Mangrove Ecosystems of Southwest Madagascar:

An Ecological, Human Impact, and Subsistence Value Assessment

by Radhika Dave, MESc 2006

Introduction

The importance of mangrove forests in maintaining crucial ecosystem functions such as nutrient filtering, supporting coral reef fisheries, and providing storm buffers has become more evident after the tsunami that ravaged parts of Asia in December 2004 (Alongi 2002; Mumby et al. 2003; UNEP-WCMC 2006). However, these vital tropical ecosystems in the coastal inter-tidal zones, covering about 181,000 km^2 (Spalding et al. 1997), continue to be under immense threat from a variety of human actions. Over the last twenty years, approximately 35% of the world's mangrove forest area has been lost (Valiela et al. 2001). Nevertheless, activities that contribute to this depletion continue. These activities include timber and fuel wood extraction, urban development, and the expansion of shrimp aquaculture, which is by far the greatest cause of mangrove loss (Valiela et al. 2001).

Mangrove ecosystems in many countries face a combination of these pressures. This is true for the island nation of Madagascar as well. Along with some of the most remote and biodiverse coral reefs, 3,270 km^2 of mangrove forest lie within Madagascar, supporting numerous coastal communities and the nation's economy (Cooke et al. 2003). There is limited documentation of these forests in Madagascar, particularly in southwest Madagascar, which is home to the nomadic Vezo fishing communities.

My summer research focused on the mangrove ecosystems of Baie des Assassins, a small bay harboring about 25 km^2 of mangrove forest, approximately 185 km north of the port city of Toliara. I aimed to explore the dynamics of the forest structure, to obtain a measure of the human impact on the forest, and to understand the subsistence value of mangroves to the local community. The indigenous Vezo populations that reside in fishing villages around and north of the Baie des Assassins use these mangroves for timber, fuel wood, and fishing. However, the intensity and periodicity of use and level of dependence on the mangrove forest is undocumented. The region around the Baie des Assassins may potentially form part of a multiple-use conservation site, thus necessitating a clear understanding of the forest structure and its significance to local communities.

Background

Nearly 98% of Madagascar's mangroves lie along the west coast of the island facing the Mozambique Channel (Roger and Andrianasolo 2003). The mangroves here are part of the Indo-Pacific domain. But like other African mangroves, Madagascar's mangroves exhibit less floral and faunal diversity than those of South East Asia (Roger and Andrianasolo 2003; Gaudian et al. 1995). A total of eleven species of mangrove trees are known in Africa, out of which eight species have been recorded in Madagascar.

Baie des Assassins lies at 22°11'S and 43°15'E within a region that is important for its coral reefs and mangroves. About half of the 50 km^2 of mangroves in the region lie within the

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Baie des Assassins (Cooke et al. 2003; Gaudian et al. 1995). Mangroves on the west coast are important breeding grounds for several commercial fish species such as mullet (*Mugilidae*), sickle fish (*Drepanidae*), and pony fish (*Leiognathidae*) (Cooke et al. 2003). These mangroves also provide local communities with timber for construction and fuel.

Madagascar is currently in the third phase of its National Environmental Action Plan, a program that prioritizes marine and coastal ecosystem management. The government aims to expand the nation's terrestrial protected area coverage from 15,000 km^2 to 50,000 km^2 and its coastal and marine protected area coverage from 2,000 km^2 to 10,000 km^2 within a period of five years (Conservation International 2003). It has taken a series of steps in consultation with various organizations to meet its aim of tripling Madagascar's protected area network and several new *Sites des Conservation*, or conservation sites, are in the planning stages. Baie des Assassins and its surrounding region may be included in one such site; hence, it is important at this stage to inform the official management and planning process with the relevant ecological and socio-economic data on mangrove use values and threats. While shrimp aquaculture increasingly is threatening mangrove habitats in the northwest part of the country and tourism has negatively impacted the mangroves of Toliara, the Baie des Assassins mangroves are yet to witness large-scale destruction brought on by these external factors.

Methods and Data Analysis

My study focuses on the peninsular region of the Lamboara village and its surrounding mangrove forests within the Baie des Assassins. This land mass, though accessible by foot from the mainland at low tide, is essentially an island at high tide. The village is comprised of the Vezo fishing community and has a population of approximately 600 people, of which 60% are children.

