Environmental Protection in Madagascar: 
An Evaluation of Program Viability

A Plan B Paper

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LIST OF ACRONYMS
(Italics indicate the English translation of the acronym)

ANGAP - *The National Association for the Management of Protected Areas in Madagascar*

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora

FAO – Food and Agriculture Organization of the United Nations

GELOSE – *Secured Local Management*

ICDP – Integrated Conservation and Development Project

IUCN – International Union for Conservation of Nature

NGO – Non-government organization

NEAP – National Environmental Action Plan

RNP – Ranomafana National Park

SAPM – System of Protected Areas of Madagascar

UNESCO – United Nations Educational, Scientific and Cultural Organization

USAID – United States Agency for International Development
I. Abstract

Madagascar is a biodiversity hotspot with many species found nowhere else on the planet. The island hosts many different climates, ranging from dry forests and savannah to tropical rainforests. Much like the Galapagos Islands, the results of Madagascar’s unique evolutionary history are highly coveted among scientists and international aid organizations. Much effort has been put into conserving the island’s ecoregions, especially following its nonalignment with the Soviet Union. Aside from recent international interest for conservation in Madagascar, the country has had a functioning environmental protection program for more than a century.

The Madagascar environmental program has been historically protective, either incidentally or directly, of this biodiversity at the policy level, but enforcement has often lagged behind policy declarations. Since the mid-19th century, many environmental laws sought to exclude people from using forest resources outright. Between 2002 and 2009, environmental laws in Madagascar began to shift from seeking to exclude local people from natural resources to creating contracts for sustainable natural resource use.

This transition of environmental law, coupled with a presidential political crisis that began in January of 2009, has been tenuous. It’s the second time environmental law has shifted tremendously in the past two decades. During this time, the Malagasy government has had to balance economic development and environmental conservation, a difficult prospect given how tied local people are to traditional land use practices. Local communities are especially sensitive and resistant to changes that prohibit traditional economic practices if a close substitute practice that preserves perceived economic sufficiency is not available. Despite this difficulty, the Malagasy government has set three policy goals for environmental protection beginning in the
early 1990s and these are: the environment must be conserved, local economies must be
developed, and local people must be participants in resource management (Henkels 2001-2002).

Four case studies are evaluated to determine how well these policy goals are being met. Meeting these three goals is an indicator of the viability of environmental protection in Madagascar. These case studies include the Masoala Peninsula Corridor, Ranomafana National Park, the Mikea Complexe, and the Vohidrazana-Mantadia Corridor. These case studies are different in more ways than the diverse environments they represent. Social groups, governance structures, and other local contexts are unique to each case study as well. The case studies are each evaluated by four criteria, including indicators of anthropogenic disturbance, perceived economic sufficiency and opportunities available for local people, enforcement ability, and political acceptability. These criteria are based on the three policy goals of the environmental protection program.

The evaluation demonstrates that the environmental protection program’s viability differs across the case studies. Much of this variability is tied to differences in enforcement ability and governance structures in each protected area, combined with local reaction to the 2009 coup d’état that unseated a democratically-elected president in favor of a military-supported autocracy. This variability carries over into the viability of the environmental program of each case study area, with the national parks of the Masoala Peninsula Corridor clearly failing and not currently viable. Ranomafana National Park is another case study that is categorically failing to achieve majority community participation and options for local economic development. Parks within the Vohidrazana-Mantadia Corridor and Mikea Complexe are still viable, with the caveat that the 2009 political crisis was likely injurious to current program viability in these cases. Out of these two case studies, the Perinet Reserve from the Vohidrazana-Mantadia Corridor and the
Kirindy Forest from the Mikea Complexe are the most successful and viable protected areas of Madagascar’s environmental protection program.

Despite Kirindy Forest’s and Perinet Reserve’s success in meeting the three policy goals of the environmental program, applying the strategies that make them successful may not be feasible across the many protected areas of the island. Three policy recommendations are given. The first relates to China’s importation of illegal rosewood, the second relates to how strict reserves are governed, and the third relates to the need for a shift away from slash-and-burn agriculture toward modernized agriculture. There are significant barriers to the implementation of these recommendations to increase the environmental protection program’s viability, and these barriers are largely contingent upon the resolution of the ongoing political crisis in Madagascar.

II. Introduction and Problem Statement

Madagascar, an island nation in the Indian Ocean with an area of nearly 59 million hectares (ha) (~226,000 square miles), has remarkable endemic\(^1\) flora and fauna, a diverse culture, and historically abundant natural resources (United States Central Intelligence Agency 2011). Despite its wealth of natural resources, chronic poverty in Madagascar is an enduring burden. The World Bank reports, as of 2009, that 71.3% of the Malagasy population is living beneath the nation’s poverty line. The same study reports 67.8% of all Malagasy live on less than $1.25 PPP\(^{ii}\) (Development Research Group, World Bank 2009) and 89.6% of all Malagasy live on less than $2.00 PPP (Development Research Group, World Bank 2009). The island nation

\(^1\) Endemic in the ecological sense means native or confined to a particular region.
\(^{ii}\) Purchasing Power Parity: An economic technique to determine relative values between two currencies by taking into account differential purchasing power by using a number of different products (Kaplinsky 2005). In this case, the technique is used to compare relative values between the American dollar and the Malagasy ariary.
was ranked the 10th poorest country in 2000 (The World Bank 2010). The average life expectancy is 60.8 years (World Bank 2011). Nearly 45% of the population is under the age of 15, while 52% of the population falls between the ages of 15 and 64 years (U.S. Department of the Army 2005).

The current state of the environment is an immediate and pressing concern for both the Malagasy government and international observers. Since the late 19th century, roughly 85% to 90% of the island’s humid and dry forests have been felled for subsistence agriculture, logging and livestock management (Green and Sussman 1990). Additionally, deforestation is occurring at a rate of roughly 100,000 ha or 308 square miles (sq mi) per year (Dolins et al. 2010). The island’s biodiversity is at risk due to traditional agricultural practices, overexploitation through hunting and logging of certain species, and uneven protection afforded to natural areas by the Malagasy government (Conolly 2008). Madagascar has few funds to support protected areas, instead relying on international aid to help mitigate the effects of poor transportation infrastructure, lack of materials for surveillance and management, and staffing issues at protected areas (Hannah 1992).

Much of the nation has yet to be globalized in any significant way, though Madagascar’s wealth of natural resources – chromite, bauxite, tropical timber, vanilla, and precious stones – has positioned it as a supplier of different commodities to the world market (United States Central Intelligence Agency 2011). Aside from being an exporter of natural resources, Madagascar has, between 1989 and 2009, received foreign aid for economic development projects and environmental conservation. This aid is important for Madagascar’s three broad policy goals in relation to its environmental protection program: environmental conservation, local economic development, and majority public participation in forestry and natural resource
governance. This funding helps local people develop sustainable land use practices, maintain and expand transportation infrastructure, and develop ecotourism, among other things.

Both ecotourism and local development aid have been supported by Madagascar’s far-reaching, but difficult to enforce, environmental laws. In the early 1990s, Madagascar, with the aid of international organizations like USAID and the World Bank, developed policies that sought to link environmental conservation and economic development with ecotourism, and the goals of its environmental protection program were shaped to achieve this link. Despite these environmental policy aspirations, there has not been much recent evaluation or synthesis of Madagascar’s environmental protections as a whole. Notably, there has not been much research published in connection to the 2009 coup d’état that saw the Malagasy government isolated from the international community. International reaction to this event denied most of the financial aid that supported Madagascar’s environmental conservation and economic development programs. Recognizing the high importance both the Malagasy government and the international community have placed on environmental protection, this paper seeks to evaluate the environmental protection program’s viability in achieving the policy goals of environmental conservation, local economic development and majority participation given this recent political uncertainty.

III. Methodology

This paper will introduce relevant background information tied to environmental protection in Madagascar. Highlighted information includes an introduction to the people of Madagascar, their beliefs, the progression of Malagasy environmental law since the mid-19th century, land use practices, political and economic realities. Important ecological and
biogeographical information is also highlighted. Taken together, this information demonstrates the interconnectivity of competing interests in Madagascar, with special consideration for the relationship between local people and the environment and how this relates to environmental protection on the island.

The island is economically, environmentally, and socially diverse. There is a multitude of different land types that local people use in different ways. There also are different environmental conservation tactics being used by the Malagasy government and aid groups across the island. This heterogeneity requires an analysis that uses case studies, each one representing a natural area that has been placed under protected status by the Malagasy government. These case studies were chosen based on the biogeography and ecology they represent, the ways in which local people interact with these areas, the extent to which economic development and ecotourism is incorporated into each protected area’s viability, and the quality of scholarly work referring to each selected area. The case studies also strive for geographical representativeness, sampling many environmental land types that occur on the island.

These case studies are evaluated using a set of four criteria, all of which are derived from the goals of Madagascar’s environmental policy, as well as recurring themes and values found in scholarly work linked to the island’s environmental protection program. This method for choosing criteria comes out of program evaluation value theory, a concept that will be explained in the Criteria section. Criteria are then applied to each case study to indicate the extent policy goals are being met to determine program viability. Scholarly work related to each criterion is synthesized and informs these evidence-supported, normative conclusions about the viability of Madagascar’s environmental protection program.
IV. Background

Many people in Madagascar have made their living off the land since Polynesian boats first landed on the island around two millennia ago (Wright and Rakotoarisoa 1995). For those not living in cities, working the land is a necessity of life. Cultivating the earth for rice production, or clearing an area for grazing by their staple livestock, the zebu, ensure that local communities are able to persist. Economic transactions occur at a very local level, with bartering for goods without currency commonplace within and between rural communities. Communities obtain currency by selling their commodities in city markets, specifically cash crops like vanilla and clove, which is used in turn to obtain materials and products for familial and communal use.

According to the U.S. Central Intelligence Agency, the estimated population in Madagascar as of July 2008 was roughly twenty million and the growth rate was three percent (United States Central Intelligence Agency 2011). The population is reliant on food that is produced on the island, and agricultural production is decentralized, traditional, and requires constant conversion of forest to productive land. Currently, population growth is increasing demand on scarcer forest resources that are required for traditional agriculture. Much of the original forest has been converted to agricultural land or fallow areas in the past century. By 2002, 1.7 million ha (~6,500 sq mi) of rainforest – less than 34% of its original extent (Green and Sussman 1990) – was protected by the Malagasy government. Protection of natural areas often runs up against the aim to maximize economic efficiency, and at times, the ability for local communities to continue existing. Refer to Figure 1 on the next page for geographic information on noteworthy cities, protected areas, and roads in Madagascar.

* Bos indicus, also known as the Brahmin cattle.*
Figure 1 indicates cities (white), protected areas (yellow), and roads (gray).

Many developing nations, Madagascar especially, have historically extracted their natural resources to be on the same path of development as developed nations (Mies 2008).
Globalization is also pressuring developing countries to provide resources to a global market, especially where developed countries no longer have access to those resources or have deemed it environmentally irresponsible to do so at home (Mies 2008). For instance, the Malagasy government has recently considered selling half of the island’s arable land – 1.3 million ha (~5,000 sq mi) – to Daewoo Logistics, a South Korean multinational, for maize production for food and ethanol (Walt 2008). Another contract was considered for exporting freshwater to Saudi Arabia (Draper 2010). Despite these pressures and historical pathways, Madagascar has attempted to develop economic value in conserving the environment and promoting it through local economic development projects and ecotourism. Policies that have sought to develop local economic development and ecotourism have, at times, not been well-received by the citizenry of Madagascar.

The recent turmoil in the Malagasy government over the proposed Daewoo Logistics contract has demonstrated a lack of political acceptability over some economic development programs. In February 2009, the mayor of the capital city of Antananarivo and popular disc jockey, Andry Rajoelina, declared himself President of Madagascar, inciting a coup against the administration of President Marc Ravalomanana (Mattis 2010). Public support dropped for Ravalomanana in January 2009 following his administration’s support for the Daewoo Logistics contract, his opponents claiming that he supported neocolonialism and sought to starve the citizenry (Sodikoff 2009). The Malagasy Armed Forces supported Rajoelina, forcing Ravalomanana to abdicate power and flee the country in March 2009.

The Rajoelina administration is not seen as having legitimacy either domestically or internationally. The United States, the European Union, the African Union, the World Bank, the United Nations, the Southern African Development Community, and the International Monetary
Fund refuse to recognize the administration (Mattis 2010). These powers have called for Rajoelina to step down and restore democracy, and have punished the government with economic sanctions and the withdrawal of development aid. This is significant, as 70% of government spending – nearly $270 million (World Bank 2010)– during the Ravalomanana administration came from foreign aid (Mattis 2010). The spillover effects include paralysis of essential social services, like education and health care, and funding for the national park system. Diplomatic attempts to dissolve this essentially autocratic regime have thus far failed (Mattis 2010), although presidential elections are set to occur sometime in May 2011 (Business Monitor International 2011). The political turmoil in Madagascar is a primary driver in what environmental protection outcomes will be produced, with some analysts lamenting that the new administration has eroded the environmental gains made in the past twenty-five years (Coleman 2010).iv

a. Social beliefs

Despite occupying the island for nearly two millennia, local people often lack information about endemic species. Social traditions, including constrictions created by fady, do not often refer to endemic species, instead focusing on livestock and other creatures that are part of daily life (Dolins et al. 2010). Sociologists have noted that many Malagasy children are unfamiliar with Madagascar’s unique species, so unfamiliar that they do not recognize that these species exist, and it follows that adults will not have much interest in conserving species that they do not recognize as existing (Dolins et al. 2010).

iv For an in-depth analysis of this change in government, see Marcus, R. “Marc the Medici? The Failure of a New Form of Neopatrimonial Rule in Madagascar.” Political Science Quarterly. 125:1. 2010.

Fady are systems of beliefs that are either supernatural or traditional in nature. They provide spiritual and social guidance to actions an individual should follow.
Consistent among the cultural diversity of Madagascar is the belief of *fady*, or a system of prohibitions that dictates how one should act toward the environment, family, ancestors, labor, and many other social relationships (Tengö et al. 2007). *Fady* provide informal but powerful constraints against certain actions, and this is particularly important given the uneven protection of national parks and limited compensation provided by the Malagasy government (Jones, Andriamarovololona and Hockley 2008).

There is a continuum of *fady* that, if broken, can lead to consequences ranging from social disapproval to supernatural retribution. *Fady* are very local; communities 25 kilometers apart might not share the same *fady* due to having different ancestors (Tengö et al. 2007). Given the apparent supernatural damage that might be done by even interacting with certain species, *fady* can produce a conservation effect, even if that was not the original intention of the *fady* (Tengö et al. 2007). In the Androy region of Madagascar, near Fort Dauphin on the island’s southernmost tip, incidental environmental conservation occurs in many different ways as a result of *fady*, with forest plots left undisturbed due to local spiritual and social beliefs (Tengö et al. 2007) (see Appendix A).

According to some recent studies, *fady* may change over time in response to systematic changes in culture, environment, and economics (Draper 2010). For example, a *fady* that prohibited selling wild-harvested foods fell to the wayside when economic conditions were particularly harsh (Jones, Andriamarovololona and Hockley 2008). While *fady* represent an informal and diverse system of social expectations across the island, the governance structure around environmental conservation represents specific, formal rules about what is and is not acceptable behavior (Henkels 2001-2002). Given Madagascar’s ongoing political turmoil since 2009, conditions may have changed and some information presented may be outmoded.
Aside from *fady*, there are other forms of cultural value systems at work in local communities. These are often tied to agriculture and working in the forests. For example, some highland communities share the aesthetic value of creating openness in landscapes through clearing trees and large shrubs (Bloch 1995). Other communities see *tavy* and other land-clearing measures as “saving” land by mixing their labor with it to make the land productive (Kull 2008).

Taken together, these beliefs can promote degradation or conservation of the environment, and these beliefs vary greatly among Madagascar’s communities. Recent environmental policy planning has tried to show greater sensitivity towards *fady* and other beliefs to align environmental protection with current belief structures (Tengö et al. 2007).

**b. Land use practices and local economy**

There are two types of agricultural land use predominating in Madagascar. The first, rice paddy production, predominates in the central plateau, while the second, slash-and-burn agriculture, predominates near the coastal regions (Dolins et al. 2010). The central plateau consists mostly of savanna interspersed with dry forests and rainforest, while coastal regions have mangroves, rainforest, and dry forest interspersed with savannah. Slash-and-burn, or *tavy* as it is known to locals, is used in forested regions despite being outlawed by the government (Dolins et al. 2010). This form of agriculture is successful for local people because the periphery of rainforest and littoral forest is much drier than the area within the forest itself, making it easily managed by fire (Quammen 1996).

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vi Slash-and-burn agriculture aimed at clearing forests for subsequent rice planting

vii Transitional Broadleaf forest found near coastal regions
Burning rainforest deposits nutrients into the soil quickly, but eliminates the complex nutrient cycling that had occurred when the burned rainforest was intact (Styger et al. 2007). Contrary to the teeming biodiversity of rainforests, the tropical soil is typically very poor due to nutrients being leached from the ground by consistent rains, though comparatively rich soil exists in the extinct volcano zones of Ankaratra, Itasy, and Tsaratanana in the middle and northern parts of the island (Laney 2002). The typically nutrient-poor soil, now enriched by burning, is then available to farmers to use for planting rice – the staple Malagasy food – or maize. This poor soil quality allows for only a few seasons of agricultural use before nutrients are depleted. When this occurs, the land becomes fallow, and the cycle of tavy begins again on another portion of forest (Styger et al. 2009).

