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Resource demand estimates for sustainable forest management: Mngazana Mangrove Forest, South Africa

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Keywords: *Bruguiera gymnorrhiza* (L.) Lam., construction timber, Eastern Cape, forest product utilization, mangroves, *Rhizophora mucronata* Lam., rural building styles, sustainable forest management

ABSTRACT

Since democratization in 1994, South African forest policies have promoted sustainable forest management. However, implementation has been problematic due to limited information concerning forest product utilization. This paper investigates and quantifies timber use from the Mngazana Mangrove Forest, Eastern Cape Province, South Africa. Three local communities utilize stems of the mangrove species *Rhizophora mucronata* Lam. and *Bruguiera gymnorrhiza* (L.) Lam. for building construction. There were two distinct building shapes, circular and rectangular. On average, 155 stems were used for circular buildings and 378 stems for rectangular buildings. Most buildings were constructed using mangroves as well as indigenous timber from coastal scarp forests. The proportion of mangrove stems in buildings varied from 0 to 95%. The annual demand for mangroves was estimated to be 18 400 stems. Due to the high annual demand, projected human population growth rates have a minor influence upon future demand values. For effective sustainable forest management, the standing stock at Mngazana should be restricted to the two mangrove species utilized for building construction, and a forest inventory performed so that demand for building can be compared to supply.

INTRODUCTION

Over the last decade, global advancements in forest management have progressed towards Sustainable Forest Management (SFM), a term first incorporated into Agenda 21 and the Forest Principles which were both outputs of the United Nations Conference on Environment and Development (UNCED) 1992. Agenda 21 called for enhanced sustainable management of all forests, whereas the Forest Principles stated that ‘forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual needs of present and future generations’. It also specified that these needs include forest products such as wood and wood products (United Nations General Assembly 1992: 291, 292). Since its inception, the SFM concept has evolved through international forest policy dialogue, as well as country and eco-regional initiatives. These activities have resulted in global alterations to forest policies and forest management strategies (FAO 1994).

Although South Africa did not participate in UNCED, global developments have influenced its policies and since democratization in 1994, forest policy has striven to broaden access and sustainable use of indigenous forests (Lawes *et al.* 2004a). The new South African Constitution promotes conservation, ecologically sustainable development and the use of natural resources within justifiable social and economic development (RSA 1996a). Furthermore, the White Paper on Sustainable Forest Development in South Africa (RSA 1996b), and the National Forest Act (RSA 1998), both acknowledge the vital role of forests in the livelihoods of rural communities. These policies recognize the obligation which the country has, to use its natural resources to further the development of the poor (Willis 2004). Thus, South African policy promotes the sustainable use of forests. Forest biomes and their management have been well researched (Muir 1990; Oribi *et al.* 2002; Lawes *et al.* 2004a), but implementation of management plans sometimes poses a problem. There is also a paucity of information on the usefulness of the forests, especially to local people and on actual removal of wood and other products (Lawes *et al.* 2004).

SFM approaches have been applied to mangrove forests (International Tropical Timber Organization 2002), but no examples exist for South Africa’s mangroves, even though their forest products are utilized by local communities (Bruton 1980; Ward *et al.* 1986; Steinke 1999; Rajkaran *et al.* 2004). Mangroves in South Africa are located along the Indian Ocean coastline in the provinces of KwaZulu-Natal and Eastern Cape. Over 17 years, a reduction of 7% in mangrove area has been reported for the Eastern Cape, and easily accessible forests that lie outside of protected areas are under great pressure from resource users (Adams *et al.* 2005). Mangrove ecosystems have a positive influence on coastal protection, nutrient cycling and export, sediment trapping, and serve as breeding and nursery grounds for fish (Lugo & Snaedakar 1974; Hogarth 1999; Mumby *et al.* 2004). South African mangrove habitats are threatened and as a result, many authors have called for greater conservation and management efforts (Branch & Grindley 1979; Day 1981; Ward *et al.* 1986; Berjak *et al.* 1997; Steinke *et al.* 1995).