To evaluate the direct use value of this mangrove forest in the daily lives of Lamboara residents, I conducted semi-structured interviews with 30 households in the village, accounting for about one-third of the population, with the aid of a translator who was also my research assistant. I asked questions to assess the level of dependence and the variety of human services provided by the mangroves. When available, information on the source site of mangrove wood and other products was also recorded. I collected data from the end of June through mid-July, which coincided with the seasonal northern migration of many fishermen in search of better fishing. Hence, most of the respondents for my social survey were women and older men, essentially, those who remained in the villages.

To assess species composition and level of human impact in the mangrove forests, I selected four sites to be sampled ranging in distance from the village of Lamboara (Figure 1). The first site (Site A), is located adjacent to the village on the same land mass. Site B is a small island across the water channel from the village. Sites C and D are on the fringes of the mainland of Madagascar, also across the water channel from the village, but not connected to Site B. Site A is the closest to the village followed by Site B, Site D, and finally, Site C. Within each site, three 10 meter by 10 meter plots were laid out to record the mangrove species composition, to collect diameter (according to CARICOMP 2001) and height measures for mature trees, and to record the number of cut tree stumps as a measure of human impact. Randomly placed subplots were set within each plot to record the species type and number of seedlings and saplings as a measure of regeneration (CARICOMP 2001).

The relative density of the five species recorded was calculated using the formula worked out by Cintrón and Schaeffer-Novelli (1984). Multivariate analysis of variance was conducted on square root transformed data for height and diameter for mature trees—those with diameter greater than 2.5 cm at breast

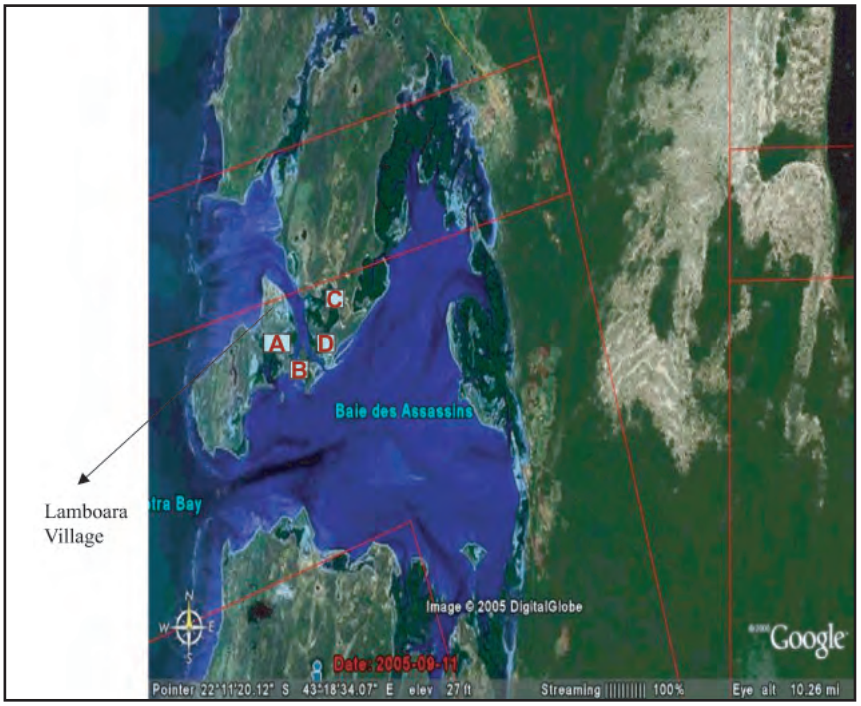
height—to test for differences in these variables as a function of differing site locations. These sites are presumably differentially impacted because of distance from village and stated use by respondents. I analyzed the human impact index in the form of ratio of stumps to mature trees for variation between the four sites. I used diameter size class distribution of trees to detect differences between sites in species rejuvenation. Finally, I performed paired t-tests to detect significance in the difference between the mean abundances of mature trees and juveniles.