*Tavy* represents one vector of the larger environmental degradation issue in Madagascar. Other current kinds of land use in Madagascar are directed towards resource extraction for both subsistence and trade. The local people are dependent on the clearing of rainforests for many reasons (USAID 2009). First, the wood proves to be useful in the construction of homes and as fuel for fires that aid food preparation, night heating, and laundry cleaning. Second, clearing forests displaces resident creatures and makes it easier to hunt them for meat. Third, clearing rainforests is the first step to cultivating pastureland for sustaining herds of zebu. Zebu are used in maintaining agricultural land and are valued for their meat and hides.

The economic opportunities afforded to most Malagasy are limited, especially in terms of trade beyond familial subsistence. This is especially true outside of the urban centers, where villages are largely not connected with the country’s neglected transit infrastructure (Moser, Barrett and Minten 2005). Most options require subsistence from the land, chiefly centered on cultivation of staple crops like rice, maize, cassava and tapioca, harvest of fruit-bearing trees like
mango and banana, hunting small game, and raising zebu. Kindling and building materials are either gathered from nearby forests or community eucalyptus plantations (Nicoll and Langrand 1989). Additional economic value might be derived from crafts which are taken to market at provincial capitals, or by selling a surplus of zebu or cash crops. Precious stones, like sapphire, are a prominent economic boon to villages in the northern and southern parts of the island. However, like the diamond market, the local people doing the extraction work are paid comparatively little based on the artificial scarcity value created by firms selling sapphires directly to consumers (Peel 2000).

Even with 80% of the population employed in the agricultural sector, including forestry and fishing, Madagascar does not produce enough food to feed its population (United States Central Intelligence Agency 2011). The nation must import between 200,000 and 300,000 metric tons of rice and nearly 100,000 metric tons of wheat per year in order to meet the demand for food (FAO 2008). Chart 1, shown below, lists the top twenty food items that Madagascar imports as of 2007 (FAO 2011). The Food and Agriculture Organization of the United Nations (FAO) has begun agricultural initiatives to put more arable land into production and increase farming in fallow areas with the aid of fertilizers (FAO 2008). Distributing rice via both FAO aid activities and local producers has been difficult given Madagascar’s poor transportation infrastructure, a problem that the FAO cannot resolve any time in the near future.

The FAO was, until 2009, actively aiding an agricultural shift away from maize toward sorghum in southern Madagascar. The dry climate makes growing maize particularly difficult, though sorghum can flourish in such conditions. Sorghum is viewed by both the FAO and local

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viii A grain that can be used in the creation of couscous, flour, porridge, and molasses. Can also be used as feedstock for zebu.
farmers as an appropriate and acceptable alternative to maize, as farmers had grown it until a long period of drought made the crop extinct in southern Madagascar (USAID 2009).

**Madagascar’s Food Imports for 2007**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Product</th>
<th>Quantity (in Tons)</th>
<th>Value (in Thousands)*</th>
<th>Unit Value* (Per Ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rice Milled</td>
<td>186,150</td>
<td>56,600</td>
<td>304</td>
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<tr>
<td>2</td>
<td>Soybean oil</td>
<td>44,818</td>
<td>29,984</td>
<td>669</td>
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<tr>
<td>3</td>
<td>Food Wastes</td>
<td>26,235</td>
<td>28,617</td>
<td>1,091</td>
</tr>
<tr>
<td>4</td>
<td>Wheat</td>
<td>98,225</td>
<td>27,500</td>
<td>280</td>
</tr>
<tr>
<td>5</td>
<td>Sugar Refined</td>
<td>52,056</td>
<td>18,284</td>
<td>351</td>
</tr>
<tr>
<td>6</td>
<td>Sugar Raw Centrifugal</td>
<td>50,237</td>
<td>16,812</td>
<td>335</td>
</tr>
<tr>
<td>7</td>
<td>Flour of Wheat</td>
<td>32,109</td>
<td>10,626</td>
<td>331</td>
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<tr>
<td>8</td>
<td>Palm oil</td>
<td>13,623</td>
<td>8,777</td>
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<td>9</td>
<td>Food Prep Nes</td>
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<td>10</td>
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<td>11</td>
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<td>5,179</td>
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<td>12</td>
<td>Macaroni</td>
<td>8,113</td>
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<td>13</td>
<td>Milk Skimmed Dry</td>
<td>1,562</td>
<td>4,718</td>
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<tr>
<td>14</td>
<td>Oil Hydrogenated</td>
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<td>15</td>
<td>Cotton lint</td>
<td>3,249</td>
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<td>16</td>
<td>Maize</td>
<td>8,160</td>
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<td>Tallow</td>
<td>5,009</td>
<td>3,180</td>
<td>635</td>
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<tr>
<td>18</td>
<td>Tobacco, unmanufactured</td>
<td>712</td>
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<td>19</td>
<td>Sorghum</td>
<td>4,980</td>
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<tr>
<td>20</td>
<td>Pastry</td>
<td>1,339</td>
<td>2,008</td>
<td>1,500</td>
</tr>
</tbody>
</table>

*Chart 1*

Source: FAO 2011
FAO analyses have concluded that Madagascar can become self-sufficient in meeting its internal demand for food with internal food production, and that it could even become an exporter of rice and other staple food crops regionally, especially to nearby island nations and countries in mainland Africa (FAO 2011).

The FAO, USAID, and other aid organizations have consistently found that rice and other traditional crops should not be replaced with unfamiliar crop varieties. The aid groups cited significant cultural resistance to both changes in how agriculture is conducted (the culturally-rich tavy that is tied to fady versus more modern plantation-style rice production) and differences in the food product taken to market (Hume 2006). For instance, many local people prefer to eat traditional varieties of rice compared to those that are nonnative or GMO products. Aid groups do hope, through education and proper technological deployment, that agricultural methods will be able to be changed, even if different crop varieties cannot be produced (Hume 2006).

In those protected areas where natural reserves, like Perinet, and larger national parks, like Masoala, exist, local people have a different portfolio of economic options from which to choose. Many park rules restrict or ban traditional forms of land use, such as tavy, instead allowing only those economic activities that support environmental conservation. Conservation seeks to not only protect vulnerable natural areas, but to economically commoditize natural areas and generate value for a variety of groups, including local people, ecotourists, and even pharmaceutical firms as well. Economists have argued that the non-use values of protected areas associated with ecotourism or local economic development can outweigh use values associated with logging and agriculture (Gössling 1999). For instance, existence value for rainforest alone can approach $19/ha per year (Adger et al. 1995). Local people can engage in ecotourism or development projects funded by foreign aid. Ecotourists are able to experience natural areas in
Madagascar and pay for services that support the local economy. Pharmaceutical firms are able to take advantage of the bank of genes, venoms, and perfumes that conservation generates, too (Hayden 2003). The option value\textsuperscript{ix} of having these resources for future use can exceed $90/ha per year (Adger et al. 1995). Compare this to direct use per family unit for hatsake,\textsuperscript{x} which is farmed in an area ranging from one to ten ha. A two ha plot yields one to eight tons of grain, worth about $50 per ton (Tucker 2007). Depending on soil productivity, it may be the case that non-use benefits could exceed benefits from direct use, but many Malagasy are unwilling to set aside land when they and their families need to be fed in the short term.

In the early 1990s, the common wisdom put forth by much of the economic development literature was that environmental conservation could be bundled with ecotourism to promote sustainable development, and throughout the 1990s ICDPs focused on this interaction (Krüger 2005). Ecotourists interact directly with local people, and the economic interactions that do take place are not constrained by transaction costs. Local people do not necessarily need to take their product to market or be paid a fraction of a good’s total worth when they can sell directly to a consumer. The guarantee that a protected area will continue to be in the same place for years to come has encouraged not only upkeep of transit options – a continuous road and railway between Antananarivo and Perinet, for example – but also different economic opportunities for local people as well. Hospitality services, crafts, t-shirts, souvenirs, processed foods from the urban areas, and much more are demanded by tourists who seek out these preserved natural areas. In 1995, nearly 75,000 ecotourists visited Madagascar. Each ecotourist spent nearly $800 on average, and ecotourism receipts\textsuperscript{xi} in total exceeded $60 million. Ecotourism receipts made up

\textsuperscript{ix} Refers to the value of a resource’s possible future use
\textsuperscript{x} Equivalent of tavy; slash-and-burn for the production of maize
\textsuperscript{xi} Tourism receipts refer to the amount of foreign currency entering a country through tourism transactions, including travel, lodging, recreation, and other categories
nearly 20% of Madagascar’s exports (Gössling 1999). There is hope that these additional economic benefits will help persuade local people to keep as much forest as possible out of agricultural production.

*Figure 2* illustrates the economic effects of ecotourism (Gössling 1999):

![Diagram of economic effects of ecotourism]

The figure estimates that local people in Madagascar could receive a range of payments from groups on ecotourism excursions, ranging from 1% to 35% for any one service. Owning a hotel or operating a restaurant would be particularly profitable so long as there is a steady stream of ecotourists. Hospitality and other services can be profitable as well, as the currency disparity between the dollar (or euro) and the ariary encourages these sellers to engage ecotourists with bartering. Sellers are able to take advantage of the ecotourists’ inelastic demand for goods and services, as well as their disposition to not barter, and to instead sell at higher prices.

There are also opportunities for local people to pursue that deal with endangered species products. Illegal logging and poaching are activities that occur in Madagascar on a daily basis (Schuurman and Lowry II 2009). Pushback to this kind of exploitation came in the form of

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1 ariary = $0.0005
CITES and policy interventions at the Malagasy central government level, though enforcement on the island remains tenuous and inconsistent. However, CITES policy interventions have been successful in the past.

For example, hunting and “ranching” chameleons is an acceptable practice depending on the social restrictions related to fady, and local people have shifted from agriculture to the chameleon trade to reap the benefits of higher prices and significant import demand in other countries. Local people who became chameleon suppliers did so for other reasons aside from high global demand, too (Carpenter et al. 2005). Since tavy and other sources of traditional economic value were banned, local people had to find other ways to support themselves. The chameleon trade was one market they could enter into easily, especially in collusion with local officials that administered the parks.

This study (Carpenter et al. 2005) was conducted to assess the extent Appendix II and Appendix III chameleon species (see Appendix E) were exported by Madagascar and other African countries (Carpenter et al. 2005). The study found that CITES provided a sufficient framework to regulate the chameleon trade. In 1988, given the ability to export at high prices to meet worldwide demand, Madagascar eased restrictions on export controls of Appendix II and some Appendix III chameleon species (Carpenter et al. 2005). This national easing led to exponential harvesting of chameleons, which alarmed the CITES Secretariat, the international body responsible for promulgating regulation on endangered species products. There were fears that exponential increases in harvest would destabilize the chameleon populations and plunge them toward extinction. The CITES Secretariat requested that importing Party members suspend imports of chameleons (except Furcifer pardalis, F. oustaleti, F. lateralis and F. verrucosus) from Madagascar. These actions were followed by a national initiative in 1999 to establish a
management structure for the chameleon trade, the net result of which was a massive reduction in chameleon exports in 1999 and 2000. After this initiative, 94.7% of chameleons exported from Madagascar were in the four species specified by CITES (F. pardalis, 43.9%; F. verrucosus, 4.4%; F. oustaleti, 7.0%; and F. lateralis, 39.4%), the remaining 5.3% belonged to 27 other species, the most common of which was Calumma parsonii (4%).

*GRAPH 1:* Illustrates the total export numbers of chameleons from Madagascar and associated policy interventions (EMP denotes national law restricting chameleon exports)

Source: (Carpenter et al. 2005)

The study showed that CITES enforcement was effective in driving down the number of chameleons exported annually. Though it is certainly the case that these chameleons are still being exported, it is done in much smaller quantities to meet demand of exotic species collectors. This policy action ensured that the demand would be diminished through tough enforcement, and chameleons would be sustainably harvested even as illegal exporting and importing was ongoing. Sixty-nine percent of the demand for chameleon’s came from the United States, and the new regulations greatly diminished market access to both the demand and supply sides (Carpenter et al. 2005). This lack of access forced both the demand and supply sides to substitute
chameleons with other pets (for U.S. pet stores) and different animal exports (if available) or different lines of business altogether.


Management of the environment has been a part of Malagasy policy since the rule of the Merina monarchy in the mid-1800s. Environmental policy changed significantly over the course of the next 150 years, reaffirmed after French colonization and dissolution of the monarchy in 1896 and again after Madagascar’s independence from France in 1961. A summary of this information can be found in Appendix B. Under the monarchy, centered in the current capital of Antananarivo, laws referencing the environment were put into place. In 1868 the Code of 101 Articles appeared and in 1881, the Code of 305 Articles followed (Henkels 2001-2002). These articles focused primarily on civil law, criminal law, and procedure. Articles 101-106 forbade burning of the forests and settling of the people in the forest, from concern of guaranteeing interior and exterior security (Henkels 2001-2002). Historical interpretation also points to the monarchy wanting to extend exclusive ownership over forested areas, not unlike how the English monarchy declared forests under its personal ownership centuries ago (Grant 1991). The articles had everything to do with the monarchy’s control of the island’s natural resources, rather than for the sake of environmental conservation. Article 105 forbade the practice of tavy: “One may not clear the forest by fire without the goal of cultivating rice fields, corn or other crops. One who clears by fire a new terrain or expands those which exist already, that person will be put in irons,” (Sibree 1881).

Following the French colonization of Madagascar in 1896, the Water and Forests Service, established that same year introduced the notion of the “domaine de l’Etat,” which declared all of
Madagascar's forests public domain and forbade clearing these “zones en defens”
(Gade 1996). The progressive disappearance of the island's unique flora and fauna prompted the creation of ten Integrated Natural Reserves closed to all human beings in 1927 (Tyson 2000). Local people were effectively excluded, with authorized scientists being the only ones allowed into these reserves. To counteract the disappearance of the forests, the French introduced plantations of fast-growing, non-native pine and eucalyptus trees, an excellent substitute for building materials and the creation of kindling and charcoal (Raik 2007). Despite the nonnative regrowth of trees on the island’s central plateau, the French accelerated deforestation on the island both by coffee cash-cropping in the eastern rainforests and by opening forests to logging concessions, especially for the prized ebony, rosewood, and palisandre (Raik 2007). The Water and Forest Service was unable to enforce regulations on concessionaires once the forests were open to logging, due to a lack of capital, labor, and political will (Raik 2007). This enforcement problem continues to persist today.

When Madagascar declared its independence from France in 1961, comprehensive environmental legislation was created. Property rights were given to local people, and they had an obligation to develop and cultivate the land, regardless of any environmental value. In 1962, then-President of Madagascar Philibert Tsiranana made this obligation clear by requiring that every man on the island must plant 100 seedlings per year or pay a tax (Tyson 2000). This time period saw the continued centralization of forest management authority and led to local people often being oppressed by the forest service. By the mid-1970s, Madagascar had moved from a socialist democracy to a socialist dictatorship, nationalizing all industries and centralizing government power. Despite the strong commands given by the central authority, the government

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xiii French phrase for protected areas.
forest service was plagued by corruption, insufficient resources, and an inability to traverse the island’s difficult terrain (Ganzhorn et al. 1997).

In 1990, the government’s commitment to environmental conservation was reaffirmed after nearly two decades of a closed, quasi-communist society closely associated with the Soviet Union (Raik 2007). Madagascar became a socialist democracy once again; open to foreign capital and foreign ideas. The charter document for much of Madagascar’s environmental policy is called “The National Policy of the Environment.” The Charter recognized the environment as a priority preoccupation of the country's general interest, the duty of each to protect it, and the right of each person to be informed of and participate in decisions capable of exerting some influence on the environment (Charte de l’Environnement, ARTS. 1990). Aid agencies like the World Bank and United States Agency for International Development (USAID) increased their funding for environmental projects. By 1992, these groups and the Malagasy government reached a consensus that developed the National Environmental Action Plan (NEAP). NEAP was designed to include three, five-year phases.

Between 1992 and 1997, the first phase of NEAP created protected areas and developed institutions for these areas’ management, including the non-profit Association Nationale pour la Gestion des Aires Protégées (ANGAP) (Raik 2007). ANGAP was given management authority of a network of 44 parks and reserves by the Malagasy government (Swanson 1997). This relationship was modeled on the South African National Parks Board, where a government minister has an oversight, non-executive, relationship to the non-profit board managing the national parks, and the organization itself enjoys administrative and financial autonomy from the government of Madagascar (Swanson 1997). ANGAP was in part funded by USAID, with the ultimate goal to create a standardized method of conservation and development for each new
protected area across the island, regardless of the social considerations or local environmental context (Swanson 1997).

An important part of this donor funding was to recruit agrarian labor to police parks and disseminate park information (Sodikoff 2009). The funding made it possible to hire only a small segment of the community for work towards conserving environmental areas. There is evidence that this labor also engaged in cash-cropping, hunting and fishing of endangered species, and illegal logging, often as a result of being underpaid (Sodikoff 2009). The integrated conservation and development projects (ICDPs) were designed to create small projects for communities, but they often failed in producing economic opportunities that endured. The ICDP system ultimately failed, as local people still practiced *tavy* even as schools and community buildings were being built and economic compensation was moving forward. The disjointed nature of the development projects, directed by a standard model of development that was supposed to be effective in all areas, did not adequately take into account local contexts (Raik 2007).

