Ecological and social issues Availability and uses of four timber tree species in Menabe, Madagascar

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Photograph 1.
The supporting structure of this house under construction in Mandraotra is made of *Cedrelopsis gracilis*, one of the preferred species for this purpose.
Photograph E. Graf.

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RÉSUMÉ

DISPONIBILITÉ ET UTILISATIONS DE QUATRE ESSENCES À BOIS D'ŒUVRE DANS LA RÉGION DE MÉNABÉ, MADAGASCAR

Les forêts sèches de l'Ouest de Madagascar ont une grande valeur écologique et sociale. D'une grande diversité biologique, elles sont une source importante de produits forestiers ligneux et non ligneux pour les populations rurales. Au Ménabé central, l'abattage sélectif accroît la pression sur plusieurs essences appréciées, qui semblent se raréfier. Cela pose des problèmes à la fois écologiques et sociaux, car la raréfaction de ces essences contraint les populations à prélever d'autres essences moins adaptées. Cette étude est centrée sur la disponibilité et les utilisations des quatre essences privilégiées pour le bois d'œuvre dans le Ménabé central, *Securinega seyrigii, Cedrelopsis grevei, C. gracilis* et *C. microfoliolata*. Plus précisément, il a été déterminé les stocks disponibles et leur utilisation annuelle dans deux villages, Ampataka et Mandraotra. La question principale était de savoir si la demande villageoise peut être satisfaite à long terme. Il apparaît que la régénération fait globalement défaut. À Ampataka, l'essence *Cedrelopsis grevei* est absente dans l'étage végétatif tandis qu'à Mandraotra les quatre essences étaient absentes. Il est donc vraisemblable que la disponibilité des quatre essences est insuffisante pour satisfaire la demande villageoise à long terme. Afin de réduire ce déficit à l'avenir, les plans de gestion forestière et les modes d'utilisation devront être améliorés et adaptés, et des études devront être menées sur les processus de régénération afin d'en améliorer la connaissance.

Mots-clés : *Cedrelopsis*, *Securinega,* bois d'œuvre, disponibilité, utilisations du bois, soutenabilité, forêt sèche occidentale, Madagascar.

ABSTRACT

AVAILABILITY AND USES OF FOUR TIMBER TREE SPECIES IN MENABE, MADAGASCAR

The western dry forests of Madagascar are highly valuable both ecologically and socially. They are very rich in biodiversity and are an important source of timber and non-timber forest products for people in rural areas. In Central Menabe, selective logging is increasing pressure on a number of valued species, which seem to be increasingly scarce. This is raising ecological and social problems, since the species are becoming endangered and people are having to switch to other less appropriate species. This study investigated the availability and uses of the four most important species used to build housing in Central Menabe, i.e. *Securinega seyrigii, Cedrelopsis grevei, C. gracilis* and *C. microfoliolata*. Specifically, we determined available stocks and annual use in the two villages of Ampataka and Mandraotra. The main question needing an answer was whether demand in the villages can be satisfied in the long term. It appears that there is an overall lack of regeneration. In Ampataka, *Cedrelopsis grevei* did not occur in the shoot layer and in Mandraotra, all four species were absent. It is therefore likely that the availability of the four species cannot satisfy demand in the villages in the long term. To reduce the deficit in future, forest management schemes and uses should be adapted and improved, and regeneration processes need to be studied to ensure better understanding.

Keywords: *Cedrelopsis*, *Securinega,* construction timber, availability, timber uses, sustainability, western dry forest, Madagascar.