Results and Discussion

Five species of mangrove trees were found in the mangrove stands surrounding Lamboara. These are (Malagasy common names in parenthesis): *Avicennia marina* (*hafihafy*), *Rhizophora mucronata* (*tangandahvy*), *Sonneratia alba* (*songery*), *Bruguiera gymnorrhiza* (*tangampoly*) and *Ceriops tagal* (*tangambavy*). However, only *Rhizophora*, *Ceriops*, and *Bruguiera* were found in plots across all four sites and only two individuals of *Sonneratia* were found, one each in Sites B and D. Site A, which is closest to the village, is used mainly for collecting fuel wood and occasionally pole wood,[1] with *Ceriops* exhibiting the highest relative density of 51% for mature trees.[2] *Ceriops* showed a similar high relative density when compared to the other four species in Sites B (51%) and C (72%), but was relatively less abundant in Site D (21%). Among sites, *Ceriops* had the highest relative dominance of 31% followed by *Rhizophora* at 28.2%.[3] *Ceriops* also showed the highest relative density across sites at 49.6%, while *Rhizophora* and *Bruguiera* had similar overall relative density of 21.6% and 21.9%, respectively. Based on the analyses performed on the data for mature trees, the diameter and height of mature trees does not vary significantly at sites with differing distances from the village. Diameter size class distribution for all the vegetation at each of the four sites showed the reverse-J shape characteristic of species with good rejuvenation (Lykke 1998).

Regeneration, measured as the total num-

Figure 1. Location of Lamboara village in Madagascar



ber of seedlings and saplings found at each site, and the number of mature individuals showed similar variance in abundance across the four sites. This was true for all the sites except B, where the total number of overall seedlings and saplings is markedly less for *Ceriops tagal* than its adult abundance (Figure 2). A paired t-test conducted on the total number of mature individuals and total regeneration indicated that there was no significant difference (at *p* value of 0.05) in means of mature and juvenile tree numbers (*p* of 0.094). The next step would be to perform another analysis of variance to determine any significant difference between species and groups (juveniles and adult trees) for each of the sites.

It is also worth noting that consistently high stump abundance equal to the abundance of mature trees was found in Site B (Figure 3). Site B is a small island and experiences a mixed use pattern of fuel wood and pole wood collection. Site C, which is farthest from the village and is used for its relatively taller wood, had a highly variable human impact index in its plots. One of its plots exhibited a 2:1 ratio of stumps to mature trees (Figure 3).

Houses in Lamboara are made from pole wood that originates from the surrounding mangrove forests. In addition to using pole wood and collecting dead wood for use as fuel, Lamboara residents also collect crabs in the mangroves during neap tides and shrimp when in season. Occasional use of *Avicennia marina* to treat stomach ailments and fevers was also observed. Shellfish (*Murex sp.*) are harvested from the mangroves for consumption. Their shells are burned to produce lime. When mixed with sand it is called *sookay* and is used as cement in constructing the walls and floors of some houses or sold to other villages upon request. A considerable amount of pole wood

Figure 2. Variation in abundances of mature trees and regeneration (total number of seedlings and saplings) across sites