After the abandonment of these ICDPs, aid organizations and the Malagasy government sought new ways to encourage development and conservation. Mirroring the constitutional reforms of the early 1990s to decentralize government, environmental conservation policies began using bottom-up, democratic participatory programs to encourage conservation and development (Peters 1998). The second phase of NEAP incorporated a new forestry law known as GELOSE in 1997 (Raik 2007). In sum, GELOSE allows for negotiated contracts among the state, the municipality, and community forestry boards. More recently, in 2000, GELOSE was amended so that the process of transferring forestry rights to a local community

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xiv For more investigation of this trend, see Durbin, J. and Ralambo, J. “The role of local people in the successful maintenance of protected areas in Madagascar.” *Environmental Conservation* (1994) 21, 2: 115-120.
xv Acronym for the French Gestion Locale Securisee, meaning Secured Local Management
only needs the signature of the state and community forestry board (Kull 2002). This change was made to speed up the process by which natural resources were distributed among communities.

The third phase of NEAP came out of President Ravalomanana’s Durban Vision. In the period between 2004 and 2008, the Durban Vision began expansion of protected areas from 1.6 million ha (6,100 sq mi) to 6 million ha (23,000 sq mi), with completion set to occur by 2012 (see Appendix C). This amount of protected area would meet the International Union for Conservation of Nature’s (IUCN) recommendation that Madagascar place 10% of its total area under some form of government protection, up from 2.4% previously (DEF/ANGAP 1992). These areas would also be defined by the IUCN list of protected areas, which delineates these areas into different categories based on appropriate levels of human use (see Appendix D).

Instead of being managed by ANGAP, the majority of protected areas are co-managed by community forest boards and the government (Raik 2007). This change effectively dissolved ANGAP by 2007 and replaced it with the System of Protected Areas of Madagascar (SAPM), though ANGAP forestry agents would still patrol parks and help enforce park rules (Butler 2006). This arrangement through SAPM gives both a level of central and local control, where GELOSE contracts allow sustainable harvesting of resources from protected areas. NGOs were supposed to play a strong supporting role in resource management plans and zoning of different activities (Raik 2007), but the Rajoelina administration’s hostility toward NGOs following their pull out from Madagascar has likely diminished such a role.

Aside from this modern charter which has created numerous laws related to forestry and Madagascar’s nascent national park system under NEAP, there is also customary and civil law

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that shares in environmental governance. Customary law, known as dina, varies widely across
the island, much like how fady may be different from village per village. Dina is promulgated
within each community by what is roughly analogous to a city council. This group determines
how to regulate crimes, extract natural resources, tie traditional customs with modern laws,
interpret all contractual relations within the community, elaborate and adopt works in the
community interest, and maintain dina that ensure security (Henkels 2001-2002). The GELOSE
environmental law is administered through dina locally, specifically in terms of regulating the
extraction of resources (Henkels 2001-2002).

Civil law, which guided the NEAP process, is also guided by international law. The
Convention on the International Trade of Endangered Species (CITES) is a prime example of an
international body, the CITES Secretariat, helping recognize policy gaps around the welfare of
flora and fauna specimens. The aim of CITES is to ensure that the international trade in
specimens of wild animals and plants does not threaten their survival (Convention on
International Trade in Endangered Species of Wild Fauna and Flora 2011). The following is an
excerpt from the CITES statement of intent:

“CITES works by subjecting international trade in specimens of selected species to certain
controls. All import, export and introduction from the sea of species covered by the Convention
has to be authorized through a licensing system. Each Party to the Convention must designate
one or more Management Authorities in charge of administering that licensing system and one or
more Scientific Authorities to advise them on the effects of trade on the status of the species.”

CITES also classifies animal species into different categories based upon their
endangered status (Convention on International Trade in Endangered Species of Wild Fauna and
Flora 2011). Appendix I species are considered threatened by extinction and/or highly
endangered. Nations that are Parties to CITES cannot trade Appendix I species except for
extraordinary circumstances. Appendix II species are considered threatened and/or endangered,
and trade must be controlled to ensure the species’ survival. Appendix III species are considered threatened and/or endangered by one Party nation of CITES, and trade restrictions are brought before the secretariat for consideration (see Appendix E).

These three different Appendices provide a ratcheted level of protection for endangered species based either upon scientific evidence of their endangerment or individual Party valuation. Each Appendix has different levels of bureaucracy and transaction costs, and it is interesting that the level of bureaucracy increases with the endangered status of specific species. Essentially, CITES is set up in such a way to raise the transaction costs where appropriate to diminish the ability for consumers and suppliers to operate an endangered species product market.

CITES does benefit from the redundancy created by having multiple Parties abiding by the same rules as to what is and is not illegal to trade in terms of species products. Where a would-be exporting country of endangered species products and a would-be importing country of products are both Party to CITES, a smuggling operation must bypass two, if not more, layers of security in order to make illicit goods available. This increase in transaction costs, including monetary and logistical expenses for moving illicit goods, as well as the consequences via the judicial system, makes such ventures unappealing to all but the most tenacious of poachers and smugglers.

Madagascar has ratified and is Party to CITES (CITES 2011). However, the level of corruption in the country significantly undermines the ability of the Malagasy government to prevent export of protected species and protected species products from the country. Park officials, police, and the port authority can all regularly be bribed to get illicit products to consumers (Draper 2010). The enforcement ability of other Party countries helps diminish this shortcoming.
In spite of its progress in promulgating environmental laws, the ongoing government crisis and policy movement toward decentralization makes it difficult to uniformly implement laws. Added to these difficulties are institutional blocks, corruption in services, and the pressure of time and money (Henkels 2001-2002). Madagascar is rising to these and other challenges, notably by embracing local authority when centralized enforcement often resulted in failure.

d. Ecology and Biogeography

Madagascar is unmatched in its floral and faunal biodiversity. Its separation from the Gondwana supercontinent between 80 and 140 million years ago and its relative isolation from the mainland has influenced evolution in significant ways (United Nations Environment Programme and United Nations Conference on Trade and Development 2008). Among researchers, it is known as “the Eighth Continent” (Tyson 2000) or, perhaps more ambiguously given its evolutionary history and ongoing environmental crisis, “the world out of time” (Lanting 1990). Of the more than 14,000 plant species so far discovered on the island, 85% are endemic and found nowhere else in the world. Of the genera from which these plant species originate, 25% are endemic. Baobabs, euphorbia, orchids, and aloes are only some examples of the island’s unique flora (Irwin et al. 2010).

The fauna of Madagascar show even further biodiversity. The number of invertebrate species, including the phyla of Arthropoda, Annelida, and Mollusca, is estimated to exceed 100,000. One hundred forty species of fish have been recorded, 90 of which are endemic. There are more than 250 species of amphibians as well, with a level of endemism exceeding 99%, and over 300 species of reptiles, 85% of which are endemic. Bird species are 283 in number at a level of endemism just below 50%. Just over 200 species of mammal are found on the island, 70% of
which are endemic (Irwin et al. 2010). Some recognizable examples of the endemic faunal species include lemurs, tenrecs,\textsuperscript{xvii} the Malagasy fish eagle, chameleons, frogs, and land leeches. Further biodiversity estimates can be found in Appendix F (Goodman and Benstead 2005).

There is growing evidence based on molecular systematics, the fossil record, and paleogeography that the four extant groups of placentals found on the island, including tenrecs, rodents, canivorans, and lemurs, likely rafted to Madagascar from what is today Mozambique at different periods of time after Madagascar had broken away from the Gondwanan supercontinent. This colonization occurred multiple times, changing the evolutionary trajectory of the island (Krause 2010) (see Appendix G).

There are many levels of ecology and biology to consider when evaluating the rapidity of environmental degradation in Madagascar. One scientific tool that can capture environmental degradation is known as the area effect, a biogeographical concept postulated by MacArthur and Wilson in 1967. The area effect demonstrated small islands tend to harbor fewer species than large islands, and small islands host fewer immigrations and more extinctions (Quammen 1996). Although Madagascar has a land mass of nearly 227,000 sq. mi and is the fourth largest island in the world overall, its rainforests are fragmented and are themselves islands among fallow fields and secondary growth composed of invasive plant species. Much of the rainforest remaining is not contiguous and many of the species, especially those that specialize in a particular ecological niche, found within the rainforest simply cannot survive in the agricultural areas created by slash-and-burn methods (Quammen 1996). These “islands” of rainforest are decreasing in size, harboring fewer species and leading to more local, if not total, species extinctions.

\textsuperscript{xvii} Family: Tenrecidae; A hedgehog-like mammal found only in Madagascar, the Seychelles, Comoros and other surrounding islands.
To put habitat loss into perspective, in 1953, forests covered nearly 62,000 sq mi, or 27% of the island’s total area, which has been reduced to just over 32,000 sq mi, or 17% of the island’s total area, in 2000 (Harper et al. 2007). Roughly 8% of this forest cover is rainforest, with dry forest and littoral forest contributing the remainder. In 2000, more than 45% of forest existed in patches of less than 50,000 ha (roughly 200 sq mi), and over 80% of this forest area was less than one mi from an edge (Harper et al. 2007). With such a large amount of forest near an ecological edge, there are continued concerns that rainforest within one mile will be degraded regardless of further anthropogenic use. Differences in abiotic factors, anthropogenic pressure and land use, invasive species, and other stresses also impart different impacts on forests. Climate change is also projected to have deleterious effects on remaining natural vegetation and protected areas from shifting ecozones, further pressuring the environment with an ultimate anthropogenic disturbance (Irwin et al. 2010).

The primary driver for laws and social consequences around the environment is tied directly to habitat and species loss, along with the growing scarcity and fragmentation of habitat. There is strong evidence that anthropogenic disturbance through local agricultural practices and hunting and gathering generally lead to negative physiological and population-level reactions in flora and fauna species (Allnutt et al. 2008) (Draper 2010) (Green and Sussman 1990) (Lehtinen, Ramanamanjato and Raveloarison 2003). In flora, increasing human impact selects for structurally simpler plant species and aids invasion by generalist species (Irwin et al. 2010). In fauna, reaction to disturbance is complex and varied. Moderate disturbance can increase diversity for class Insecta when more habitat heterogeneity occurs as a result (Irwin et al. 2010). This trend can be explained by examining how insect species take advantage of

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xviii Generalist species can survive in a variety of ecological settings and can make use of an array of resources. Specialist species are can survive in a narrow set of ecological settings and may be reliant on one kind of resource.
ecological niches changing in an area. For example, sun-loving species that thrive on forest gaps and shade-loving butterflies that prefer deep forest might exist in the same area where a stand of trees was recently logged (Quammen 1996). When forest is in small fragments or experiences heavy disturbance (i.e. tavy or clear cut logging), insect species loss becomes more likely due to a lack of ecological niches. Between 1950 and 2000, heavy disturbance has led to the extinction of 9.1% of insect species on the island (Allnutt et al. 2008).

In amphibians and reptiles, habitat fragmentation generally leads to decreasing diversity in forest fragments of decreasing size (Irwin et al. 2010). Additionally, amphibian and reptile species sensitivity to ecological edges is correlated with the threat of local extirpation and possibly extinction (Lehtinen, Ramanamanjato and Raveloarison 2003). Birds are likewise sensitive to ecological edges and habitat fragmentation (Watson, Whittaker and Dawson 2004).

Mammals, especially lemurs, are sensitive to decreasing forest fragment size. For example, in fragmented rainforest, the lemur species *Propithecus diadema* have smaller home ranges, exhibit less frugivory, are less aggressive and less playful compared to groups in undisturbed forest (Irwin 2008). Comparatively, *Hapalemur griseus* shows little difference between fragmented and undisturbed forest, other than a few dietary differences with no apparent health implications (Martinez 2008).

Reactions to anthropogenic disturbance in Madagascar vary considerably based on different proximate impacts and the life histories of the taxonomic groups affected (see Appendix H). Disturbance is highly correlated with a reduction in species diversity and greater species turnover, with grassland generalists from Madagascar’s plateau replacing forest

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xix Fragmentation is represented by two variables: forest patch size and proximity of forest to non-forest edge. (Harper et al. 2007)
xx Prey selection that favors fruit over other sources
xxi Species turnover refers to the ratio of local extirpation and colonization of different species in a defined area
specialists, especially specialists that are sensitive to ecological edges (Irwin et al. 2010). Despite this trend, there are noticeable gaps in research. For example, reaction to anthropogenic disturbance in mammals other than lemurs is not well studied.

V. Madagascar’s Environmental Protection Program: Is it Viable?

The Malagasy government, along with numerous NGOs and organizations like the World Bank, USAID, and the United Nations Development Programme, are well-aware of the threat unchecked resource use poses to the island’s environment integrity. These organizations recognize that time – marked by habitat loss and species extinctions – is running out.

In the broadest sense, Madagascar’s policy goals for environmental protection hinge upon habitat conservation, local economic development, and full community participation (Henkels 2001-2002). To be clear, these goals are for Madagascar’s environmental protection program as a whole, and not individual actors or organizations. All three of these need to be addressed in order for environmental protection to be successful. If there is no new local economic development, people will continue using destructive traditional land use practices, justifiably, for their own survival. If there is not full community participation, it is likely that enacted environmental protection will not be politically acceptable and, as a result, difficult to enforce. If there is no environmental conservation, then the environmental protection program has failed absolutely.

These goals are not defined quantitatively in any way, but they do refer to net change and magnitude. Protected areas should largely exhibit no net change or positive net change in terms of biodiversity. However, the biodiversity should mirror historic species richness, rather than the high level of biodiversity that may be seen when, for example, grassland species colonize forest
as it is undergoing habitat disturbance. Local economic development should not make people less well off, though exchanging their portfolio of traditional economic opportunities with roughly equivalent opportunities that mesh with the existence of protected areas is acceptable. Additionally, the majority of local people, on average, should participate in protected area conservation and management.

Taken together, the environmental protection program needs to have either met or be in the process of meeting these goals in order to be viable. If any one of these things is out of alignment, the ability for the program to endure is called into question. For example, the ICDP strategy during the 1990s did not see full community participation, did not ensure environmental conservation, and, depending on the local context, made local people economically worse off.

Contextual evidence and the degree to which aspects of the environmental protection system continue or change determine viability. In this analysis, criteria based on indicators of anthropogenic disturbance, economic sufficiency, and enforcement ability will be used to assess different protected areas and determine their viability.

VI. Case Studies

Figure 3 refers to a map of Madagascar illustrating the case study areas used for this analysis, which include the Masoala Peninsula Corridor, the Mikea Complexe, the Vohidrazana-Mantadia Corridor, and Ranomafana National Park.
Masoala Peninsula Corridor

Masoala National Park is Madagascar’s largest and most-recognized national park. The 230,000 ha (~900 sq mi) park is theoretically supportive of environmental conservation, but its large size makes it notoriously difficult for enforcement to patrol and halt tavy or illegal logging that may be occurring. It is home to some of Madagascar’s most critically endangered species, including the Madagascar Serpent Eagle (*Eutriorchis astur*) and Red-Ruffed Lemur (*Varecia rubra*). Like RNP, Masoala National Park has tavy agricultural practices running up against its
borders, and possesses more pervasive selective logging, bushmeat hunting, and other kinds of anthropogenic disruptions within its boundaries. Masoala not only contains lowland and mid-altitude forest, but mangroves, littoral forest, marshland, and coral reefs as well.

Its popularity with ecotourists resides not only in the flora and fauna that live there, but also on the ecotourism association that helps provide visitors with guides, transportation, and lodging. The Zurich Zoo in Switzerland has also recently constructed a state-of-the-art facility that is analogous to the rainforest of Masoala, acting as a conduit to promote conservation and tourism in Madagascar (Bauert et al. 2007). The park was an integrated conservation development project from 1992 to 1997, with NGOs involved in promoting ecotourism in the park as well as protecting ecosystem services. It is home to red-ruffed lemurs (*Varecia variegata rubra*), carnivorous pitcher plants (*Nepenthes masoalensis*), and tomato frogs (*Dyscophus antongili*) (Ormsby and Mannle 2006).

The Makira Forest is a 371,000 ha (1,400 sq mi) area in northeastern Madagascar, directly adjacent to Masoala National Park’s western edge. Makira consists of lowland and mid-altitude rainforest (Golden 2009). It also is one of the largest remaining blocks of contiguous forests remaining on the island. Along with Masoala, it is one of the most biologically diverse ecosystems on the island. It was one of the areas set to be protected under the Durban Vision, but its current status is chaotic given the ongoing political crisis. Marojejy National Park, a 60,000 ha protected area to the north of Masoala National Park, shares many of these same characteristics and harbors the critically endangered Silky Sifaka lemur (*Propithecus candidus*) (Draper 2010).

**Mikea Complexe**

The Mikea Complexe of Madagascar makes up over 370,000 ha (1,400 sq mi) of the island’s southwestern region (Seddon et al. 2000). The primary habitat found in this region is dry
forest and savannah. Mikea Forest is one of the protected areas in this region, notable for being a “spiny forest” made up of various deciduous tree species, towering baobabs, and octopus trees for which the spiny forest has its namesake (Tucker 2007). Fauna include the threatened Madagascar Sparrowhawk (*Accipiter madagascariensis*), the critically endangered Madagascar Fish Eagle (*Haliaeetus vociferoides*), the popular and highly recognizable Ring-tailed Lemur (*Lemur catta*) and the critically endangered Radiated Tortoise (*Astrochelys radiata*) (IUCN 2011). Mikea Forest is a recent addition to Madagascar’s protected area system, promulgated under the Durban Vision. Unlike the other case studies, this region does not produce rice due to the dry climate. Instead, the local people hunt and gather in the forest and implement slash-and-burn land management to develop fields for maize and zebu.