The Mngazana Mangrove Forest (MMF) in the Eastern Cape was selected for study, as mangrove trees have been harvested throughout the forest (Rajkaran *et al.* 2004) and local communities use them with other

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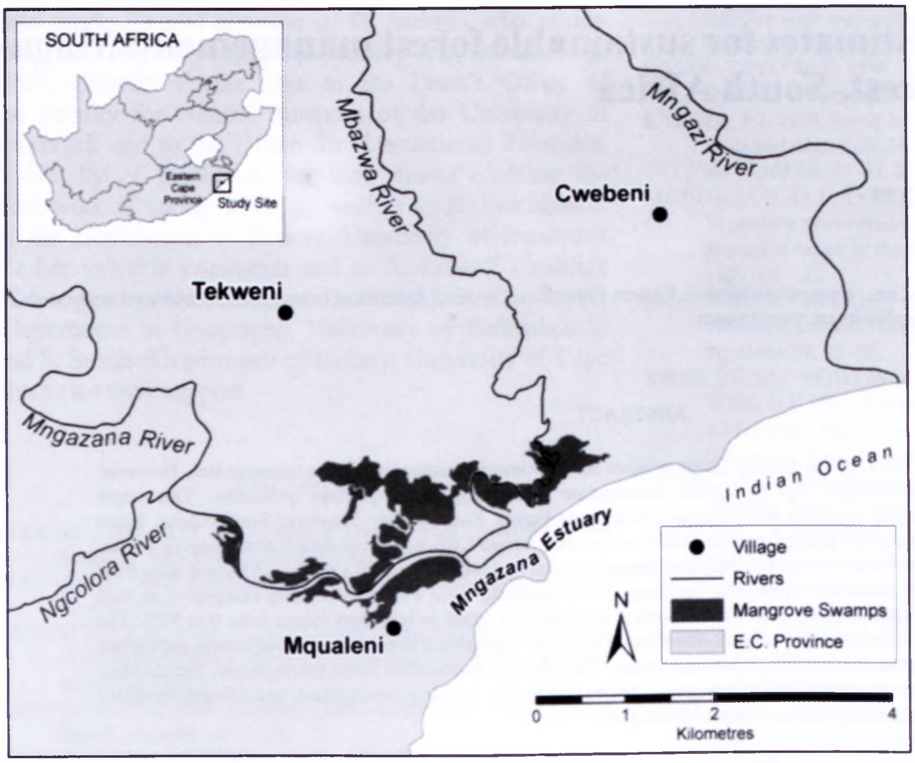

FIGURE 1.—Location of the Mngazana Mangrove Forest and study villages, Eastern Cape, South Africa.

indigenous wood species as building construction materials. In the villages surrounding the mangroves there are limited employment and income opportunities. People have restricted means to purchase building construction materials and thus over 90% of dwellings are traditional huts or structures made from natural materials (Statistics South Africa 2001). Every South African citizen has the right to access adequate housing (RSA 1996a) and the communities at Mngazana are dependent upon the local natural resources, including the mangrove forest, to meet their housing needs. At Mngazana the buildings are typical of rural styles constructed from indigenous wood; a wooden framework is made to which stone and mud walls and roofing materials are added (Liengme1983; Cunningham 1985; Shackleton *et al.* 2002).

This paper investigates the SFM concept focusing on the estimation of empirical values for forest product utilization. Through the case of the MMF, the intricacies of precisely calculating demand for housing construction timber is presented and the usefulness of these estimates to SFM considered. Firstly, the total numbers of mangrove stems within standing structures is quantified. Secondly, the current annual demand for mangrove stems for building construction is evaluated. Thirdly, future demand for mangrove stems is predicted under different scenarios. Finally, the contribution the demand estimates can make to a mangrove SFM strategy and the wider relevance of the case is discussed.

The context of the Mngazana Mangrove Forest

The topography of the Mngazana area is a tidal flat, up to 1 500 m wide in places, attributed to the geological formation, the Ecca and Beaufort Groups of the Karoo Sequence (Harrison *et al.* 1999). These groups are composed of conglomerates, sandstones and mudstones which produce weakly structured, shallow soils when weathered (Nicolson 1993). The average annual rainfall is 1 200 mm, and 70% occurs in summer. The vegetation includes a coastal strip of dune forest, mangroves, saltmarsh and inland grassland and forest patches.