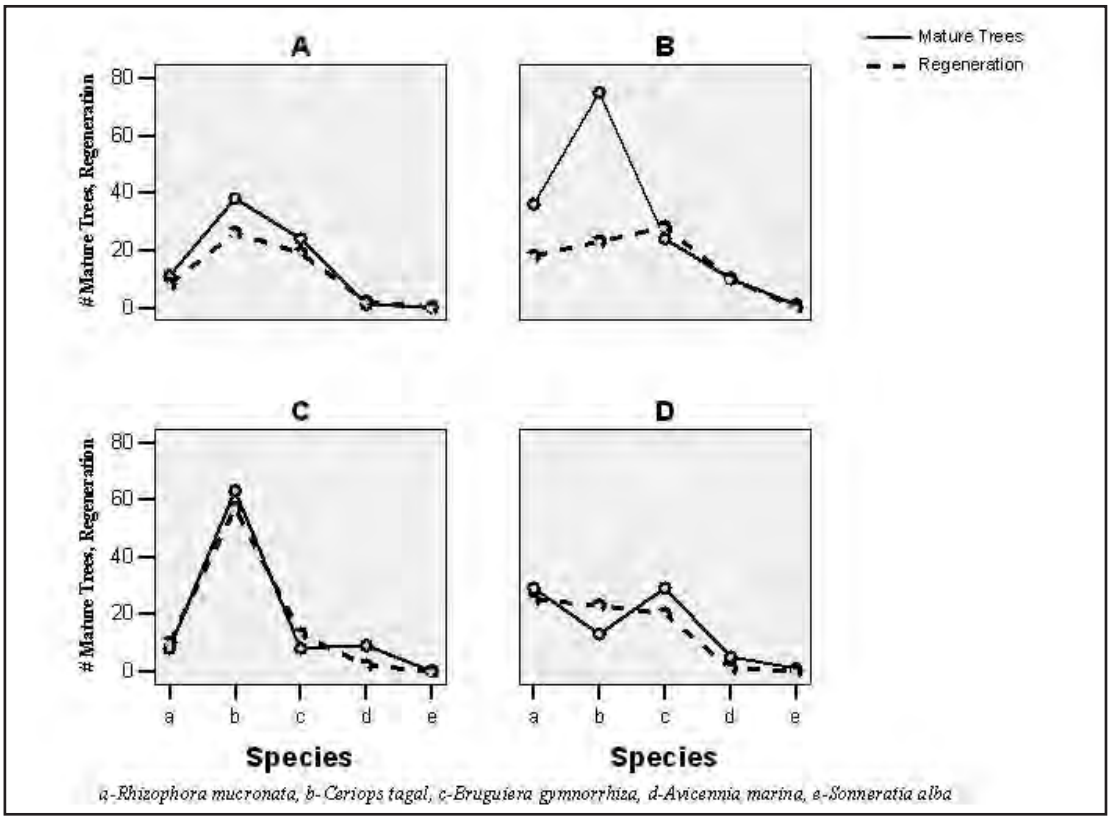
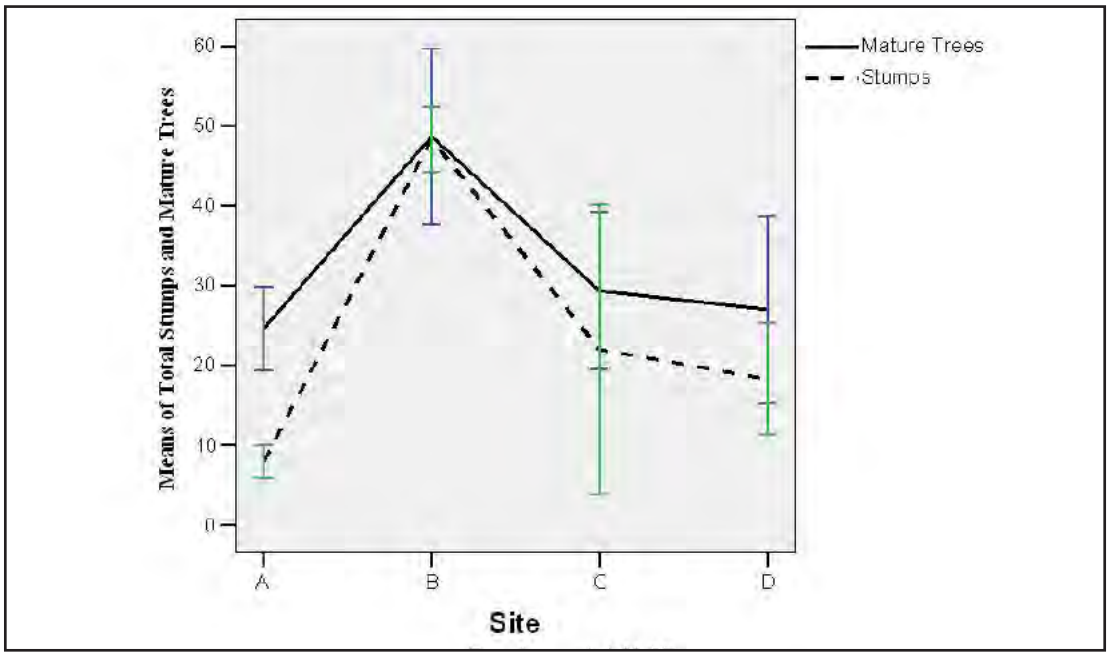