Since the Mikea Forest became protected under Malagasy law in 2007, the local people within the forest’s boundaries have been forced to switch from maize production to either specialized hunting and gathering or manioc (cassava) farming (Tucker 2007). These activities are restricted, however, to within 10 km of the Mikea Forest’s periphery (Tucker 2007).

While not part of the Mikea Forest proper, Kirindy Forest is another area that shares similar attributes, including the spiny forest and many of the same species. It’s also the only place in Madagascar to find the Giant Jumping Rat (*Hypogeomys antimena*) and Berthe’s Mouse Lemur (*Microcebus berthae*) (IUCN 2011). A key difference at Kirindy compared to Mikea is the forest governance structure. Kirindy’s forest resources are controlled by locals through a NGO pilot program, whereas Mikea Forest is principally administered by the government and is partly a strict reserve, preventing resource extraction altogether.

**Vohidrazana-Mantadia Corridor**

The Vohidrazana-Mantadia corridor encompasses 480,000 ha (~1850 sq mi) and includes the Perinet special reserve as well as Mantadia National Park and Maromizaha Reserve (Styger
et al. 2007). This forest is mid altitude rainforest, home to endemic species such as the weasel-like Fossa (*Cryptoprocta ferox*) and the Red-fronted Brown Lemur (*Eulemur rufifrons*) (IUCN 2011). The forests in this corridor, with the exception of the Perinet special reserve, face disturbance by selective harvesting of flora and fauna and uncontrolled fires (Klanderud et al. 2010). The Perinet Reserve in Analamazaotra is home to the *Indri indri*, a large, black and white lemur that is notable for its piercing, humpback whale-like songs. Perinet was one of ten special reserves first established in 1927 under French colonial rule (Quammen 1996). These special reserves were created to each represent a specific ecological community. The reserve is 810 ha or three sq mi. When it was first created, the Perinet Reserve was still surrounded by temperate rainforest. Today, the area is effectively insulated on all sides by roads, fencing, rice fields, and eucalyptus plantations.

**Ranomafana National Park**

Ranomafana National Park (RNP) was established in 1991 in the southeastern part of the island. In 2007, it was recognized as part of a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO). The park has an area of 41,600 ha, or 161 square miles, and is Madagascar’s third-most visited park (Peters 1998). Slash-and-burn agriculture has closed in on its periphery in the past decade. Local people are conflicted about the value of the park, as it runs up against rice production but brings tourist traffic to the area. The park is host to many endangered species, including black and white ruffed lemurs (*Varecia variegata*), greater bamboo lemurs (*Prolemur simus*), golden bamboo lemurs (*Hapalemur aureus*), and Milne–Edward’s sifakas (*Propithecus edwardsi*), as well as redbellied lemurs (*Eulemur rubriventer*), lesser bamboo lemurs (*H. griseus*) and aye-ayes (*Daubentonia madagascariensis*), all of which are a draw for ecotourists (Dolins et al. 2010).
VII. Criteria

The following criteria will be applied to each case study: indicators of anthropogenic disturbance, economic sufficiency, enforcement ability, political acceptability. These criteria were developed through a values-centric methodology of program evaluation known as values inquiry (Henry 2002). Values inquiry is a specific type of systematic inquiry that proposes that the indicators chosen as the basis for judgments about program success be justified by the process used to obtain them. How criteria are chosen must come out of stakeholder involvement, democratic deliberation, or another method of systematic values inquiry.

The Malagasy government, in coordination with international organizations that are its principle funders, has promulgated environmental protection goals through collaborative discussions and a democratic process. The published literature on environmental protection in Madagascar provides a record of researchers communicating and reviewing other researchers’ work. This deliberation can be both democratic and rigid given the peer-review process, ensuring that work used in this analysis is well-founded and valid. The literature comes out of many disciplines, including anthropology, ecology, philosophy, economics, sociology, and policy studies, and this diversity lends itself to many values that inform this evaluation. It is also important to note that the criteria reflect whose values are at work on the issue of environmental conservation in Madagascar.

The following criteria are representative of Madagascar’s three broad environmental protection program goals, which are environmental conservation, local economic development and majority public participation (Henkels 2001-2002). Environmental conservation is captured by the extent of anthropogenic disturbance, used as a criterion below, which is measured by many methods across the literature (Allnutt et al. 2008) (Benstead, Barnes and Pringle 2001).
Observing land use change, habitat change, changes in taxonomic groups, species richness, and others metrics are means by which researchers learn the quality of environmental conservation of a protected area.

Local economic development is captured by the criterion “economic sufficiency.” Across the literature, central economic questions revolve around how to provide sufficient economic opportunities to local people using substitutes to traditional land use practices (Sommerville et al. 2010) (Tucker 2007) (Carpenter et al. 2005) (Gössling 1999) (Whitehurst 2007) (Draper 2010) (Keck, Sharma and Feder 1994) (Peters 1998). A large portion of this economics literature uses qualitative interviews to determine whether or not local people see their economic options as efficient. For this reason, the criterion for economic sufficiency below does not make a distinction between economic interactions that affect environmental conservation one way or the other, instead only capturing what local people perceive as economically efficient. In Madagascar, the strength of an economic program succeeds or fails based on whether local people find economic value in it beyond what they had at their disposal prior to the program’s start. Even if the economic program has some enforcement behind it, if the economic value does not exceed that of traditional practices, traditional practices will still occur and potentially become more difficult to observe. For example, the ICDP at RNP sought to build up ecotourism capacity, but local people did not perceive the value of ecotourism to exceed that of tavy, so tavy continued in the buffer zones of RNP (Peters 1998).

The goal of majority public participation is captured by the political acceptability criterion. The sociological, philosophical and anthropological literature often demonstrates that programs without public acceptance do not endure (Conolly 2008) (Global Witness 2009)
The environmental policy changes since the early 1990s have been rapid and significant, and this criterion captures what local people think about the value of these changes to governance, economics, and society.

This political acceptability criterion seeks to determine whether there are conditions present that allow public participation in each case study and evaluate to what extent people support the presence of a protected area locally. Public participation in the environmental protection program is much more difficult to evaluate, and much of the literature does not attempt to quantify or qualify who is involved and participating in the protected area program. There is also some vagueness in the Malagasy government’s definition of majority public participation, which could capture everything from local people becoming involved with their local forestry council to simply observing and not undermining the rules of a protected area. However, the literature does capture whether local communities accept a protected area. This knowledge is valuable in determining whether a protected area has some groundwork in place that can support public participation.

The enforcement ability criterion is tied not to the three environmental protection policy goals, but rather the Malagasy government’s ability to dictate and implement those policy goals. The policy studies literature often points to enforcement ability as part of the basis for a program to be implemented and maintained over time (Raik 2007) (Brahic 2009) (DEF/ANGAP 1992) (Hannah 1992) (Jones, Andriamarovololona and Hockley 2008) (Kull 2002) (Nicoll and Langrand 1989) (Mattis 2010). The criterion will assess whether administration and enforcement are able to exert legitimate authority to uphold rule sets of a protected area.
Indicators of Anthropogenic Disturbance

Is there evidence that humans are affecting the environment around them through traditional agriculture, logging, and other practices? Are there indications of corrosive environmental change in a natural area after it is placed in the environmental protection program? Ecological resilience in the face of anthropogenic disturbance is perhaps the most fundamental criterion to determining whether a national park or reserve is viable. There are many different measures used by ecologists to evaluate the current level of disturbance in a habitat to historical levels. The Shannon-Wiener Diversity Index, for example, provides a rough estimate of both the level of species diversity and number of individuals in a plot (Spellerberg and Fedor 2003). The data are then compared in either a time-series – when comparing the biodiversity and number of individuals of multiple species against historical records – or longitudinal analysis – when comparing the biodiversity and number of individuals of multiple species against a similar habitat. Aerial and satellite imagery can be used to measure forest loss. Researchers may also choose to analyze, through a variety of methods, species that occupy various ecological niches to determine whether and how anthropogenic disturbance affects these species. Interviews with local people may also be used to determine whether or not a species is present in an area, and whether its presence has changed over time.

Economic sufficiency

This criterion seeks to evaluate to what extent local people have access to economic opportunities that they find sufficient. When living near a protected area, do local people perceive that their economic options and opportunities as sufficient compared to the economic options that were available before the protected area was formed? Is the protected area economic portfolio economically valuable in ways that sufficiently meet or exceed the previous portfolio? These economic options and opportunities can range from interactions internal to a family or
village - subsistence agriculture and livestock production, for example – to external interactions with ecotourists or aid groups. Since environmental protection can often run up against economic opportunities and deny these opportunities outright, it is important local people perceive that they have economic options available that roughly equal or outweigh unsustainable practices tied to land use and extraction of natural resources. Without sufficient economic substitutes, local people often suffer from lack of food, increased unemployment, and an increased likelihood that the protected area will be undermined by people actively going into the area to extract resources, among other things.

**Enforcement ability**

Does the protected area have adequate commitment of park workers and police to ensure park protection? How reliable is their authority? This criterion is important because, without the ability to enforce the environmental program or interact with communities near protected areas, there are few constraints on how people will use natural resources. Park administration is responsible for both proactively communicating with local communities about what is and what is not allowed in the protected area and reactively enforcing park rules where they are violated. Both community communication and enforcement are vital in ensuring that the environmental protection program promulgated by the Malagasy government is implemented.

**Political acceptability**

Is the protected area and its governance structure acceptable to local people? Are the social and economic constraints and opportunities created by the environmental protection program acceptable? This criterion is focused on the political acceptability from the perspective of local people alone. Ultimately, they exert the largest anthropogenic impact on ecosystems in Madagascar and any environmental protection program needs to be responsive to their needs and
concerns in order to be seen as legitimate. If the program is not responsive to their needs, local people suffer and may extract natural resources illegally as a result.

VIII. Evaluation

*Table 1* shows a summary of key information from the case studies presented above.

**Case Study Key Information**

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Key Protected Areas</th>
<th>Total Area (ha)</th>
<th>Vegetation Type</th>
<th>Principle Land Use</th>
<th>Unique Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masoala Peninsula Corridor</td>
<td>Masoala National Park; Makira Forest; Marojejy National Park</td>
<td>660,000</td>
<td>Low and mid-altitude rainforest; Littoral forest; Mangrove</td>
<td><em>Tavy</em>, Selective logging (rosewood), Bushmeat Hunting</td>
<td><em>Eutriorchis astur</em>; genus <em>Dalbergia</em>; <em>Varecia rubra</em></td>
</tr>
<tr>
<td>Mikea Complexe</td>
<td>Mikea Forest and Kirindy Forest</td>
<td>371,340</td>
<td>Spiny forest; Dry deciduous forest</td>
<td><em>Hatsake</em>, Tuber foraging, Selective logging, Cassava farming</td>
<td><em>Accipiter madagascariensis</em>; <em>Haliaeetus vociferoides</em>; <em>Lemur catta</em>; <em>Astrochelys radiata</em></td>
</tr>
<tr>
<td>Vohidrazana-Mantadia Corridor</td>
<td>Perinet Reserve; Vohidrazana and Mantadia Forests</td>
<td>428,000</td>
<td>Mid altitude humid forest</td>
<td><em>Tavy</em>, selective logging</td>
<td><em>Cryptoprocta ferox</em>; <em>Eulemur rufirfrons</em>; <em>Indri indri</em></td>
</tr>
<tr>
<td>Ranomafana National Park</td>
<td>Ranomafana Forest</td>
<td>41,600</td>
<td>Mid altitude humid forest</td>
<td>Fallow area rice production</td>
<td><em>Varecia variegata</em>; <em>Prolemur simus</em>; <em>Daubentonia madagascariensis</em></td>
</tr>
</tbody>
</table>

*Table 1*

**Masoala Peninsula Corridor**

*Indicators of Anthropogenic Disturbance*

Since the political crisis in 2009, Masoala has undergone significant ecological disturbances. *Tavy* has begun to eat away at the park’s boundaries, rosewood has been harvested in such a way that local people must journey further into the reserve to log it, and bushmeat hunting, especially of lemur, has proceeded on a large scale to meet the demand of urban restaurants.
Since April 2009, exports of rosewood from genus *Dalbergia* have been conservatively estimated at roughly 1150 containers, each carrying 144 logs, valued at nearly $230 million total (Global Witness 2009). Due to the low density of rosewood per hectare, loggers sought to expand their operating areas inside and around Masoala reserve – over 20,000 ha (~80 sq mi) between April 2009 and May 2010 (Barrett et al. 2010). Additionally, since rosewood must be floated downstream to port or shipping off point, four or five lighter trees are logged to raft each rosewood log downstream. This process consumes hundreds of trees daily. This amount of selective logging aridifies the soil and reduces endemic species diversity (Barrett et al. 2010).

There is also evidence that species turnover to invasive non-native species and generalists from rainforest specialists have occurred (Irwin et al. 2010).

Increased forest access has also lead to the emergence of a bushmeat market in Madagascar (Golden 2009). While bushmeat has been gathered for occasional familial use, a market for bushmeat, especially in urban areas, has grown substantially since 2009. Until very recently, the issue has remained largely unstudied, but has been identified as a substantial risk to mammal conservation (Golden 2009). Bushmeat hunting is more prevalent in those communities that do not have livestock, and many communities around Masoala and Makira fall into this characterization.

In the Makira Forest, 23 species of mammal are hunted for consumption. This information came from a study that interviewed 312 households. The researcher noted that 95% of the households had consumed bushmeat over the length of a year, with more than 50% eating *Eulemur albifrons*, the brown lemur, despite protection being afforded to it and other lemur species (Golden 2009). The study also suggests that sustainable levels of bushmeat hunting must occur at a human population density of 1.0 person per sq. km, but currently occurs at a
population density of greater than 37.0 persons per sq. km. Bushmeat hunting has ramped up considerably since 2009, with hundreds of cooked lemurs being brought to port city restaurants (Brahic 2009). This trend is not sustainable, with park workers noting that lemurs are completely missing from some areas of Masoala National Park. The loss of lemurs from the Masoala Peninsula Corridor has been directly attributed to the influx of locals logging rosewood who want to eat something other than rice (Draper 2010).

Taken together, selective logging threatens to fragment forest in Masoala National Park and overhunting threatens the ability for lemur populations to flourish. This is by far the most intensive, documented environmental overexploitation since the political crisis began in 2009.

**Economic sufficiency**

Chinese demand for tropical lumber is often cited as a driving force in the endangerment of rosewood (Patel 2007). China is not a Party of the CITES convention, and this removes the barrier of importing illicit species to the country (Convention on International Trade in Endangered Species of Wild Fauna and Flora 2011). Wealthier homebuilders in China have taken a liking to rare rosewood and palisandre as building materials, and the scarcity of these hardwoods makes the trade very lucrative for exporters in Madagascar (Patel 2007).

Criminal networks, corrupt officials, domestic transporters, and Chinese exporters have taken advantage of Madagascar’s limited control of its vast coastline and limited enforcement ability to move thousands of logs to China, and export of rosewood has increased exponentially following the coup in 2009 (Schuurman and Lowry II 2009). Whereas the value of much of Madagascar’s fauna is the degree to which it is alive and healthy when it reaches consumers, and thus requires quick transport to diminish stress on the creatures and prevent costly deaths, logs need only be of a quality that would be conducive to either home or furniture construction.

Malagasy workers earn $0.40 (Barrett et al. 2010) to $25 (Draper 2010) for each rosewood tree
harvested depending on their position, as opposed to the $20,000 or more a rosewood armoire would be sold for in China (Barrett et al. 2010). Still, these amounts can far exceed the $1 to $2 many Malagasy live on from day to day, enough so that men are able to afford to purchase motorcycles in the port city of Antalaha, due east of Masoala National Park (Draper 2010).

When asked why illegal logging is present in Marojejy National Park, at the northernmost extent of the Masoala Peninsula Corridor, researchers found the following results, which are presented in the Table 2 below:

Table 2: Local people are asked why illegal logging is occurring in Marojejy National Park.
Source: (Draper 2010)

Most respondents answered that illegal logging was either a substitute for another cash crop, was pursued due to the high prices it fetched, or because of poverty that rural village life entails. The Marojejey National Park is a protected area set aside by the Malagasy government, and along with most of the Corridor is one of the last few places on the island to host these rare flora species, and it is the combined effect of resource scarcity and lack of enforcement that makes these tree species both precious and accessible (Randriamalala and Liu 2010). Since many
villages near national parks, especially those that are not near any park entrances, can neither take advantage of the ecotourism economy nor receive of international aid for local development projects, local people are left with few economic choices to ensure their livelihood. Due to gripping poverty, local people in Madagascar tend to maximize their exploitation of the environment for minimal profits, with logging of rosewood perhaps the most profitable (United Nations Environment Programme and United Nations Conference on Trade and Development 2008).

The economic benefits of ecotourism are extended primarily to local guides and “gateway” communities at the parks’ entrances. These local communities enjoy higher profits from the goods and services they sell, largely because they provide convenient access to these goods and services and the markup is still beneath what ecotourists would be paying in their home country. Outside of these communities, and perhaps even internally to these communities where the wealth is not shared, ecotourism isn’t valued as readily. The Masoala case study also demonstrates the existing tension between the internationally-backed environmental conservation legislation that values long term benefits and the economic philosophy of many local people to extract and maximize economic benefits on a short timescale.