The MMF is a riverine mangrove forest that is situated within the Mngazana Estuary (31°42'S 29°25'E), Eastern Cape. It is the third largest mangrove forest in South Africa (Ward & Steinke 1982) covering an area of ± 145 ha (Adams *et al.* 2005) and is composed of the mangrove species *Avicennia marinia* (Forssk.) Vierh., *Bruguiera gymnorrhiza* (L.) Lam. and *Rhizophora mucronata* Lam. The estuary is biologically important with the highest recorded invertebrate diversity for east coast estuaries (Branch & Grindley 1979) and rated first in the region using a botanical importance rating system (Colloty 2000) and 22nd in South Africa for its biodiversity importance (Turpie *et al.* 2002). The MMF has been heavily disturbed, and Rajkaran *et al.* (2004), using GIS analysis, estimated that over 40% of the forest showed a ratio of one adult tree to two harvested stumps, indicating that the harvesting intensity was extremely high.

The area is inhabited by Xhosa-speaking Mpondos. Prior to democracy in 1994, the area was classified as a homeland by the apartheid government and consequently is poorly developed (Ashley & Ntshona 2003). There are three villages surrounding the Mngazana Estuary; Mqualeni, Cwebeni and Tekweni (Figure 1). In these villages, ± 30% of the population have received no schooling, less than 10% of the labour force are employed and over half of the homesteads are female-headed (Statistics South Africa 2001). The land is in trust to the Tribal Authorities but owned by the state, and community members may utilize the land subject to legislation and local rules. The communities at Mngazana and a non-profit organization hope to devise a SFM plan for the mangrove forest that will permit mangrove harvesting.

METHODS

Investigations focused upon *Rhizophora mucronata* and *Bruguiera gymnorrhiza* as these species are utilized exclusively for building construction. They are harvested by cutting the main stem at its base; this entire stem minus branches is used in building construction. It has been suggested that *R. mucronata* can regenerate after cutting 'if cut high enough on the stem that live branches (with leaves) are spared' (Walters 2005a: 344), but coppicing of cut stems has never been observed at Mngazana for *R. mucronata* and *B. gymnorrhiza* (Adams *et al.* 2005) and thus, under the current cutting regime, one stem equates with one tree destructively harvested. Therefore, demand (and supply) calculations can use numbers of individual trees rather than weight and volume measurements of wood.

Mangrove utilization for building construction purposes has been determined through empirical observations supplemented by information from semi-structured interviews with homestead occupants and group discussions. As house construction activities only occur every few years, a respondent's recollections concerning quantities of materials used may not be very precise, so empirical observations are generally more reliable (Shackleton & Shackleton 2004). The villages of Mqualeni, Cwebeni and Tekweni were selected for study. There are 574 homesteads in these villages (Statistics South Africa 2001) and of these, 108 (19%) were randomly selected and surveyed, 32 in Cwebeni, 48 in Tekweni and 28 in Mqualeni. The semi-structured interviews with homestead occupants were in Xhosa (the vernacular language spoken in the area) with English translation. The interviews were designed to elicit information regarding mangrove characteristics, utilization and building longevity. Within each homestead the number and shape of individual buildings were recorded. Buildings constructed with mangroves were identified and the number of mangrove poles utilized in each structural unit (wall poles, roof poles and roof laths) was counted. The diameter of mangrove stems used in each structural unit was determined by sampling a random ten exposed stems and measuring the diameter using metal callipers to the nearest millimetre. The length of stems used for different units was obtained through group discussions. The presence of alternative building materials was also recorded. Three group discussions with community members were held from October 2003 to October 2004 and relevant information from these has been included for comparative purposes. Groups were composed of members of the Mngazana Mangrove Management Forum and interested villagers from all three villages, between 11 to 20 people attended each meeting.

Human population growth rates were estimated from the 2001 South African census (Statistics South Africa 2001) and the population estimates of the United Nations (United Nations 2005). The following terminology will be used throughout this paper: homestead: an area allocated for a family's dwellings, usually consisting of several different individual buildings; mangrove used as a prefix to structural unit, building or homestead denotes use of mangroves in construction. Utilization was calculated at different scales of structural unit, building, homestead and village using the procedure summarized in Figure 2.

RESULTS

Mangrove utilization

Group discussions and direct observations indicated that the main use of mangroves is for building construction: *Rhizophora mucronata* and *Bruguiera gymnorrhiza* are the only species utilized for this purpose. An extremely small minority of homesteads used these species for non-building construction purposes such as fencing. *Avicennia marinia* was collected by some homesteads for fuel wood; dead wood was preferred to green wood. There was a low frequency of collection because non-mangrove tree species were also utilized for fuel wood. This study focuses upon construction use because it is the predominant use of green mangrove wood.