Figure 3. Variation in abundances for mature trees and stumps across sites



collected from the mangroves is used to burn the shells, make drying lattices, walls, fences, and torch lights for night fishing of sea cucumbers. No charcoal production takes place in the Baie des Assassins region, and most people collect dead branches for fuel wood. Women are generally the ones to collect fire wood and crabs, while pole wood collection and finishing is a predominantly male activity. Occasionally, some women collect crabs for sale within the village to augment their income from fishing, selling each palm-sized crab for about 200 ariary (equivalent to $0.11 at the time of research).

Cutting pole wood and producing *sookay* is also a means of earning additional income for some people in the village, who sell them to people from other coastal villages north of the Baie des Assassins. Pole wood fetches varying prices depending upon the quality and size—pole wood for constructing houses is sold for anywhere from 600 to 1,200 ariary for poles 8 cm in diameter and 3 to 4 m long. Similarly, a sack of *sookay* (the size of a 50 kg rice bag) will be sold for 1,000 ariary ($0.53) to others within the village and to outsiders if it is in demand.

The mangrove species preferentially harvested for pole wood in the Lamboara region are *Rhizophora*, *Ceriops*, and *Bruiguiera*. This is also a preference seen in other parts of Africa, such as in Kenya's Mida Creek region (Dahdouh-Guebas et al. 2000). *Rhizophora*, *Ceriops*, and *Bruiguiera* grow long and tall and have different properties that make them valuable for constructing different parts of houses or fences. While *Bruguiera gymnorrhiza* is well-suited to constructing roofs due to its strength, *Rhizophora mucronata* is considered ideal for building walls and especially for use as thicker corner poles because it can withstand saline conditions better (Dahdouh-Guebas et al. 2000). *Ceriops tagal* yields thinner poles and is used for the interweaving structures of the walls or towards the construction of fences or small sheds for poultry.[4]

According to Kairo et al. (2002), field observations show that in a mixed stand of *Rhizophora* and *Ceriops*, there is a tendency for natural regeneration to favor *Ceriops*, irrespective of the harvested crops. This has implications for the long term species composition of the

Lamboara forests as well. If the forest structure shifts to a predominantly *Ceriops* forest, then a more socially desirable forest of *Rhizophora* may give way to an inferior one from a local economic viewpoint (Kairo et al. 2002).

Conclusions

The local communities surrounding Baie des Assassins are highly dependent upon the mangroves for a variety of services and subsistence needs. Small-scale, selective extraction of individual mangrove trees may have little effect on the entire mangrove ecosystem, but it removes individual trees. *Rhizophora* species do not sprout again following cutting, while *Avicennia* do (Ellison and Farnsworth 1996). Since the forest is composed of, at most, five species of trees supporting a variety of faunal assemblages, drastic reduction in a single species can potentially reverberate throughout the ecosystem. However, ecosystem functions of each mangrove species is not yet quantified in ways that can inform management decisions (Ellison and Farnsworth 1996).

In the case of the Lamboara mangroves, human use of the forests is not leading to outright loss of forested area; however, a shift in species composition and forest structure may be changing the forest qualitatively. While the ecological impact of shifts in dominant species is difficult to estimate from the data gathered and from other studies (Kairo et al. 2002), the subsistence function of the forests may be changed or weakened more perceptibly. All four study sites exhibit higher regeneration by *Ceriops tagal* in comparison to *Rhizophora* and the other species (See Figure 2). *Ceriops* also has the highest relative density. Further multi-year data collection on forest structure and human use can yield conclusive information to determine if the forests surrounding the village are undergoing a species shift.

Ecological data should be augmented with information collected during household surveys to determine which species are under the most harvesting pressure. The next steps will be to disseminate these results to the Lamboara residents in order to produce a community-initiated management plan to govern the use of mangroves in this region of Baie des Assassins.

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Endnotes

1 Based on interviews with village residents.

2 Relative Density = (Number of individuals of a species/Total number of inividuals) x 100.

3 Relative Dominance = (Total basal area of a species/Basal area of all species) x 100.

4 Based on interviews with village residents.

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