RESUMEN

DISPONIBILIDAD Y USOS DE CUATRO ESPECIES DE MADERA DE CONSTRUCCIÓN EN LA REGIÓN DE MENABE, MADAGASCAR

Los bosques secos de Madagascar occidental poseen un alto valor ecológico y social. Encierran una gran diversidad biológica y son una importante fuente de productos forestales maderables y no maderables para las poblaciones rurales. En el centro de la región de Menabe, la tala selectiva aumenta la presión sobre algunas especies especialmente apreciadas y cuya presencia es cada vez más escasa. Esto plantea una serie de problemas ecológicos y sociales, ya que la rarefacción de dichas especies lleva a la población a buscar otras especies menos adaptadas. Este estudio analiza la disponibilidad y usos de las cuatro especies preferidas para madera de construcción en el Menabe central, *Securinega seyrigii, Cedrelopsis grevei, C. gracilis* y *C. microfoliolata*. Más concretamente, hemos determinado las existencias disponibles y su utilización anual en dos pueblos: Ampataka y Mandraotra. El principal interrogante consistía en saber si la demanda campesina podía verse satisfecha a largo plazo. Los resultados muestran una ausencia global de regeneración. En Ampataka, *Cedrelopsis grevei* está ausente en el piso vegetativo, mientras que en Mandraotra las cuatro especies están ausentes. Parece por tanto verosímil que la disponibilidad de las cuatro especies sea insuficiente para satisfacer la demanda campesina a largo plazo. Si, en un futuro, se quiere reducir dicho déficit, habrá que mejorar y adaptar los planes de manejo forestal y los modos de utilización. También habrá que realizar estudios sobre los procesos de regeneración para mejorar su conocimiento.

Palabras clave: *Cedrelopsis*, *Securinega,* madera de construcción, disponibilidad, utilización de la madera, sostenibilidad, bosque seco occidental, Madagascar.

Introduction

Madagascar (together with the Indian Ocean Islands) is one of the 34 identified biodiversity hotspots on Earth (Conservation International, 2007). About 85 % of its 10,000 to 12,000 plant species (Direction des Eaux et Forêts, 1996) and 94 % of its trees and shrubs (Koechlin, 1972) are endemic. The biota is forest-dependent to a high degree (Dufils, 2003). Forest cover has been decreasing at an alarming rate. Between 1990 and 2000, forested areas decreased by 9 % and covered 20 % of total land area in 2000 (Earth Trends, 2003). Different factors like slash-and-burn or shifting cultivation have caused forest degradation and deforestation. Because of the rapid disappearance of forested areas, a great many forest-dependent species are now threatened. The remaining forest areas are therefore of high ecological value.

To conserve natural resources and biodiversity, the government of Madagascar undertook in 2003 to increase the protected area network from the existing 1.7 million hectares to more than 6 million hectares, or 10 % of the country's area, within the next five years (Conservation International, 2003).

Forests also have high social value as they are still an important local resource for rural populations. The four tree species investigated in this study (*Securinega seyrigii* Leandri, *Cedrelopsis grevei* Baill., *C. gracilis* J.-F. Leroy, *C. microfoliolata* J.-F. Leroy) are the most important species for housing construction in Central Menabe (photographs 1 and 2). They are declining because of increased pressure from selective logging and for the local population, they are becoming increasingly hard to find in the forest (Haingomanantsoa, 2007). This is raising an ecological and social problem, as the species are becoming endangered and people are having to switch to other less suitable species.

The purpose of this study was to examine whether or not the availability of these four species can satisfy village demand in the long term. Specifically, we conducted a forest inventory to determine available stocks of these species in the forest areas used by two villages and compared the results with annual use of the species.

This study is part of a project on "Participatory Landscape Management" (PFM) under way in the Menabe region. The project is aiming to "set up scientific bases for sustainable, multifunctional and participatory management of a forest landscape in Central Menabe" (Dirac *et al.*, 2006).

Materials and methods

Study area

The study was carried out in the two villages in the Menabe region, Ampataka and Mandroatra (figure 1). The study area has a semi-arid climate (Koechlin *et al.*, 1997), with a rainy season from November to March/April and a dry season from April to November. Average annual precipitation is 711 mm, and average annual temperature 25.3°C (Walter, Lieth, 1967). Geologically, the terrain is sedimentary sandstone and clay. Soils are of the tropical ferrous type on sandstone (Le Bourdiec *et al.*, 1969). The resident forest is the so-