**Enforcement ability**

The enforcement ability is lacking in Masoala National Park and Makira Forest. Park staff are insufficient in number and their authority is not respected by local people exploiting the forest (Draper 2010). This lack of power harms the Malagasy government’s ability to protect the area, while also undermining other protected areas across the island. Park workers are also effectively outgunned and threatened by criminal organizations exploiting rosewood. Death threats and even murder of park officials has occurred when loggers were confronted (Patel 2009).
Park officials have also lost the ability to administer to protected areas in the Masoala Peninsula Corridor effectively following the suspension of most financial aid, save humanitarian relief, to Madagascar following the 2009 coup. For example, the $110 million U.S. Millennium Challenge Account grant that helped pay for enforcement of park regulations was withdrawn once President Ravalomanana was swept from power (Ploch 2010).

The local city governments around the parks occasionally arrest the timber barons thought to be illegally harvesting rosewood. However, reflecting the chaotic legal status of logging permits, timber barons are effectively able to use their wealth to bribe, extort, and intimidate officials, or simply pay some out of court settlement if they are ever found guilty (Draper 2010).

In many ways, the illegal activities occurring in Masoala are representative of a total loss of government capacity to administer. Dispossessed people that had been made worse off under the environmental protection program resented the economic restrictions and lack of opportunities, and they continue to push back on what little there is currently of the government’s administrative capacity.

While the parks of the Masoala Peninsula Corridor were closed for a time following the 2009 coup, local police and park officials have since reopened the parks to visitors but have had little impact on the burgeoning rosewood trade (Innes 2010).

Political acceptability

The national park system, coupled with the promises of economic incentives through ecotourism and perhaps even foreign aid, is not well respected by many local people. There are simply too many people living around the parks to receive the benefits of ecotourism or development projects, and financial compensation for not using the land is problematic given government corruption. On the other hand, the weak enforcement protecting the park makes it
seem as though there is no park system at all. This situation is politically acceptable because the governance structure, post-2009 coup, is much less rigid and is largely up to local communities and individuals to sort out. There is also the sense that this near-anarchic governance environment has diminished the anxiety in local communities around meeting natural resource restrictions while sacrificing familiar, traditional practices. People feel empowered when they are given economic opportunities, which the rosewood trade readily provides. This lack of government power is therefore politically acceptable to local people.

    Whereas these communities were greatly constrained in what they could gather from Masoala National Park leading up to the coup due to rules set by the Malagasy government, those constraints are now unenforced. Restaurants can serve lemur to the point that many species have become scarce or absent in the 20,000 ha of Masoala National Park exploited by loggers. Rosewood can be sent to China, with timber barons effectively operating outside the law in broad daylight (Draper 2010). People can pursue whatever is most economically valuable without worry about park rules. Those groups of people worried about the economic losses from dwindling ecotourism or value environmental conservation do not find this situation politically acceptable.

**Mikea Complexe**

*Indicators of Anthropogenic Disturbance*

The spiny, dry forests found in this southwestern quadrant of the island are used in dramatically different ways compared to the island’s rainforests. Local people living among the dry forests have traditionally subsisted on a portfolio of foraging, fishing, farming, herding, and market-oriented activities (Tucker 2007). These practices have been in place for hundreds of years, and are an integral part of local culture and society. None of the local foraging activities target endangered species recognized by the International Union for Conservation of Nature.
(IUCN 2004). Foraging activities do target various species of tubers, tenrecs, birds, and some common lemurs.

Despite this light foraging footprint, the dry spiny forests are threatened by subsistence agriculture, livestock and charcoal production (Seddon et al. 2000). Forest cover declined 15.6% between 1962 and 1999 (Seddon et al. 2000). Hatsake, similar to tavy in utilizing slash-and-burn on forest to create agricultural land, is used to grow maize. Like elsewhere on the island, the soil is poor and can only sustain a few seasons of agricultural use before more forest is needed for agricultural conversion (Tucker 2007). This has led to forest fragmentation in the Mikea Complexe and smaller areas of dry spiny forest altogether. Ecologically, species diversity is driven down, genetic diversity can be driven down depending on the species affected, and generalist savannah species begin colonization of disturbed areas (Raharimalala et al. 2010).

One study assessed species richness in the Mikea Complexe, with the aim to assess the impacts of forest clearance on community composition by comparing changes in species presence and abundance, determine which environmental factors are affecting community shifts in different vertebrate groups, and within each group assess the sensitivity of each species to deforestation (Scott et al. 2006). In comparing six forested and six cleared areas, the study found a significant decline in species richness and community structure in cleared areas, with canopy loss as a primary driver. Lizards and small mammals experienced the greatest declines in species richness, while birds experienced the greatest shift in community structure, with generalist and introduced species with wider geographic ranges supplanting the spiny forest specialists.

In 2003, hatsake was banned by the Malagasy government, with the military actively going into forests to force any recalcitrant farmers to comply with the new law (Tucker 2007).

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xxii The number of different species in a defined area
xxiii Hatsake uses slash-and-burn methods to grow maize
As of 2007, there was also consideration for banning people outright from some portions of the Mikea Forest. Given that acting president Andry Rajoelina has reversed many environmental regulations, or simply does not have the funding to back enforcement of environmental laws, and has publicly stated that foreign aid organizations are conspiring against him and undermining his rule (Rhett 2011), it is unclear whether the local people of the Mikea Forest have returned to hatsake and the ecological degradation it entails.

While ecotourism does occur in the Mikea Complexe, especially in the Kirindy Forest, there have not been many studies looking at ecological impacts. The region does host two highly recognizable endemic species: the ring-tailed lemur (Lemur catta) and the baobab tree (Adansonia spp.). Given the information available about local use of the forest, however, and recognizing that forest disturbance is connected to trail creation, camping, and the movement of people through the forest on set trails, it likely has less impact than local foraging, trapping, and fishing.

Kirindy Forest, separate from Mikea Forest proper but part of the Mikea Complexe, has experienced different land changes compared to the Mikea Forest. Kirindy, which encompasses an area of 140,087 ha (~540 sq mi), has lower rates of deforestation, higher rates of reforestation, and less net change than nearby unprotected forest (Whitehurst, Sexton and Dollar 2009). Most anthropogenic disturbance that does exist in Kirindy Forest occurs along the ecological edge that separates the forest from agricultural land. Kirindy occupies an area where spiny forest transitions to dry deciduous forest, and conservation has recently become a top priority given 97% of dry deciduous forest in Madagascar has been lost (Whitehurst, Sexton and Dollar 2009). Like Mikea Forest, locals implement hatsake for maize production and to cultivate young grasslands that are preferred grazing for zebu (Whitehurst, Sexton and Dollar 2009). Selective
logging from the Kirindy Forest is illegal, but does occur and can reduce forest cover and aid fragmentation considerably (Ganzhorn et al. 2001). Even in less fragmented forested areas like Kirindy, since the extent of dry deciduous forest is only 3% of its original extent, species are increasingly affected by anthropogenic disturbance (Ganzhorn et al. 2001). Durrell Wildlife Conservation Trust has shown success in reducing illegal selective logging in the Kirindy Forest through compensation payments to local communities, but it is unclear whether Kirindy and the small extent of dry deciduous forest will be able to persist in the long term, especially in the face of climate change (Hannah et al. 2008).

**Economic sufficiency**

The Mikea Complexe is economically diverse, with sugar and sisal plantations at its northernmost point, tilapia farming in lakes, and subsistence foraging and agriculture found throughout. In many ways, the region faces similar challenges that the rest of Madagascar faces. Local people want to maximize profit in the short run given the scarcity and uncertainty of food and other resources.

Maize was the primary cash and subsistence crop for many communities near Mikea Forest (Tucker 2007). When maize was banned by the Malagasy government and the prohibition initially enforced by the military, the local people had to substitute into different kinds of farming, including cassava, and limited foraging and fishing. Despite this policy change, it may be the case that maize has once again become viable since 2009 given the deterioration of protected area enforcement in Madagascar.

Local people do not see the value of switching from maize to cassava. Maize takes three months to grow, while cassava can take nine months or more before suitable harvest yields can occur. Cassava can boast larger harvests than maize, nearly quadrupling maize’s caloric content, but the rewards are offset to occur near the end of the dry season, whereas maize can be
harvested and stored a month or more before the dry season begins (Tucker 2007). Local people prefer the faster payoff that maize provides. Maize production ensured constancy of food through this “hunger period”, which was supplemented by hunting and foraging. Households often have constrained labor, making cassava farming difficult given its high labor costs to extract weeds and travel costs to plant within the 10 km buffer zone in the forest. Therefore, households would rather economize labor instead of land, and maize production fits this paradigm with its low need for upkeep throughout its growth cycle (Tucker 2007).

Durrell Wildlife Conservation Trust, a NGO that promotes environmental conservation with the ultimate goal of preventing species extinctions, has had success in the Kirindy Forest in compensating local people for conserving the dry spiny forest, though not through lump sum payments (Sommerville et al. 2010). While Kirindy Forest is protected and its management rules includes sanctions against foraging and hunting in the forest, it is different in one key way compared to Mikea Forest. Instead of the military and ANGAP managing the forests, local community forest associations do. The forest associations implement and enforce management rules and grant permits for the multi-use areas of the forest. Durrell provides payments to these local communities contingent upon the number and abundance of species present, as well as forest governance indicators and monitored threats. Payments are distributed based on performance relative to other communities participating in the program. Each community participating in the program has received $250 to $2230 in in-kind incentives yearly depending on these factors. The forest association then decides what to use the incentives for, typically purchasing electric generators, building materials, cooking supplies, bicycles, and zebu (Sommerville et al. 2010). To put this amount in perspective, maize grown around the Mikea Forest sells for $0.05 to $0.06 per kilogram, with one ton fetching around $50. This amount may
be used for community use only, but communities in the Mikea Complexe have exported maize to Indian merchants from the Seychelles in the past. The strong market demand from the Seychelles contributed significantly to an increase in the use of *hatsake* in the 1990s, though the trading relationship fell apart once restrictions on *hatsake* were implemented (Tucker 2007).

Ecotourism is present in both the Mikea Forest and Kirindy Forest, but at a reduced level compared to those parks that have rainforest. There has not been much research on ecotourism impacts at either Mikea Forest or Kirindy Forest, despite ecotourism often being trumpeted by the Malagasy government and international organizations as leading to sustainable development in these areas (Whitehurst 2007).

*Enforcement ability*

Research indicates that forest management is upheld in both Mikea and Kirindy Forests, but only in Kirindy is the forest management politically acceptable. Mikea Forest is likely now experiencing an inability to enforce rules about *hatsake* or foraging exclusion zone beyond ten km from the forest’s periphery, given its lack of power under the current central government administration. Going into 2009, however, Mikea Forest had an intermittent but strong Malagasy Armed Forces commitment to enforce the environmental protection rules which mostly prevented continued degradation of the forest.

The Kirindy forest associations continue to get compensation from Durrell, despite the nation’s political instability. The local forestry boards are the primary administrative and enforcement entity, and many people find this preferable to being administered by the central government (Sommerville et al. 2010). The economic compensation approach, while not the perfect policy tool to ensure all communities near Kirindy Forest follow the protected area restrictions, is having net positive conservation effects on the forest (Sommerville et al. 2010). In
many ways, this economic compensation supports enforcement of Kirindy Forest’s rules by preempting unsustainable resource extraction with economic value exceeding such extraction.

**Political acceptability**

Economic considerations and perceived fairness of the community forestry associations are the primary drivers of political acceptability. The ban on maize, a staple food that was integrated into the majority of meals, occurred recently enough and without proper substitute that makes such a policy intervention difficult to accept. Cassava is not perceived as a worthwhile alternative to maize, and this dramatic cultural change over what kind of food is available is not politically acceptable to the majority of people living near Mikea Forest. Likewise, the strict reserve nature of the Mikea Forest core prevents access to traditional foraging techniques, such as gathering tubers, which were very sustainable options for subsistence. There really isn’t any worthwhile compensation for Mikea Forest as there is in Kirindy Forest for conserving the environment.

Additionally, the governance structure for the area around the Mikea Forest is top-down as of 2008, while Kirindy’s governance is bottom-up. In Kirindy Forest, local people can exert much greater control on management outcomes by influencing and voting on community forestry board leaders. The governance style has contributed to greater acceptance of the Kirindy Forest protected area. Of people polled in Kirindy Forest, 60% perceived the compensation process and community forest associations as fair, 29% were unsure of the fairness, and 11% perceived the system to be unfair (Sommerville et al. 2010). Mikea Forest lacks this option for direct participation, and this lack of participation, as well as the seemingly unjust exclusion of many traditional practices, makes the governance structure untenable and politically unacceptable for local people. Like in Ranomafana National Park, local people may simply pursue hatsake deep within Mikea Forest’s interior to evade forestry agents.
**Vohidrazana-Mantadia Corridor**

_Indicators of Anthropogenic Disturbance_

The Vohidrazana-Mantadia Corridor is one of the largest stretches of rainforest left on Madagascar. Of particular interest is the Perinet reserve in the southern extent of the Vohidrazana-Mantadia Corridor. Perinet stands as an example of what the future ecology could look like if more forest is converted to rice fields via *tavy*, leaving only small islands of forest that are valuable only in bringing in ecotourists and scientific researchers.

Around 80 individuals from *Indri indri*, one of Madagascar’s largest lemur species, inhabit the Perinet reserve, the number having stayed about the same from 1976 to 1996. However, in a study published in 2011, researchers estimated that only 32 indri inhabit the reserve (Junge, Barrett and Yoder 2011). Ecologists have said that, in the long run, eighty animals are not enough to keep the population viable (Quammen 1996). Ecologists refer to the term “minimum viable population” when analyzing whether a species can continue to persist into the future. The concept is by no means a hard and fast scientific measurement, but rather a qualitative assessment of a species behavior, biology, available resources, environmental stressors, presence of other flora and fauna, and so on. For example, availability of resources may be plentiful but genetic diversity may be constrained due to lack of individuals. This would mean that the genetic load, or burden of potentially harmful recessive alleles that a population carries, may become more prominent as the likelihood of breeding between close relatives increases as the population decreases.

Perinet’s small size and popularity with ecotourists, given its proximity to the capital Antananarivo and dedicated passenger rail line, has an implication for ecological health that is different from all other cases. In Perinet, ecotourists, not local people, are the primary form of

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*xxiv* Alleles are an alternative form of a gene which codes for distinct traits. Allelic expression was discovered by Gregor Mendel through experiments with pea plants.
disturbance for the reserve (Stephenson 1993). Though _tavy_ and logging separated Perinet from the Mantadia-Vohidrazana corridor, ecotourists perpetually disturb the indri of the reserve. In many ways, the Perinet reserve is like a zoo exhibit, allowed to stand because it ensured ecotourists a view of the otherwise furtive indri.

A comparative study examined the indri living in the Perinet reserve to those living in an undisturbed section of forest to the east of Ranomafana National Park. Researchers found that the populations of indri showed different attributes. The Perinet indri showed significant physiological changes, such as a high white blood cell and lymphocyte\textsuperscript{xxv} count, due to the increased incidence of pathogens from humans (Junge, Barrett and Yoder 2011). The Perinet indri also had lower protein and electrolyte values (Junge, Barrett and Yoder 2011), among many other health disparities, compared to the indri living in undisturbed forest. This is due to the fact that the Perinet reserve does not offer as many nutritional sources as pristine forest allows.

Anthropogenic disturbance has not been studied extensively throughout the rest of the corridor. There has been assessment of succession of plant species near ecological edges and in fallow areas where rice farming has been abandoned (Styger et al. 2007). Specifically, these areas of disturbance promote the colonization of invasive flora species, pressuring edges of forest more than _tavy_ would alone. There has also been assessment of species richness of amphibians in both secondary forest growth occurring in fallow areas and undisturbed rainforest habitat. Compared to undisturbed forest, secondary forest demonstrates 54\% of amphibian species occurring in undisturbed rainforest, while rice fields demonstrate only 12\% of those amphibian species that occur in in undisturbed rainforest (Vallan 2002).

\textsuperscript{xxv} Lymphocytes are a type of white blood cell that determine the specificity of immune response to foreign substances and microorganisms.
Despite these changes recorded in flora species as well as amphibians, some mammalian species do not seem as reliant on having canopy cover. Notably, the aquatic tenrec, *Limnogale mergulus*, and multiple species from genus *Chiroptera* do not see the same magnitude of change experienced by the non-mammalian species. Abundance of *L. mergulus* was found to be nearly the same in both forested and disturbed areas lacking canopy cover, a fact that seems counter to the suspicion that it is highly vulnerable to habitat change because it occupies a specialized ecological niche. So long as its streambed foraging areas were still supporting insects, *L. mergulus* principle prey, the aquatic tenrec’s presence in disturbed areas would continue (Benstead, Barnes and Pringle 2001). Multiple bat species, too, showed a surprising lack of response to habitat degradation. Many chiropterans demonstrated highest activity in degraded areas, including rice fields and eucalyptus plantations, while species richness was highest in adjacent undisturbed forest. Landscapes that include disturbed habitat – secondary forest, agriculture, plantations, and villages – and undisturbed habitat – pristine forest - are ideal for bats. Chiropteran diversity is ultimately promoted because this mix of habitat provides both roosting and foraging sites for species that rarely use intact forest (Randrianandrianina et al. 2006). There is a limit to how much habitat modification these species can tolerate, as tenrecs need streams with fair enough water quality to ensure insects survive, and chiropterans can only persist so long as roosting areas are available even if insects are plentiful.

