Local protection of tropical dry forest: taboos and ecosystem services in southern Madagascar

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Abstract

Forests protected by local taboos represent a practice found in many areas of the world. However their role in sustaining ecosystem processes and conservation of biodiversity is poorly investigated. In southern Madagascar, formally protected areas are nearly totally absent, despite that this is an area of global conservation priority due to high levels of endemism. Instead numerous forest patches are informally protected through local taboos. In southern Androy, we found that all remaining forest patches larger than 5 ha were taboo forests, with effective protection and use restrictions. We mapped and characterized 186 forest patches in five study sites in Androy, and investigated spatial distribution, species composition, and the rules and sanctions associated with the patches. Nine different types of forests were identified, ranging from <1 ha to 142 ha representing a gradient of social fencing from open access to forests with almost complete entry restrictions. The taboo forests and non-protected forests differed in species composition but not in species richness. Twelve ecosystem services were identified as being generated by the forest ecosystems, including capacity of binding soil, providing wind break, as habitats for wildlife and sources of honey and wood. In conclusion, we found a social capital related to forest management to be present in Androy, with a well-functioning sanctioning system perceived as legitimate among local inhabitants, although not explicitly directed towards conservation of biodiversity or ecosystem services. In Androy, the current challenge is to secure conservation of the forest patches and their capacity to generate services, but without compromising the cultural values or the local capacity to adaptively manage the forest ecosystems.

Key words: sacred forests, taboos, ecosystem services, dry forests, local protection

1. INTRODUCTION

Conservation and management of biodiversity has largely focused on protected areas, but the majority of the world's biodiversity is found outside national parks and nature preserves (Szaro and Johnson 1996). Outside formally protected areas, local management practices interact with ecosystem processes and may alter biological diversity at genetic, species and landscape level (Sheperd 1992, Barrow 1996, Brookfield 2001), eroding or enhancing ecosystem services that underlie human development and wellbeing (Daily 1997, Millennium Ecosystem Assessment 2003). Areas protected through local informal institutions, such as habitat taboos, have seldom been incorporated into biological conservation schemes, partly due to narrow definitions of what constitutes conservation (Berkes et al. 2003, Lingard et al. 2003).

In many parts of the world, local habitat taboos nonetheless often provide effective protection of smaller ecosystems, for example in West Africa (Lebbie and Guries 1995, Kokou et al. 1999), East Africa (McClanahan et al. 1997, Mgumia and Oba 2003), Southern Africa (Byers et al. 2001), India (Gadgil and Guha 1993), and China (Liu et al. 2002), see also Ramakrishnan (1998). Such informally protected areas have been found to generate important ecosystem services for local livelihoods, for example non-timber forest products (e.g. medicinal plants, fruits, and firewood), firebreaks, watershed protection, and protection of freshwater sources (Lebbie and Guries 1995, Ramakrishnan 1998, Virtanen 2002, Boraiah et al. 2003) and serve as refugia in areas of overexploitation of forest resources (Okafor and Lapido 1995).

In Madagascar, a country with some of the highest levels of endemism in the world (Goodman and Benstead 2003), governmental policy aims to expand protected areas from 1.7 to 6 million ha within the next five years, representing 10% of the country's area (Anonymous 2003). Although protected areas are present in most vegetation types in Madagascar, in one area, the southern dry forests, formal protected areas, i.e. having governmental recognition, are nearly totally absent. In the new protected area policy, specific attention is therefore directed to this southern dry forest (Fenn 2003). The southern dry spiny forest of Madagascar is dominated by the plant family Didiereacae, and has the highest level of plant endemism in all of Madagascar at the generic (48 per cent) as well as the species level (95 per cent) (Koechlin 1972). Recently, the spiny forest was listed as one of the 200 most important ecological regions in the world (Olson and Dinerstein 2002). Forest cover has been reported to decline rapidly since the early 1970s, principally due to cattle herding, timber harvesting and charcoal production (Sussman et al. 1994). In Androy, the central part of the spiny forest area, there are several hundreds of small patches of sacred forests that have remained relatively untouched, even in the most intensively used areas (Clark et al. 1998). However, due to the local taboos, (i.e. *fady* or *faly*) and strong entry restrictions, very little is known about these forests.

Places or habitats protected by informal institutions related to belief systems are often referred to as sacred (Ramakrishnan 1998). Here, we use the term taboo forests as a direct translation of the local word used, *ala faly.* Taboo forests can be seen as a subset of sacred forests. We investigated and analyzed taboo forests and their institutions in relation to resources, ecosystem management, and conservation of the dry spiny forest in southern Androy. Institutions are defined as the humanly devised constraints and their enforcement characteristics (North 1990). Taboos are seen as informal institutions, e.g. the rules-in-use (Ostrom 1990) that are not devised and enforced by an external third part. Colding and Folke (2001) argue that although not necessarily perceived as

instruments of resource management by the people who practice them, taboos nevertheless often show a similarity to the institutions of formal nature conservation. Further, Colding et al. (2003) argue that sacred forests can function as important sources for renewal and forest regeneration in the landscape. Most studies on sacred forests in different parts of the world have mainly been carried out to assess their role as reservoirs of biodiversity. The role of sacred forests as components of dynamic ecosystem processes and biodiversity conservation at a landscape scale has so far received limited attention (Gadgil et al. 1998). We addressed the following questions:

- What is the spatial distribution and species composition of the taboo forests in comparison with non-taboo forests?
- To what extent do taboo forests contribute to generation of ecosystem services?
- What are the rules and sanctions associated with the taboo forests?

2. Study area

The Androy region is located in the very southern part of Madagascar, bordered by the rivers Mandrare to the east and Menarandra to the west, between lat 25^0 02' and 25^0 12' S and long 45^0 94'and 45^0 12' (Figure 1). The southern plains are sandy with occasional patches of dense forest, whereas the northern part is a hilly upland on crystalline Precambrian bedrock (Battistini and Richard-Vindard 1972). The inhabitants of the Androy region, the Tandroy, are primarily a herding people, but particularly in south-central Androy where population densities are the highest, they also rely on cultivation of maize, cassava, sweet potato and beans. The local cattle, the zebu, have a central role, economically as well as culturally (Heurtebize 1986).

The Androy region is one of the poorest in Madagascar, characterized by semi-arid climate and shallow soils, and drought and seasonal famines occur frequently (Dostie et al. 2002). Average annual temperature range between maximums around 30 degrees C to minimums down to 15 degrees C (Donque 1972). The irregular rainfall averages less than 500 mm per year, declining from north to south and from northeast to southwest (Battistini and Richard-Vindard 1972). The dry season usually lasts eight to nine months, but can locally extend over several years (Dewar and Wallis 1999, Richard et al. 2002). Violent rainstorms, which may bring almost half the total annual rainfall in one day, are not unusual (Battistini and Richard-Vindard 1972).

The study area is part of the dry spiny forest ecoregion or the Madagascar spiny thickets, which extends across southern and southwestern Madagascar (WWF 2001, Fenn 2003). The forest ecosystems are characterized by the presence of the Didiereaceae family and aphyllus shrubby species of *Euphorbia* (Koechlin 1972). *Alluaudia procera* (Didiereaceae) is the characteristic species of the forests in the northern-central part of the study area, while *Euphorbia decorsei* is the dominating characteristic species of forests in the southern part. Due to the sparse ground cover of herbaceous plants and grasses and high water storage in stems and branches of woody plants, fire is not a structuring process in these semi-arid ecosystems (Koechlin 1972). In response to the seasonal and localized precipitation patterns, the Tandroy migrate seasonally with their herds to find water and pasture for their zebu. In Androy, only three small formal natural reserves exist, the Cap St. Marie Special Reserve, Berenty Private Reserve, and Kaleta private reserve.