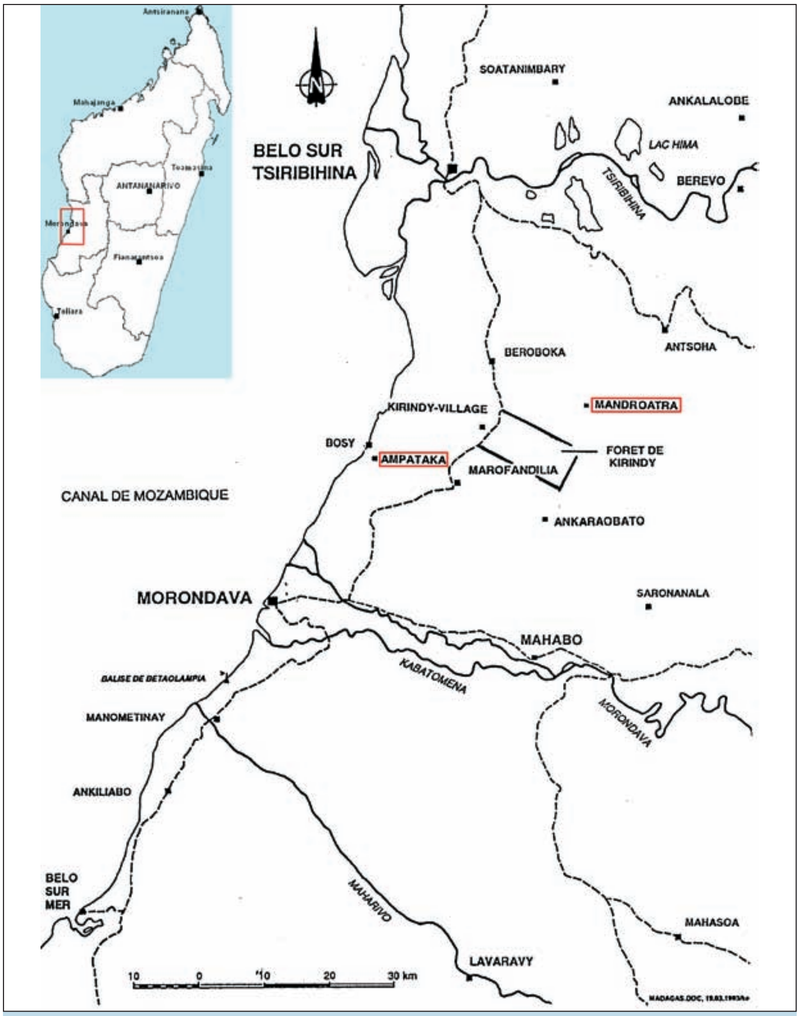

Figure 1.
Study area showing the study villages of Ampataka and Mandraotra.
Source: adapted from *Groupe de foresterie pour le développement* (2006).

Photograph 2.
A living *Cedrelopsis grevei* tree, an important construction timber species, near Ampataka.
Photograph E. Graf.

called western dry forest (Moat, Smith, 2007) and the region comprises one of the largest residual areas of this forest type in Madagascar (Sorg *et al.*, 2003). Biodiversity is very high, with more than 200 ligneous species (Rakotonirina, 1996) characterized by three different stories. Generally, the upper story is deciduous, while the lower stories may also contain some evergreen species (Koechlin, 1997).

About 60 % of the population in Central Menabe is rural, living in areas with a fairly low human population density where life is basically agricultural and forest products still play a major role (Sorg *et al.*, 2003). Timber is used for different purposes, such as firewood and construction and to make fences, carts, pirogues or tools. But also, a lot of non-timber forest products like medicinal plants, food or honey are gathered by the villagers. Forest areas are also important for hunting, rituals and cults (Favre, 1996).

Species investigated

Securinega seyrigii, Cedrelopsis grevei, *C. gracilis* and *C. microfoliolata* are the most important and most valued species for housing construction in Central Menabe. The wood is relatively hard, providing straight logs with high resistance to fungal and insect attacks. This facilitates construction and ensures both durability and stability. (Haingomanantsoa, 2007). These species occur only in Madagascar (Tropicos, 2008) and grow to 8-15 m in height and 30 cm in diameter (Rohner, Sorg, 1986).

The "Central Menabe" Protected Area

In March 2006, an Act was passed for temporary protection for the "Central Menabe" protected area as a national park. The aim is to ensure biodiversity conservation and sustainable natural resource management that ensures the welfare of villagers (Minenvef, 2006).

The western dry forest part of the protected area consists of a central zone with priority conservation status and a zone for village use which is managed by the villagers. This zone is further divided into a protection zone and a felling zone. No timber use is allowed in the protection zone, but villagers may extract resources from the felling zone for their personal use. We therefore focused on the felling zone to determine available stocks (figures 2 and 3).