Mangrove stems in standing structures

Buildings constructed from mangroves are circular or rectangular. Both of these shapes are constructed from structural units of wall poles, wall laths and roof poles. Wall poles are positioned vertically and then laths laid at ninety degrees to these to produce a framework.

The average number of mangrove stems used in building units constructed *entirely* from mangroves was calculated for all three villages (Table 1). A circular building if constructed entirely from mangroves would utilize 155 stems, ± 110 of these would be wall laths and the remainder wall or roof poles. Rectangular buildings composed of only mangrove stems utilize more than double the number of stems (± 378 stems), because the wall laths require 335±151 stems. Requirements for wall and roof poles are approximately similar. The average diameter of poles was 6.1±2.0 cm (n = 787) and the average diameter of laths was 3.3±1.0 cm (n = 550). Group discussions revealed that poles and laths over 2 m long were utilized.

However, mangroves are utilized in conjunction with other timbers, the percentage of mangroves within these structural units shows variation (Figures 3, 4). Mangroves compose a high percentage of building mate-

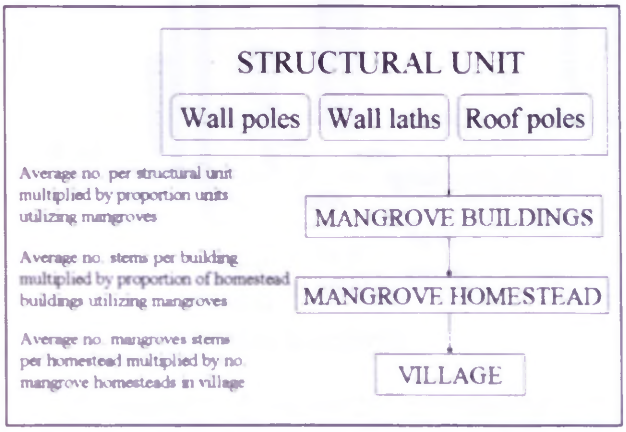

FIGURE 2.—Summary of method used to calculate demand for mangrove stems within each village.

TABLE 1.—Average no. mangrove stems (± std dev.) per building unit constructed *entirely* from mangroves in three villages studied

	Tekweni	Cwebeni	Mqualeni	Average
Circular building				
Wall poles	22 (n = 1)		24±10 (n = 3)	23±8 (n = 4)
Wall laths		96 (n = 2)	125±7 (n = 2)	111±17 (n = 4)
Roof poles	19±6 (n = 37)	24±5 (n = 21)	22±2 (n = 2)	21±6 (n = 60)
Extrapolated				**155**
Rectangular building				
Wall poles		30±6 (n = 2)		25±9 (n = 10)
Wall laths	336±69 (n = 3)	372±172 (n = 19)	281±118 (n = 13)	335±151 (n = 35)
Roof poles	10±1 (n = 2)	15±6 (n = 2)	44 (n = 1)	18±15 (n = 5)
Extrapolated				**378**

rials in the roof poles of circular buildings (up to 100%) and the wall laths of rectangular buildings (75% or more). In other structures, mangroves account for 50% or less of materials. The percentage of mangroves utilized showed variation between the villages studied. Mqualeni Village showed the most consistent use of mangroves and they were utilized in all structural units composing ± 30% to 80% of all stems. In Cwebeni and Tekweni, the percentage of mangroves used shows wider variations. All the roof poles in circular buildings in these villages are mangroves, but mangroves make up 10% or less of wall poles and laths. Rectangular buildings in these two villages display different patterns; mangroves make up 75% or more of wall laths but only up to 25% of wall and roof poles.

A one-way between-groups analysis of variance was conducted to explore the impact of village location upon the number of mangrove stems used in different-shaped buildings. There was a statistically significant difference at the $p = < 0.05$ level for the number of mangroves stems per circular building between villages (F(2, 59) = 10.7, $p = 0.00$). Post-hoc comparisons using the Turkey HSD test indicated the mean score for Maqualeni (M = 72.80, SD = 64.76) was significantly different from Cwebeni (M = 33.00, SD = 28.70) and Tekweni (M = 20.17, SD = 7.50). There was no statistically significant difference at the $p = < 0.05$ level in the number of mangrove stems used in rectangular buildings between villages (F(2,36) = 2.32, $p = 0.11$).

