remarkably close to that of East Africa (Bond et al. 2008; Vorontsova et al. 2016) and most of Madagascar's endemic grass lineages have arrived from tropical Africa (Hackel et al., 2017), leading to the expectation that regional grass checklists in Madagascar may be similar to those in Africa. Specialist Poaceae checklists in three much larger areas of Tanzania have recorded 123 grass species in the Mkomazi National Park (Vollesen et al. 1999), 200 in the Serengeti Ecosystem (Williams et al. 2016), and 239 in the Selous Game Reserve (Vollesen 1980). This is the first study to present regional grass diversity in Madagascar as comparable to equivalent ecosystems in Tanzania.

POACEAE ENDEMICITY. Poaceae endemicity for Itremo is documented here for the first time: 36 species (36.4%) are endemic to Madagascar, and these are present across all vegetation types except the disturbed roadsides and fallow fields. More than a quarter (28%) of the species found in the grasslands are endemic, 38% of those in the tapia forests are endemic, as well as 30% of those on rocky outcrops. For Madagascar as a whole, 217 of 541 grass species are endemic. This country wide endemicity level of 40% is low compared to Madagascar's other plant families (e.g., Buerki et al. 2013), but Poaceae are unlike other families in their broad distribution ranges and lower levels of endemism across the world (e.g., Sandel et al. 2017). Poaceae endemicity in the Malagasy floristic region is in fact in line with other subtropical islands, or somewhat higher than other subtropical islands (Vorontsova et al. 2016). Hence Poaceae endemicity in Itremo is in line with the expectations for a Malagasy natural grass flora.

POACEAE SPECIES ECOLOGY. Our species inventory has documented a complex flora with a different group of grasses defining each of Itremo's habitats, in accordance with their adaptations and evolutionary niches. There is a broad division between two types of strategies: C_3 often broad-leaved forest grasses and bamboos tend to be restricted to high moisture, often shaded, fire protected gallery forest and riverine environments (Table 1: group I), while generally C_4 frequently erect and caespitose species are found in drier open-canopy regularly burned ecosystems (Table 1: group II). Each of these two habitat types is home to endemic species, but the frequently burned habitats of group II have a particularly large number of species restricted to the highlands: *Andropogon ibityensis, Andropogon itremoensis, Panicum cinctum, Panicum ibityense, Andropogon ivohibensis, Oldeania ibityensis, Setaria bathiei,* and *Styppeiochloa hitchcockii*. Grasses of the quartz and marble rock outcrops have the most restricted distribution ranges. Tapia forest and grassland have almost the same continuous Poaceae ground layer, although some species preferentially grow in the tapia forest (i.e., *Panicum ibityense* and *P. perrieri*).

GRASSLAND ORIGINS AND CONSERVATION. Total Poaceae diversity in Itremo correlates with fire, sharp elevational gradients, strong disturbance, and high exposure to sunlight, as expected for a largely C_4 flora with anatomic and biochemical adaptations that allow limiting photorespiration in exposed environments (Sage et al. 1999; Sage 2004). Sixty-eight species (69%) of the Itremo Poaceae have a C_4 photosynthetic system, including seventeen out of 36 Madagascar endemics (47% of Itremo endemic grasses are C_4). Hackel et al. (2017) have documented 45 C_4 grass lineages endemic to Madagascar, with divergences and crown ages compatible with the Miocene grassland expansion 3–8 million years ago (Edwards et al. 2010, Strömberg 2011). It seems plausible that Itremo's C_4 grasses diversified and established the grass-dominated ecosystems as part of the global Miocene grassland expansion. However, it is worth noting here that the model of C_3 versus C_4 photosynthetic types signifying open versus closed canopy vegetation is an oversimplification: the different C_4 grass clades have different C_4 subtypes which occupy quite different ecophysiological niches (Visser et al. 2012, Christin and Osborne 2014). The history of Madagascar's grasses and grasslands is a complex story which needs to be studied carefully by detailed functional ecology studies for the different ecoregions and habitats, clades, and functional groups.

Malagasy grassland has traditionally been assumed to constitute secondary vegetation resulting from human-driven forest degradation (Perrier de la Bâthie 1921, Humbert 1927, Koechlin et al. 1974). A relatively recent shift in thinking has suggested that considerable parts of Malagasy grasslands could be both natural and ancient (Bond et al. 2008, Willis et al. 2008), likely part of the global C_4 grass biome expansion during the Late Miocene–Pliocene (Strömberg 2011, Hoetzel et al. 2013). The commonly cited figure of 90% forest loss across Madagascar has now been thoroughly discredited (McConnell and Kull 2014) and may be nothing but a bibliographic myth (Lowry et al. 1997). Understanding the difference between old growth grasslands and superficially similar secondary vegetation (severely degraded forests, or derived open woodlands) is a complex task (Veldman 2016) which is outside the scope of this study. It is generally agreed that old growth grasslands frequently differ from secondary vegetation by their greater species diversity, and greater species endemicity (e.g., Parr et al. 2014, Veldman et al. 2015, Veldman 2016). Our results demonstrate a high diversity (34 species) and a significant level of endemicity (13 species, 40%) of Poaceae in grasslands of the Itremo Massif PA. Our results thus lend support to possible natural origins of Itremo grasslands. Experimental studies on vegetation response to fire and disturbance regimes are required for further understanding of the likely history of these systems.

These ecosystems need protection to preserve their unique species. Tapia forests and rocky outcrops are already included in the conservation target sites in the Itremo Massif PA, and we suggest grassland could be included in the future. A grassland conservation strategy can only be achieved by first gaining a greater understanding of grassland histories and functional types, something which has not previously been attempted for the central highlands. Moat and Smith (2007) admit their failure to distinguish between the many kinds of open canopy vegetation primarily due to their high seasonality, and a specialist study of these formations is needed. Yet another research gap currently preventing the formation of a grassland conservation strategy is our lack of knowledge of herbaceous non-grass plants found in the grassland understory.

CONCLUDING REMARKS

The first specialised taxonomic inventory of the Itremo Massif Poaceae has revealed this family to be the most diverse of the new protected area, with 99 species in 56 genera and all but four of

these believed to be native to the area. Endemicity is low compared to other plant families but in line with the rest of Madagascar's grasses, and high compared to grasses in other parts of the world: 36.4% of the species are endemic to Madagascar, including 22.2% which are restricted to the central highlands, plus two local endemics. As expected, forest grasses intolerant of fire are largely C_3 and form an ecological group distinct from the open canopy grasses which burn regularly and are largely C_4. Significant levels of diversity and endemicity across multiple habitats are comparable to the complex and specialised grass floras of Tanzanian protected areas. The natural habitat with the greatest species diversity is the tapia woodland and the majority of its grasses are the same as those found in the grassland, suggesting ecological similarity between tapia and grassland. More than half of Itremo's grasses are C_4, approximately half of all endemics are also C_4, and these have likely diversified across Madagascar during the global Miocene grassland expansion around 3–8 million years ago. Our data are insufficient for any conclusions on ecosystem identity or origins: nevertheless, this first record of grass diversity and grass endemicity in the grasslands as well as all the other vegetation types is in line with what we would expect to see in natural ecosystems.

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SUPPLEMENTARY MATERIAL

Available online only

Table S1. List of Poaceae species recorded in the Itremo Massif Protected Area, their habitats, distribution ranges, and photosynthetic types. (Please note that the native versus introduced status of Madagascar's non-endemic grasses is largely unknown and challenging to establish, and the status presented here is a preliminary one with little data available to support it. In contrast, the endemicity data are presented here with support from herbarium work and a literature review)

Supplementary material 1. Key to the subfamilies of grasses found in the Itremo Massif.

Supplementary material 2. Key to the genera of grasses found in the Itremo Massif.

ARTICLE

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Trade of parrots in urban areas of Madagascar

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ABSTRACT

The live capture of parrots is causing increasing concern across Africa. In Madagascar, home to three species of parrot (*Coracopsis nigra, C. vasa, Agapornis canus*), no study has examined how these species are being extracted from the wild and traded. In this study, we examined the procurement, length of ownership, and the end of ownership of pet parrots. Data were collected via household surveys (n = 440 interviews in 9 towns), market visits (n = 17 markets in 6 towns), and opportunistic data collection methods in urban, Malagasy towns. Most *Coracopsis* spp. are purchased (59%) or captured directly by the owner from the wild (22%), although we were unable to determine how *A. canus* was procured. Survey respondents reported purchasing *Coracopsis* spp. for the price of USD 5.36 ± 3.20. The average *Coracopsis* spp. was kept in captivity for 3.17 ± 2.51 years. No survey respondents provided information on the purchase price or length of ownership for *A. canus*. Ownership ended primarily when *Coracopsis* spp. escaped/flew away (36%) or died of unknown causes (21%). *A. canus* also flew away, although this was only reported in one instance. In-country demand appears to be met by a trade network of both informal and formal actors. It is unclear whether current protections for Madagascar's parrots, as far as the domestic market is concerned, are sufficient to ensure sustainable extraction of live individuals.

RÉSUMÉ

La capture de perroquets vivants est une préoccupation grandissante en Afrique. À Madagascar, qui abrite trois espèces de perroquets (*Coracopsis nigra, C. vasa, Agapornis canus*), aucune étude n'a examiné la manière dont ces espèces sont extraites de la nature et vendues et achetées. Dans cette étude, nous avons examiné l'acquisition, la durée de possession, et la fin de possession des perroquets domestiques. Les données ont été collectées grâce à des études dans les ménages (n=440 enquêtes dans 9 villes), des visites dans les marchés (n= 17 marchés dans 6 villes), et à une collecte de données opportunistes dans des zones urbaines malgaches. La plupart des *Coracopsis* sont achetés (59%) ou extraites directement de la nature par les propriétaires (22%) ; il nous a été impossible de déterminer les moyens utilisés pour l'obtention d'*A. canus*. Les personnes interrogées ont déclaré l'achat des espèces de *Coracopsis* pour la somme de 5,36 ± 3,20 dollars US. En moyenne, ces espèces ont été gardées en captivité pendant 3,17 ± 2,51 ans. Aucune personne interrogée n'a procuré d'information sur le prix d'achat ou la durée de possession pour *A. canus*. Pour les espèces de *Coracopsis*, la possession s'est principalement terminée lors de la fuite/l'envol (36%) ou la mort liée à des causes inconnues (21%). La fuite d'*A. canus* a également été déclarée, mais dans un cas seulement. La demande locale semble être satisfaite par un réseau commercial d'acteurs formels et informels. Il n'est cependant pas encore clair si la protection des perroquets de Madagascar, permet que l'extraction de ces espèces pour le marché domestique soit menée de façon durable.

INTRODUCTION

Across the globe, 2,600 of the more than 9,600 bird species in existence are registered as being subject to trade (FAO 2011). The live capture of birds is causing increasing concern and parrot populations across Africa are declining (Martin et al. 2014). Parrots (Psittacidae) are among the most threatened group of bird species in the world, with 28% of species threatened on the IUCN Red List (Olah et al. 2016). In Ghana, 90-99% of Grey parrot (*Psittacus erithacus*) populations have been extirpated in the last two decades, due to habitat change and degradation, and the trade (both domestic and international) of this species (Annorbah et al. 2016). In the Democratic Republic of Congo, the live capture of parrots for the international market has caused a decline in *P. erithacus* populations (Hart et al. 2016). Studies such as these have focused primarily on the international market and there are few studies examining the keeping of parrots as pets in countries where they are endemic (Drews 2001).