Data collection and analysis

Available stocks of the four species were determined by conducting a forest inventory in the Ampataka and Mandroatra felling zones in April and May 2008. Annual use was estimated by using and adapting existing studies on the two villages.

Available stocks

The forest inventory was conducted by means of the stratified sampling method, with each felling zone in each village making up one stratum. The samples were chosen by systematic random grid sampling. A total of 41 samples were covered by the inventory. The samples were divided into four compartments. Trees where d ≥ 15cm were in compartment A (20 m x 20 m), trees where 5 cm ≤ d ‹ 15 cm were in compartment B (10 m x 10 m), trees where d ‹ 5 cm were in compartment C (5 m x 5 m) and trees where h ‹ 1.50m were in compartment D (1 m x 1 m).[1] The compartments were arranged in a nested pattern. From the sampling point, the sample always lay in a northward direction. The species were recorded for all diameter classes. Diameter at breast height and form were recorded for diameter classes A, B and C. Form was divided into straight and bent logs, with inclined trees considered as straight logs. The forest inventory produced the available stock per hectare.

The results of the forest inventory were extrapolated for the relevant areas and form and diameter classes. The forested area was determined from satellite images. Lakes and recent cultivation areas or savannah were excluded as they do not contribute to the available stock. It was assumed that only straight logs are usable for housing construction and bent logs are not. Diameter class D is not yet used as construction timber and Haingomanantsoa (2007) indicates 12 cm as the largest diameter used. Therefore, only diameter classes C and B were considered as available stock.

Annual use

Two different studies (Haingomanantsoa, 2007; Rasoloaritsoa, 2007) provide information on timber use in the two villages. Both were carried out in Ampataka but only Rasoloaritsoa (2007) dealt with the case of Mandroatra. Annual use of the four species for housing construction was estimated from the timber requirement per house, the number of houses, timber durability and species composition. The number of houses was assumed to be constant. For Ampataka, the mean of the two sources was used.

Satisfaction of demand

The time factor has not been taken into consideration up to now. To assess whether or not the forest can satisfy village demand in the long term, its development over time needs to be taken into account. However, only limited information was available on tree growth, tree age, regeneration and forest dynamics in the four species. In addition, the system is affected by external factors that are difficult to take into account, such as population growth, changing use patterns, soil, climate and competition.

However, to give an idea of potential development, we made a number of quantitative estimations of annual increment, ingrowth and outgrowth. This approach must be considered as exploratory and absolute values should be regarded with caution.

Tree growth and increment per year are highly dependent on light availability, precipitation, soil conditions and especially on the species. Murphy and Lugo (1986) give an overall annual tree diameter growth of 1-2 mm in tropical dry forests. Schwitter and Michaud (1986) studied the increment of *Commiphora guillauminii* H. Perrier in the study area, finding an average of 1.8 mm per season. The figure was higher in smaller diameter classes (10-20 cm: 2.9 mm per year, 20-30 cm: 1.3 mm per year), indicating initially rapid

Figure 2.
Felling zone at Ampataka.
Source: adapted from Google Earth.

Figure 3.
Felling zone at Mandraotra.
Source: adapted from Google Earth.

growth and slower growth thereafter. Deleporte *et al.* (1996) measured a height increment per year of 0-20 cm for *Commiphora guillauminii* and 5-50 cm for *C. grevei* at 7 years of age. Height at 7 years was 0.2-1.0 m for *Commiphora guillauminii* and 0.5-3.0 m for *C. grevei*, which therefore seems to grow faster than *Commiphora guillauminii*. On the other hand, *Commiphora guillauminii* produces relatively weak and lightweight wood, whereas *C. grevei* timber is a very hard and heavy (Rohner, Sorg, 1986). This would in fact assume less rapid growth of the four species, contradicting what was found above.

These studies show that information about increment is limited, and we therefore assumed an increment of 2.5 mm per year for diameter classes B and C. This results in a secondary

[1] The relevant diameter classes are labeled A, B, C and D in the rest of this paper, and the related terms are defined as the canopy, overstory, understory and shoot layer.