**Economic sufficiency**

In the past, local people around the southern end of the Vohidrazana-Mantadia Corridor have used the reliable rail system from Toamsina, east of the corridor and a port, to Antananarivo to shuttle an economically valuable commodity: frogs from the genus *Mantella*. For local people engaging with the narrow opportunities of the ecotourism industry and the reduction of traditional foraging and agricultural practices, there are different payout schemes associated with
exporting *Mantella* to consider. For example, if a local person hunted the various species of the frog genus *Mantella*, they might consider the following payout scheme:

**Mantella Trade Value Chain**

<table>
<thead>
<tr>
<th>Exported animals</th>
<th>Hunters</th>
<th>Collectors</th>
<th>Exporters</th>
<th>International market price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>MGA 60-400</td>
<td>MGA 150-1,200</td>
<td>MGA 6,600-33,000</td>
<td>MGA 69,000-159,000</td>
</tr>
<tr>
<td></td>
<td>($0.03-$0.20) per animal</td>
<td>($0.07-$0.60) per animal</td>
<td>($3.30-$16.50) per animal</td>
<td>($34.50-$80) per animal</td>
</tr>
</tbody>
</table>

*Table 2: Monetary value gained by exchanging a specimen of *Mantella* at different points in the market. Source: (United Nations Environment Programme and United Nations Conference on Trade and Development 2008)*

Local people would receive between $0.03 and $0.20 for individual frog specimens, compared to private sellers that make between $35 and $80 by selling an individual frog to a collector elsewhere in the world. Economic theory might say that local people, especially familial groups, might participate in both exporting *Mantella* and replanting fallow fields so as to receive an optimal balance of costs and benefits in a system constrained by park rules (Tucker 2007). Specifically, a family might have members actively seeking specimens of *Mantella* while other members maintain rice fields. There are a number of confounding factors that determine the payoff schedules for both strategies, such as amount of *Mantella* in the area or nutrients in a fallow field, but ideally families would want a mixed portfolio of economic options to minimize risk while optimizing access to food and payments for *Mantella*.

The Vohidrazana-Mantadia Corridor, especially Perinet, enjoys the economic benefits associated with ecotourism. Perinet was one of the very first reserves created in the early 20th century, and its connection to both a major rail line and roadway have arguably made it one of the most accessible protected areas in Madagascar. The reserve brings in more than 30,000 visitors a year (Junge, Barrett and Yoder 2011). Local people have more opportunities because of this guaranteed stream of foreigners. The service industry around Perinet is especially
sophisticated compared to much of the island, with Malagasy and French entrepreneurs running a variety of shops and hotels around the park. Some hotels are situated closer to the Mantadia and Vohidrazana forests as well, using Perinet as a hook to entice ecotourists to visit other parts of the Corridor.

Despite these economic benefits, locals still seek out ways to implement *tavy*. There is evidence that *tavy* is being conducted by locals who are unable to attain land through local and state authorities, instead choosing to furtively clear forest inside the large Corridor (Schoonmaker Freudenberger 1995). However, a World Bank study in an area adjacent to Mantadia National Park in the Corridor found that lack of access to markets and poor transportation infrastructure reduced agricultural intensification, thus helping safeguard the Corridor from additional unsustainable agricultural exploitation (Keck, Sharma and Feder 1994).

*Enforcement ability*

The Vohidrazana-Mantadia Corridor features some of the best enforcement ability on the island. Partly, this is due to the concentrated nature of ecotourism in the area and diminished corruption among government officials. This increased concentration of wealth and economic opportunities has likewise minimized harvesting and *tavy* near Perinet, though they still occur. Economic opportunities support enforcement of park rules, especially when economic opportunities are perceived to be contingent upon the upkeep of those rules. The local governments of the ecotourism gateway communities and park workers are also very involved in educating community members about the value of the protected areas. Economic incentives tied to ecotourism, rather than draconian park rules, are the primary driver of environmental conservation and observance of protected area restrictions throughout much of the Corridor.
Political acceptability

Environmental protection is politically acceptable throughout those ecotourism gateways in the corridor, especially Perinet. This is in part because ecotourism in the area is concentrated around the Perinet Reserve and Vohidrazana and Mantadia Forests and many members of the community benefit from goods and services sold to ecotourists. Near the Perinet Reserve, people are not upset that they cannot log the forest or use traditional agricultural practices. Many members of the community realize the economic value of having a rare lemur species that is accessible to ecotourists, and how in many ways this value exceeds many traditional economic practices. Having this economic value makes the governance style of Perinet and the nearby Vohidrazana and Mantadia Forests acceptable. These economic opportunities can offset the loss of traditional economic activities, but these benefits cannot be extended to all communities or communities that do not experience much ecotourism traffic. Some researchers have noted from aerial photography that tavy is occurring in core areas of the park, demonstrating that economic incentives and park rules are not going far enough in compensating people and administering to park protection (Styger et al. 2007).

Ranomafana National Park

Indicators of Anthropogenic Disturbance

Tavy dominates the periphery of Ranomafana National Park, though the eastern border of the park has been fallow for some time, and secondary growth forest consisting of bamboo and weedy shrubs has sprouted up. On the western side of the forest, paddy rice fields dominate. The forest itself shows signs of human disturbance going back a century or more. Felled trees, bark shavings, footpaths, and cattle dung all point to an anthropogenic presence in what is marketed as “undisturbed” forest (Peters 1999).
In and around Ranomafana National Park, there has been a marked decrease in soil fertility, especially since the French colonial period. The soil around Ranomafana has been characterized as some of the poorest in Madagascar and the world (Peters 1999). Due to the low levels of nutrient availability, tavy practices are less productive, prompting local people to convert more land to achieve acceptable yields. Despite RNP being a strict reserve being open only to ecotourists and scientists, many of the 30,000 local people that live near the park do not know that it is a strict reserve. This has led to some conflict between park personnel and local villagers over land use, and further forest disturbance (Jones, Andriamarovololona and Hockley 2008).

Compared to Masoala, Ranomafana’s ecology is in much better shape despite the anthropogenic disturbance. There aren’t large hunting parties going through and collecting hundreds of lemurs and, though selective logging occurs, it is nowhere near the scale found in Masoala. Studies have also concluded that the disturbance and fragmentation of the forest, especially near the periphery, does not strictly follow the ecological relationship of decreased forest area leading to diminished species richness (Irwin et al. 2010). Instead, only correlation between forest fragmentation and diminished species richness was found, with an area relationship having no predictive power. For example, 54 species of birds occur in the least disturbed parts of Ranomafana National Park, but only 5 to 23 species are found among the fragmented and perpetually disturbed parts of the forest (Irwin et al. 2010). Twelve species of lemur can be found in the undisturbed parts of Ranomafana forest as well, and three to nine species can be found in RNP’s fragmented and disturbed areas. Despite these significant differences in the presence of bird and lemur species among undisturbed and disturbed,
fragmented forest, some species’ presence remains unchanged. Small mammals, especially rodents, show no change in their abundance between disturbed and undisturbed forest area.

Given this information, there are indications that ecological changes have occurred in RNP, but nothing so corrosive that has over the past fifty years forced a species into local extinction.

**Economic sufficiency**

The presence of an economic exclusion zone in RNP would decrease the economic sufficiency of local people. Though RNP had one of the most successful ICDPs of the entire world in the 1990s, the economic benefits linked to ecotourism did not bring in sufficient revenue to offset the loss of natural resource extraction (Peters 1998). Especially between 2002 and 2009, the local people had to convert fallow regions to rice production instead of converting forest (Peters 1999) (Dolins et al. 2010). Converting falls is not as productive as converting forest due to a lack of nutrients in the soil. While many local people have simply considered expanding rice fields to balance the inadequate rice yields, there is a cap on labor that prevents this strategy.

Like other national parks, gateway communities reap the benefits of ecotourism, though benefits are not obtained by all individuals within these communities. Aside from this general trend often stated in the literature, few studies have been conducted assessing ecotourism or economic aid deployment around Ranomafana National Park.

**Enforcement ability**

Until 2009, RNP showed excellent protection of the ecology. It had a strong enforcement capability that was used to ensure the park rules were followed. In 1990, 13 villagers were arrested for conducting *tavy* inside the park’s boundaries. Also in 1990, a timber concessionaire – a well-connected individual to Madagascar’s national police force – was arrested for recurring
logging operations within RNP (Peters 1998). The power of the administrating officials in enforcing park rules has periodically led to conflicts with local people, especially on those rules that effectively prevent local people from performing traditional practices.

Despite this strong administrative ability, after the 2009 coup d’état and subsequent withdrawal of most international aid to the island, the forest administration presiding in RNP is effectively without funds to perform enforcement and administrative practices. No study has assessed this impact at the time of writing.

**Political acceptability**

The strict reserve rules of RNP and its strong enforcement ability are posited against the livelihood of the local people. The Ranomafana area has a history of land use conflicts. Under French colonial rule, violations of anti-deforestation regulations subjugated many local people to forced labor and imprisonment. In the intervening period between 1960 and the park’s creation in 1991, Ranomafana forest was considered protected by the Malagasy government, but extensive permitting allowed foraging and resource extraction (Peters 1999). This system was respected by the local people and government officials, as it regulated the amount of resources being extracted while allowing local people greater flexibility to observe traditional practices.

By the mid-1980s, there was growing international interest in Madagascar’s unique ecology and heightened concern that it would be lost to unsustainable land use practices. After engaging in discussions beginning in 1984, the Malagasy government, funded primarily by USAID assistance, made the policy decision to protect Ranomafana forest as a strict reserve and national park. Permits for extractive use were rescinded, and allegations were made by local people that this was an attempt by foreigners to take away their land (Peters 1999).

To local people, the strict reserve is not politically acceptable. Despite being potentially politically acceptable by scientists and ecotourists because the park safeguards biodiversity, the
lack of acceptability on the part of local people threatens the ability of RNP to endure. Local people characterize it as simply going too far in restricting what they can do. It diminishes their ability to survive (Jones, Andriamarovololona and Hockley 2008). Going from *tavy* with adequate levels of rice harvested, supplemented by food sources from the forest, to fallow field rice production and no access to food sources in the forest is a dramatic change. After the implementation of the park, the local populace experienced no growth, far lower than the 3% population growth for Madagascar as a whole. The lack of population growth is a striking example of how park rules have posited the interests of biodiversity ahead of people (Peters 1999).

It is unclear how political acceptability of the park has changed since 2009. Enforcement is no longer funded and park rules cannot be readily enforced. It is likely that local people have greater access and ability to extract resources from the forest because of this, and for that reason, much like how Masoala National Park’s governance is perceived and politically acceptable post-2009, the park has become more acceptable.

**IX. Evaluation Matrix**

Criteria have been applied to each of the case studies, and relative rankings are given based on the evidence presented above. Rankings consist of four marks (+ or -) that demonstrate the degree to which each case study is meeting each criteria. The evaluation matrix was created with each criterion's questions in mind, which are found below. Synthesis and justification for the rankings can also be found in the paragraphs following the matrix. Ideally, a viable protected area would have: few indications of anthropogenic disturbance, economic opportunities that are

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Case Study 1</th>
<th>Case Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropogenic disturbance</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Economic opportunities</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

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seen by communities as exceeding the value of traditional land use practices, an effective park enforcement ability, and public acceptance of the protected area.

**Evaluation Matrix**

<table>
<thead>
<tr>
<th>Case Studies</th>
<th>Anthropogenic Disturbance Indicators</th>
<th>Economic Sufficiency</th>
<th>Enforcement Ability</th>
<th>Political Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Masoala Peninsula Corridor (post 2009 coup)</strong></td>
<td>++++ =</td>
<td>++++ =</td>
<td>+--- =</td>
<td>+++- =</td>
</tr>
<tr>
<td><strong>Mikea Complexe</strong></td>
<td>+++- ↗, but = in Kirindy Forest</td>
<td>+++- ↗</td>
<td>+++- ↖</td>
<td>+++- ↗</td>
</tr>
<tr>
<td><strong>Vohidrazana-Mantadia Corridor</strong></td>
<td>+++- =</td>
<td>+++- ↖</td>
<td>+++- ↖</td>
<td>+++- =</td>
</tr>
<tr>
<td><strong>Ranomafana National Park</strong></td>
<td>+++- ↗</td>
<td>+++- ↗</td>
<td>++++ ↖</td>
<td>+++- ↗</td>
</tr>
</tbody>
</table>

Pluses (+) and minuses (-) denote how well each case study is meeting each criteria. Arrows note likely directionality either in a positive (↗: toward a +), negative (↘: toward a -), or equal (=: no change) direction following the 2009 *coup*.

The chaos attributed to the 2009 *coup* hit Masoala particularly hard, but in many ways the worst has passed. In the matrix above, Masoala is ranked using evidence from both before and after the 2009 *coup*. Masoala is really the only area where scholarly work has been done to look at the effects of the political crisis, and the evaluation matrix above reflects a current criteria ranking and associated directionality. The parks in the Masoala Corridor reopened to ecotourists in 2010, and there are signs rosewood exports are beginning to decrease as the trees become scarcer and further away from rivers. However, the economic drivers for rosewood may guarantee its local extinction from Masoala and surrounding areas because it still makes economic sense to extract it. It is difficult to project if or when local extinction would occur, as there are many variables – including global market price, global demand, transportation costs,
and government ability to enforce CITES regulations – for which to take account. Likewise, lemur species are experiencing a decrease in population due to the number of loggers hunting them while exploiting rosewood. Selective logging has ecological consequences, especially in the local aridification of the rainforest, and can make core areas of the park especially susceptible to invasive species.

Economic sufficiency is roughly equal due to the decreasing occurrence of rosewood exports coupled with the renewal of ecotourism at Madagascar’s most visited and internationally recognized park. Enforcement ability has increased, as there are some park workers trying to enforce park rules. When the 2009 crisis began, park workers were forced to leave when loggers targeted them with physical violence. The return of park workers in 2010 shows some, albeit weak, enforcement ability. Political acceptability is currently strong, as both ecotourism and rosewood logging are happening simultaneously while bringing sizeable economic benefits with minimal government intrusion. Despite evidence of some recovery, the Masoala Peninsula is not currently a viable part of the environmental protection program, needing strong government intervention to disband the rosewood and bushmeat trades.

The Mikea Complexe’s ability to remain viable is tied to the enforcement ability of park management, in the case of Mikea Forest, or community forest associations, in the case of Kirindy Forest. Both of these are viable, but Mikea Forest less so due to the heavy-handed restrictions against traditional land use practices and the lack of economic alternatives. Since the collapse of foreign aid for environmental conservation, the ability of the park administration to enforce rules is greatly diminished. At worst, this collapse would return Mikea Forest to pre-2007 levels of use by local people, when Mikea Forest was not a protected area. Political acceptability likely increased as a result, as Mikea Forest’s exclusion zone would be difficult to
enforce without the needed funding for park management. Kirindy remains viable because forest governance is highly participatory and on a local level. Additionally, economic compensation is available at Kirindy, which helps spread out the costs of conservation among the community.

The Vohidrazana-Mantadia Corridor is likewise able to remain viable due to the local economy being strongly tied to ecotourism. Economic sufficiency dropped in the area when ecotourists ceased traveling to Madagascar following the 2009 coup. Enforcement ability has dropped due to lack of funding, which may mean some loss of the forest to tavy and other natural resource exploitation. Rampant exploitation of resources that is seen in the Masoala Peninsula Corridor is not present in the Vohidrazana-Mantadia Corridor. People in areas surrounding key destinations for ecotourists, notably the Perinet Reserve and the entrances to the Vohidrazana and Mantadia Forests, likely do not find the political instability surrounding the coup politically acceptable, as it greatly diminished the amount of visiting ecotourists. People not close to these destinations who must rely on a traditional portfolio of economic options are likely see the decrease in enforcement ability as politically acceptable because protected area restrictions would be largely unenforced.

Ranomafana National Park is a strict reserve and has had difficulty in providing economic opportunities and community participation to the park. Its strong enforcement ability has greatly reduced indicators of anthropogenic disturbance despite these other considerations. Unlike Mikea Forest, Ranomafana does not even provide a zone for traditional foraging. The governance of Ranomafana is not politically acceptable because it asks local people to sacrifice too much of their well-being, and it is likely that once the funding for administration of the park ceased the behavior of local people changed dramatically. For instance, foraging and tavy likely resumed so that people could better support themselves. This park is not viable, as the
relationship between the local communities and the administrating officials is too adversarial for the park to endure. A change, at least towards Mikea Forest’s design of having an area from which to forage from, is needed.

X. Conclusions and Recommendations

Environmental conservation, local economic development, and majority participation are the key policy goals of Madagascar’s environmental protection program. Balancing these three objectives, however, has proven difficult for the Malagasy government even with international support leading up to the coup. There are scientific, technical, social, and political challenges that must be met to accomplish these policy goals. In the past two decades, Madagascar’s environmental protection program has progressed rapidly. The rapidity of the program’s deployment has revealed the complex conflicts between environmental conservation and economic development, as well as the deep ethical issues around these three objectives.

A key problem that plagues the environmental protection program in Madagascar is tied to the lack of consent of the governed. While the Malagasy government has over the past two decades consulted international organizations to decide which natural areas should be placed under government protection, it has not sufficiently engaged communities near natural areas to inform them of environmental protection plans or given weight to their concerns. Mikea Forest and RNP both demonstrate how local people react negatively when not consulted about major policy changes that significantly affect their livelihoods (Tucker 2007) (Peters 1999). Though the GELOSE contracts were an honest attempt to engage communities and distribute natural resource rights, reviews of the system between 2005 and 2009 showed that local elites were able to obtain a disproportionately amount of resources (Pollini and Lassoie 2011). The contracts also
provided further legal binding to exclusionary natural resource rules, perpetuating poverty in many communities.