In Madagascar, home to the Black parrot (*Coracopsis nigra*), the Vasa parrot (*C. vasa*), and the endemic Grey-headed lovebird (*Agapornis canus*), the live capture of parrots has received little attention (Martin et al. 2014). To date, no study has examined how parrots in Madagascar are being extracted from the wild and traded, despite evidence that it is not uncommon for parrots to be kept as pets (Reuter et al. 2017). This is notable as the live capture of animals in Madagascar is causing increasing concern (Schwitzer et al. 2013). Amphibians and reptiles are captured,

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sometimes to the point of near-extinction (e.g., Grenoble 2013), and transported internationally via organized trade networks (Andreone et al. 2005) for pet or medical/medicinal purposes. Similarly, lemurs are also often live captured for the pet trade; over 28,000 lemurs were estimated to be kept as illegal pets in urban households between 2010 and mid-2013 (Reuter et al. 2016a), with 30 species affected (Reuter and Schaefer 2016).

In Madagascar, the trade of parrots has been primarily recorded in anecdotal reports (McBride 1996) or in export databases (UNEP-WCMC 2016; but see Reuter et al. 2017). Though there is evidence to suggest widespread ownership of pet parrots in Madagascar (Reuter et al. 2017), there is little information on how these parrots are extracted from the wild and transported to areas where many pet owners live, such as in urban areas. One anecdotal report regarding the capture of *Coracopsis vasa* for the international pet trade, noted that exporters would pay USD 2.54 for one *C. vasa* (regardless of age or condition) captured in northeast Madagascar (McBride 1996). Parrots are occasionally consumed by some communities in Madagascar (McBride 1996, Gardner and Davies 2014). In the Kirindy forest, the number of *Coracopsis* spp. eaten for food exceeded those captured for the pet trade (Dowsett 2000, Ekstrom 2004). In contrast, *C. vasa* are not considered to be "edible" in western Madagascar south of Kirindy (Randrianandrianina et al. 2010). In this study, we aimed to increase understanding of the trade of the three parrot species in Madagascar, including procurement, length of ownership, and the end of ownership.

LEGALITY OF PARROT TRADE AND OWNERSHIP. A 2006 domestic law determined that CITES Appendix II species can only be extracted (captured or hunted) with a permit and within national quotas determined by the Malagasy government (quotas advised upon by the CITES Scientific Authority, Durbin 2007). The extraction of the species (even with a permit) may be further restricted to national hunting seasons (Randrianandrianina et al. 2010) which do not consider the biology of different species (Rakotoarivelo et al. 2011). Due to regulatory burdens and difficulty getting permits, most extraction likely occurs illegally (similar to bushmeat hunting, Golden et al. 2014) without permits (Rakotoarivelo et al. 2011).

International export of these species is regulated as they are listed in CITES Appendix II. A moratorium on trade of *C. vasa* was issued in 1995 (Martin et al. 2014) after the Malagasy government did not establish harvest quotas for export (though the primary threat to the species appeared to be habitat degradation, CITES 2008). There have been no reported exports of the species from Madagascar since 2000 (UNEP-WCMC 2016). For *Coracopsis nigra*, there have been no exports since 2006 (prior to which wild-caught individuals were exported for commercial reasons, UNEP-WCMC 2016). Wild-captured *Agapornis canus* continue to be exported for commercial reasons (as opposed to non-commercial, scientific, educational, zoo, breeding, or other purposes, UNEP-WCMC 2013) from Madagascar (750 individuals in 2013 and 300 in 2014, UNEP-WCMC 2016); an annual export quota of 3,500 individuals was established in 1993 (CITES Notification No. 744). It is not clear whether there is substantial illegal export of the three species; a database on illegal animal seizures did not list Madagascar's parrot species (Wildlife Trade Tracker, http://wildlifetradetracker.org/). Since 1981, 4,242 *C. vasa*, 5,875 *C. nigra*, and 117,549 *A. canus* have been reported to CITES as being exported (considering the larger of both exporter and importer-reported numbers, UNEP-WCMC 2016).

METHODS

We employed various methods, including household surveys, market visits, and opportunistic data collection (detailed below). We present both qualitative and quantitative data from these data collection efforts.

ETHICAL RESEARCH STATEMENT. International standards for research ethics were followed and research was approved by an ethics oversight committee (Institutional Review Board, University of Utah). Research followed all national and local laws pertaining to the survey of adults in Madagascar. Research was authorized by locally elected officials in every town and commune in which research took place. This research required no government research permits.

STUDY SPECIES. We collected data regarding the following species: greater vasa parrot (*Coracopsis vasa*; Least Concern; decreasing population; BirdLife International 2016a), lesser vasa parrot (*C. nigra*; Least Concern; stable population size; BirdLife International 2016b), and the grey-headed lovebird (*Agapornis canus*; Least Concern; stable population size; BirdLife International 2016c). Though there are no published population estimates of these three species (BirdLife International 2016a,b,c), they are common across Madagascar (e.g., Martin et al. 2014).

All three species have plant-based diets (Hino 2002, Bollen and Elsacker 2004). In regards to habitat preference and range, *Coracopsis vasa* is considered edge-sensitive (Watson et al. 2004) and is found along coastal regions (BirdLife International 2016c). *Coracopris nigra* is not known to be edge-sensitive and is found in agricultural settings, forests, and grasslands (BirdLife International 2017b). *Agapornis canus* is found along Madagascar's coastal regions and has a large range that includes much of the country (BirdLife International 2016c). Although *A. canus* may be present in some agricultural landscapes and shrublands, their absence in edge or matrix habitats may indicate edge-sensitivity (Watson et al. 2004) and they are not typically found in forests (BirdLife International 2017).

STUDY AREA. Data were collected in ten urban towns throughout central, southern, and eastern Madagascar (Figure 1). Towns were always located within the habitat range of at least one of the three study species, had human populations ranging from 12,000 – 1.05 million people, and were found at altitudes ranging from sea-level to 1,500 meters (Table S1). Most of the urbans towns surveyed had daily open-air markets selling a range of animals.

Towns were selected at regular intervals for surveying along a 747-km highway 'transect' (following Reuter et al. 2016a,b) beginning in Toamasina (formerly known as Tamatave, eastern Madagascar) and going central/south via the RN2/RN7 roads down to the town of Fianarantsoa. In addition, the towns of Tôlanaro (formerly known as Fort-Dauphin) and Toliara (formerly known as Tulear) in the southern portions of the island were sampled; these towns were not sampled using our overland, 'transect' approach due to safety concerns regarding travel by car.

The towns selected for surveying included five of the seven largest towns in Madagascar (from largest to smallest:

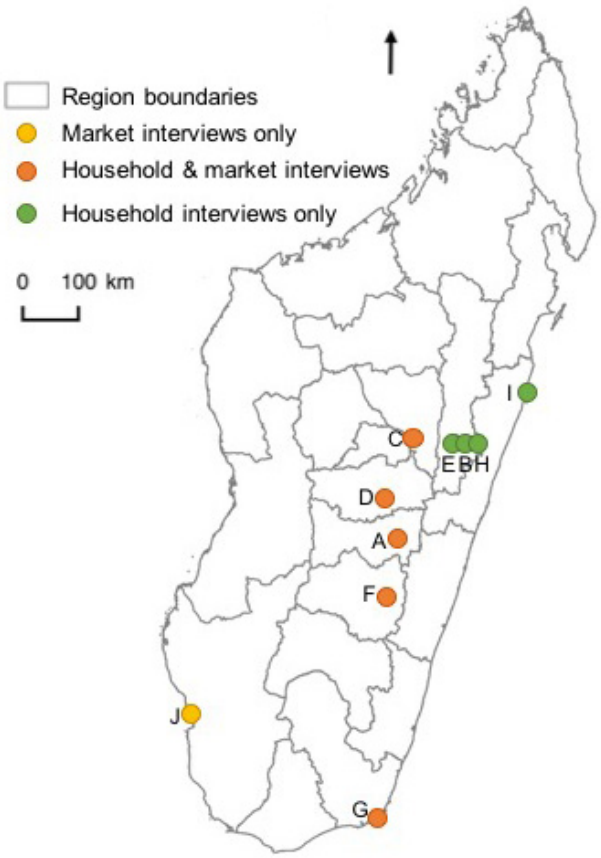

Figure 1. Towns visited for data collection during this study. Administrative boundaries of regions are provided for geographical reference. Letters shown on the map correspond with the town codes in Table S1.

Antananarivo, Toamasina, Antsirabe, Fianarantsoa, Toliara). Towns were located in eight of the country's 22 administrative regions, with at least seven different ethnicities found across the towns. The combined human population of the ten towns was approximately 1.91 million people out of Madagascar's urban population of 7.27 million people, (UNDP 2013). The total population of Madagascar is approximately 22.92 million people (World Bank 2016).

DATA COLLECTION USING HOUSEHOLD SURVEYS. During July and August 2016, we visited households (n = 440) in nine urban towns (Figure 1, Table S1). For household surveys, following Reuter et al. (2016a,b) we used random sampling stratified by administrative unit with 5-10 interviews conducted across as many different communes/quarters in each town as time would allow. To ensure independent sampling, only one adult was interviewed per household. If an eligible individual refused to participate or if nobody was present, sampling continued at the next household. Interviews were anonymous and no identifying information was collected. Verbal informed consent was received and interviews were conducted by a two-person team comprised of one international project leader and one trained Malagasy translator.

Interviewees were asked whether they had ever seen a pet parrot. We were clear to use a variety of local words for the words 'pet', 'parrots', and 'lovebirds' (in both Malagasy and French). We asked about parrots and lovebirds separately, as grey-headed lovebirds were not typically considered to be parrots by respondents. We always used translators that were fluent in the local dialect spoken to ensure that the most appropriate common names for the animals were used. We did not provide images of birds to facilitate species identification. However, when an individual did not recognize the local name, we did occasionally show photos of the three species on mobile phone devices. If the answer to our first question was yes, we asked: Where, when, and how many did you see? We recorded information about *Coracopsis* spp. and *Agapornis canus* separately on our datasheets and in the database used for analysis. Respondents could choose not to answer any question; they could also choose to respond to questions with "I don't know" or "I don't remember".

Similar to other studies on pet ownership in Madagascar (Reuter et al. 2016a), no efforts were made to define or limit the recall period as the purpose of this research was to collect baseline/foundational information about the ownership of pet parrots in Madagascar. Long recall periods are preferred when asking interviewees about rare events (noting the researchers' implicit assumption that ownership of pet parrots in Madagascar would be rare). Long recall periods of rare events can provide more accurate information than the extrapolation of data collected over shorter recall periods (Jenkins et al. 2011, Golden et al. 2013). However, it is important to note that based on the format of the questioning, respondents may have only reported their most recent or the most memorable encounter with a pet *Coracopsis* spp. or *A. canus*.

Following Reuter et al. (2016a), we did not ask individuals whether they had owned a pet parrot directly, because of the potential for increased interviewee discomfort. We anticipated that some interviewees would be uncomfortable disclosing the ownership of wild animals, like parrots, to foreign researchers who did not have a history of working in the towns where surveys took place (also given that most pet parrots have been illegally extracted from the wild, even if people are generally not aware of environmental laws, Keane et al. 2010). Some interviewees indicated voluntarily that they were current or former owners. In such cases, we asked the following questions: How did you procure the bird? How long did you have your bird? How did ownership end? Sometimes non-owners (e.g., individuals that did not self-report owning the parrot or individuals who clarified that they were not owners) also told us information about how parrots were procured, how long they were owned, and how ownership ended. Studies on the ownership of pet lemurs in Madagascar show evidence that non-owners are able to provide a wide range of information about wild animal pets that they have encountered (Reuter and Schaefer 2016, Reuter et al. 2016a,b).