The social organization of rural Madagascar is based on the *fanjakana* on the one hand, representing the formal institutions of Malagasy society, whereas traditions and customs, the

fokonolona, add informal rules and norms to the institutional framework. Untitled, uncultivated land are technically state domain (Kull 2004), and permits issued by the Forest Service (Eaux et Forêt) are needed to clear land for agriculture, to harvest timber, and to sell timber, dead wood or charcoal. In practice, the traditional land claims inherited from the ancestors *(tanin-drazana*) are still effective in Androy and local customs are an important factor in forest management. A recent legislation scheme of Madagascar, the GELOSE (*Gestion Locale Securisée* or secured local management) from 1996 makes possible contracts between the central government, local communities and the forest service for the transfer of management rights over identified natural resources (Antona et al. 2002, Kull 2004). The GELOSE includes legal recognition of locally devised rules for resource management, *dina*, as bylaws enforced by the community.

2.1 Taboos in Madagascar and Androy

Taboos, or *fady*, meaning forbidden, or 'you shall not' are important components in social interactions and creation of identity that continuous to have high relevance for human behavior in Madagascar (Gennep 1904, Ruud 1960, Lambek 1992, Walsh 2002). A number of *fady* are related to human interaction with the environment, e.g. species specific taboos on the wild boar, lemurs, birds, and tortoise (Ruud 1960)**,** temporal taboos regulating the harvest of resources during parts of the year (Ruud 1960), and place-specific or habitat taboos concerning a habitat such as e.g. a lake, mountain, or forest (Walsh 2002, Horning 2003). Some types of *fady* are enforced only within a specific group or for a specific person, such as taboos related to various food items, whereas other types are enforced on all inhabitants and visitors in a geographical area, which is often the case with habitat taboos (Walsh 2002).

In Androy, customs and traditions are long lived and mostly followed (Parker Pearson 1997). The *faly*, or taboo, is part of the laws inherited from the ancestors, and respect and reverence of the ancestors and other spirits require the Tandroy to follow the prohibitions of the *faly*. According to local beliefs, individual and community relationship with the ancestors highly influences prosperity and success in life (cf. Middleton 2001). The taboo forests in Androy, *ala faly*, link the present with the past and the living with the dead (Parker Pearson et al. 1995).

3. MATERIAL AND METHODS

Distribution of forest in the study area was analyzed with Arcview 3.2a (ESRI Inc.), using a LANDSAT 7 ETM+ satellite image from 2000-05-28 with a resolution of 30m. Field mapping of forest patches was carried out in three steps. First, in southern Androy, forest patches larger than 5 ha as identified from the satellite image within an area of approximately 34 000 ha were mapped, see Figure 2. Secondly, a high-resolution study was carried out in the village of Ambonaivo in southern Androy, where informants were asked to describe and show us areas that were protected or considered *faly*, taboo. Thirdly, the existence of taboo forests in additional sites in northern and western Androy were investigated (Figure 2). Previous experience and literature sources were used to identify particular sites with taboo forest (Heurtebize 1986, Clark et al. 1998, Lingard et al. 2003). Fieldwork was carried out during six weeks in November-December 2002, during five weeks in April-May 2003 and three weeks in January 2004. Mapping and ground thruthing of forest patches in the field was carried out with GPS and with the help of local guides.

Based on interviews, identified patches were classified according to cultural status, type of protection, and sanctions into three main categories: forest patches without *faly*, patches that are *faly* due to the presence of tombs (*ala kibory)*, and patches that are *faly* for other reasons than tombs, see Table 2. ArcView 3.2a was used to combine interview information with landscape data. Patch size was determined from the satellite image for all patches that could be clearly distinguished from the matrix vegetation.

Persistence over time of forest patches in southern Androy was investigated using a forest map from 1961 based on aerial photos (Foiben- Taotsarintanin'i Madagasikara, FTM 1961) to compare with the 2000 Landsat image. Patches larger than 5 ha were identified in both sources using Arcview 3.2a Spatial Analyst. As map projection and forest classification differed between the source materials, a qualitative comparison of presence/absence of forest patches > 5 ha was carried out.

3.1 Study sites

Southern Androy has the highest population of Androy, ranging from 100-350 persons/km^2 (SAP 2002). It is located on the sandy plain south of Route National 10 going between Fort Dauphin (Tolagnaro) and Tulear, roughly between the cities of Ambovombe and Ambondro (Figure 1). The area has a highly cultivated landscape, interspersed with forest patches clearly visible on satellite images. The area is characterized by ancient sand dunes and *Alluaudia procera* does not occur naturally. The village of Ambonaivo with surroundings, where the high-resolution study was carried out is recognized as having a high abundance of taboo areas that are well protected. Population density is 162 persons/km^2 and the village is located just south of Route National 10, approximately 15 km from Ambovombe.

Northern Androy. The sites in north Androy are located on crystalline bedrock where the cover of dry spiny forest is more coherent. Population densities are lower compared to the south, 10-20 persons/km^2, and have a shorter settlement history. The public forests are used extensively as seasonal pasture also by families living in other areas, and temporary settlements are common.

Southwest Androy. Lavanono is located on the Karembola plateau, approximately 39 km south of Beloha, in Tranovaho commune that has a population density of approx. 10 persons/km^2 (SAP 2002). Lavanono is a coastal community that differs from the others sites as catch of fish and lobster contributes to local livelihoods. There is also a small tourist resort run by the village (Lingard et al. 2003).

3.2 Floristic analyses

Floristic analyses were made in two types of forest patches, taboo forests with tombs and limited human access, *ala kibory*, and public forests with few restrictions on human access and extraction of resources. We used two sampling methods: A) in forests where we were permitted access, a 20m x 20 m plot was randomly placed in the forest patches and all woody species >1,0 m in height identified and counted, B) in forests where access was not permitted we made floristic analyses in transects, by walking along the edge of the patch and counting and identifying woody plant species >1,0 m height within a four m wide transect. The length of transects varied from 32 m around a small patch (0.6 ha) to 90 m around a larger patch (28 ha). Analyses of species richness in relation to sampling effort revealed that species richness in the large *ala kibory* were likely to be underestimated, while sampling efforts in the plots of smaller patches were adequate and close to estimates of S_{max} using the Chao index (Henderson 2003).

Analyses of plant community composition, comparing *ala kibory, salata* (see table 3) and public forests were made using a Polythetic Agglomerative Hierarchical Clustering (PAHC) (McGarigal et al. 2000) with the software PRIMER v.5 (Clarke and Warwick 2002). In PAHC a resemblance matrix computed on standardized data is analyzed and a hierarchy of increasingly large clusters is built. In our analysis the distance matrix was based on group average linkages. PAHC is especially well suited for analyses of community similarity/dissimilarity when the purpose of the analysis is mainly descriptive and the sample size is low to moderate (i.e. sampling entities < 50). The variables included in the PAHC analysis were: species count of woody species (> 1 m height) and abundance estimates. Similarity was also tested with an ANOSIM test using PRIMER v.5.

The dominant tree species in northern and central Androy, *A. procera,* produces clearly visible tree rings, which, due to occasional supra-annual periods of draught, may not necessarily correspond to annual growth rings (see Grau et al. (2003) for a discussion of dendrochronology in subtropical forests). In two of the plots drilled cores from *A. procera* were taken for estimations of age expressed as no. of growing seasons. The cores (0,5 cm in diameter) were drilled through the centre of each stem (n= 30-100 individuals per plot) using a standard dendrochronology drill, and stored in sealed plastic tubes until analyzed under a microscope in the lab. Due to the branching slender architecture of *A. procera* drilling was not possible on small trees and our estimates thus give the distribution for trees >10 cm diameter at breast height (dbh).