The environmental program places the impetus for change between people and the environment disproportionately on the local people. Economic development that has sought to provide opportunities to Malagasy communities, but is often programmed to accommodate environmental conservation, tends to perpetuate impoverished conditions. When economic development or economic cornerstones of communities are restricted by environmental protection laws, local people do not see the benefit. Diminished health, decreased access to food, and breakdown of traditions has resulted due to environmental conservation-driven land use restrictions.

Out of the case studies presented, only two protected areas stand out as successfully balancing environmental conservation, local economic interests and public participation while demonstrating sufficient enforcement capability. Kirindy Forest and the Perinet Reserve both provide sufficient economic compensation to communities to ameliorate unsustainable natural resource use. Kirindy Forest’s environmental protection is aided by the Durrell Wildlife Conservation Trust’s compensation to communities based on surrounding species richness, while Perinet is dependent on the transportation infrastructure that conveys ecotourists from the capital, Antananarivo. These protected areas are viable because the economic incentives are concentrated in a few communities, and these incentives exceed the value of traditional agriculture, logging, and bushmeat hunting. Natural resource use is diminished locally, but it is highly likely that these communities’ need for natural resources is externalized to other communities and natural areas in Madagascar. This problem aside, Kirindy and Perinet provide the best examples of
politically acceptable, well-administered economic development and environmental conservation.

The other case studies, notably in the Masoala Peninsula Corridor, Mikea Forest and RNP, are not successful in balancing the well-being of both human and ecological communities. The 2009 political crisis precipitated a de facto shift in the Masoala Peninsula away from environmental conservation entirely. In Mikea Forest and RNP, decreased food access and the anxiety this diminished access promotes is the central problem that threatens to undermine these protected areas. Local economic development and public participation are both severely lacking in these two protected areas, casting doubt that these important environmental protection goals are being met. In Masoala, the boom in rosewood logging has promoted local economic development in the short run at a heavy cost to the largely undisturbed, continuous rainforest. Tight governmental controls on resource extraction and lack of government control altogether both bring unfavorable consequences to either local people or the environment.

Applying the strategies of Kirindy and Perinet to all protected areas, while well-intentioned, is not feasible unless certain benchmarks are met. First, the international community must either recognize the current autocratic regime and renew financial assistance or renew financial aid if the May 2011 elections are seen as fair and democratic. This would restart the environmental protection programs that were largely suspended following the 2009 coup. However, leading up to the coup this amount of aid only had less-than moderate success in developing agricultural and economic capacity for communities, with many communities ultimately worse off if they are restricted from extracting natural resources from protected areas. Extending meaningful economic benefits that persist beyond the lifespan of an international aid initiative to build a school or to establish limited alternative farming methods are needed. The
cycle of poverty must be broken if the environmental protection program is to be viable in the long term. Dispossessed communities that have not been engaged about how they will be governed have not been presented with economic alternatives in the face of restrictions on traditional land use, and have no choice but to exploit the forest to feed their families are effects of environmental conservation that the program cannot afford if it is to persist into the future.

In applying the strategies of Kirindy and Perinet, deeper ethical concerns need to be addressed as well. The nature of the strict reserves like RNP places moral value on the environment rather than on local people (Miller, Minteer and Malan 2011). It’s clear that, in areas where local people are totally excluded from the forest, they suffer at the expense of maintaining natural areas. This represents a significant ethical problem that often is only acted on when it fits with environmental conservation plans that communities should be given consideration (Miller, Minteer and Malan 2011). Another ethical problem, while perhaps not exceeding issues around the rights of indigenous populations, is that, without the environmental protection program as a whole, the remaining forests in Madagascar would be jeopardized by slash-and-burn agriculture and logging. Within decades, the remaining continuous tracts of forest would become heavily fragmented and perhaps gone completely. Ecosystem services would be significantly disrupted. Human communities would be significantly threatened by natural resource exhaustion without the ability to know to change consumption habits or utilize new technology. The examples of Kirindy Forest and the Perinet Reserve do show possible paths out of these moral and practical problems, but there are significant hurdles to applying similar programs across the island.

Even if these recommended efforts were successful, the strategies of Kirindy Forest and the Perinet Reserve may not be duplicable. RNP, for instance, attempted to scale up ecotourism
to the level found in the Vohidrazana-Mantadia Corridor, only to fail. There simply is not
enough ecotourism demand to fund the majority of Madagascar’s protected areas. Likewise, it
would be unprecedented for NGOs to fund all the protected areas of Madagascar to meet the
environmental protection goals in the same way the Durrell Conservation Trust has in Kirindy
Forest. Different strategies are needed to make the environmental protection program viable
across the whole of Madagascar.

In terms of broader recommendations for the environmental protection program as a
whole, there are three points of leverage that could potentially resolve some of Madagascar’s
most dire land use issues. The following recommendations are presented in the order of least
important to most important in having positive impacts for the program. It is also important to
recognize that many of these policy alternatives are difficult to implement given the
powerlessness of the government in many areas of the country.

While not applicable to many other areas of Madagascar, some intervention against
illegal logging in Masoala Peninsula must be taken. The “rosewood massacre” in the Masoala
Peninsula has severely undermined the ability of the protected areas to function. This illegal
extraction of rosewood is driven by demand in China. The two policy alternatives that would
best resolve this situation would be either international pressure on China or renewed aid support
for the Malagasy government so that it may be able to better enforce park rules. Neither of these
options is currently politically feasible, but an investigation is still valuable in exploring possible
solutions to the problems created by the logging of rosewood.

China has historically had high demand for endangered species products for traditional
medicine, and the cultural value around traditional medicine has in part prevented ratification of
CITES and any policy movement on the rosewood issue. Another difficulty in trying to influence
China is that the individuals demanding rosewood goods are wealthy and well-connected to the
government. These individuals’ unwillingness to forego rosewood goods translates into the
government’s unwillingness to stop incoming rosewood imports. The United States, other
nations, and environmental conservation groups would like to see China’s ratification of CITES,
but these groups, especially nation-states, see risks in provoking China on economic issues. For
example, China’s majority control of the rare earth mineral\textsuperscript{xxvi} market – over 95% control over
the extraction of rare earth minerals – has been used by the Chinese government to punish
nations that try to press an opposing economic policy. In late 2010, China stopped exports of rare
earth minerals to Japan, and greatly reduced exports to the United States after Japan sought a
reaffirmation of its ownership of the Spratly Islands in the South China Sea. With such risks, it is
unlikely that nations would push China on ratifying CITES, especially when there are no direct
benefits for these nations (except Madagascar). It is also unlikely that the government of
Madagascar would seek to stop exports of rosewood if it meant a more tenuous trade relationship
with China.

Likewise, renewed international support for the Malagasy government is unlikely to
occur until democratic and fair elections take place. Elections were supposed to occur in May
2011, after having been pushed back several times since late 2009. It is unclear if or when
elections will occur, or if the current leader Andry Rajoelina can be trusted to not subvert the
democratic process. Until the political crisis is resolved, it is unlikely that Madagascar will be
able to support the institutions that guide and protect the environmental protection program.
Logging of rosewood will continue to occur, which is largely preferable to many stakeholders
compared to any sort of economic conflict with China. Unfortunately, by the time either policy

\textsuperscript{xxvi} Rare earth minerals are used in many electronic products, including military equipment, cellphones, solar cells, and many others
alternative becomes politically feasible, it will likely be the case that rosewood will be extirpated from Masoala Peninsula, given the current incidence of illegal logging.

Another policy leverage point involves how protected areas are governed. From the analysis provided, it’s clear that strict reserves should allow some extraction of natural resources, or agricultural aid in surrounding areas should be greatly increased so that local people are able to have access to adequate subsistence. While this may increase habitat disturbance, it is important to note that nearly all of the case studies presented have some level of illegal harvest of food and wood from protected forest areas. Local people do not trust a governance system that makes access to basic necessities an uncertainty. Opening the forests to some extractive use, combined with agricultural intensification programs that provide farmers with access to fertilizer and some modern farm implements, would potentially allow both people and ecological communities to flourish. Since many of the protected areas are currently *de facto* open to resource extraction due to the Malagasy government’s inability to fund the environmental protection program, it’s unclear whether a change in rules would be meaningful. If the Malagasy government is able to reconstitute its environmental protection program to pre-2009 levels, a rule change for strict reserves is necessary to help local people.

Finally, any policy option that greatly reduces the occurrence of *tavy* while providing some economic alternatives to local communities would be far and away the best policy intervention and should be pursued. Unlike the previous two policy recommendations, a policy intervention to reduce the incidence of *tavy* and other types of slash-and-burn agriculture could be applied across Madagascar. *Tavy* has caused much of the deforestation in Madagascar, and reducing dependence on this form of agriculture would decrease the conversion rate of forest to temporary agricultural production. The reduction and elimination of *tavy* has been part of the
environmental protection program since its inception, and even long before that. Historically, *tavy* has been illegal since the mid-1800s, and has been enforced with threats of imprisonment. The policy tool of imprisonment has its limits, however, and has been difficult to implement and has failed in putting any meaningful end to the practice.

The FAO and USAID had, in 2008, sought to bring agricultural intensification to Madagascar. Agricultural intensification would be particularly useful for those communities near the Mikea Forest, especially if maize can be replaced with the more dry-tolerant sorghum. The South Korean multinational Daewoo Logistics, too, sought to dramatically increase the scale of agricultural intensification so that corn products could be exported back to South Korea. Daewoo Logistics’s economic interest in Madagascar’s arable land confirms those reports by FAO and USAID cited earlier that Madagascar can become a food exporter. Agricultural intensification means greater reliance on fertilizers and other chemicals to attain much higher and more permanent crop yields compared to slash-and-burn agricultural methods. This increased chemical use has environmental implications, but it seems that agricultural intensification pollution may be a favorable alternative to farming practices that destroy forest outright. It may also be favorable compared with communities near protected areas suffering due to lack of access to food.

The Daewoo Logistics deal that ultimately led to the ouster of President Marc Ravalomanana is the sort of policy solution that Madagascar needs. Unfortunately, the deal was framed as providing land to South Koreans so food and ethanol could be sold to South Koreans. The deal was not framed as feeding Madagascar, and the disconnect between the reality of food shortages and the export of food or conversion of food into fuel really diminished the political acceptability of the deal. The ability for a corporation or another well-funded organization to
develop modern agriculture capacity in Madagascar may not be currently feasible due to the current political instability in Madagascar. Corporations are unwilling to invest in modernizing Madagascar’s agriculture when there is so much uncertainty around the Malagasy government’s capabilities and isolation from the international community. It is also unlikely that agricultural intensification would occur through a government or nonprofit organization given the international boycott of the current Malagasy government. However, if democratic elections do take place and Madagascar can return to some normalcy, modernizing the agricultural practices in Madagascar is absolutely a first priority.

Taken together, these policy solutions cannot occur until there is some change in the Malagasy government. Specifically, Andry Rajoelina and his military support will have to abdicate power before the international community views the Malagasy government as legitimate. Democratic elections must also take place, in part to ensure that a new president is representative of the people’s wishes and therefore has legitimacy to govern. The government must also demonstrate that it is capable of projecting its power outside of the national capital of Antananarivo and the provincial capitals. Currently, the government is perceived as having abdicated power in many rural areas of the country. Until elections occur and Madagascar is once again acknowledged by the international community, these recommendations are not feasible to implement. Despite this failing, these policy recommendations are the best strategies in making the environmental protection program more viable in obtaining the policy goals of environmental conservation, local economic development, and majority public participation.
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## Appendix A

### Fady in the Androy Region of Madagascar

<table>
<thead>
<tr>
<th>Category</th>
<th>Size range (ha)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Forest patches with tombs, <em>ala kibory</em></strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burial forests</td>
<td>127</td>
<td>&lt;1 to 142</td>
</tr>
<tr>
<td>Recent burial grounds</td>
<td>5</td>
<td>Radius &gt; 30 m</td>
</tr>
<tr>
<td><strong>Forest patches without tombs</strong>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Salata</em>**</td>
<td>18</td>
<td>&lt;1-3</td>
</tr>
<tr>
<td><em>Honey groves, <em>ala fano–hofa</em></em>*</td>
<td>8</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>Forest patches with spirits</strong>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest patches with spirits</td>
<td>6</td>
<td>Diffuse borders</td>
</tr>
<tr>
<td>Private forests</td>
<td>4</td>
<td>&lt;1-3</td>
</tr>
<tr>
<td>Ceremonial places</td>
<td>3</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Memorial places</td>
<td>3</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

Table: Categories of taboo forest patches according to reason for taboo, restrictions implied, and sanctions. Source: (Tengö, et al. 2007)
### Appendix B

**Summary of evolution of environmental law pertaining to forestry in Madagascar**

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>DOMINANT NARRATIVE</th>
<th>POLICY</th>
<th>ROLE OF GOVERNMENT</th>
<th>ROLE OF GOVERNED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Colonial (through 1895)</td>
<td>Madagascar was once fully forested</td>
<td>Cutting live firewood forbidden</td>
<td>Create and enforce repressive forest policy (through banning deforestation)</td>
<td>Abide by centrally-created laws</td>
</tr>
<tr>
<td></td>
<td>Deforestation resulted from human activity</td>
<td>Burning and settling in forests forbidden</td>
<td>Ensure forests (i.e., royal property) are preserved for the use of royals</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clearing the land for agriculture forbidden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colonial (1896-1961)</td>
<td>Madagascar’s forest resources are for French use and to enrich France</td>
<td>Reforestation of fast growing species</td>
<td>Create and enforce repressive forest policy (through establishing conservation areas or banning deforestation)</td>
<td>Abide by centrally-created laws</td>
</tr>
<tr>
<td></td>
<td>Malagasy are unable to manage forests</td>
<td>Hunting lemurs forbidden</td>
<td>Manage forests unilaterally</td>
<td>Resist centrally-created laws by continuing tavy as a cultural practice</td>
</tr>
<tr>
<td></td>
<td>Reforestation is needed for human consumption and development</td>
<td>Forest fires and deforestation forbidden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Logging concessions established</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Colonial (1962-Present)</td>
<td>Early Independence (1962-1991)</td>
<td>The State is the only legal manager of forest resources</td>
<td>Deforestation forbidden</td>
<td>Abide by centrally-created laws</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hunting of several species forbidden</td>
<td>Create and enforce repressive forest policy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Manage forests unilaterally</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reforestation mandatory</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NEAP Era (1992-Present)</td>
<td>Conservation is needed to save Malagasy biodiversity</td>
<td>Integrated conservation and development projects</td>
<td>Create protected areas</td>
</tr>
<tr>
<td></td>
<td>Standardized models are appropriate</td>
<td>Fences and fines</td>
<td>Enforce laws</td>
<td>Use economic development activities as an alternative to resource extraction</td>
</tr>
<tr>
<td></td>
<td>Community-based Forest Management</td>
<td>Decentralization of forest management</td>
<td>Transfer management rights and responsibilities to local people</td>
<td>Conserve and manage forests for long-term sustainability</td>
</tr>
<tr>
<td></td>
<td>The state is ill-equipped to manage forests effectively everywhere</td>
<td>Empowerment of local forest users to make decisions regarding forests</td>
<td>Monitor and oversee local-level management decisions</td>
<td>Adhere to principles established by the government or third-party NGOs</td>
</tr>
</tbody>
</table>

**Source:** (Raik 2007)
Appendix C

Protected Areas of Madagascar: Current and Proposed

Map: Current Protected Areas (Blue); Proposed Protected Areas under the Durban Plan (Red); Sensitive Environmental Areas (Green)

Source: (Durbin 2006)
### Appendix D

**IUCN List of Protected Area Categories**

<table>
<thead>
<tr>
<th>Basic categories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Scientific Reserve/Strict Nature Reserve: Managed mainly for science or wilderness protection. Tourism: not permitted (only for scientific purposes).</td>
</tr>
<tr>
<td>II</td>
<td>National Park: Managed mainly for ecosystem protection and recreation. Tourism: high priority.</td>
</tr>
<tr>
<td>III</td>
<td>Natural Monument/Natural landmark: Managed mainly for conservation of specific natural features. Tourism: high priority.</td>
</tr>
<tr>
<td>IV</td>
<td>Nature Conservation Reserve/Managed Nature Reserve/Wildlife Sanctuary: Managed mainly for conservation through management intervention. Tourism: permitted (basically including hunting tourism).</td>
</tr>
<tr>
<td>V</td>
<td>Protected Landscape or Seascape: Managed mainly for landscape/seascape conservation and recreation. Tourism: high priority.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Additional categories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI</td>
<td>Resource Reserve: Tourism: basically permitted.</td>
</tr>
<tr>
<td>VII</td>
<td>Anthropological Reserve/Natural Biotic Area: Tourism: permitted with reservation.</td>
</tr>
<tr>
<td>VIII</td>
<td>Multiple Use Management Area/Managed Resource Area: Tourism: high priority (basically including hunting tourism).</td>
</tr>
<tr>
<td>IX</td>
<td>Biosphere Reserve: Tourism: permitted.</td>
</tr>
<tr>
<td>X</td>
<td>World Heritage Site (Natural): Tourism: high priority.</td>
</tr>
</tbody>
</table>

Source: IUCN
Appendix E  
CITES Appendix I, Appendix II, and Appendix III Classifications

Appendix-I specimens

1. An import permit issued by the Management Authority of the State of import is required. This may be issued only if the specimen is not to be used for primarily commercial purposes and if the import will be for purposes that are not detrimental to the survival of the species. In the case of a live animal or plant, the Scientific Authority must be satisfied that the proposed recipient is suitably equipped to house and care for it.