Table I.
Number per hectare of the four species per diameter class.

Species	Diameter class	Research sites (N/ha)	
		Ampataka	Mandraotra
Securinega seyrigii	A (d ≥ 15 cm)	9	63
	B (5 cm ≤ d < 15 cm)	359	121
	C (d < 5 cm)	593	171
	D (h < 1.50 m)	1 481	0
Cedrelopsis grevei	A (d ≥ 15 cm)	0	0
	B (5 cm ≤ d < 15 cm)	19	0
	C (d < 5 cm)	59	29
	D (h < 1.50 m)	0	0
Cedrelopsis gracilis	A (d ≥ 15 cm)	0	5
	B (5 cm ≤ d < 15 cm)	15	43
	C (d < 5 cm)	15	29
	D (h < 1.50 m)	370	0
Cedrelopsis microfoliolata	A (d ≥ 15 cm)	0	4
	B (5 cm ≤ d < 15 cm)	15	43
	C (d < 5 cm)	133	114
	D (h < 1.50 m)	370	0

growth period (time span between ingrowth and outgrowth) of 40 years for diameter class B and 20 years for diameter class C. The secondary growth period for diameter class D was assumed to be 5 years, implying a height increment of 30 cm per year.

Annual outgrowth for each diameter class was obtained by dividing the available stock by the secondary growth period. Annual ingrowth in a particular diameter class is identical to annual outgrowth from the lower diameter class. Comparing annual ingrowth, outgrowth and use for each diameter class thus gives an idea of how future availability will evolve.

Results

Table I presents available stocks per hectare in the two research sites. In the shoot layer at Ampataka, *Cedrelopsis grevei* was absent while at Mandroatra, all four species were absent. All three *Cedrelopsis* were absent in the canopy at Ampataka and *Cedrelopsis grevei* did not occur in the canopy at Mandroatra.

The forested area covered 1305 ha in Ampataka and 895 ha in Mandroatra. The proportion of straight logs varied from 73 % to 87 %.

Table II and Table III show available stocks, annual use and annual ingrowth and outgrowth of each species and diameter class at Ampataka and Mandroatra.

Discussion

Securinega seyrigii reserves at Ampataka are still very high. The available stock of diameter class B could theoretically satisfy demand for about 1,600 years. Annual ingrowth is higher than annual outgrowth. The situation is less promising for the other species and diameter classes used in Ampataka. Available stocks are relatively small and could satisfy demand for about 40-130 years. Furthermore, annual ingrowth for *Cedrelopsis grevei* is zero, and therefore lower than annual outgrowth, because of its absence in the shoot layer. The relatively high rate of use worsens the situation.

In Mandroatra, all four species were absent in the shoot layer, resulting in a lack of annual ingrowth in the understory. Fortunately, the understory is not additionally affected by village use. In the overstory, reserves of *Securinega seyrigii* and *Cedrelopsis microfoliolata* are relatively high and could theoretically satisfy demand for about 870 and 630 years, respectively. For *Cedrelopsis gracilis*, reserves are relatively small and could theoretically satisfy demand for about 150 years. There are no reserves of *Cedrelopsis grevei*.

The current situation points to a future lack of the critical classes described above. The situation seems precarious in Mandroatra especially, as all species are absent in the shoot layer. In addition, annual use is somewhat underestimated because of illegal felling and uses for purposes other than housing construction. Moreover, available stocks give no information about the distribution of the relevant trees within the forest. The trees still available are assumed to be located in dense forest a long way off from the village, because preference is given to felling easily accessible trees.

There could be several reasons for the regeneration deficit, as the natural regeneration process is complex and influenced by a great many different factors, including the den-

Table II.
Annual recruitment, removal, use and available stock in the Ampataka felling zone [N].

Ampataka	Diameter class	Annual recruitment	Available stock	Annual removal	Annual use
Securinega seyrigii	B (5 cm ≤ d ‹ 15 cm)	28,045	340,041	8,501	213
	C (d ‹ 5 cm)	280,446	560,892	28,045	0
Cedrelopsis grevei	B (5 cm ≤ d ‹ 15 cm)	2,864	17,900	447	497
	C (d ‹ 5 cm)	0	57,279	2,864	435
Cedrelopsis gracilis	B (5 cm ≤ d ‹ 15 cm)	716	14,320	358	185
	C (d ‹ 5 cm)	71,599	14,320	716	0
Cedrelopsis microfoliolata	B (5 cm ≤ d ‹ 15 cm)	6,444	14,320	358	0
	C (d ‹ 5 cm)	71,599	128,878	6,444	0

Table III.
Annual recruitment, removal, use and available stock in the Mandraotra felling zone [N].