3.3 Interview survey

Information on taboo forests and local institutions for forest management was obtained through semi-structured interviews and informal conversations in line with the qualitative research interview approach described by Agar (1996) and Kvale (1996). Informants were persons with local authority or experience and knowledge about forests or local customs, including representatives of both *fokonolona* and *fanjakana*, that were identified using snowball sampling (Bernard 1995). Questions were asked about habitat taboos and other rules for forest use, sanctions and enforcement, in general and for specific forests. To address the religious context of the Tandroy *faly*, interviews where held with traditional healers, priests and converted Christians. The two forest officers active in the study areas were also interviewed. These informants were men, except for two women healers. Interviews on perceptions of the benefits generated by the sacred forests were also held with other villagers, including women and representatives from different age groups. Table 1 lists number of informants at respective sites. When permitted, sacred forest patches were visited and entered, always accompanied with local guides. A Malagasy-speaking member of the research team translated between English and Malagasy during all interviews.

4. RESULTS

We found a number of taboo forests in all study sites, all together 186 patches scattered in the landscape. In the south most remaining patches in the agricultural matrix were taboo forests. These forests differ from the more contiguous forests further north both in species composition and species richness. In the northern locations, where human population densities are lower and settlement history shorter, taboo forests are fewer and generally represent clusters enclosed by public forest. Human interaction and resource extraction from the taboo forests were highly

restricted by the taboos including heavy sanctions that were perceived to be enforced by spiritual powers as well as the local community.

4.1 Distribution and types of forest patches

Mapped patches were grouped into three categories, see Table 1. Size was determined for 114 patches, ranging from less than a hectare to a few that were larger than 100 ha. The largest taboo forest was found around Belindo, 142 ha (listed under other location in table 1). In table 2 we classified the patches according to the purpose for protection, cultural status and strength of protection, separating the taboo patches without tombs into subcategories. The taboo patches without tombs were generally small, none were found to be larger than 3 ha.

All mapped forest patches larger than 5 ha in south-central Androy, see Figure 2, were found to be *ala kibory* (taboo because of the presence of tombs). 63 patches larger than 5 ha were mapped, all together covering 3.6% (1238 ha) of the studied area, with an average size of 20 ha. Size distribution of the patches is shown in Figure 4. In the comparison with the 1961 map data on forest patches larger than 5 ha in southern Androy, 11 out of 80 patches ha had been lost between 1961 and 2000, i.e. 86% of the patches remained. The cultural status of the lost patches is not known.

The detailed mapping in Ambonaivo included 76 patches. Patches with areas determined (n=48) had an average size of 12 ha. Size distribution, with separation into forest categories, is shown in Figure 5. Taboo forests were also found at the three locations in northern and southwest Androy, where altogether 60 taboo patches were mapped. Size was determined of 8 patches, ranging from 5 to 142 ha. Average size of these patches was 69 ha. Compared to southern Androy, we found differences in restrictions associated with the *faly*, and in the burial practices, which has implication for protection and patch dynamics, see further below.

4.2 Analyses of plant community structure in forest patches

The dominating plants in the forests surveyed in southern Androy (n=12) were *Euphorbia decorsei, E. oncoclada, Commiphora humbertii*, and *Kalanchoe beharensis.* Plant density was highest in *ala kibory*. Woody species diversity was similar in *ala kibory* and public forests and slightly lower in *salata* (Table 3). Analyzing diversity index does not show any significant differences between the three forest types. Note that it is likely that the estimates in common/public forests are better than in *ala kibory* forests since in the latter access restrictions may have resulted in underestimations of species richness.

The PAHC analysis revealed that *ala kibory* forests, that are least affected by human activities, are clearly clustered (Figure 6), and they were found to be significantly different from *salata* and public forests using the ANOSIM test (p=0,002, Primer v. 5). One *ala kibory* is grouped together with the other patches. Interestingly, in this *ala kibory* the plot sampling method was used for assessing species diversity instead of transect (see Table 3), which indicates that our different sampling methods may influence the cluster analysis. The results suggest that it is not species number *per se* that separates the *ala kibory* from other forest types, but rather the species composition, which is not reflected in biodiversity indices (Table 3).

In northern Androy both *ala kibory* forests and common/public forests were dominated by species of Didiereaceae, *Alluaudia procera*, and *A. dumosa*, with relatively high abundance of

Euphorbia decorsei, *Cederelopsis grevei*, and *Commiphora sp.* As compared to the southern patches, species richness of woody plants was generally lower and tended not to differ between the sacred and the public forests, but sample sizes were very limited and no further analyses were made (Table 4). The relative age structure of *Alluaudia procera* populations differed between the two sites, one being a taboo forest and the other one a public forest (Figure 7).

4.3 Ecosystem services generated by forests

Species composition and age structure of forest patches are properties that are likely to have importance for the capacity of the forest habitat to generate certain ecosystem services. In table 4 we have listed a number of ecosystem services mentioned by local informants, in response to the question of the role and benefits of the dry spiny forest. Additional important services generated by the taboo forests ecosystems such as pollination and pest control are also listed in Table 4.

The *ala kibory* carry a strong cultural value and were considered to "protect the ancestors" and "the trees grow with the spirits of the ancestors". The forest patches were associated with particular ancestors and clans and were important for identity and sense of place in the landscape. The memorial groves (table 3) function as historical documents in the local context and the ceremonial groves were used for prayers, healing, and e.g. circumcision ceremonies.

The harvest of goods generated by the taboo forests was highly restricted, but some resources could be harvested from some forests. Harvest of honey and dead wood was allowed in honey groves. In the northern locations, taboo forests were a source of large trees for coffins, however cutting must be preceded by ceremonial sacrifice of zebu. In Lavanono, hunting was allowed in burial forests that are no longer active. In Mareny, the taboo forests were occasionally used for grazing during situations of extreme scarcity of cattle fodder.

In southern Androy, important ecosystem services provided by the taboo forests as perceived by several informants were binding sand and acting as wind break to prevent sand drift and dune movement, which are considerable problems for agriculture. Informants in all locations mentioned the role of taboo forest as habitats for wild life such as lemurs (*Lemur catta*, *Propithecus verreauxi verreauxi)*, radiated tortoise (*Geochelone radiata)*, tenrec (*Echinops sp.)*, guinea fowl (*Numida meleagris mitrata)*, and other bird species. Some of these species were hunted outside the taboo patches, for example guinea fowl and tenrec. In the northern sites of Manave and Mareny, informants said that the *Lemur catta* and *Propithecus verreauxi* prefer taboo forest, as they are undisturbed by humans and contain large *Alluaudia procera* (Bergvind and Norman, unpublished data).

At least some informants had an understanding of the ecological processes that the taboo forest ecosystem contributes to, such as seed dispersal. Two informants recognized the role of the old growth forests in some taboo forest patches as a source of seeds for forest regeneration: "this forest (of young *Alluaudia procera*) is an extension of the old forest in the west. By the wind and the birds the seeds are spread here". The forest that is referred to is an old *ala kibory* of 50 ha approximately 1 km away. One informant in Lavanono saw a link between forest cover and rain "if there are trees it will rain and there will be water in the fields". Many informants stated that the taboos protect the forest that is essential for their survival.

4.3 Local institutions related to forest patches

For all taboo forests, the *faly* implied a ban on damaging or disrespecting the area through burning, cutting, or polluting by defecating or peeing. Many patches had additional restrictions tied to them, see Table 2. Two sets of sanctions for violating the prohibitions were identified: a) sacrifice of zebu or sheep, the number decided by the clan elders; and b) supernatural sanctions where ancestral or other spirits bring misfortune, disease or death on the culprit. The latter can be described as self-enforced or self-imposed (Colding and Folke 2001), as it is related to beliefs in the power of the spirits. Areas with tombs, *ala kibory,* were found to have the highest protection, as the restrictions are strongest, and Christians as well as other people who do not fear the power of the spirits respect the *faly*. The physical sanctions were required whether you believe in the self-enforced sanctions or not. The fine was related to the damage caused, but there was often a minimum amount that must be paid (see table 3). The strongest sanctions were imposed for burning, whereas for example picking of fruits at the forest border resulted in a low punishment.