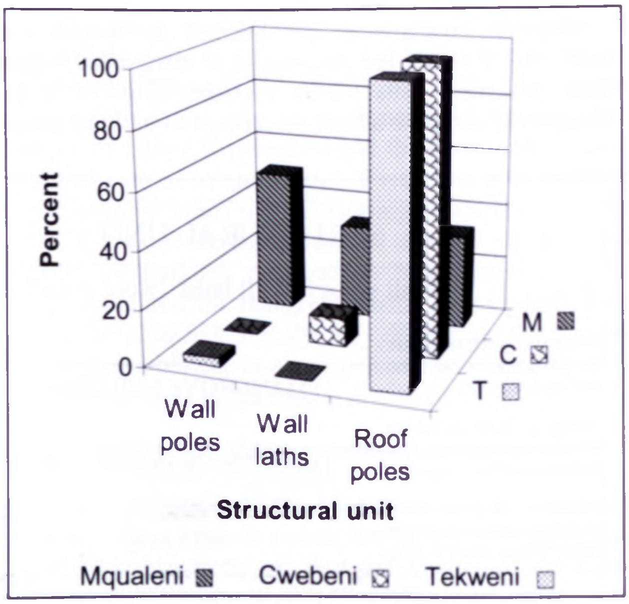

FIGURE 3.—Percentage of mangrove stems used within structural units in circular mangrove buildings.

Typical homesteads in the villages studied consist of circular and rectangular buildings, constructed from a variety of materials including indigenous timber and blocks.

Thus a conversion factor was utilized to estimate the number of mangrove stems utilized per homestead (Table 2). This conversion factor was the average number of mangrove stems in mangrove buildings multiplied by the average number of buildings containing mangroves in homesteads (that utilized mangroves). Accounting for these variations, mangrove homesteads used an average of 89 stems in Tekweni, 346 stems in Mqualeni and 397 stems in Cwebeni. The percentage of homesteads utilizing mangroves was 54% in Tekweni, 79% in Mqualeni and 88% in Cwebeni.

At the village scale, the total number of homesteads using mangroves was 67 in Mqualeni, 96 in Tekweni and 272 in Cwebeni and the estimated total number of mangrove stems utilized was 8 581 stems in Tekweni, 23 108 stems in Mqualeni, 108 034 stems in Cwebeni. Thus in total, 139 723 mangrove stems were utilized in standing structures within buildings at the time of the study.

Current annual demand for mangrove stems (2004)

The percentage of new buildings compared to the total number of buildings was 3% in Tekweni, 16% in Cwebeni and 18% in Maqualeni. As the different-shaped buildings utilize different amounts of mangrove stems,

TABLE 2.—Conversion of mangrove utilization figures from buildings to homestead level

	Tekweni		Cwebeni		Mqualeni	
	C	R	C	R	C	R
Average no. stems per building (a)	21	255	33	358	61	254
Average no. buildings containing mangroves per homestead (b)	0.37	0.32	0.43	1.07	0.55	1.23
Average no. mangrove stems per homestead by building shape (a × b)	8	81	14	383	34	312
Total average no. mangrove stems per homestead	89		397		346	

C, circular building; R, rectangular building.

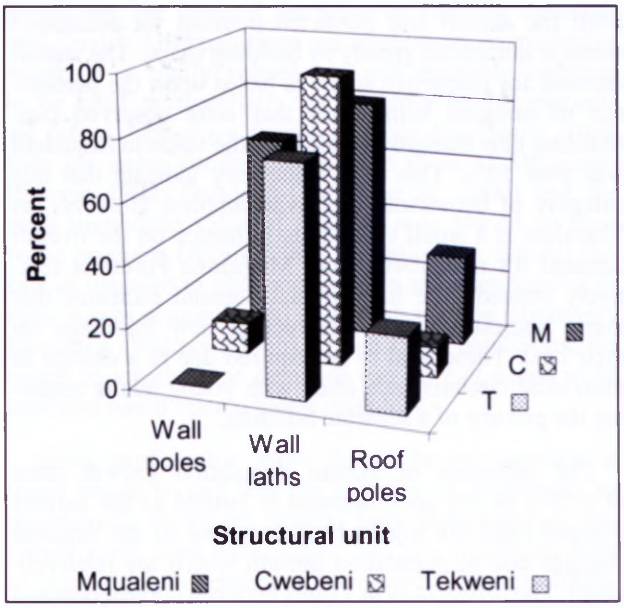

FIGURE 4.—Percentage of mangrove stems used within structural units in rectangular mangrove buildings.