We did not provide interviewees with a definition of a pet parrot but individuals reported to us on birds that were both caged and not caged (i.e., had clipped feathers or where otherwise kept in an uncaged manner). Pet parrots typically included birds that had a clear human owner (regardless of whether they were caged or not). We excluded birds seen in the wild, zoos, or reserves. The two *Coracopsis* spp. look physically similar but can be differentiated by their different flight patterns and calls (Forshaw 2010: 146), which may not be observable in caged birds or unknown to individuals that have not observed both species in the wild. Thus, we anticipated a priori that it would be difficult for urban respondents to differentiate between *C. nigra* and *C. vasa*, especially if they only quickly saw the pet parrot. Therefore, aside from differentiating between *Coracopsis* spp. and *Agapornis canus* (based on the respondent's use of local or partial scientific names), no further species identification was done. We acknowledge that respondents in more rural areas, or where wild *Coracopsis* spp. are common, might have been able to differentiate

between these two species. Given the semi-structured nature of interviews (Rietbergen-McCracken and Narayan 1998), we noted additional information that respondents provided to us (above and beyond their answers to the core questions listed above) as they spoke to us about the *Coracopsis* spp. and *Agapornis canus* that they had seen as pets.

In this study, we present data on the procurement, length of ownership, and the end of ownership. Data were reported by individuals that had seen or owned the three target species. Out of 440 household interviews (Table S1), 161 individuals (37 ± 11% of respondents, towns as replicates) reported having seen a *Coracopsis* spp. in captivity and a total of 39 individuals across all towns volunteered that they were past or current owners of *Coracopsis* spp. Only 20 individuals in total (4.5% of all interviewees) had seen an *Agapornis canus* in captivity. Only one individual interviewed reported having previously owned an *A. canus*. We present the data on *A. canus* because no other data on their ownership as pets have been published, but the small sample size means that these results should be treated as preliminary and merit further research.

VISITS TO OPEN-AIR MARKETS. During the same time period in which we conducted household surveys, we also opportunistically visited 17 established, well-known, open-air markets in 6 towns (Figure 1., Table S1) at least once when the market was open and at its busiest (e.g., in the morning, during the business week). In some towns, there is a one day of the week ('market day') when more vendors will be selling goods than on other days. We tried to time our visits with these market days but often this was not the case. The time period of our visits coincided with the national 'hunting season' when birds can be extracted legally with permits (Randrianandrianina et al. 2010). Some wild animals are routinely sold (usually dead; sometimes alive) by select vendors in urban markets in Madagascar (the same types of markets that we visited, Reuter et al. 2016b). We are not aware of any studies examining how the volume of wild animals sold (alive or dead) differ in markets in Madagascar between hunting and non-hunting seasons.

When visiting markets, we visually ascertained whether parrots were being sold during our visit. When possible, we also briefly interviewed a selection of sellers in the markets (at least two individuals per market, generally those selling other types of living birds) to understand whether parrots had ever been sold at the market in the past. In addition, these market sellers were asked whether they had ever sold parrots. If the answer was yes, we asked: How did you procure the birds? How much did you sell them for? Additional or more in-depth market visits could not be conducted due to time and resources limitations.

OPPORTUNISTIC DATA COLLECTION. We undertook opportunistic data collection on two occasions, when we happened to come across vendors selling parrots. We conducted brief unstructured interviews with these vendors and asked: How did you procure the birds? How much did you sell them for? In the case of the second vendor, it appeared that the individual was trying to solicit a purchase of the birds in question from the foreign researcher; we therefore qualify the price-related data in the results as being the price for 'foreigners' (as opposed to the normal market price).

ANALYSIS. Results are presented as mean values with 95% confidence intervals (calculated as 1.96 standard deviations from the mean). Sample sizes are typically small and therefore towns are not used as replicates in analyses unless otherwise noted. Price-related data are presented in Malagasy Ariary, with U.S. dollar (USD) equivalents in parentheses, based on the exchange rate of 1 August 2016 (MGA 2983 to USD 1; United Nations Treasury 2016). For comparison, 81.3% of the population lives on < USD 1.25 per day (UNDP 2013). We present only price data from 2015 and 2016.

RESULTS

PROCUREMENT OF BIRDS. From the household interviews, 30 owners and 19 non-owners provided information on how *Coracopsis* spp. were procured. *Coracopsis* spp. were usually procured via purchase from a third party (59% of n = 49), although sometimes the bird had been captured by the owner from the wild (22%), received as a gift (16%), or an individual had found and hatched parrot eggs (2%). One respondent noted that the Coracopsis spp. was caught after clearing agricultural fields.

Only two people indicated how *Agapornis canus* were procured and both respondents said the species was captured from the wild using "sticky traps" (see Discussion). The two street-side vendors of birds opportunistically found by researchers provided information about how they had sourced the birds they were selling. The first vendor, selling both *Coracopsis* spp. and *A. canus*, purchased the birds from third-party individual(s) (it was not clear whether these individual(s) were the same individuals extracting birds from the wild). The third-party individuals sourced *Coracopsis* spp. from a location 117 km distant from the vendor, though within the habitat range of the species. *A. canus* were sourced by third-party individuals from locations 27 km and 22 km distant from the vendor, though not within the habitat range of the species. The second vendor, selling only *A. canus*, had taking them from the wild. Neither capture method nor distance from the source location was revealed.

PURCHASE AND SALE OF BIRDS. From the household interviews, 13 owners and four non-owners could recall the purchase price of the *Coracopsis* spp. that they had encountered. Four individuals had purchased *Coracopsis* spp. in 2015 and 2016, paying an average of 16,000 ± 9,561 MGA per bird (n = 6; USD 5.36 ± 3.20; range: 2,000 – 35,000 MGA). Three of the four individuals provided information about the location of purchase; birds were purchased directly from people who had caught them (n = 1) and from markets (n = 2).

Researchers were not able to visually confirm the sale of parrots during the brief visits to 17 established open-air markets where a range of other animals were sold. However, researchers were informed by vendors that the sale of parrots had happened in the past and would happen again in the future, typically on large market days or on an ad hoc basis. Two individuals interviewed in Antananarivo at open-air markets had previously sold *Coracopsis* spp. (in 2005 and 2014). These individuals both continued to sell domestic birds (e.g., chickens, ducks) at the market. However, both individuals stopped selling parrots because they were hard to source. One of the two individuals indicated that there was no demand because no one was exporting birds.

The two street-side vendors of parrots opportunistically found by researchers, were stand-alone vendors, not near existing markets. In both cases, birds were in cages being sold on the side of the road; once in the middle of a major city and the second time along a well-traveled road between two large cities. The first vendor observed was situated at a street-side location selling 20 *Agapornis canus* (15 in a ~0.03 m^3 cage; 5 kept in a ~0.03 m^3 cage) and 3 *Coracopsis* spp. (2 kept in a ~0.06 m^3 cage; 1 kept in a ~0.06 m^3 cage; Figure 2). The cages were in full sunlight, none had water, and only one cage appeared to have some dried corn and rice available as food (Figure 2). The vendor reported purchasing *A. canus* for 1,000 MGA (USD 0.34) and selling them for 4,000 MGA each (USD 1.34; selling 6 per month on average), purchasing smaller-bodied *Coracopsis* spp. for 20,000 MGA (USD 6.70) and selling them for 50,000 MGA (USD 16.76; selling 4 per month), and larger-bodied *Coracopsis* spp. for 30,000 MGA (USD 10.06) and selling them for 60,000 MGA (USD 20.11; selling 1 per month). The second vendor that we observed, was selling three pairs of *A. canus*. Each pair was kept in a ~0.03 m^3 cage with no water and seeds/grains for food. The vendor indicated the sale price (likely an elevated sale price for foreigners) would be 100,000 MGA (USD 33.52) per breeding pair.

LENGTH OF OWNERSHIP. Eighteen owners and three non-owners provided estimates for the length of time that a *Coracopsis* spp. was kept in captivity (Figure 3). The average *Coracopsis* spp. was kept in captivity for 3.17 ± 2.51 years (n = 21, range: 0.08 – 25 years). No respondents provided information on length of ownership for *Agapornis canus*.

END OF OWNERSHIP. Twenty-four owners and 14 non-owners were able to provide information on how ownership of *Coracopsis* spp. ended (Figure 4). Only one respondent provided information on how *Agapornis canus* ownership ended (the bird flew away).

DISCUSSION

The purpose of this paper was to increase understanding of the trade of pet parrots in urban areas of Madagascar. Worldwide, nearly 30% of the 355 species of parrots are currently threatened with extinction (Tella and Hiraldo 2014). The domestic trade of parrots in Madagascar has been poorly studied, therefore it is important to increase research on their extraction and trade to better understand how to enforce bird trade regulations and to create awareness of the impact on wild populations. We found that pet parrots are procured from a series of formal and informal entities with the final owner usually purchasing their parrot from a third party. We hypothesize that most extraction of pet parrots from the wild is illegal. In addition, we found that pet parrots were kept alive for relatively short periods of time and that ownership usually ended with the death of the parrot, which is important information should future analyses aim to understand the sustainability of parrot extraction in Madagascar.

Figure 2. Parrots for sale, as photographed (with permission) at the two vendors that were found during the course of this study. Left and center *Agapornis canus*, right *Coracopsis nigra*.

PROCUREMENT OF PARROTS. Owners procured their parrots (either purchased from a third party or captured from the wild) at different points along the commodity chain. The trade of parrots in Madagascar is likely similar to the trade of wild animals in Africa, which takes place via a series of formal and informal entities (Bennett 2002, Kümpel et al. 2010, Reuter et al. 2016b). 'Formal' trade typically involves a consistent set of actors and venues (Bowen-Jones et al. 2003) while 'informal' trade structures involve businesses that lack large capital investments, that are ephemeral, or that exist outside government oversight (Benjamin and Mbaye 2014). The legality of trade, and the 'visibility' of trade (e.g., how aware the general public is of the trade), are not equivalent to the formality of the trade. Depending on the context, the trade of an item can be illegal but formalized and visible (Reuter et al. 2016b). Similar to the bushmeat trade in Madagascar, the trade of parrots elsewhere in the world has been conducted through a combination of informal and formal entities. In Mexico, most parrots are opportunistically poached in rural areas by informal entities and then transported to urban areas by more formalized middlemen and sellers (reviewed by Pires and Clarke 2011).

Our data are limited but we document that most birds seem to be purchased by their urban owners from a third-party (as opposed to being personally extracted from the wild; in contrast to pet lemurs in urban areas, Reuter et al. 2016a). These third-parties include both informal and formal entities. For example, the two street-side vendors we opportunistically came across, could be considered 'formal' and 'informal', respectively. The first vendor was seen by researchers selling parrots in the same location multiple times over the months in which data were collected. This vendor regularly sold parrots (providing us with the average number sold per month) and sourced his/her parrots from a third-

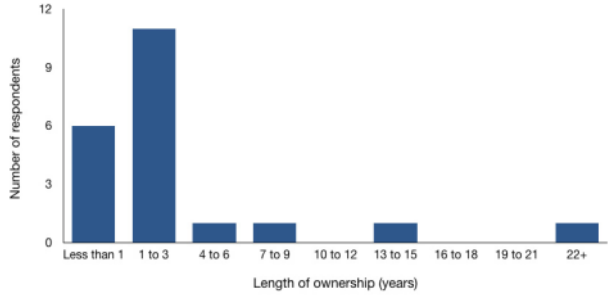

Figure 3. The length of ownership (in years) of *Coracopsis* spp. as reported by 21 respondents.