The degree of protection of an individual *ala kibory* depends upon whether it is still used for burials and whether it is still respected by the descendants of the dead. The local community, in particular the clan that owns the patch, monitors compliance of the taboos. If forest damage is found, a clan meeting is called to establish guilt and sanctions. When the clan no longer lives nearby, a deal had in some cases been set up with other residents in the area to monitor their *ala kibory* and report violation. The owner clan would inspect the patch on a regular basis. Of the 132 mapped *ala kibory,* 26 were found not to be active for burials any more.

According to the informants, transgressions of taboos do occur in abandoned as well as in active burial forests, and there are more violations of *faly* during hard times. However, if the owner clan was still monitoring the forest, incidents were followed by sanctions. Although the taboo forest patches formally are under the same state regulation as the public forests, it is clear that it is the locally devised rules that govern behavior in the taboo forests. The local *faly* rules are more restrictive than the state rules at the specific locations, and sanctioning is much stronger and more efficient. If a tree is cut without permission from the Forest Office, the fine is 50 000-200 000 MGF depending on species, whereas if cutting is carried out in an *ala faly,* the punishment is never less than 1 zebu, and often a bull is required. A zebu costs around 1 000 000 MGF (approx. 180 USD in January 2004).

Although many of the taboo forests were said to be old, existing at least since before colonial time, i.e. before the 1920's, new *faly* areas are also established, to e.g. form a new burial ground, or because of a demand from a spirit communicated through an *ombiasy,* a spiritual medium. According to interviews, at least 10 taboo areas have been established within the last 50 years, in all cases on an area that was previously a field. We also found several examples where the border of the taboo area had been recently expanded. As the taboo on cutting is kept, there is potential for forests to expand in an area where forests resources otherwise are quickly exploited.
Tree planting around tombs of *Alluaudia procera* and *Moeringia sp.* is done especially in southern Androy, as a symbol of sacredness in the landscape or around tombs.

Several informants, including two key informants, were concerned that the respect of the *faly* is declining as Christianity and the modernization of society including schools and tourism devalues the authority of the elders and the traditional beliefs that protects the forest. Among the sites of this study, Lavanono was the one most affected by external influences, with comparatively high

immigration of other ethnic groups, lobster trade, and small tourism business. There, two out of four mapped *ala kibory* were expressed to have eroded *faly*.

5. DISCUSSION

Colding and Folke (2001) suggest that social taboos may function as invisible systems of local resource management. Management of the forest patches in Androy can be described as a complex of knowledge-practice-and beliefs, where the belief component is of prominent importance (Gadgil et al. 1993). The taboo forest patches in Androy constitute social-ecological legacies as constants in the landscape and are maintained by the interactions between people and ecosystem. Interestingly, the taboo forests provide little direct economic benefits to the local population but still have a very strong protection. In sacred forests in other parts of the world, harvesting of medicinal plants, fuel wood, vegetables etc. has been found to be a part of management (Boraiah et al. 2003, Horning 2003, Mgumia and Oba 2003). However, it is getting increasingly recognized that traditional management of natural resources is often embedded in rituals and practices inseparable from local religious practices (Gadgil et al. 1993, Berkes 1999). Our findings strongly suggest that there is a social capital related to forest management in Androy, with a well-functioning sanctioning system perceived as legitimate among local inhabitants, although not explicitly directed towards conservation of biodiversity or ecosystem services.

However, the taboo forests may still provide considerable ecological benefits. Our data indicate the value of the taboo forests in Androy for *in situ* conservation of dry spiny forest habitats and species (see Khan et al. 1997, Mgumia and Oba 2003). They may be particularly important in southern Androy, as the diversity in the forest patches is very high compared to the surrounding agricultural landscape and the species composition is unique due to the biophysical conditions that are separate from other parts of the Androy region (Koechlin 1972). In northern Androy, the taboo forests represent reservoirs of old growth forest, within a forest that is highly impacted by livestock grazing and human resource harvesting. Throughout Androy, the local inhabitants appreciate the role of the forest patches as wildlife habitats. Two of the species mentioned, the *Lemur catta* and the *Geochelone radiata* are endemic to southern Madagascar and a conservation priority in the region (WWF 2001). None of theses species are hunted or consumed by the Tandroy as they are considered taboo (Lingard et al. 2003). Our informants also perceived a number of indirect ecological benefits provided by the taboo forest patches, such as the regulation of processes that may have adverse effects on local livelihoods, e.g. sand drift and local climate. In addition, the taboo forests, often being old growth forests, can serve as important sources of propagules and dispersal agents necessary for forest regeneration and recolonization (e.g. Chazdon 1998, 2003) and generate other regulating ecosystem processes, such as pollination of crops and non-cultivated plants and regulation of pests on crops and livestock (Altieri and Schmidt 1986, Greenberg et al. 2000, Hooks et al. 2003, De Marco and Coelho 2004).

To include the taboo forests in a formal conservation scheme requires a framework that recognizes and respects the belief component of the management system in Androy. We agree with e.g. Brosius (2004) and Horning (2003) who argue that for conservation strategies to be successful, we must find ways to integrate local institutions for ecosystem management *as points of departure*, to strengthen them, and not to undermine and replace them. For example, regarding

the *kaya*, the sacred forests in the coastal zone of Kenya, an initial attempt to preserve their unique biodiversity value was taken when they were declared forest reserves. However, this caused vigorous protest among the stewards of the forests, the local elders, who were convinced that this would strongly compromise local access and management rights (Wilson 1993). Instead, one approach to strengthen the protection of *kaya* has been to declare them national monuments under care of the National Museums of Kenya, which had strong support among the elders. However, evidence shows that the type of protection has not been sufficient to withstand the strong drivers of coastal development, in particular from external investors (Nyamweru 1996).

Effective enforcement of rules is a critical issue in successful conservation of biodiversity in formal protected areas, such as national parks. However, enforcing rules is often costly and in resource poor countries such as Madagascar, national and regional institutions for biodiversity conservation and natural resource management are often weak and with limited funds for park management (Barrett et al 2001). Colding and Folke (2001) suggested that local institutions can provide a functioning mechanism for monitoring and enforcement of certain rules at low cost.

However, as have been shown in many cases of community-based management, it is essential to transfer not only the responsibility and cost of forest management and protection to the local community, but also the authority to do so (e.g. Fabricius and Koch 2004). Antona et al. (2002) show that it is mainly withdrawal rights and neither full property nor management rights that have been transferred to the local community in the GELOSE contracts aiming to decentralize forest management in Madagascar (see also Kull (2004) for a discussion on the GELOSE legislation and local ecosystem management). Johannes (2002) emphasizes the importance of securing the self-organizing capacity of the local institutions to remain efficient and legitimate. The system of habitat taboos in Androy is not static, and the sites in this study display considerable variance over a small distance in cultural practices and rules for taboo forests. Johannes (2002) argues that heterogeneity in local practices can be a strength of locally devised management systems that improves the capacity of the management system to respond to social and ecological change in an adaptive way.

Conclusion

With the planned tripling of protected areas in Madagascar, addressing factors such as informal institutions, rule compliance, and landscape ecological processes are essential for successful implementation. The taboo forests of Androy could be very valuable as part of a network of forest habitat for conservation of regional biodiversity and generation of ecosystem services (cf. Khan et al. 1997). It is essential that conservation activities in Androy do not counteract existing protection by applying a formal scheme that is too narrow and rigid. For example, Cox and Elmqvist (1992, 1997) report on several village reserves in Samoa where management control resides with the local village councils. However, local control was found to be very vulnerable to interference from outside conservation NGOs. Furthermore, none of the present IUCN categories for protected areas (IUCN 1994 habitat/species management area, protected landscape/seascape, managed resource protected area) allow for bottom-up control of protected area management. Still, the IUCN categories are the basis for the current plan to triple protected areas in Madagascar (J.-P. Paddack, personal communication). More appropriate categories needs to be developed that can fully encompass social and ecological dynamics.