Ampataka	Diameter class	Annual recruitment	Available stock	Annual removal	Annual use
Securinega seyrigii	B (5 cm ≤ d ‹ 15 cm)	5,951	84,311	2,108	97
	C (d ‹ 5 cm)	0	119,027	5,951	0
Cedrelopsis grevei	B (5 cm ≤ d ‹ 15 cm)	1,112	0	0	62
	C (d ‹ 5 cm)	0	22,234	1,112	0
Cedrelopsis gracilis	B (5 cm ≤ d ‹ 15 cm)	1,112	33,351	834	230
	C (d ‹ 5 cm)	0	22,234	1,112	0
Cedrelopsis microfoliolata	B (5 cm ≤ d ‹ 15 cm)	4,447	33,351	834	53
	C (d ‹ 5 cm)	0	88,935	4,447	0

sity of parent trees, fructification, seed dispersal, predators, germination conditions and surrounding vegetation (Deleporte *et al.*, 1996 reproduced from Hunziker, 1982).

For *Securinega seyrigii*, *Cedrelopsis gracilis* and *Cedrelopsis microfoliolata*, the number of seed trees seems to be sufficient, since trees do exist in the canopy and regeneration does occur. For *Cedrelopsis grevei,* however, the number of seed trees seems to be insufficient as no regeneration was found and there were no trees in the canopy. But this is not the only reason. In a study on skid tracks opened, *Securinega seyrigii*, *Cedrelopsis grevei* and *Cedrelopsis microfoliolata* had numerous seed trees but low regeneration (Felber, 1984). Different reasons are put forward: the species are generally not very reproductive, seeds are in dormancy, seeds are consumed by animals or damaged by fungi or bacteria. In the study by Rakotonirina and Prélaz (1982), the three *Cedrelopsis* species emerged readily after square plots were cleared.

Human influence affects regeneration by removing seed trees. In addition, felling can damage seed trees and regeneration. Trampling by people or cattle also damages seedlings and shoots. On the other hand, felling also promotes regeneration, especially of the light-demanding genus *Cedrelopsis*, by creating clearings that let in more light (Razanatsimba, 2007).

The aim in developing a protected area is to ensure biodiversity preservation and sustainable natural resource management that ensures the welfare of villagers. In the light of this goal, the availability of the four species is unlikely to satisfy future demand from the villagers. The lack of regeneration, especially at Mandroatra, is liable to cause shortages in the future. Therefore, in the long term, these important species for housing construction will disappear. Haingomanantsoa (2007) indicates the same trend.

If sustainable management is neglected, overexploiting the dedicated forest area could satisfy village demand overall now and in the near future, as availability is still relatively high. In the case of a short or medium term deficit for *Cedrelopsis grevei* or *Cedrelopsis gracilis*, the protection zone could provide backup supplies.

Conclusions and recommendations

Results show a worsening regeneration deficit for all four species, especially in Mandroatra. Our analysis therefore concludes that availability of the four species is unlikely to satisfy demand from the villagers in the long term. Solutions to avert the problem are on the one hand to reduce use, and on the other hand to increase availability by changing forest management schemes.

Use could be reduced by changing house construction habits and introducing new technologies. For example, verandas could be constructed on only two sides (instead of four) and timbers could be treated improve their durability (Haingomanantsoa, 2007). Another solution might be to use air-dried clay bricks to build houses. To reduce pressure, timber use could be diversified to include other suitable species (Haingomanantsoa, 2007). Zones that are still regenerating should be protected to aid reconstitution. Damage by trampling or felling should be avoided in the vicinity of regeneration. Regeneration processes are very complex and further studies on regeneration and growth habits of the four species (dispersal behaviour, light requirement, suitable soil characteristics, increment) could provide the information needed to develop more appropriate management schemes that would increase their abundance.

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