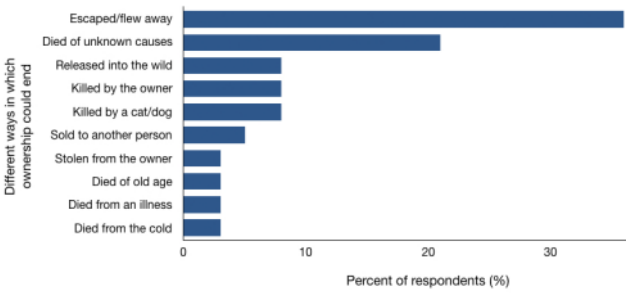

Figure 4. The way in which ownership of *Coracopsis* spp. ended, as reported by 38 respondents.

party. The second vendor appeared to be selling the birds on an irregular basis; since he/she extracted them personally from the wild, it might have been an *ad hoc* method of income. Finally, we document that parrots are sometimes sold at open-air markets though the timing seemed irregular. This is similar to the sale of bushmeat in Madagascar, where large urban markets generally have no more than one individual selling bushmeat on a daily basis with additional individuals selling bushmeat on large 'market days' or when supply is high (Reuter et al. 2016b).

The sale price for *Coracopsis* spp. (USD 5.36 ± 3.20 as reported by Malagasy respondents) is similar to the prices of wild caught parrots sold for domestic trade in other developing areas of the world (e.g. USD 5-10 in Bolivia, reviewed by Pires and Clarke 2011). It is unclear how much the price varies for these species across Madagascar, though we provide evidence that prices for parrots can vary by buyer (e.g., if the buyer is Malagasy or a foreigner). Similarly, the price of a captive lemur varies from USD 1.03-13.65 in Madagascar (Reuter et al. 2016a) depending on the buyer, location, and age/species of the lemur (with prices of up to USD 100 for 'naïve' foreigners). Our data were not sufficient to examine changes in price over time, though this would be interesting to examine in future studies. Legislative measures – like CITES listing a species – have led to price increases in international markets for other animals in the past (reviewed by Tapley et al. 2011).

Some owners do capture their pet parrots directly from the wild. Very few individuals described how parrots were captured (and we did not ask directly regarding this aspect of procurement). In regards to hunting of *Coracopsis* spp., Gardner and Davies (2014: 24) report that they are "easily catapulted as [they] perch on high, exposed branches". In regards to *Agapornis canus*, two respondents mentioned "sticky traps"; Gardner and Davies (2014) also report that *A. canus* is captured at lake edges using *Folotsia grandiflora* (= *Cynanchum grandidieri* Liede & Meve Apocynaceae) resin on branches. Plant-based sticky substances have been used to 'sticky-trap' birds in Madagascar, whereby these sticky substances are used as a bird lime (Richardson 1967) and spread onto surfaces where the birds often land, thereby allowing them to be caught alive and relatively unharmed. There are several other types of capture methods that could be used including netting and traps with nooses. Nets are used to capture bats in Madagascar (Reuter et al. 2016b) while nooses (that tighten around the neck or foot of a bird) are described in Gardner and Davis (2014) and have been employed to capture birds. These noose-traps are set in areas where there is a high density of birds and in the case of *A. canus*, fences are sometimes erected to guide the birds towards the traps (Gardner and Davies 2014). It should be noted that no one mentioned the poaching of parrots from their nests.

As noted above (see Methods), the authors hypothesize that most parrots in Madagascar are likely extracted without permits (and therefore illegally). If so, the current protections may be insufficient in ensuring that the extraction of live individuals is done sustainably (Reuter et al. 2017). In other words, the current protections around Madagascar's parrots do not seem to be enforced such that the extraction of animals from the wild is being tracked in any meaningful way. Therefore, it cannot be determined whether extraction rates are sustainable in the long-term. Nationally, there are limited consequences of enforcement for a range of legal and illegal natural resource uses (Sommerville et al. 2010). This is notable as Madagascar is party to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES 1983) and the CBD (Convention on Biological Diversity, UN 1992) and has therefore agreed to regulate international and domestic trade. If Madagascar is to begin better regulation of the domestic trade of wild animals (both dead and alive), an understanding of the trade and commodity chains are important pieces of information. For example, an in-depth analysis on the commodity chain of bushmeat in Madagascar highlighted several options for regulation at each point on the commodity chain (Reuter et al. 2016b).

LENGTH OF OWNERSHIP. Our study suggests that pet parrots are kept alive in captivity in Madagascar for short periods of time (3.17 ± 2.51 years). However, elsewhere in the world, the maximum lifespan of these species in captivity has been recorded as 38 years for *Coracopsis nigra*, 29 years for *C. vasa*, and 16 years for *Agapornis canus* (Young et al. 2011). This may be because pet parrots in Madagascar are kept in a range of environments that do not allow for adequate movement and nutrition, with some birds showing various stereotypical behaviors (Reuter et al. unpublished data). We have little data as to why some pet parrot owners may be providing low levels of care, but there are several reasons why this may be the case. First, parrot owners may view their pets as having low value (with replacement birds being easily available should the pet parrot die) and may therefore treat them as dispensable (though several owners spoke fondly of their pet parrot). Second, owners of exotic pets often do not know how to best care for exotic pets (Soulsbury et al. 2009). In the United States, pet birds are sometimes ignored or neglected because of behavioral problems (Luescher 2006: 160). In Madagascar, pet lemur owners are not easily able to access information on how to keep these animals as pets (Reuter and Schaefer 2016). This may also be the case with pet parrots.

END OF OWNERSHIP. Our data suggest that the ownership of *Coracopsis* spp. ends with the death of the parrot 51% of the time (with various causes of death) and with the escape of the parrot 36% of the time. We found very little quantitative information on how parrot ownership ends in other areas of the world. One book suggested that in the United States, birds with behavioral problems (even valuable birds) are often neglected or gifted to others (Luescher 2006: 160). This information, along with the data on the average length of ownership, is interesting in regards to the larger question about whether or not the pet parrot trade in Madagascar is sustainable. Though our study cannot answer that question, the information provided here is certainly relevant to those types of analyses.

CONCLUSIONS AND NEXT STEPS

In this study, we found that pet parrots kept in urban towns in Madagascar are often purchased from third-parties, including markets and individuals that function as both formal and informal traders. We hypothesize that most extraction of parrots is illegal. We further hypothesize that the trade and ownership of parrots is not hidden (meaning, efforts are not made to conceal the ownership of pet parrots by owners). We document that the sale of parrots is often done on an *ad hoc* basis. For example, we had difficulty locating and interviewing sellers/traders of live parrots using rapid assessment methods. We were only able to speak with live parrot vendors when they were opportunistically found. This

may be part of the reason why the domestic trade of parrots in Madagascar has received so little attention in the literature.

As evidenced in this study, much remains to be learned about the trade of parrots in Madagascar. For example, in our study, respondents may have under-reported sightings of both *Coracopsis* spp. and *Agapornis canus*. This could have been due to: 1) the short interview time, 2) the fact that research teams were not well-known to communities being interviewed, 3) that many of the parrots in question were likely extracted illegally (though knowledge of environmental laws is low), and 4) respondents not recognizing which animals/species they were being interviewed about. In addition, a higher sampling effort may have yielded more relevant data for this study, especially if the sale of living parrots is uncommon; for comparison, in one study in Madagascar, less than 1% of 354 open-air market sellers of meat had sold bushmeat in the three-days prior to being interviewed (Reuter et al. 2016b). As such, there are continued gaps in knowledge that make it difficult to suggest harvest quotas or other quantifiable measures of sustainable extraction of the three species (Beissinger and Bucher 1992). Therefore, we suggest additional research on the extraction and trade of parrots that could help inform where and how often they are captured as pets, in addition to increased understanding about their habitat ranges and total population numbers. Unless the conservation and scientific community turn their attention to Madagascar's parrots, it is likely the Government will continue to be unable to set extraction quotas.

It is clear that, especially in Madagascar, there are a large number of pressing conservation priorities. In this context, it may be counter-intuitive to advocate for additional research and conservation outreach on these three species, all of which are classified as 'Least Concern' on the IUCN RedList (BirdLife International 2016a,b,c). However, the authors would argue that baseline research, perhaps as an addition to ongoing research initiatives (e.g. market surveys, bushmeat studies, habitat surveys) and outreach (e.g., expansion of conservation programming to include birds) would be useful for Madagascar's parrots. This could help ensure that awareness is proactively raised and that, if possible, the conservation community is notified early if there appear to be population declines in the three species (as would be the case if a large number of bird vendors would suddenly have a harder time sourcing parrots from the wild). The lack of studies on similar topics in the past have sometimes masked large conservation issues (e.g., studies on the bushmeat trade in Madagascar in the late 2000's drastically increased awareness of this problem, e.g., Golden 2009, Jenkins et al. 2011).

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SUPPLEMENTARY MATERIAL

Available online only

Table S1. The ten towns in Madagascar (Figure 1) where data were collected, with population, number of households interviewed, number of individuals who knew someone who owned or had previously owned a bird, number of individuals who themselves owned or had previously owned a bird, number of markets visited, and number of markets where pet parrots (*Coracopsis nigra*, *C. vasa* and *Agapornis canus*) were for sale. (Town codes correlate to the codes shown on Figure 1, population estimates for cities were obtained from http://www.ilo.cornell.edu/ilo/data.html, or from local officials, habitat range data taken from BirdLife (2016a,b,c), *does not include the respondents who had personally owned a parrot)

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A history of conservation politics in Madagascar

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ABSTRACT

In this article, I argue that reconciling conservation and livelihoods in Madagascar requires an examination of the historical processes and political-economic systems through which the strong foreign influence on conservation has formed. I begin by documenting how a group of scientists and policy-makers came together in the 1970s and 1980s to mobilize global attention to the importance of protecting Madagascar's flora and fauna. I illustrate how their influence materialized not only through formal political negotiations and bureaucratic practice but also via informal collaborations across multiple geographic and institutional sites. Then, I examine how the critical historical conjuncture of the mid-1980s—with its emphasis on biodiversity, sustainable development and neoliberalism—prompted a reconfiguration in power relations among public, private, and nonprofit actors. This reconfiguration provided the political-economic context for the transformation of a scientific campaign into a well-funded foreign aid agenda, encompassed in the Madagascar National Environmental Action Plan. I illustrate how, although numerous actors advocated for integrated conservation and development approaches throughout Madagascar's environmental history, the political, scientific, and financial strength behind the international conservation lobby often overpowered the push for more comprehensive or integrated development approaches. Finally, I conclude by arguing that effective and equitable conservation in Madagascar will require transforming the power relations that have both created Madagascar's environmental crisis and efforts to redress it.