Even though management authority in Androy should remain at the local scale, there is a need for local institutions to be nested with institutions at higher levels. Such nesting of institutions can help enforcing protection against external drivers such as markets and infrastructural development (Barrett et al. 2001, Brown 2003). Erosion of local institutions due to cross-scale factors such as cultural changes, policy interventions, tenure instability, migration, and education is experienced in many parts of the world (e.g. Sheperd 1992, Wilson 1993, Horning 2003, Kajembe et al. 2003, Gokhale 2004). This is also true in Androy, where pressure on forest resources is likely to increase due to increasing aridity, expanding markets for charcoal fuelled by urbanization, and infrastructure development. The current challenge is to secure protection of the forest patches and their capacity to generate services, but without compromising the cultural values and the local capacity to adaptively manage the local ecosystems.

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Figures and tables

Figure 1. The studied area in Androy region, southern Madagascar. Southern and northern Androy are indicated with dashed lines. The study site Lavanono in south western Androy is not included.

Figure 2. Location of study sites in northern Androy and mapped taboo areas (stars) and plots (marked squares) for vegetation sampling. Only forests with tombs, *ala kibory,* are showed in this view.

Figure 3. Southern Androy with a circle indicating location of the detailed mapping in Ambonaivo. White polygons indicate mapped patches > 5 ha, other *ala kibory* are indicated by squares, and other taboo forests by triangles. Marked squares indicate sites for vegetation sampling.

Figure 4. Size distribution of taboo forest patches in south Androy larger than 5 ha (n=63). All of these were found to be *ala kibory,* burial forests.

Figure 5. Size distribution of forests patches mapped in the high-resolution study in Ambonaivo (n=51).

Figure 6. Cluster analysis tree, indicating similarity between forest patches based on species presence and abundance.

Figure 7. Comparison of age distribution of the characteristic and economically important *Alluaudia procera* in a taboo forest patch (*ala kibory)* and a public forest. Note that age refers to growing seasons and not years.

Table. 1. Study sites, number of informants, number of studied forest patches at the different sites classified into three categories. Not all patches could be visited and are thus not indicated in the map of Figures 2 and 3.

Table 2. Categories of taboo forest patches according to reason for taboo, restrictions implied, and sanctions. Note that for all patches the taboo implies ban on burning, cutting and polluting (see text).

Table 3. Woody plant species richness in southern and northern Androy. In southern Androy, five taboo forest patches with tombs (*ala kibory*), three taboo areas with weaker protection (*salata*) and three public forests with few restrictions in human use were analyzed. In northern Androy woody plant species richness in two taboo forests (*ala kibory*), and two public forests with few restrictions in human use were analyzed.

Table 4. List of ecosystem services generated by the sacred or taboo forests. The upper rows lists services or benefits mentioned by local informant, indicating how well spread the perception was. The last rows lists additional ecosystem services as identified by the research group.

Figure 1

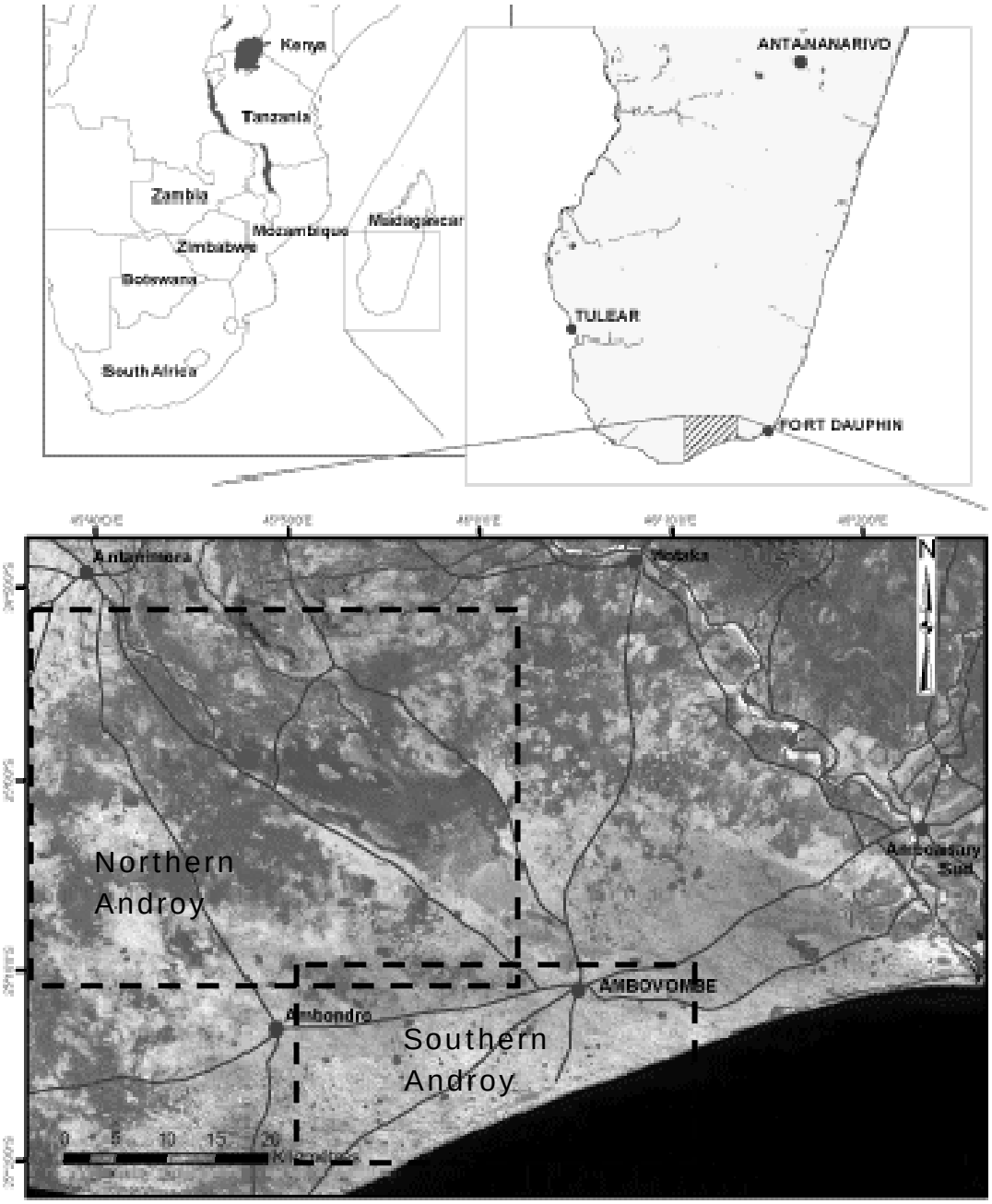
Kenya
Tanzania
Zambia
Mozambique
Zimbabwe
Botswana
South Africa
Madagascar
ANTANANARIVO
TULEAR
FORT DAUPHIN
Antanimora
Mahaka
N
Northern
Androy
Ambovombe
Ambondro
Southern
Androy
0 5 10 15 20