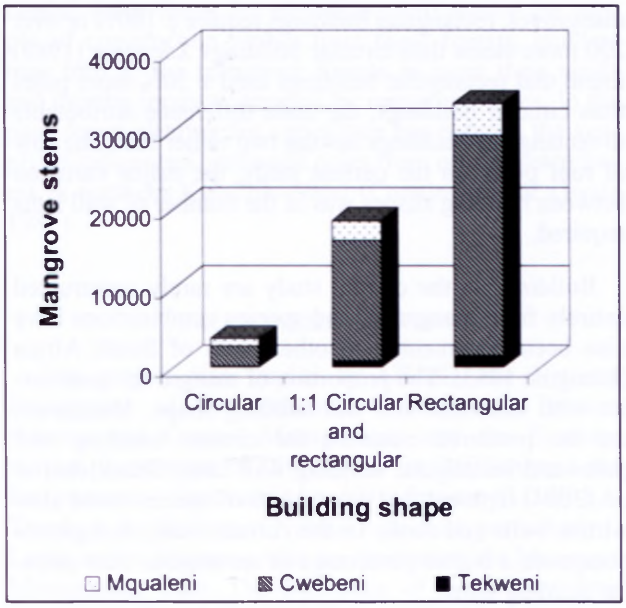

FIGURE 5.—Demand for mangroves in 2004 under different building-shape scenarios.

the shape of buildings constructed has an important influence upon demand for mangrove stems. The ratio of circular to rectangular mangrove buildings in the villages studied was 1:1, thus the current demand for stems can be calculated using this building shape ratio. Circular buildings utilize fewer mangrove stems than rectangular buildings, thus demand from circular buildings represents the minimum number of stems necessary to fulfil housing requirements and demand from rectangular buildings represents maximum demand. Using these demand scenarios, the minimum demand would be for 3 700 stems, the 1:1 demand would be for 18 400 stems and the maximum demand for 33 500 stems (Figure 5).

Group discussions suggested that the longevity of mangrove buildings was 10 years and homestead surveys suggested an average of 20 years, thus, the average is 15 years.

Predicting future demand scenarios

Future demand for mangrove stems can be estimated using human population growth predictions derived from past growth rates or demographic models. Past rates (1996–2001) of annual human population growth in all three villages was 3% (Statistics South Africa 2001). However, this census data may underestimate the impact of HIV/AIDS upon the population and as the most direct demographic consequence of HIV/AIDS is an increase in mortality (Whiteside 2001) demographics will change. The United Nations demographic models take account of the effect of HIV/AIDS and in South Africa annual human population growth rates were estimated to be 0.78% for the period 2000 to 2005 (United Nations 2005).

The influence of a decade of human population growth on mangrove stem demand can be estimated using the different human population growth forecasts and various building-shape scenarios (Figure 6). These estimates suggest that under the 0.78% human population growth rate, demand in all building scenarios over the next ten years will increase gradually but it will not exceed more than 0.5% of the current demand figure. Under the 3% human population growth forecast, demand for mangrove stems increases by 6% of current estimated values, and in the maximum demand scenario of rectangular buildings, an additional 2 628 stems per year would be required in 2015 compared to current values.

DISCUSSION

The investigations have demonstrated that different-shaped buildings require a different total number of resource stems. In buildings constructed entirely from