RÉSUMÉ

Dans cet article, j'avance que pour réconcilier la conservation de la nature et les moyens de subsistance des gens à Madagascar, il faut commencer par un examen critique des processus historiques et des systèmes économiques politiques qui ont eu une forte influence étrangère sur la conservation dans le pays. Je commence par documenter comment un groupe de scientifiques et de responsables politiques se sont réunis dans les années 1970 et 1980 pour mobiliser l'attention mondiale sur l'importance de protéger la flore et la faune de Madagascar. J'étudie comment leur influence s'est matérialisée non seulement par des négociations politiques officielles et des pratiques bureaucratiques, mais aussi par des collaborations informelles dans de nombreux endroits sur le terrain et dans les institutions. Ensuite, je montre comment la conjoncture historique du milieu des années 1980 qui était caractérisée par un accent mis sur la biodiversité, le développement durable et le néolibéralisme, a permis de reconfigurer les relations de pouvoir entre les entités publiques, privées et les organisations à but non lucratif. Cette reconfiguration a forgé le contexte politico-économique dans lequel ces acteurs dévoués ont transformé une campagne scientifique en un programme d'aide étrangère bien financé et inclus dans le Plan National d'Action pour l'Environnement de Madagascar. Je montre comment, bien que de nombreux acteurs aient depuis longtemps défendu les approches intégrant conservation et développement pour protéger l'environnement de Madagascar, la force politique, scientifique et financière derrière le lobby de la conservation a souvent surpassé les efforts consentis pour des approches plus exhaustives et intégrées de développement. Enfin, je conclus en faisant valoir que pour réaliser la conservation efficace et équitable à Madagascar, il faudra transformer les relations de pouvoir qui ont à la fois créé la crise de l'environnement à Madagascar et les efforts destinés à la redresser.

SETTING THE STAGE FOR CONSERVATION POLITICS

For decades, scholars, policy-makers and practitioners have debated how to balance conservation and development in Madagascar, where the challenge is particularly acute because of the country's concurrent biological wealth and immense human poverty. Critics have called for radically new conservation approaches to make conservation more effective while also upholding the basic human rights of the Malagasy people. While Madagascar's charismatic fauna—particularly lemurs—have attracted invaluable international attention and funding, the costs and benefits of conservation have been unequally distributed (Ferraro 2002, Desbureaux and Brimont 2015), and, many have argued that the lives of lemurs are often prioritized over the lives of the Malagasy people (Peters 1998, 1999, Harper 2002, Reibelt and Nowack 2015). Scholars have proposed a range of ways to redress this inequity via sustainable revenue generation from local resource use (Erdmann 2010, Bertrand et al. 2014), greater institutional support and incentives for integrated conservation and development (Gezon 1997, Pollini 2011), and the greater empowerment of local communities (Ferguson and Gardner 2010, Mercier and Merali 2015). However, underpinning the struggle over conservation and human rights in Madagascar remain con-

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trasting ontologies and values (Keller 2009, Kaufmann 2014), historically-grounded allegiances to misguided narratives and simplistic approaches to complex human-environment interactions (Scales 2011, McConnell and Kull 2014, Scales 2014), and the disproportionate influence of foreign scientific institutions and conservation organizations on the environmental agenda (Duffy 2006, Sarrasin 2007, Horning 2008, Kull 2014,Waeber et al. 2016).

In this revised chapter from Corridors of Power (Corson 2016), I trace the rise of this influence. The foundations for contemporary environmental conflicts and international interest in Madagascar's flora and fauna date to pre-colonial times, but, in this article, I focus on a relatively short period of time: the 1960s to the 1990s. I trace how a group of scientists and policy-makers came together to mobilize global attention to the importance of protecting the country's flora and fauna. I argue that their influence materialized not only through formal political negotiations and bureaucratic practice but also via informal collaborations across multiple sites. Certain scientific meetings, trips and political conferences provided opportunities to craft conservation priorities, to draft institutional protocols, and to develop relationships that continue to influence Madagascar conservation politics today. The critical historical conjuncture of the mid-1980s—in which agendas around biodiversity conservation and sustainable development emerged in the context of rising neoliberal policies—then prompted a reconfiguration in power relations among public, private, and nonprofit actors. This reconfiguration provided the political-economic conditions for these dedicated actors to transform a scientific campaign into a well-funded foreign aid agenda, encompassed in the Madagascar National Environmental Action Plan (NEAP). In the context of the Madagascar government's embrace of structural adjustment reforms, the environmental agenda offered an avenue to attract much-needed foreign exchange in the context of restructuring (Sarrasin 2005, Horning 2008).

The conceptualization of NEAP at this historical moment shaped the realm of possibilities for its subsequent agenda. The neoliberal reduction of the state and concurrent embrace of private and nonprofit participation in formerly state policy-making processes converged with an expanding environmental movement, which catalyzed the World Bank's development of environmental policy, and rising global attention to biodiversity. These processes shaped the politically viable narratives used to frame Madagascar environmental challenges, the strategies that could be invoked to redress them, and the actors granted the authority to manage its resources. Although numerous actors advocated for more decentralized and integrated conservation and development approaches throughout Madagascar's environmental history, the political, scientific, and financial strength behind the international conservation lobby often overpowered the push for more comprehensive or integrated development approaches.

By weaving material from personal and national archives with that from key informant interviews and historical policy documents from donors, non-governmental organizations (NGO) and government agencies, I add ethnographic insights to the well-documented history of conservation politics in Madagascar (e.g., Kull 1996, Andriamahefazafy and Méral 2004, Mercier 2006, Sarrasin 2007, Rakoto Ramiarantsoa et al. 2012, Kull 2014). In doing so, I hope to illustrate the importance of focusing not just on official events, institutions and policies, but also on the ways in which political economic context has shaped individual agency and interactions and the value of attending to the informal spaces that influence policy (see also Corson et al. 2014). Ultimately, I assert that we must move our critiques beyond a focus on specific conservation projects and programs to the historically grounded, transnational and political-economic systems that sustain them in order to reconcile conservation and livelihoods in Madagascar. As we unravel sedimented historical layers, we begin to see how these systems have shaped both our contemporary understanding of Madagascar's environmental crisis and the resources invested to redress it. With its American-centric perspective, this article does not offer a complete account of the history of Madagascar's environmental program; rather it provides a window into some of the historically grounded relationships that created it. Likewise, because I agreed to protect individual confidentiality except in selected cases, I provide only general organizational associations for interviewees and have downplayed the role of a number of individuals, many of whom continue to influence Madagascar conservation politics.

THE SEEDS OF FOREIGN-FUNDED CONSERVATION. The origins of contemporary international scientific interest in Madagascar's biodiversity can be traced to early scientific expeditions from Europe, efforts to classify Madagascar's species, and resulting international scientific debates, which were recorded as far back as the mid-seventeenth century and extended into the French colonial era (Feeley-Harnik 2001, Andriamialisoa and Langrand 2003, Anderson 2013). This early scientific interest in Madagascar's species informed research and conservation in the French colonial era. The colonial government also brought tenets of scientific forestry and rational economic exploitation, which promoted utilitarian ideas of forest management for the greater good and the separation of areas for wood production and soil protection (Bertrand et al. 2004, Kull 2004). However, the state lacked the human and financial resources to contain significant deforestation by commercial exploiters. Eventually, concerns about forest loss prompted the creation of "nature reserves" and later "special reserves" and "national parks", which formed the backbone of the protected area system for decades (République Française 1928, Saboureau 1958, Andriamampianina 1987, Randrianandianina et al. 2003).

From the end of World War I to the late 1960s, the Académie Malgache and the Institut de Recherche Scientifique de Madagascar (IRSM) facilitated numerous zoological expeditions, and foreign scientific interest in Madagascar's lemurs intensified in the mid-twentieth century. Supported by IRSM, the French primatologists Jean-Jacques Petter and Arlette Petter-Rousseaux began studying lemurs in the 1950s. In 1960, the year of independence, David Attenborough, aided by the ornithologist Georges Randrianasolo of IRSM, made the first commercial film about wild lemurs for a Western audience. Collaboration among Malagasy and foreign researchers also led to various scientific research projects under the Centre National de la Recherche Scientifique. The American anthropologist John Buettner-Janusch brought lemurs back to Yale University to study in the 1960s and later founded the Duke Primate Center (now called the Duke Lemur Center) (Jolly 2015). Encouraged by Buettner-Janusch, the primatologist Alison Jolly began studying ring-tailed lemurs in 1962, followed by Robert Martin, Alison Richard, and Bob Sussman, who began their research in the 1970s. These researchers, among others, became key advocates for conservation in Madagascar, and they attended the *Conférence Internationale sur la Conservation de la Nature et*

de ses Ressources à Madagascar in 1970 (Andriamialisoa and Langrand 2003, Jolly and Sussman 2007).

The 1970 conference laid the foundation for subsequent foreign engagement in the conservation of Madagascar's flora and fauna. Sponsored by a number of international research and conservation organizations, it was organized by Petter, with the French Musée national d'Histoire naturelle and Monique Ramanantsoa Pariente, the daughter of General Ramanantsoa, who became Madagascar's interim president in 1972. "The idea of organizing a conference," a former Malagasy official recalled, "came from a few foreign scientists, and some Malagasy, who were worried about the growing degradation of forests" (Interview, 10 October 2005). It focused primarily on nature conservation: the slogan "Malagasy Nature, World Heritage" was visible everywhere (Jolly and Sussman 2007: 28). The attendees—primarily foreign and Malagasy researchers and conservation NGO representatives—produced a variety of recommendations and resolutions on the international scientific importance of Madagascar's environment, including one to create a World Wide Fund for Nature (WWF) office in Madagascar (IUCN 1972).

This key moment brought together scientists and policy-makers to focus on the importance of Madagascar's species. However, the ambition to expand this awareness was accompanied by concerns about foreign influence and attempts to downplay the social impacts of conservation—both tensions that continued to limit the effectiveness of the subsequent environmental agenda for ensuing decades. Kull (1996) cites an intervention by Etienne Rakotomaria, the director of scientific research, critiquing foreign organizations and scientists for dominating the discussions. Likewise, Jolly recalls being escorted out of the conference by Charles Lindbergh and Sir Peter Scott, the founder of WWF-International, after presenting a paper that she and her husband, the well-known economist Richard Jolly, had written entitled "Conservation: Who Benefits and Who Pays?" Lindbergh and Scott "instructed her that although it was obvious that poor people who lose their land pay most of the price of reserves, she should not say so. It would set back the cause of conservation to raise such issues" (Jolly and Sussman 2007: 28). As she recollects further, "That paper did not appear in the published proceedings. I did a very brief paper that I scribbled at the time because someone said 'do tell us about lemurs.' That made it into the proceedings. But Who Benefits and Who Pays? did not." She went on to explain the reasons behind this effort to silence her: "The conservationists had been fighting a battle to get heard, particularly in Africa. So the last thing they wanted was something that raised a question that was threatening" (Alison Jolly, pers. comm. 19 July 2010).

Concerns expressed at the conference about foreign interests driving conservation reflected a spreading dissatisfaction with the degree to which the French continued to influence political and economic affairs in Madagascar. The momentum that it inspired stalled in the wake of the 1972 revolution against economic conditions and French domination of the university, schools, and government, which eventually led to Lt. Comm. Didier Ratsiraka's Second Republic, with its Leninist scientific socialism agenda and an emphasis on poverty reduction. The government turned away from France and other Western countries and toward Russia, North Korea, and China. It nationalized key sectors of the economy, such as agriculture, and borrowed heavily from external sources to finance a national investment plan (Marcus 2004, Sarrasin 2005, Sodikoff 2007). From 1972 until the mid-1980s, when the government turned back to the West for foreign aid, many foreigners found it difficult to visit the island. Western governments and NGOs alike were reluctant to pledge significant funds to conservation there, and the Ratsiraka government gave research permits to only a handful of biologists during this time. Foreign scientists who did enter often came through higher education system partnerships (Andriamialisoa and Langrand 2003, Fenn 2003, Jolly and Sussman 2007).