Figure 2

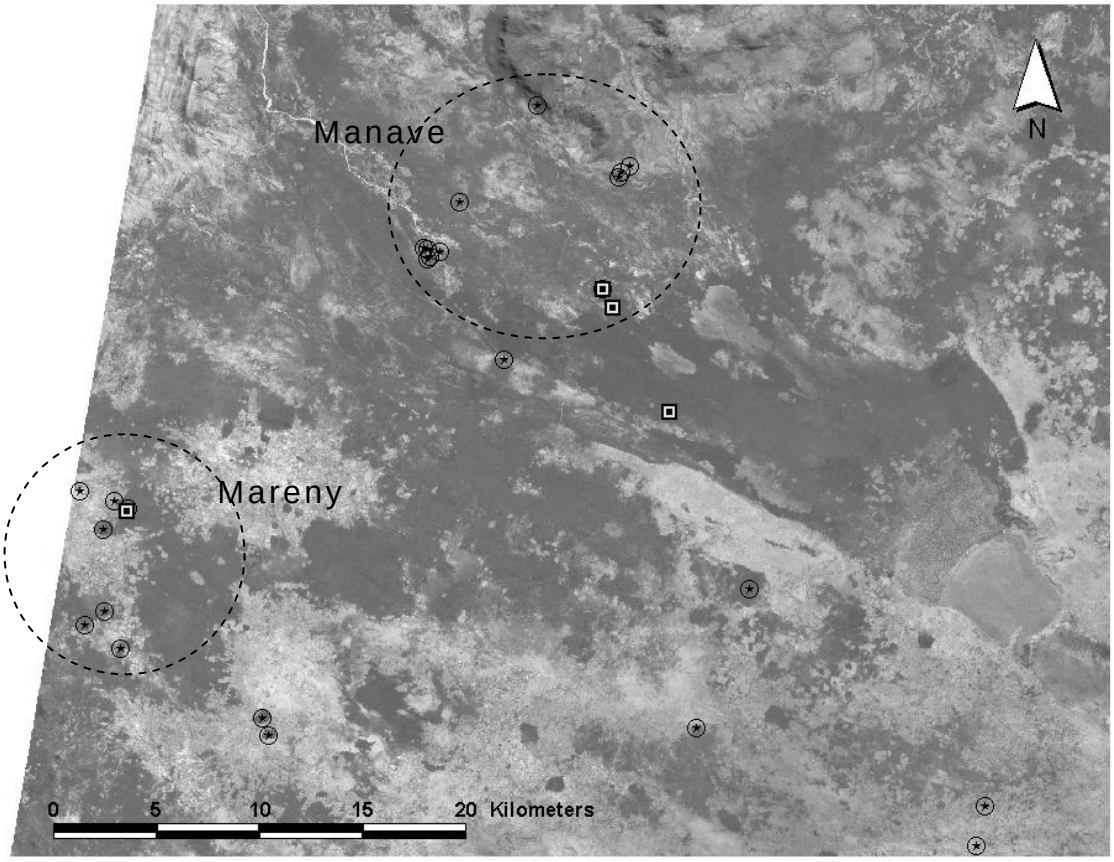

Figure 3

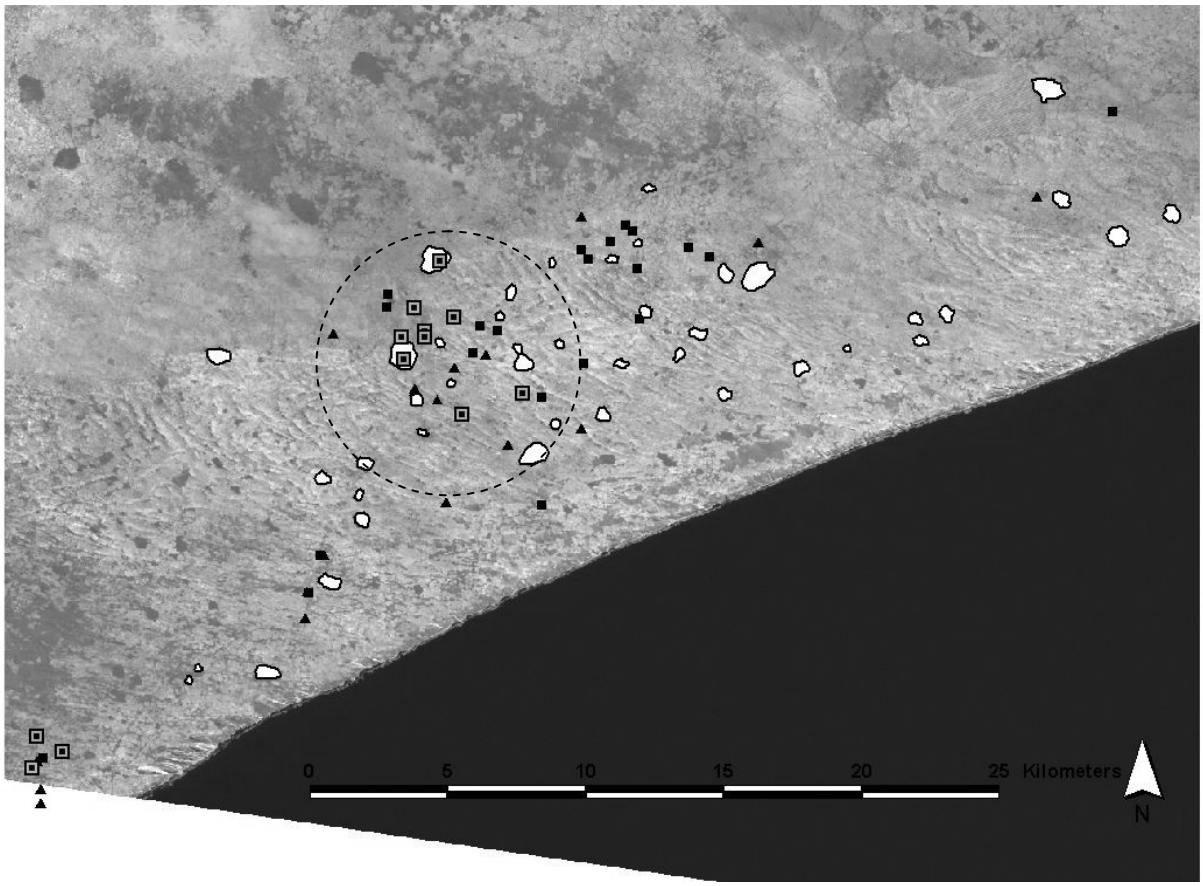

Figure 4

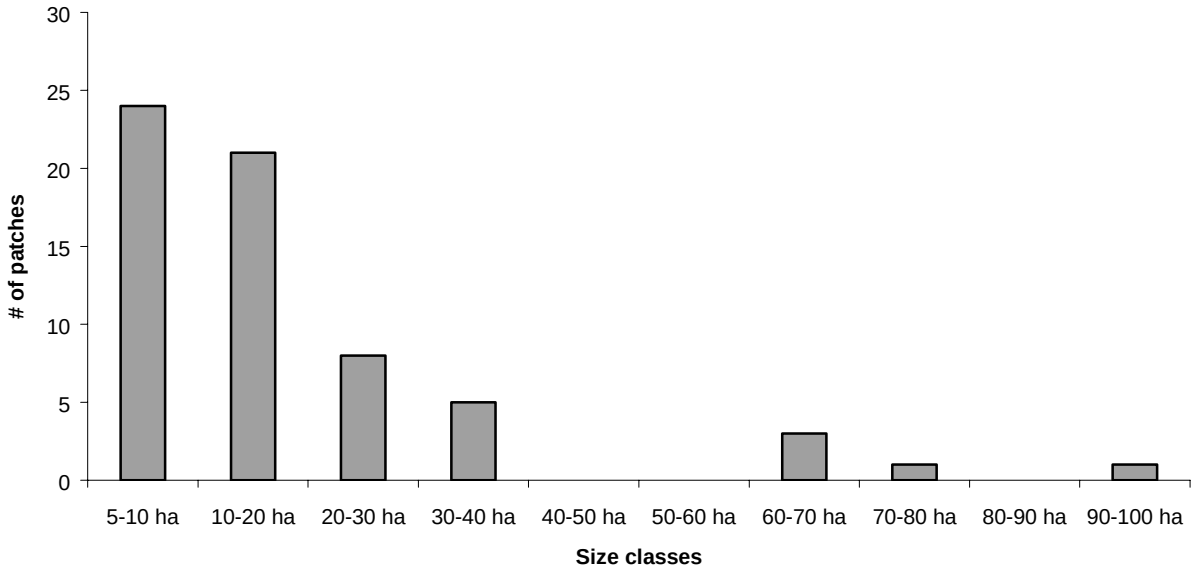
30
25
20
15
10
5
0
# of patches
5-10 ha
10-20 ha
20-30 ha
30-40 ha
40-50 ha
50-60 ha
60-70 ha
70-80 ha
80-90 ha
90-100 ha
Size classes