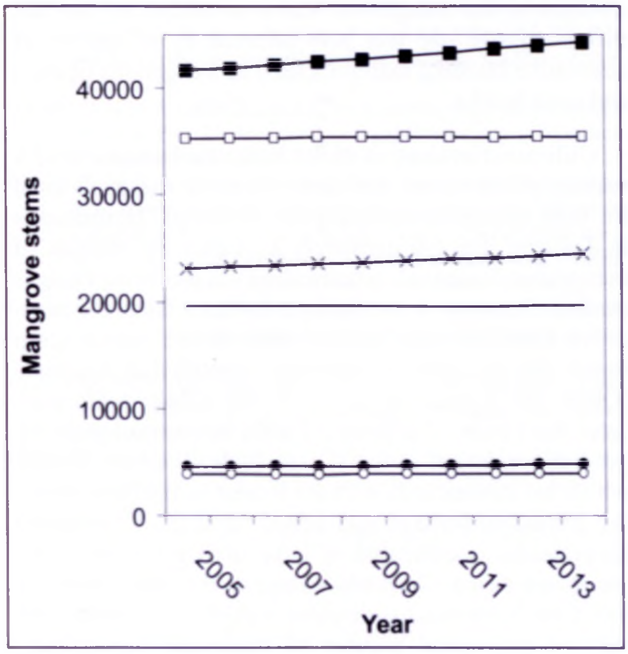

FIGURE 6.—The predicted demand for mangrove stems under different population growth forecasts and building-shape scenarios. -■- 3% growth (rectangular); -□-0.78% growth (rectangular); -*-3% growth (circular and rectangular); — 0.78% growth (circular and rectangular); -◆- 3% growth (circular); -○- 0.78% growth (circular).

mangroves, rectangular buildings require ± 100% or over 200 more stems than circular buildings. Liengme (1983) found that rectangular buildings used ± 50% more poles than circular buildings, the main difference attributable to rectangular buildings having two rather than one row of roof poles. In the current study, the major variation between building shapes was in the number of wall laths required.

Buildings in the current study are rarely constructed entirely from mangroves and species combinations have also been documented in other parts of South Africa (Liengme 1983). The proportion of mangroves used varies with structural unit and building shape. Mangroves are the preferred materials for circular building roof poles and rectangular building wall laths. Shackleton *et al.* (2004) reported that proportions of species could alter within walls and roofs. In the current study, mangroves composed a higher percentage of rectangular than circular building stems.

The average distance from surveyed homesteads to the mangrove boundary was 393 m in Mqualeni, 1 733 m in Tekweni and 2 040 m in Cwebeni. Mangrove use varied spatially between the villages; mangroves are used for all structural units in both circular and rectangular buildings in Mqualeni Village, however in Tekweni they are rarely used as roof poles and never used as circular building wall laths. Circular buildings have curved walls and group discussions revealed that indigenous species from the coastal scarp forests were preferred for this purpose because they were more flexible than mangroves. In Mqualeni Village, mangroves were often used for circular wall laths as the mangrove resource was nearby, ± 400 m from homesteads. Similar examples of resource selection for less preferred species due to higher availability and ease of collection have been documented by Nomtshongwana (1999) and Walters (2005b). In the current study, the relationship between mangrove use and distance to the mangroves was confounded by the fact that mangrove use was also affected by utilization of alternative building materials such as indigenous timbers and sand blocks.

Utilization evaluation at the homestead scale shows a variety of mangrove and non-mangrove materials used for both circular and rectangular buildings. Homesteads in Tekweni use approximately a quarter the amount of mangroves compared to homesteads in the other villages studied. Tekweni is the furthest distance from the mangrove forest and also has proximity to the coastal scarp forest that can provide building construction materials (Obiri 1997). Analysis of use at the village scale indicates that observed differences at the homestead scale are generally enlarged at the village scale. Tekweni Village which has homesteads with the lowest utilization values, the lowest percentage and actual number of mangrove homesteads, is estimated to have used less than 9 000 mangrove stems. Cwebeni Village at the other extreme, has high homestead utilization values and a high percentage and actual number of mangrove homesteads. These factors combine to produce utilization figures of approximately 100 000 stems.

Demand for a resource may constantly change and the dynamic needs to be understood (Ellery *et al.* 2004). Both the annual and predicted demand for mangrove stems is influenced greatly by building shape. The annual demand for mangrove stems is based upon the percentage of sampled homesteads that were observed constructing new mangrove buildings, the value in Mqualeni was over 50%. This high value may indicate that this category of homestead was over-sampled. However, as Mqualeni is a small village, its influence on the overall demand for mangroves from Mngazana Forest is relatively limited. The high annual demand indicates that many homesteads are constructing new buildings on their land. These tend to be required due to a change in individual circumstance often with young adults requiring the privacy of a separate building.

The influence of human population growth rates of 0.78% or 3% upon demand is limited as the current demand rates are high when compared to the demand changes due to population growth which are relatively small. The differences in values between current demand in 2004 and predicted demand in 2015 due to human population growth suggest that there are factors other than human population growth which are influencing the construction of new buildings. These factors may include maturing children who desire their own private room or marriage of family members who remain on the homestead and family members returning to live at the homestead such as migrant workers. Although demand is predicted to show minor changes due to human population growth rates, it could change drastically due to the shape of the new buildings being constructed.