In the late 1970s and 1980s, scientists and conservationists concerned that Madagascar's environment was in grave danger began working with key Malagasy policy makers to build the political infrastructure for the subsequent conservation agenda. The WWF-International office, called for in the 1970 conference resolutions, was established by presidential decree in 1979 (Repoblikan'i Madagasikara 1979). Following the resolution's mandate that the director is Malagasy, and at the behest of Petter, Barthélémi Vaohita was appointed the WWF-International representative. An accord between WWF and the Madagascar Ministère de l'Enseignement Supérieur et de la Recherche Scientifique (MESupReS) then established the WWF program of action in Madagascar. Among other things, the accord acknowledged the need for information about park management and ecosystem dynamics; recommended preparation of an inventory of fauna and flora; and committed WWF to mobilizing foreign aid for conservation (MESupReS and WWF-International 1983). In turn WWF-U.S. gave $US120,500 for seven years to the Bezà Mahafaly reserve, which Guy Ramanantsoa of the University of Madagascar, Alison Richard, and Robert Sussman had created in 1975 as a training ground for students at the University of Madagascar's School of Agronomy (Richard and Ratsirarson 2013). Further, in an effort to raise public awareness about Madagascar's flora and fauna in the United States, Thomas Lovejoy of WWF-U.S. commissioned Jolly to write A World Like Our Own, which was published in 1980 (Jolly and Sussman 2007).

A series of meetings, trips, and conferences, some of which took place outside of Madagascar, then cemented critical relationships among Malagasy government officials and scientists. In 1979 Césaire Rabenoro, the president of the Académie Malgache, hosted an international meeting on lemur biology. Gerald and Lee Durrell of Jersey Wildlife Preservation Trust (JWPT) (now the Durrell Wildlife Conservation Trust), among others, attended this meeting (Jolly and Sussman 2007). In November 1981, following a visit by Barthélémi Vaohita to the United Kingdom, a group of foreign scientists working in Madagascar held an informal gathering in Cambridge, England, to discuss how to promote nature conservation in Madagascar. In February 1983 the JWPT invited relevant Malagasy authorities to a follow-up meeting on the island of Jersey in the Channel Islands (Durrell 1983), where Gerald Durrell had founded the Jersey Zoological Park in 1959 as a breeding center for endangered species. Participants from the Cambridge meeting, Malagasy authorities from relevant ministries and technical organizations, and additional representatives of various universities, museums, and wildlife organizations from the United States and Europe attended the Jersey meeting. The goal was to highlight foreign interest in Madagascar's flora and fauna for the Malagasy authorities and to address the problematic process for obtaining research permits. It was at this meeting that Petter also raised the idea of holding a follow-up conference to the 1970 conference (Durrell 1983).

While foreign scientists were concerned about the challenges of obtaining research permits, the Madagascar government was overwhelmed by the number of uncoordinated proposals from foreigners wanting to conduct scientific research in the country. In Jersey, Madame Berthe Rakotosamimanana, then Director of Scientific Research with MESupReS, laid out a plan to facilitate the process for foreign scientists. Although some research institutions, such as Strasbourg and Duke universities, had formal agreements with MESupReS, individual researchers often approached the Madagascar government separately. In an attempt to redress the issue, WWF-International and the ministry signed an annex to their existing accord that established an International Advisory Group of Scientists (IAGS) to coordinate biological research conducted by foreigners (MESupReS and WWF-International 1983). Composed of Roland Albignac, Lee Durrell, Alison Jolly, Bernd-Ulrich Meyburg, Jean-Jacques Petter, Peter Raven, and Alison Richard; this group screened biological research proposals, which they then forwarded to WWF and the appropriate ministries in Madagascar, with the goal of expediting permission to conduct research. Reflecting the priorities of the WWF-International program and the interests of the group, the IAGS emphasized the need for biological surveys: "For conservation purposes, the research most urgently needed by Madagascar concerns up-to-date biotic inventories of her last remaining natural habitats" (Durrell 1984). Sheila O'Connor began conducting research in the early 1980s, and in 1986 WWF-International hired Martin Nicoll and Olivier Langrand to conduct a review of existing protected areas and to propose new priority areas to protect these habitats.

These meetings cemented critical personal relationships, introduced protocols, identified programmatic priorities, and institutionalized the place of the foreign, Anglophone, scientific community in Madagascar environmental politics. In particular, the emphasis on biological surveys continued as the environmental program expanded. As the group channeled funds and permits toward specific research priorities these early assessments created the scientific basis for the biodiversity portion of the NEAP and the foundation for the eventual expansion of Madagascar's protected areas. When the country reopened to the West after the decline of the socialist regime in the 1980s, these advocates found themselves at the center of an emerging global political transformation.

THE INTERNATIONAL DISCOVERY OF MADAGASCAR. The 1980s marked an important turning point in Madagascar's environmental history. As a result of extensive borrowing and capital flight, the country's foreign debt was over $US1 billion, and the government signed its first International Monetary Fund (IMF) agreement in 1980, under which donors agreed to reschedule or refinance Madagascar's debt in exchange for the acceptance of an IMF stabilization program (Brown 2000, Marcus 2004). In reaction, donor assistance rose rapidly—from $US36.3 million in 1976 to US$217.6 million in 1988 and to US$365.5 million in 1991 (Horning 2008).

At this critical historical juncture Madagascar burst into the international limelight. Key events underpinned its emerging international fame. These included the discovery in 1986 of the golden bamboo lemur, the growing awareness of the rosy periwinkle's use as a treatment for childhood leukemia, and a widely publicized satellite image of Madagascar in 1984 from the American space shuttle Discovery, which showed "Madagascar bleeding to death" as reddish-brown water from eroded soils poured into the Betsiboka River estuary off the northwest coast (Gezon 2000, Simsik 2002). "Madagascar returned to the world map after a decade of isolation largely through the lens of conservation—perhaps literally through the camera lens, as images and stories of lemurs, chameleons, orchids, erosion, and deforestation made it to television documentaries and popular publications" (Kull 1996: 67). A senior international conservation NGO representative who had been working in Madagascar at the time said, "What really happened is that all of a sudden at the national level, at an international level, beyond the circle of scientists, there was a discovery of the importance of biodiversity in Madagascar" (Interview, 29 September 2006).

Madagascar's emergent fame was fueled by rising global interest in biodiversity and sustainable development. Sponsored by the Smithsonian Institution and the National Academy of Sciences, the 1986 National Forum on BioDiversity was convened in Washington, D.C., with the explicit intention of raising congressional awareness about global species loss (Takacs 1996). At this forum, Russell Mittermeier identified Madagascar as one of the top six mega-diverse countries (Mittermeier 1988; see also Mittermeier et al. 1998). Then, in 1988, the ecologist Norman Myers introduced the idea of protecting critical regions with high concentrations of endemic species that faced habitat loss and proclaimed Madagascar one of the world's top ten biodiversity hotspots (Myers 1988, 1990, Myers et al. 2000). Much of the emerging interest in biodiversity focused on Madagascar as a high-priority country. At the same time, environmentalists were pushing development donors to fund environmental programs under the auspices of sustainable development. First articulated in 1980 in the World Conservation Union (IUCN) World Conservation Strategy, the concept of sustainable development offered a way for aid donors to endorse environmental issues without opposing their overarching mandate to promote economic growth, and it gained global prominence quickly as a result (Redclift 1992). The IUCN strategy also recommended that countries prepare national conservation strategies (IUCN 1980), and in 1984 Madagascar became the first country in the Afro-tropics to follow the IUCN recommendation (Repoblika Demokratika Malagasy 1984).

The 1984 strategy reflected the IUCN framing of conservation as a means of advancing rather than impeding sustainable development. It also linked natural resource management to food security: "It appears more and more obvious that the management of natural resources for sustainable development is an urgent necessity and should constitute the pivot around which government policy secures food self-sufficiency will hinge in the future" (Repoblika Demokratika Malagasy 1984, summary, author's translation). In doing so, it marked a transition in emphasis in Madagascar environmental politics from nature conservation, which had been the focus of the 1970 conference, to "the environment", and it established the groundwork for a comprehensive national environmental agenda. In 1984 Barthélémi Vaohita convinced every Malagasy minister to sign Madagascar's national conservation strategy, a bureaucratic endeavor that constituted a meaningful step toward building environmental awareness across the government (Jolly and Sussman 2007). The decree that adopted into legislation the strategy also established the *Commission Nationale de Conservation pour le Développement* (CNCD), assisted by a *Comité Technique Permanent* (CTP) that reported to

the director general of planning (Repoblikan'i Madagasikara 1984). Finally, the strategy formed the basis for a 1985 WWF-International and IUCN-sponsored conference, the idea for which Jean-Jacques Petter had first raised in Jersey two years before.

With the involvement of policy makers and politicians from Madagascar and overseas, the *Conférence de Madagascar sur la Conservation des Ressources Naturelles au Service du Développement* (referred to in English as the Second International Conference on Conservation and Development in Madagascar), moved the challenge of addressing Madagascar's environmental degradation from the scientific into the political realm. In contrast to the conference in 1970, the one in 1985 was perfectly timed to meet rising donor interest in Madagascar. Funds did materialize to implement its recommendations, and its recommendations shaped the development of the subsequent World Bank-led Madagascar NEAP. As a senior international conversation NGO representative recalled, "That was the defining moment, at the 1985 meeting. From there, the World Bank took over and started to think about putting together these national environmental action plans" (Interview, 29 September 2006). As shown below, the Madagascar NEAP ultimately became a model for other countries preparing the plans.

Importantly, even as the conference brought the issue of Madagascar's environment into the political realm and linked conservation and development, scientists continued to influence conservation policy. In the three years between the conference and the issuance of the NEAP, a number of critical events occurred. Two pre-conferences, both held in the Solimotel in Antananarivo, concentrated on scientific research. The first, sponsored by the Ministère de la Recherche Scientifique et de la Technologie pour le Développement and organized by Lala Rakotovao, the director for environmental sciences research, concentrated on the state of research on forest ecosystems in Madagascar (Rakotovao et al. 1988). The second, organized by Russell Mittermeier and Alison Richard and sponsored by the IUCN Species Survival Commission (SSC), aimed to develop a list of Species Conservation Priorities in Madagascar. In a memo to potential participants the organizers wrote, "Special emphasis should be placed on identifying the highest priority species that are in the greatest danger of extinction, and also the most important parks and reserves. This information will be incorporated into a list of recommendations to be presented at the National Conservation Strategy Conference the following week, and will also serve as the basis for an IUCN/SSC Action Plan on Species Conservation Priorities in Madagascar" (Mittermeier and Richard 1985). These scientific assessments informed a subsequent conservation action plan, and the 1985 conference and associated side meetings furthered informal collaboration among scientists, donors, and Malagasy policy makers. In a 1985 memo to researchers wanting to work through the IAGS, Chairwoman Lee Durrell wrote, "I urge each of you who cannot attend the meetings to provide me with something I can present, so that, as foreigners, we can show that we are united in our aim to study, get results and therefore help sustain Madagascar's unique natural resources" (Durrell 1985). The IUCN Primate Specialist Group of the SSC was instrumental in pushing for funding for primate conservation in Madagascar, and after this conference WWF-U.S. began fundraising.