Figure 5

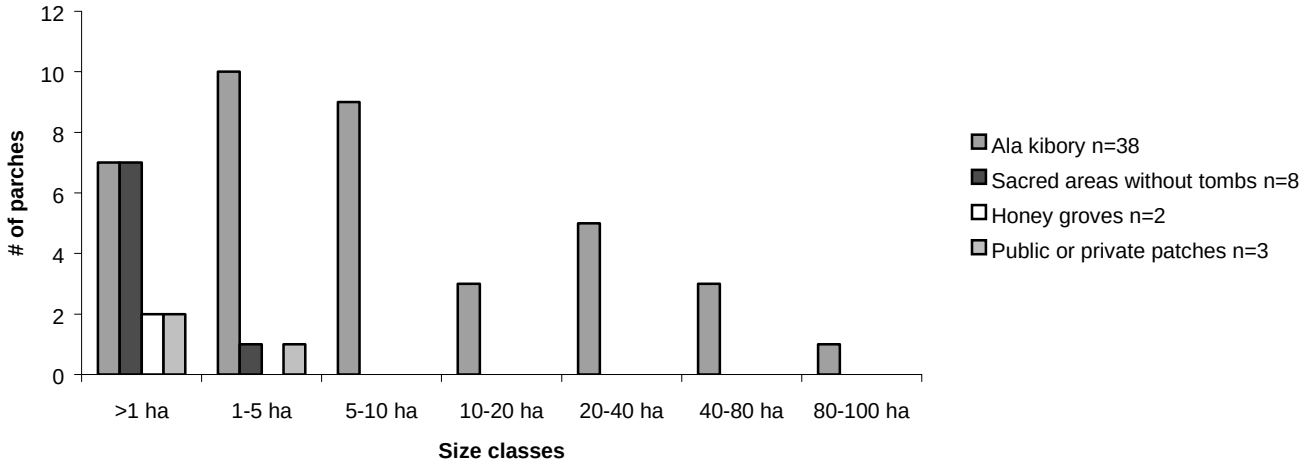
12
10
8
6
4
2
0
# of parches
>1 ha
1-5 ha
5-10 ha
10-20 ha
20-40 ha
40-80 ha
80-100 ha
Size classes
Ala kibory n=38
Sacred areas without tombs n=8
Honey groves n=2
Public or private patches n=3

Figure 6

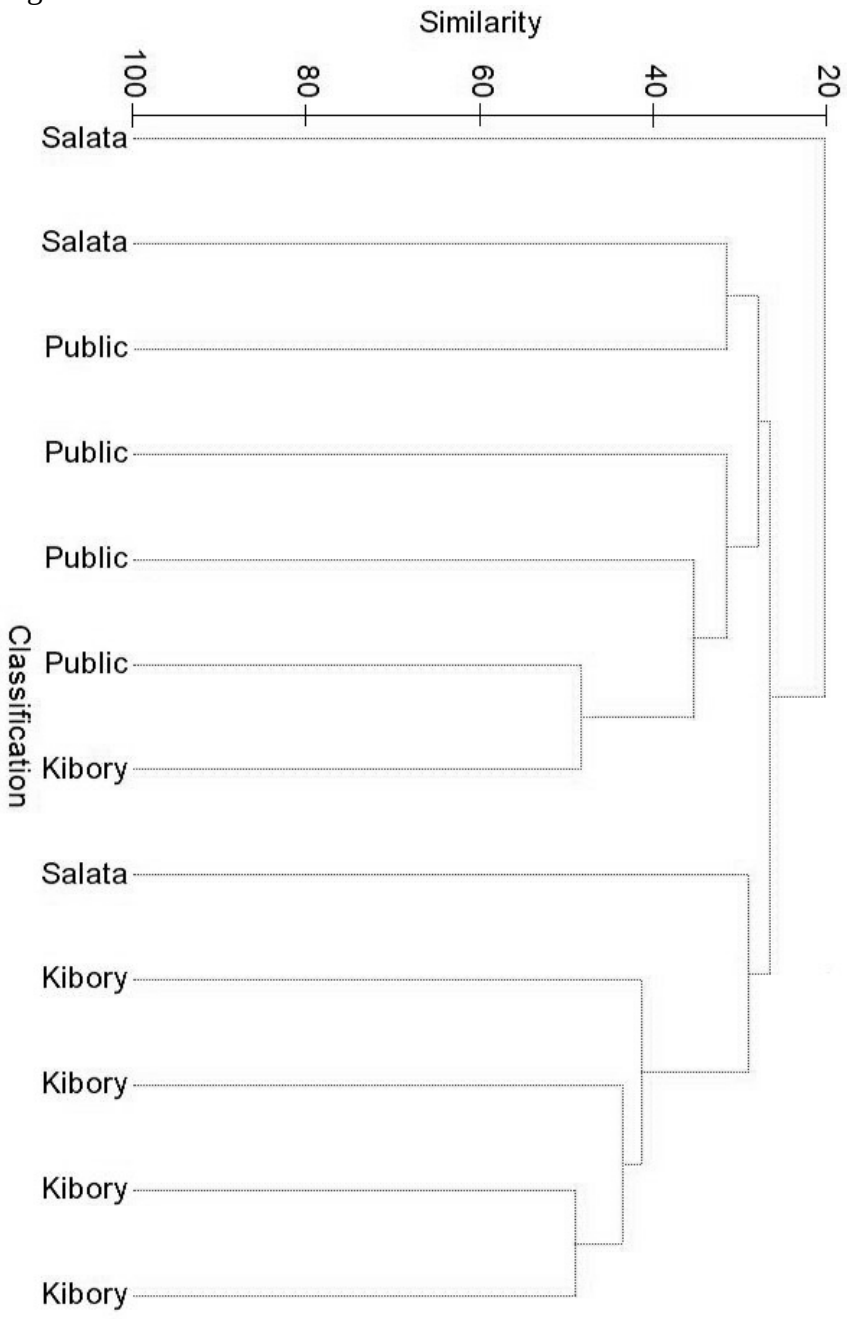
Similarity
100
80
60
40
20
Classification
Salata
Salata
Public
Public
Public
Public
Kibory
Salata
Kibory
Kibory
Kibory
Kibory