In the past, fuel wood models were devised that predicted future demand scenarios and an impending ‘fuel wood crisis’, however this never materialized; the models failed partly because they did not appreciate the complexity of rural energy and focused upon supply without accounting for demand changes (Shackleton *et al.* 2004). Humans demonstrate adaptability to resource decline and increasing scarcity and Shackleton (1993) reported that where demand for the preferred fuel wood—dead wood—outstripped supply, harvesters responded by selecting the non-preferred live wood resources and even developed strategies to circumvent legislation. Factors such as these may well influence the demand scenarios presented for Mngazana, particularly as although mangroves are generally preferred for building construction, the inhabitants are not strictly reliant upon them and can obtain alternative timber resources from the indigenous terrestrial forests or use mud or sand blocks for construction.

A previous study concerning wood utilization for building construction focused upon quantities used per building (Liengme 1983). This study demonstrates that the number of stems required per building, the proportion of a species used in different structural units, the building shape and the proportion of buildings constructed from different materials must all be evaluated so that a realistic estimate of wood use can be determined.

Sustainable Forest Management at Mngazana must recognize that the local communities utilize the mangroves for building construction and that the people have a right to access mangrove wood products. Given the socio-economic status of the local communities at

Mngazana, the demand for low-cost building materials will persist. Although there are alternatives to mangrove wood, it is highly valued and will probably continue to be used preferentially for building in the immediate future. Mangrove forests in other developing countries are under similar pressures to those of Mngazana (Semesi 1992; Dahdouh-Guebas *et al.* 2000) and the most immediate value of mangroves is placed on their wood products (Alongi 2002). Additionally, natural forests as opposed to plantation forests are often viewed as open access resources and as a result may be intensively harvested (Walters 2005b). Given these conditions, the extent to which these demands can be met needs to be analysed based upon a forest inventory.

SFM implies that there should be no decrease in wood products and that the capacity to regenerate be maintained. However, studies have demonstrated that 'small-scale, local woodcutting can be a significant form of ecological disturbance in mangroves' (Walters 2005a: 345), and it has been shown that forest structure was dramatically altered.

A desktop extrapolation, to determine the sustainability of current extraction rates, was made using published data from Adams *et al.* (2005). They reported that the density of trees greater than one metre high in the Mngazana Estuary was 230 *Bruguiera gymnorrhiza* trees and 489 *Rhizophora mucronata* trees per hectare. As the Mngazana Estuary covers an area of 145 ha this suggests that there are ± 104 255 trees > 1 m height of *B. gymnorrhiza* and *R. mucronata.* With an estimated annual demand of 18 400 stems, the annual off-take would be approximately 17.6%. The resource would last for five and a half years at the current demand, without any recruitment. This is only sustainable in the very short term. Such a desktop extrapolation can be used as a guideline within an adaptive management context. Further investigations concerning recruitment and growth rates are required to accurately assess sustainability. As Mngazana has already been subjected to past harvesting, the forest must be assessed to determine whether the present community structure is functioning in a desirable state or if current stands need to be improved. Harvesting needs to be planned so that the ecosystem functioning and biodiversity are maintained. Studies suggest that mangroves can be managed sustainably for their wood, the Matang Mangrove Forest in Malaysia has been managed since 1906 for commercial purposes and continues to be productive (Hogarth 1999).

SFM should also aim to broaden the range of benefits derived from the mangroves, particularly of non-consumptive uses. Activities such as mangrove honey production, could demonstrate that non-consumptive mangrove uses have the potential to generate incomes. External factors that may affect demand also need to be considered: at Mngazana these include the link between mangrove use and use of other indigenous timbers and alternatives to mangroves such as sand blocks. In the village of Cwebeni, a group was formed to produce and locally sell sand blocks for building construction. These blocks are durable, highly regarded as building materials and, if competitively priced, could reduce demand for mangrove stems. Other factors may indirectly affect demand for mangroves, for example clearing of the coastal scarp forest for agriculture will reduce the supply of construction timber from these forests, builders may turn to the mangrove forests to meet their needs and thereby increase demand for mangrove stems. In the past, forest clearing for agriculture has reduced the supply of indigenous hardwood poles from coastal scarp forest in northern KwaZulu-Natal (Cunningham & Gwala 1986).

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