BUILDING TRANSNATIONAL RELATIONSHIPS. In October 1986 WWF officials organized a trip to Madagascar for family and staff members of the W. Alton Jones Foundation, the foundation started in 1944 by W. Alton "Pete" Jones, an oil executive with the Cities Service Company. In addition to the foundation head, Patricia Jones Edgerton, the visitors included the executive director of the Geraldine Dodge Foundation, Scott McVay, and his wife, as well as Olga Hirshhorn, the art patron and wife of the founder of the Hirshhorn Museum and Sculpture Garden, Secretary S. Dillon Ripley of the Smithsonian and his wife, Mary, and the Washington Post reporter Henry Mitchell, who went on to write articles about the importance of Madagascar that helped to activate USAID funding for the country's environmental issues (Mitchell 1987). Russell Mittermeier, Thomas Lovejoy and Alison Jolly accompanied the group. The W. Alton Jones Foundation subsequently gave $US500,000 to WWF to get the conservation program in Madagascar going in 1986–87 in order to promote the development of a national conservation policy. This trip helped to forge additional personal relationships that later advanced the conservation agenda.

A subsequent series of related events focused on lemur conservation then consolidated the advocacy efforts of scientists and conservation NGOs. In April 1986 the New York Zoological Society (NYZS) (now known as the Wildlife Conservation Society) hosted a meeting on St. Catherine's Island in Georgia that brought together representatives of various American and European conservation organizations to discuss the status of lemurs both in captivity and in the wild. As in Jersey, the participants proposed a second meeting on "The Promotion of Ecology, Conservation and Development in Madagascar" that took place on St. Catherine's in May 1987 and concentrated on protected areas, captive breeding, research priorities, and training Malagasy researchers (Anonymous 1987, Mittermeier 1987). Mittermeier, as the chairman of the IUCN/SSC Primate Specialist Group and director of the WWF-U.S. Primate Program, invited several Malagasy dignitaries to attend. A number of zoos wanted lemurs for captive breeding, and the meeting's sponsors included WWF-U.S., the NYZS, JWPT, the San Diego Zoological Society, the Los Angeles Zoo and the Greater Los Angeles Zoo Association, the Missouri Botanical Garden, the Saint Louis Zoo, and the Duke Primate Center (Mittermeier 1987). An attendee at the meeting recalled, "[The meeting] was ostensibly about animals for zoos, but really it was about the U.S. expression of concern and the Malagasy opportunity to see the U.S. interest in zoos and animals" (Interview, 24 September 2006). The meeting ended with the signing of the 'Convention on Collaboration with Respect to Endangered Malagasy Fauna' between the Malagasy government and various zoos, which stated that lemurs could be exported only within the context of skilled captive breeding programs and commitment to current capacity building in Madagascar (Convention for Collaboration 1987).

Tensions between conservation and development goals resurfaced in these discussions as well, foreshadowing the future struggle in the NEAP between foreign conservation interests and Malagasy policy-makers' emphasis on economic development. Minister Joseph Randrianasolo, Minister of Livestock Production, Fisheries, Water and Forests, closed the St. Catherine's meeting by underscoring the importance of integrating nature conservation and sustainable use: "Our national conservation strategy is categorical on this theme," he said. "This document expounds, in straightforward terms, that the need for sustainable development is integral to the concept of conservation" (Randrianasolo 1987).

After the formal meeting, a group comprised of the Malagasy

officials, Alison Jolly, Russell Mittermeier, and others toured zoos in the United States, including the Duke Primate Center, the Washington National Zoo, the San Diego Zoo, the San Diego Wild Animal Park, the Los Angeles Zoo, the Huntington Botanical Gardens, the Saint Louis Zoo, and the Missouri Botanical Garden. This trip fostered collaboration among various Malagasy ministries as well as between these ministries and scientists. Above all, it afforded the advocates needed access to Minister Randrianasolo. The final day of the trip brought a pivotal moment: while driving around in Los Angeles, Mittermeier handed the Minister a document entitled 'A Draft Action Plan for Conservation in Madagascar', which proclaimed "Madagascar the single highest major conservation priority in the world," included a set of recommendations for the country's highest conservation priority areas, and gave five-year budget estimates for each proposed project (Mittermeier 1986; Russel Mittermeier, pers. comm. 29 December 2014). On the final day of the trip, the Minister proposed to adopt the action plan, "as a work of collaboration between Malagasy and *vazaha* [foreigners] to all the others concerned" (Jolly 2015: 94–95; see also Jolly and Sussman 2007). In this moment the previous ten years of conferences, meetings, and research agreements coalesced into a Madagascar government agenda, and the action plan subsequently informed the biodiversity portion of the Madagascar NEAP.

After a visit to Paris to meet Jean-Jacques Petter as well as IUCN and WWF-International officials, the Malagasy policy makers made a final trip to JWPT (Mittermeier 1987). Then, in 1988, the Madagascar Fauna Group formed as an international consortium of twenty-one zoos and research institutes in the United States, Europe, and Great Britain that aimed to conserve Madagascar's endangered species in line with the St. Catherine's agreement. It managed the Ivoloina Zoological Park near Toamasina and the Betampona Reserve, where captive lemurs were released, and it aided the Tsimbazaza Botanical Gardens and Zoo in Antananarivo (MFG 1994, Sargent and Anderson 2003, Jolly and Sussman 2007).

As these meetings were taking place, advocates in Washington, D.C., including from WWF-U.S., were mobilizing U.S. political interest both in biodiversity and in Madagascar. In 1988 Mittermeier chaired a World Bank Task Force on Biodiversity that raised awareness of the issue within the World Bank. That same year the Smithsonian Institution signed a Memorandum of Understanding with the Madagascar scientific research ministry, with the goals of promoting bilateral cooperation, facilitating research permits, and promoting research exchanges in various scientific fields (MRSTD and Smithsonian Institution 1988). Beginning in April 1989 the Smithsonian assembled a group of American scientists as well as policy makers from the Smithsonian, the World Bank, and USAID to discuss strategies for protecting Madagascar's biodiversity and for moving forward the NEAP (Smithsonian Institution 1990). One of the scientists recalled, "We—the research professors, the policy makers, decision makers and the finance people—had meetings called together by the Smithsonian Institution. We all contributed to a certain extent to [the Madagascar] environmental action plan by going to these meetings, by discussing these things, and sometimes writing too" (Interview, 26 May 2006). Like the trips and events discussed above, these meetings solidified informal relationships and institutionalized initial policies in Washington D.C., not just laying the foundation for the conduct of scientific research in Madagascar but also cementing the influence of U.S.-based scientists and conservation NGOs in Madagascar environmental politics.

MADAGASCAR AS THE PERFECT MODEL

Multilateral and bilateral donors then provided the finances to transform this growing scientific movement into a political reality. In 1987 the World Bank president Barber Conable announced in an address to the World Resources Institute that the Bank would create an environment department, undertake countrywide national environmental assessments, and fund environmental programs (Conable 1987). Léon Rajaobelina, then Malagasy Ambassador to the United States, offered Madagascar as a pilot country (Falloux and Talbot 1993).

The Bank began by producing internal Environmental Issues Briefs and Country Environmental Strategy Papers (Falloux and Talbot 1993, Wade 1997). In 1992 it started requiring all borrowing countries to produce NEAPs in order to qualify for structural adjustment lending (Marcussen 2003, Goldman 2005). By 1996 more than ninety countries had started a NEAP process, and seventy-four plans had been completed (World Bank 1996). Like the earlier environmental assessments, NEAPs were supposed to identify environmental problems, analyze their underlying causes, and recommend actions to address them, the goal being to mainstream the environment into the overall development planning process of a country (Greve et al. 1995). They were also intended to provide mechanisms with which to coordinate donors as well as scientific organizations, NGOs, and other institutions around complementary and integrated actions.

Reflecting the emphasis on involving civil society in policy processes that characterized the modified neoliberalism of the late 1980s (Mohan and Stokke 2000, Hart 2001), the Bank pushed the Malagasy government to involve private and nonprofit organizations in the development and implementation of its NEAP (Froger and Andriamahefazafy 2003, Sarrasin 2007). It emphasized decentralized awareness building among both populations and government authorities in order to reinforce "country ownership" and to involve "the population" (Falloux and Talbot 1993, Froger and Andriamahefazafy 2003, Andriamahefazafy and Méral 2004). To this end the plans were to be 'holistic', 'process-oriented', 'country owned and driven' (instead of donor-driven), and 'participatory': "A 'process' more than a 'product,' a NEAP seeks to provide a framework for integrating environmental considerations within the overall economic and social development of a country. As a truly national enterprise this process should be taken over and orchestrated by each interested country; it is not done for the country by a donor. The government and the civil society are partners and wide public participation is essential" (Falloux and Talbot 1993: 1).

Because Madagascar already had the National Conservation Strategy of 1984 and governmental mechanisms to coordinate its implementation in addition to well-established relationships between scientists and policy makers, the country was an ideal place to showcase the World Bank's new environmental agenda. Madagascar afforded the Bank an opportunity to appease the influential U.S.-based environmental groups who were concerned with biodiversity loss and deforestation. At the same time, the environmental agenda offered the Madagascar government an avenue to attract much-needed foreign exchange in the context of IMF restructuring (Sarrasin 2005, Horning 2008). The Madagascar NEAP became the nexus for the negotiation of diverse agendas, stemming from the World Bank, USAID, international conservation NGOs, scientists, various Madagascar government agencies, and others.

Other countries began using the Madagascar program as a model for coordinating donors and government around a unified environmental agenda and as a test for the international donor community's capacity to protect the global commons. Much of the overarching NEAP design was developed on the basis of the Madagascar plan (Mercier 2006). A former senior Malagasy official recalled that as a fifteen-year, donor-government coordinated plan it represented an entirely new way of providing foreign aid, and as a result, "a lot of countries and international organizations were interested in the [Madagascar] Environmental Action Plan" (Interview, 10 October 2005). Its designers saw an opportunity to shape not just Madagascar's future but also that of the world: the foreword to the 1988 draft NEAP states "The case of Madagascar presents the international community an opportunity to create and implement an original solution for development assistance that will preserve this biological diversity—a diversity which is part of the common heritage of all humanity. If successful, such a solution will serve as a future model for other countries" (World Bank et al. 1988: 2).

Following the 1985 conference and drawing on the 1984 strategy, the Madagascar government created an interministerial committee and a small planning unit to implement the strategy. The temporary *Cellule d'Appui au Plan d'Action Environnementale* (CAPAE), staffed primarily by private consultants, coordinated its preparation. Roughly 150 Madagascar government analysts, academics, and consultants and some 40 international environmental experts were involved in its development (Brinkerhoff and Yeager 1993, Sarrasin 2006).

World Bank missions in 1987 and 1988 under the guidance of François Falloux then pushed the NEAP forward (Brinkerhoff and Yeager 1993). The first World Bank NEAP planning mission was in October 1987; topical working groups started in late 1987 to map out priorities; and a final mission in March 1988 brought together representatives of USAID, WWF-International, the World Bank, and United Nations Educational, Scientific, and Cultural Organization (UNESCO), as well as French and Swiss consultants (World Bank et al. 1988, Sarrasin 2007). The working groups presented final recommendations at a conference in Paris in May 1988, and the draft NEAP was published in July 1988. Through these missions and working groups the World Bank enlisted bilateral donors, NGOs, scientists, and others in its vision for the NEAP; the NEAP became an "obligatory passage" for engaging in Madagascar environmental politics (Sarrasin 2007).