Figure 7

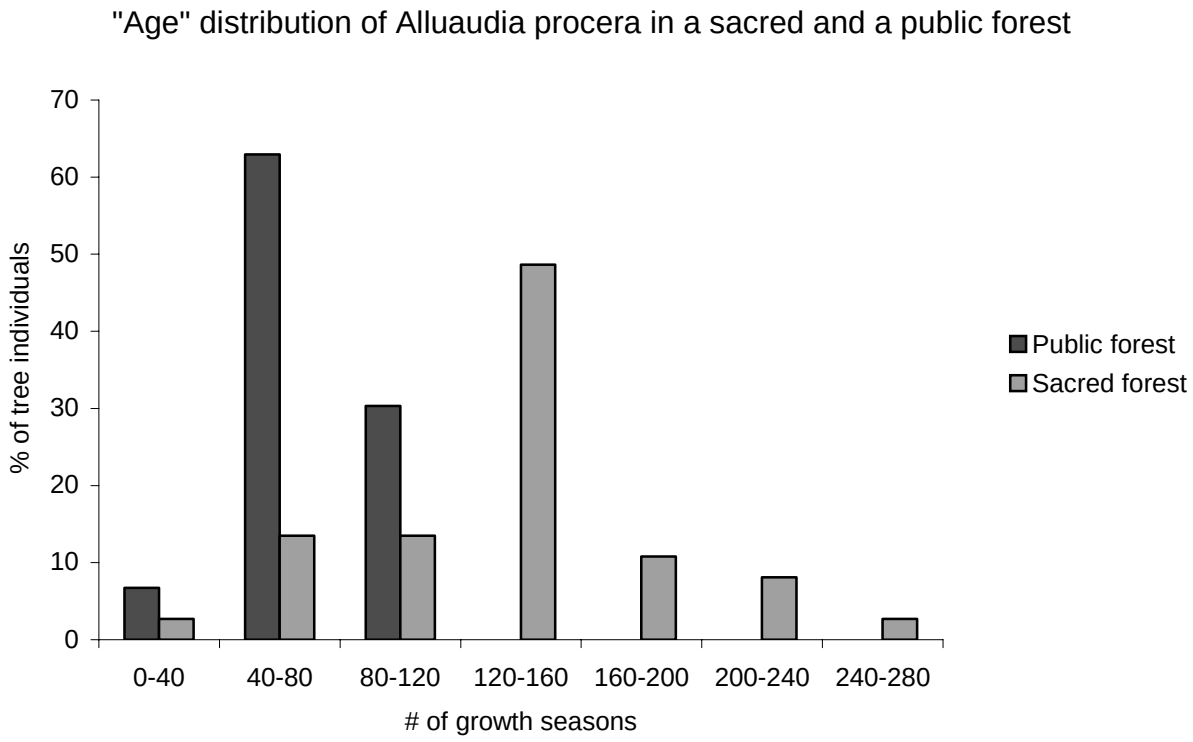
"Age" distribution of Alluaudia procera in a sacred and a public forest
% of tree individuals
70
60
50
40
30
20
10
0
0-40
40-80
80-120
120-160
160-200
200-240
240-280
# of growth seasons
Public forest
Sacred forest

Table 1.

Study sites	**Number of informants**	**No. of identified forest patches**		
		Patches without *faly*	Patches with *faly*	
			with tombs	without tombs
Southern Androy (Ambonaivo excluded)	20	1	34	7
Ambonaivo	12	4	53	19
Sites in northern Androy				
Mareny	4	1	10	-
Manave	8	0	22	8
Other locations	9	1	9	1
Site in western Androy				
Lavanono	5	7	4	5
Total	58	14	132	40

Table 2.

	n	Size range (ha)	Description
Forest patches with tombs, *ala kibory*			
Burial forests	133	<1 to 142	The respect and protection of the *ala kibory* originates from reverence and fear of the tombs of the ancestors. The forest grows with the ancestral spirits, and is therefore granted a similar reverence. Entry restrictions are strict especially in south Androy. Sacrifice of zebu is required to withdraw any resources. Some areas have additional specific taboos such as bans on wearing silver or modern clothes. To bury in a forest, 1-10 zebu must be sacrificed. Sanctions: sacrifice of at least one and up to 30 zebu. A range of 1-8 zebus was common. Self-enforced sanctions originating from the buried ancestors with power to bring misfortune and death if disturbed. Particularly strong in patches with old growth forest that has grown for a long time together with the ancestors.
Recent burial grounds	5	Radius >30 m around tombs	In north and southwest the burial practice has changed from *ala kibory* to newly established burial grounds were the tombs are clearly visible and often ornamented constructions of stone and cement. Approaching is not prohibited, and cutting may occur at burial day. Sanctions: 1-20 zebu
Forest patches without tombs			
Salata	21	<1 – 3	Small groves (southern Androy) or clumps of trees (northern and southwestern Androy) used as a temporary resting place for the dead awaiting burial. People and cattle are allowed to enter, but no resources can be withdrawn. Sanctions: Sacrifice of 1-2 zebus and self-enforced sanctions from the spirits of the dead.
Honey groves *ala fano-hofa*	9	<1	Protected for of honey production. Beehives of hollowed-out tree trunks put on the ground and in trees. Honey and dead wood can be harvested, but nothing can be cut. Only found in south Androy. Their *faly* was described as restrictions not connected to beliefs. Sanctions: Payment of money or sheep to the owner.
Forest patches with spirits	7	diffuse borders	Areas associated with spirits, *kokolampy* or *doany*, that should be respected to avoid spirit possession and misfortune. According to old beliefs, old natural forest is *faly* and should be avoided and respected, as dangerous animals or monsters reside there. Sanctions: bad luck, sudden illness, or even death. To counteract this, appease the spirit and protect community well-being, sheep or zebu is sacrificed.
Private forests	4	<1- 3	Owners can cut trees and withdraw resources, and also permit others to do so. The *faly* has been declared to enforce restrictions and prevent misuse. Sanctions: Pay zebu or money
Cere-monial places	3	< 1	Used for ceremonies such as circumcision, praying and healing. Diviners and healers (*ombiasy)* often have exclusive access. Sanctions: Strong self-enforced sanctions. Sacrifice of sheep can be demanded by the *ombiasy.*
Memo-rial places	3	< 1	E.g. ancient royal settlement, historical battle field, or mass grave from an epidemic disease. Sanctions: Self-enforced sanctions

Table 3.

SOUTH ANDROY	Forest patch size (ha)	Woody species richness	Shannon-Weiner diversity index (H')	Plant density (ha^{-1})	Sampling method (area, m^2)
Ala kibory					
1	78	22	2.748	3275	transect (128)
2	94	28	2.708	3550	transect (192)
3	2	22	2.716	2125	plot (400)
4	0.6	25	2.733	2083	transect (360)
5	2.3	25	2.826	4850	transect (250)
Mean				**3177**	
Salata					
1	1.3	9	2.034	425	plot (400)
2	<1	20	2.496	1875	plot (400)
3	<1	16	2.23	1225	plot (400)
Mean				**1175**	
Public forest					
1	<1	23	2.841	2275	plot (400)
2	<1	19	2.326	2700	plot (400)
3	<1	20	2.573	1400	plot (400)
4	<1	26	2.845	3150	plot (400)
Mean				**2381**	

NORTH ANDROY	Forest patch size (ha)	Woody species richness		Plant density (ha-2)	Sampling method (area, m^2)
Ala kibory					
1	53	18		4175	transect (360)
2	114	14		925	plot (400)
Public forest					
1	contiguous	13		527	plot (400)
2	contiguous	8		2250	plot (400)

Table 4.

Ecosystem services as perceived by local informants	Mentioned by	
	Individuals	Several informants
Cultural services, including protection of ancestors, communication with spirits, and healing	x	x
Provision of honey, wood, game, emergency pasture	x	x
Providing wildlife habitats (conservation of biodiversity)	x	x
Wind break	x	x
Binding of sand dunes	x	x
Source of seeds for re-colonization	x	
Trees as attractors of rain	x	

Additional services not mentioned by informants	Reference
Carbon sequestration and storage	(Holloway 2004)
Soil enrichment (land rehabilitation)	(Holloway 2004)
Pollination	(Ratsirarson and Silander Jr. 2003, De Marco and Coelho 2004)
Pest control	(cf. Greenberg et al. 2000, Hooks et al. 2003)
Habitat for seed dispersing organisms	(cf. Lundberg and Moberg 2003)