2. An export permit or re-export certificate issued by the Management Authority of the State of export or re-export is also required.

An export permit may be issued only if the specimen was legally obtained; the trade will not be detrimental to the survival of the species; and an import permit has already been issued. A re-export certificate may be issued only if the specimen was imported in accordance with the provisions of the Convention and, in the case of a live animal or plant, if an import permit has been issued. In the case of a live animal or plant, it must be prepared and shipped to minimize any risk of injury, damage to health or cruel treatment.

Appendix-II specimens

1. An export permit or re-export certificate issued by the Management Authority of the State of export or re-export is required. An export permit may be issued only if the specimen was legally obtained and if the export will not be detrimental to the survival of the species. A re-export certificate may be issued only if the specimen was imported in accordance with the Convention.

2. In the case of a live animal or plant, it must be prepared and shipped to minimize any risk of injury, damage to health or cruel treatment.

3. No import permit is needed unless required by national law.

Appendix-III specimens

1. Includes a list of species at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.

International trade in specimens of species listed in this Appendix is allowed only on presentation of the appropriate permits or certificates

Source: CITES Secretariat
<table>
<thead>
<tr>
<th>Taxonomic group</th>
<th>Species richness(^1)</th>
<th>Endemism</th>
<th>State of knowledge</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishes (including elasmobranchi)</td>
<td>c. 1,110</td>
<td>very low</td>
<td>well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Porifera (sponges)</td>
<td>&gt;300</td>
<td>none</td>
<td>well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Cnidaria (corals &amp; anemones)</td>
<td>&gt;410</td>
<td>very low</td>
<td>reasonably well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Octocorallians (soft corals, sea fans, etc.)</td>
<td>222</td>
<td>62 regional endemics(^3)</td>
<td>reasonably well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Hexacorallians (hard corals)</td>
<td>208</td>
<td>some regional endemism</td>
<td>reasonably well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Mollusca (molluscs)</td>
<td>c. 1,500</td>
<td>some regional endemism</td>
<td>poorly known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Crustacea (crustaceans)</td>
<td>c. 800</td>
<td>some regional endemism</td>
<td>poorly known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Echinodermata (echinoderms)</td>
<td>c. 400</td>
<td>&gt;80 regional endemics</td>
<td>reasonably well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Marine algae</td>
<td>c. 200</td>
<td>not stated</td>
<td>reasonably well known</td>
<td>Cooke et al., p. 179</td>
</tr>
<tr>
<td>Chondrichthyes (sea turtles)</td>
<td>5</td>
<td>none</td>
<td>well known</td>
<td>Ratsimbazafy, p. 210</td>
</tr>
<tr>
<td>Cetacea (whales &amp; dolphins)</td>
<td>28(^4)</td>
<td>none</td>
<td>reasonably well known</td>
<td>Rosenbaum, p. 213</td>
</tr>
<tr>
<td>Pinnipedia (seals)</td>
<td>2</td>
<td>none</td>
<td>reasonably well known</td>
<td>Rosenbaum, p. 213</td>
</tr>
<tr>
<td>Sirenia (dugongs)</td>
<td>1</td>
<td>none</td>
<td>well known</td>
<td>Rosenbaum, p. 213</td>
</tr>
<tr>
<td>Non-marine plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquatic plants</td>
<td>338</td>
<td>128 (38%)</td>
<td>poorly known</td>
<td>Andrianaereta Ranarisoa, p. 250</td>
</tr>
<tr>
<td>Bacillariophyceae (diatoms)</td>
<td>134(^5)</td>
<td>some endemic</td>
<td>poorly known</td>
<td>Spaulding &amp; Kociolek, p. 276</td>
</tr>
<tr>
<td>Pteridophyta (ferns &amp; allies)</td>
<td>580(^6)</td>
<td>265 (45%)</td>
<td>reasonably well known</td>
<td>Rakotondrainibe, p. 282</td>
</tr>
<tr>
<td>Annonaceae</td>
<td>89</td>
<td>83 (93%)</td>
<td>reasonably well known</td>
<td>Is Thomas &amp; Armonin, p. 316</td>
</tr>
<tr>
<td>Myristicaceae</td>
<td>10</td>
<td>10 (100%)</td>
<td>reasonably well known</td>
<td>Saquet, p. 319</td>
</tr>
<tr>
<td>Moraceae (Ficus)</td>
<td>25</td>
<td>15 (60%)</td>
<td>reasonably well known</td>
<td>Dalecky et al., p. 322</td>
</tr>
<tr>
<td>Bombaceae (Adisonia)</td>
<td>77</td>
<td>6 (85-100%)</td>
<td>well known</td>
<td>Baum, p. 339</td>
</tr>
<tr>
<td>Sapotaceae</td>
<td>82</td>
<td>81 (96%)</td>
<td>reasonably well known</td>
<td>Gautier, p. 342</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>573</td>
<td>459 (80%)</td>
<td>reasonably well known</td>
<td>Labat &amp; Moat, p. 346</td>
</tr>
<tr>
<td>Melastomataceae</td>
<td>321</td>
<td>318 (99%)</td>
<td>reasonably well known</td>
<td>Almeda, p. 375</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>c. 700</td>
<td>mostly endemic</td>
<td>poorly known</td>
<td>Hoffmann &amp; McPherson, p. 379</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>41</td>
<td>38 (93%)</td>
<td>reasonably well known</td>
<td>Randrianasolo, p. 398</td>
</tr>
<tr>
<td>Balsaminaceae</td>
<td>149</td>
<td>149 (100%)</td>
<td>reasonably well known</td>
<td>Rahelivololona et al., p. 402</td>
</tr>
<tr>
<td>Gentianaceae</td>
<td>67</td>
<td>62 (93%)</td>
<td>reasonably well known</td>
<td>Wohlhauser et al., p. 459</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>79</td>
<td>40 (51%)</td>
<td>reasonably well known</td>
<td>Fischer, p. 417</td>
</tr>
<tr>
<td>Rubiaceae</td>
<td>c. 650</td>
<td>637 (98%)</td>
<td>poorly known</td>
<td>Davis &amp; Bridson, p. 431</td>
</tr>
<tr>
<td>Arecaceae (palms)</td>
<td>170</td>
<td>167 (98%)</td>
<td>reasonably well known</td>
<td>Dransfield &amp; Beentje, p. 448</td>
</tr>
<tr>
<td>Pandanaceae (Pandanae)</td>
<td>99</td>
<td>99 (100%)</td>
<td>reasonably well known</td>
<td>Callmander &amp; Laiavo, p. 460</td>
</tr>
<tr>
<td>Poaceae, Bambuseae (bamboos)</td>
<td>34</td>
<td>24 (103%)</td>
<td>poorly known</td>
<td>Dransfield, p. 467, pers. comm.</td>
</tr>
<tr>
<td>Totals(^6)</td>
<td>2,054</td>
<td>2,643 (83%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-marine invertebrates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastropoda (terrestrial snails)</td>
<td>671</td>
<td>671 (100%)</td>
<td>reasonably well known</td>
<td>Pease, p. 529</td>
</tr>
<tr>
<td>Scorpiones (scorpions)</td>
<td>40</td>
<td>40 (100%)</td>
<td>reasonably well known</td>
<td>Lozario, p. 575</td>
</tr>
<tr>
<td>Araneae (spiders)</td>
<td>459</td>
<td>390 (85%)</td>
<td>reasonably well known</td>
<td>Griswold, p. 579</td>
</tr>
<tr>
<td>Ixodida (ticks)</td>
<td>27</td>
<td>25 (93%)</td>
<td>reasonably well known</td>
<td>Klompen, p. 588</td>
</tr>
<tr>
<td>Taxonomic group</td>
<td>Species richness</td>
<td>Endemism</td>
<td>State of knowledge</td>
<td>Source</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
<td>----------</td>
<td>--------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Atyidae (freshwater shrimps)</td>
<td>27</td>
<td>20 (74%)</td>
<td>well known</td>
<td>Short &amp; Doumenq, p. 603</td>
</tr>
<tr>
<td>Palaeonomatidae (freshwater shrimps)</td>
<td>13</td>
<td>5 (39%)</td>
<td>reasonably well known</td>
<td>Short &amp; Doumenq, p. 603</td>
</tr>
<tr>
<td>Panamocidae (freshwater crayfish)</td>
<td>6</td>
<td>6 (100%)</td>
<td>well known</td>
<td>Crandall, p. 608</td>
</tr>
<tr>
<td>Potamonautidae</td>
<td>12</td>
<td>12 (100%)</td>
<td>reasonably well known</td>
<td>Cumberland &amp; v. Sternberg, p. 612</td>
</tr>
<tr>
<td>Diplopoidea (millipedes)</td>
<td>160</td>
<td>123* (77%)</td>
<td>poorly known</td>
<td>Enghoff, p. 617</td>
</tr>
<tr>
<td>Collemboidea (springtails)</td>
<td>69</td>
<td>64 (93%)</td>
<td>poorly known</td>
<td>Betesch, p. 627</td>
</tr>
<tr>
<td>Ephemeroptera (mayflies)</td>
<td>&gt;100</td>
<td>100 (c. 100%)</td>
<td>reasonably well known</td>
<td>Elouard et al., p. 639</td>
</tr>
<tr>
<td>Odonata (dragonflies &amp; damselflies)</td>
<td>181</td>
<td>132 (73%)</td>
<td>reasonably well known</td>
<td>Donnelly &amp; Parr, p. 645</td>
</tr>
<tr>
<td>Plecoptera (stoneflies)</td>
<td>12</td>
<td>12 (100%)</td>
<td>poorly known</td>
<td>Elouard, p. 661</td>
</tr>
<tr>
<td>Megaloptera (fishflies &amp; alderflies)</td>
<td>4</td>
<td>4 (100%)</td>
<td>poorly known</td>
<td>Penny, p. 662</td>
</tr>
<tr>
<td>Neuroptera (lacewings)</td>
<td>163</td>
<td>119 (73%)</td>
<td>reasonably well known</td>
<td>Penny, p. 663</td>
</tr>
<tr>
<td>Coleoptera</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coccinellidae (tiger beetles)</td>
<td>203</td>
<td>201 (99%)</td>
<td>reasonably well known</td>
<td>Cassola, p. 669</td>
</tr>
<tr>
<td>Scarabaeidae, Melolonthinae,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eburini (scarab beetles)</td>
<td>148</td>
<td>148 (100%)</td>
<td>reasonably well known</td>
<td>Andriamampianina, p. 677</td>
</tr>
<tr>
<td>Siphonaptera (fleas)</td>
<td>24</td>
<td>21 (88%)</td>
<td>reasonably well known</td>
<td>Duchemin et al., p. 687</td>
</tr>
<tr>
<td>Diptera (true flies)</td>
<td>1,796</td>
<td>1,437 (80%)</td>
<td>poorly known</td>
<td>Irwin et al., p. 692</td>
</tr>
<tr>
<td>Blephariceridae (net-winged midges)</td>
<td>9</td>
<td>9 (100%)</td>
<td>poorly known</td>
<td>Courtney, p. 702</td>
</tr>
<tr>
<td>Culicidae (mosquitoes)</td>
<td>178</td>
<td>80 (45%)</td>
<td>poorly known</td>
<td>Duchemin et al., p. 708</td>
</tr>
<tr>
<td>Simulidae (black flies)</td>
<td>27</td>
<td>22 (82%)</td>
<td>reasonably well known</td>
<td>Elouard, p. 715</td>
</tr>
<tr>
<td>Tabanidae (horse flies)</td>
<td>75</td>
<td>71 (95%)</td>
<td>reasonably well known</td>
<td>Chainey, p. 721</td>
</tr>
<tr>
<td>Therioidea (stiletto flies)</td>
<td>21</td>
<td>21 (100%)</td>
<td>reasonably well known</td>
<td>Irwin, p. 730</td>
</tr>
<tr>
<td>Trichoptera (caddisflies)</td>
<td>c. 500</td>
<td>c. 99%</td>
<td>reasonably well known</td>
<td>Gibson, pp. 740</td>
</tr>
<tr>
<td>Lepidoptera (butterflies &amp; moths)</td>
<td>4,530</td>
<td>unclear</td>
<td>reasonably well known</td>
<td>Lees &amp; Minet, p. 748</td>
</tr>
<tr>
<td>Papilionoidea &amp; Hesperioidea (true butterflies)</td>
<td>300</td>
<td>211 (70%)</td>
<td>reasonably well known</td>
<td>Lees et al., p. 762</td>
</tr>
<tr>
<td>Hymenoptera</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogynidae, Ampulicidae,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spheridae, Crabronidae (apoid wasps)</td>
<td>190</td>
<td>158 (83%)</td>
<td>reasonably well known</td>
<td>Pulawski, p. 793</td>
</tr>
<tr>
<td>Formicidae (ants)</td>
<td>393</td>
<td>379 (96%)</td>
<td>poorly known</td>
<td>Fisher, p. 811</td>
</tr>
<tr>
<td>Totals</td>
<td>5,808</td>
<td>4,871 (86%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshwater fishes</td>
<td>143</td>
<td>93 (65%)</td>
<td>poorly known</td>
<td>Sparks &amp; Stiassny, p. 849</td>
</tr>
<tr>
<td>Land vertebrates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amphibia (frogs)</td>
<td>199</td>
<td>197 (99%)</td>
<td>reasonably well known</td>
<td>Claw &amp; Vences, p. 883</td>
</tr>
<tr>
<td>Reptilia (reptiles)</td>
<td>340</td>
<td>314 (92%)</td>
<td>poorly known</td>
<td>Hawkesworth, p. 934</td>
</tr>
<tr>
<td>Aves (birds)</td>
<td>209</td>
<td>193 (92%)</td>
<td>reasonably well known</td>
<td>Hawkins &amp; Goodman, p. 1019</td>
</tr>
<tr>
<td>Mammalia (non-volant mammals)</td>
<td>101</td>
<td>101* (100%)</td>
<td>poorly known</td>
<td>Goodman et al., p. 1181</td>
</tr>
<tr>
<td>Mammalia (bats)</td>
<td>30</td>
<td>18 (60%)</td>
<td>poorly known</td>
<td>Eger &amp; Mitchell, p. 1287</td>
</tr>
<tr>
<td>Totals</td>
<td>879</td>
<td>739 (84%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
On the evidence of molecular systematics, ancestors of the four endemic groups of placental mammal colonized Madagascar in single, separate events – lemurs 60 – 50 million years ago, tenrecs 42 – 25 million years ago, carnivorans 26 – 19 million years ago, and rodents 24 – 20 million years ago.

Source: (Krause 2010)
## Appendix H

### Effects of Anthropogenic Disturbance across Taxonomic Groups

<table>
<thead>
<tr>
<th>Taxonomic group</th>
<th>Habitat loss causes extinction of range-restricted species by destroying entire range habitat?</th>
<th>Habitat fragmentation: negative effects of decreasing fragment size/increasing isolation on local species richness?</th>
<th>Forest disturbance/edge effects: negative impacts on species richness?</th>
<th>Changes in hydrology (proximity to water for terrestrial taxa, water quality for aquatic taxa) negatively impact species?</th>
<th>Exotic/introduced species contributing to native species decline/loss?</th>
<th>Hunting/collecting contributing to species decline/loss?</th>
<th>Time lag (“extinction debt”) due to long generation times?</th>
<th>Region where taxa are most threatened by forest modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants</td>
<td>?</td>
<td>?</td>
<td>++</td>
<td>?</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>?</td>
</tr>
<tr>
<td>Aquatic insects</td>
<td>+++</td>
<td>³</td>
<td>+++ (via microclimate in water)</td>
<td>+++</td>
<td>?</td>
<td>–</td>
<td>–</td>
<td>Rainforest</td>
</tr>
<tr>
<td>Fishes</td>
<td>++</td>
<td>³</td>
<td>+++ (via microclimate in water)</td>
<td>+++</td>
<td>+++</td>
<td>–</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Reptiles and amphibians</td>
<td>?</td>
<td>++</td>
<td>++ (although some species increase)</td>
<td>+++ (documented for amphibians, not well known for reptiles)</td>
<td>–</td>
<td>++</td>
<td>–</td>
<td>Rainforest, dry forest</td>
</tr>
<tr>
<td>Birds</td>
<td>?</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>(mosty diminishing waterbids)</td>
<td>–</td>
<td>?</td>
</tr>
<tr>
<td>Primates</td>
<td>–</td>
<td>+++</td>
<td>++ (although some species increase)</td>
<td>?</td>
<td>–</td>
<td>++</td>
<td>+++</td>
<td>?</td>
</tr>
<tr>
<td>Other mammals</td>
<td>–</td>
<td>++</td>
<td>?</td>
<td>?</td>
<td>++</td>
<td>(Astrus)</td>
<td>+</td>
<td>?</td>
</tr>
</tbody>
</table>

++ detectable impacts.
+ + important impacts.
+++ a primary driver of species loss.
(+) = impact present but magnitude not yet appreciated.
–– = little or no impact.
? = unknown.
* = not applicable.

For aquatic taxa, we use “fragmentation” to refer to modification of watersheds in ways that subdivide one-mixing populations (e.g., lowland deforestation can isolate multiple populations of forest-dependent taxa upstream).

Source: (Irwin, Wright, et al. 2010)