ENGAGING CIVIL SOCIETY AND AVOIDING THE STATE. Foreign interests heavily influenced the negotiations. The consultant Jean-Roger Mercier (2006) recounts efforts to ensure that foreigners did not dominate the process: "While the original team was essentially composed of international experts, we rapidly co-opted several Malagasy experts and anchored our contacts with the Malagasy Government, which was involved at the highest level, [with] the then Prime Minister Victor Ramahatra bringing an incredibly pertinent vision to this NEAP preparation. Cooperation with the international NGOs was a given, with WWF having a particularly strong and competent involvement from the onset" (Mercier 2006: 50). However, as Brinkerhoff and Yeager (1993) reflect: "In the early stages of the [Madagascar] environmental movement, it appeared that Malagasy government officials, scientists, and development agents would play a lead role in orchestrating the effort. Over the long run, however, the international conservation groups and donors became key players in promoting and encouraging continued action, working with a core group of Malagasy environmentalists" (Brinkerhoff and Yeager 1993: 7). Building on the strong networks and advocacy around biodiversity that had already been established, they were able to channel political and financial support to biodiversity. For example, because WWF had the background information, the World Bank asked its staff to write the biodiversity portion of the Environmental Action Plan. The resulting conservation agenda drew on the conservation strategy of 1984 (Repoblika Demokratika Malagasy 1984), Mittermeier's Conservation Action Plan (Mittermeier 1986), and the biological surveys conducted by WWF-International (Nicoll 1988).

The massive mobilization of nongovernmental personnel allowed the World Bank to tout the program as participatory (Bhatnagar and Williams 1992), even though the participants were primarily foreign- or Antananarivo-based. In their review of the process, Falloux and Talbot (1993) lament that few Malagasy NGOs were involved, the notable exception being the Federation of Malagasy Churches, which ultimately "played a key role in disseminating information and mobilizing support for the NEAP." They continue, "A major problem at the start was that the NEAP development was confined to the intellectual and technological circles in the capital, Antananarivo. To remedy this, albeit almost too late, a series of regional seminars were organized" (Falloux and Talbot 1993: 102–103). However, pressure to speed up the process hindered regional consultations: "In an effort to maintain the momentum of the analysis, input from politicians, government officials, and farmers outside of the capital was not solicited" (Brinkerhoff and Yeager 1993: 9).

Reflecting neoliberal ideology and concerns about corruption, donors sought to simultaneously avoid and engage the state. Although the CAPAE was sponsored by the Directorate of Planning and reported to the CTP (which worked under the authority of the CNCD), it was financially and administratively autonomous from the government (Falloux and Talbot 1993, Pollini 2011). Creating the CAPAE as a parastatal organization allowed the World Bank to pay higher salaries than the government, where structural adjustment was holding down civil service salaries (Jolly 2015) and "to maintain the balance of power in favor of [donor] 'experts' while facilitating incentives for the government and Malagasy public administration in the project" (Sarrasin 2007: 442, author's translation). The CAPAE depended on foreign donors, including the World Bank, USAID, the Swiss aid agency, United Nations Development Program (UNDP), UNESCO, and WWF-International, for all of its finances, including salaries (Sarrasin 2007, Pollini 2011).

The donors committed to locating a Multi-Donor Secretariat (MDS) to coordinate the eleven donor agencies that would finance the first phase of the Madagascar NEAP in Antananarivo (Coopération Suisse et al. 1989, World Bank 1989). However, in another failed effort to promote Malagasy control, in 1989 USAID agreed to finance an MDS at the World Bank in Washington. The justification for moving the MDS to Washington was to facilitate coordination with donor and NGO headquarters outside of Madagascar and to let the newly created *Office National pour l'Environnement* (ONE) coordinate those within Madagascar. In fact, the MDS eventually became a conduit of NEAP information and experience among countries around the globe, and it helped to coordinate NEAPs across a number of African countries. In the second phase of the NEAP, a donor-financed and Madagascar-

based *Secrétariat Multi-Bailleurs* replaced the MDS and served as an interface between donors and the Madagascar Government on environmental funding and priority setting (Brinkerhoff and Yeager 1993, Falloux and Talbot 1993, Greve et al. 1995, Brinkerhoff 1996, Lindemann 2004).

By creating new institutions outside of the government, the donors could control the priorities and pace of the program, but they also had to sell their agendas to key officials in the Madagascar Government. Even as Falloux and Talbot (1993) commend the "wisdom not to entrust the NEAP preparations directly to the existing governmental structure" (Falloux and Talbot 1993: 36), they admit that the lack of parliamentary involvement resulted in a slowdown of the NEAP's formal acceptance. The CAPAE tackled the challenge of selling the NEAP to the government in part by using media consultants to educate the population about environmental issues and to build popular support for the NEAP, which in turn helped to enlist government officials (Falloux and Talbot 1993, Sarrasin 2007).

DEBATING THE BALANCE: LEMURS VERSUS PEOPLE. The NEAP had the potential to set the stage for a broad environmental program for Madagascar, but the operationalization of the plan depended almost entirely on foreign aid donor funding and so it was shaped by donor priorities. Mercier (2006) recalls the early implementation process: "Our first order of business was to define the NEAP's scope. We cast the net very widely and did not limit ourselves to conservation, though conservation was both the reason why Madagascar was so famous and courted internationally and the biggest motivation behind the preparation of the NEAP" (Mercier 2006: 50). While issues such as biodiversity conservation, urban environment and soil conservation remained core priorities in the final draft plan in 1988, other topics identified in early planning meetings such as human health, marine, and energy were marginalized in favor of education, research, monitoring, and tourism. Overshadowing the donors' conflicts over these priorities was an ongoing clash between conservation and development goals: as a government official recounted, "We were concerned with development, but the donors were interested in conservation" (Interview, 14 October 2005). As the holders of the purse strings, the foreign aid donors quickly began reshaping the plan's priorities and implementation infrastructure.

Once the NEAP was accepted in 1988, subsequent multidonor missions in 1989 negotiated its implementation. Again, foreign state and non-state actors dominated. The World Bank meeting in Madagascar in July 1989 was a pivotal moment, when Swiss, American, Norwegian, and German donors on the multidonor mission released a joint memo to the World Bank that critiqued the priorities for the first phase of the program laid out in the World Bank's summary of the 1989 Donor Evaluation Mission (World Bank 1989). They confronted the World Bank representative at the end of the first week of the joint donor mission, after the participants at the mission had spent a weekend at the Périnet Reserve. Jolly (2015: 111) describes what happened: "The aid donors sat in a grim clump at the far end from François [Falloux]. When François called on Hans Hürni [with the Institute of Geography at Berne University], Hans just rose with a paper from the donors in his hand, walked silently the length of the table, put it down in front of François and walked silently back" (see also Jolly 2004: 115). Challenging the World Bank's proposed plan of action, the memo argued that: "Due to insufficient institutional capacity and technical experience, the MDG [multidonor group] suggests scaling down the soil conservation, remote sensing / cadastre and education components. In addition, the MDG strongly feels that inadequate training and institutional capacity is the single most significant constraint to improved environmental management in Madagascar, and needs to be addressed in a more coherent way within each project component." It underscored that the biodiversity section "continues to be the most coherent component of the project, and should serve as a focal point for other project activities," and it emphasized that the proposed MDS should be based not in Washington but in Madagascar (Coopération Suisse et al. 1989: 2-3).

Again, tensions between donor interests in conservation and Malagasy interests in development surfaced: "By the next day the Malagasy counter-attacked. Viviane Ralimanga (the head of the CAPAE) herself wrote an impassioned letter saying if we thought we could just emphasize fauna and flora, we were sadly misjudging the temper of the Malagasy, as well as their needs. Philippe Rajobelina, the Deputy Director General of Planning, wrote to say that even within the biodiversity sector it was unacceptable to have more money allotted to the reserves than to peripheral development: 'There are more important primates in Madagascar than lemurs'" (Jolly 2015: 112-113, see also Jolly 2004: 215).

Again, however, money decided the conflict. By 1991 the programs proposed or in place for biodiversity totaled over $US60 million, more than $US50 million of which came from USAID, with UNDP, German, Norwegian, and proposed British aid making up the balance (Greve 1991), while Swiss aid concentrated on agriculture, sustainable forestry and rural development (Kull 2014). Nonetheless, programs like mapping, land tenure, research, and information were often oriented toward biodiversity and forests programs (Hufty and Muttenzer 2002). Even within the biodiversity program there remained tension between how much to focus on conservation and how much to integrate development, and while Integrated Conservation and Development Projects offered a balance, by the second and third phases of the NEAP they had given way to large-scale biodiversity prioritization and landscape planning. The first MDS newsletter states, "One of the major issues facing EP1 [Environment Program 1] as it approaches implementation is how to achieve the correct balance between biodiversity and natural resource conservation, scientific research and development activities for the buffer zone populations" (Greve 1990, n.p.). Yet even as donors agreed that it was important to integrate development with conservation, a long-standing emphasis within the biodiversity program on biological inventories, identification of conservation priorities, and the expansion of protected areas remained, as did the tension between conservation and development interests and the influence of foreign and Antananarivo-based organizations.

SCIENCE, POWER, AND GOVERNANCE

The historical analysis of the rise of Madagascar's foreign funded conservation agenda highlights the value of attending not just to official policy and institutions, but also to the power relations and informal interactions among the individuals engaged in them. From the mid-1970s through the launch of the NEAP in the late 1980s an assemblage of dedicated scientists, NGOs, donors, and bureaucrats worked together in both informal and formal ways to facilitate scientific research and promote conservation in Mada-

gascar. Through meetings, conferences, trips, letters, agreements, and action plans, they circulated ideas, crafted narratives, cemented personal relationships, and developed policies that laid the foundation for Madagascar's subsequent environmental program. At particular moments—ranging from major conferences to trips to park lodges—they shifted the political playing field in critical ways. Their explanations for Madagascar's environmental crisis as well as for the priority solutions to it became institutionalized; not only via the official policies that the World Bank, the Madagascar government, foreign donors, conservation NGOs, and others crafted but also through the personal relationships they developed during this period, relationships that continue to influence environmental politics in Madagascar to this day. Throughout this process, although numerous actors advocated for decentralized and Malagasy-driven, integrated conservation and development approaches, the political, scientific, and financial strength of those pushing conservation, the lack of a strong counterbalancing force and the Antananarivo-centric processes often collectively overrode them. In short, the compromises needed to maintain the political coalitions necessary for environmental support hindered the pursuit of a more comprehensive environmental agenda.

The program's concentration on biodiversity reflected not just the efforts of a group of individuals and the timing of the World Bank's environmental interest but also the particular relations of governance brought about by the rise of neoliberalism. The neoliberal reduction of the state, the participatory turn in international development, the World Bank's adoption of the environment as a central issue, and the rising scientific attention to biodiversity enabled this assemblage to transform Madagascar's conservation agenda from a scientific issue to a political one. The push for participatory policy development legitimized non-state actors' influence on the environmental priorities even as the participation was primarily by Antananarivo-based and foreign actors. Likewise, the reduction of the Madagascar state under structural adjustment and the resulting lack of state capacity and accompanying need for foreign exchange created the conditions under which the Madagascar Government had to embrace donors' priorities. Collectively, these political and economic processes created the context needed for individual actors to push forward biodiversity conservation to become the centerpiece of the subsequent environmental agenda. In this sense, strict conservation often superseded the push for more decentralized, integrated approaches not just because of the advocacy efforts of a group of individuals and the timing of the World Bank's environmental interest but also because the particular relations of governance entailed in the rise of neoliberalism brought key actors into the negotiating room, where they could then become effective advocates. Thus, the achievement of effective and equitable conservation in Madagascar will require not only pushing more comprehensive and participatory programs, but also transforming the power relations that have both created Madagascar's environmental crisis and efforts to redress it.

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Figure S1. Timeline of significant events

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