VARIATIONS IN MOPANE VEGETATION AND ITS USE BY LOCAL PEOPLE: COMPARISON OF FOUR SITES IN NORTHERN NAMIBIA

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ABSTRACT The aim of this study was to clarify variation in mopane (*Colophospermum mopane*) vegetation in northern Namibia, focusing on the differences and commonalities in vegetation structure and tree uses by local people. Four study sites representing different land units classified by landscape, land use patterns, and its use by different ethnic groups were selected. Vegetation surveys at each site found mopane as the dominant species at all sites, although mopane density ranged from 217.1 to 868.7 individual trees/ha among the sites/land units. There were four types of mopane tree shape by tree height and stem number. The ratios of other tree species to mopane differed much among land units and sites. Interviews with the local people on mopane utilization found that they were highly dependent on trees as a resource for fuel and building material, and commonly used mopane at all sites. Although the mopane utilization was similar among all four sites, the non-mopane tree utilization depended on the characteristics of the tree species composition at specific sites. Mopane vegetation was naturally characterised by the dominance of mopane, but the sites were heterogeneous in species composition, mopane tree shape, and its use by local people, which were mutually interrelated.

Key Words: *Colophospermum mopane*; Tree uses; Tree shape; Semi-arid regions; Namibia.

INTRODUCTION

Mopane vegetation is a unique vegetation type found in southern Africa, dominated by the mopane tree (*Colophospermum mopane* Kirk ex Benth), a member of the Caesalpinioideae. Many ecological and physiological studies of mopane vegetation have indicated homogeneity in species composition, which can account for more than 90% of the total phytomass (Werger & Coetzee, 1978: 352–363) with few other species present. One factor in this dominance is the root system of mopane, which is wide and shallow, preventing the growth of other plant species such as grass and herbs (Timberlake, 1999). This poor understorey vegetation ensures that fire damage is minimal (White, 1983: 94). Another characteristic of mopane vegetation is the different shapes of the trees, which range from single trunk trees to multi-stemmed shrubs (e.g., Styles & Skinner, 2000). The region dominated by dense, small mopane is called mopane shrub land (e.g., Strohbach, 2000). In contrast, tall, relatively sparsely distributed individual mopane

trees dominate the mopane woodland (Fuller, 1999).

Mopane vegetation is found in eight countries in southern Africa (Mapaure, 1994), where many different ethnic groups live. The importance of mopane as a natural resource and source of income in the daily lives of local people has been reported previously (e.g., Timberlake, 1999). Ethnobotanical research has been undertaken (e.g., Cunningham, 2001; van Wyk & Gericke, 2000) in relation to the ethnography of specific ethnic groups. There have been many studies of the natural environment and changes in its use over time that identified the effects of human settlement and subsistence on the environment. Such human activities have led to the reduction of mopane vegetation in many areas (e.g., Erkkilä & Siiskonen, 1992).

As mentioned above, mopane vegetation is distributed across a large spatial area, subject to effects from different climatic zones, topographies, and resident ethnic groups, which has lead to variation in species composition and tree use by the local people. However, the variation in mopane vegetation types in relation to the natural environment and the diverse daily lives of local people have not been discussed. To clarify the characteristics of the mopane ecosystem and ecological functions of the vegetation is important for the sustainable use of the mopane vegetation and conserving the mopane ecosystems.

For this study to identify the variation in mopane vegetation, the authors focused on the differences and commonalities of vegetation structure and the local tree uses in northern Namibia, through land unit classification. The four research sites were selected according to different features in the landscape (e.g., two mountainous areas and two plain areas) and the different ethnic groups living in these areas. The underlying hypotheses were as follows: 1) difference in the ethnicity of the local residents was related to different use patterns of mopane vegetation, and 2) different features in the landscape influenced the use of natural resources by the local people. Each site was classified into land units according to landscape, including landform and land-use patterns. Then the vegetation structures and tree use patterns were compared among land units within each site and among the four sites.

STUDY AREAS

Mopane is a semi-deciduous tree, with some trees having leaves even in the dry season. It has a characteristic leaf shape, with the leaf composed of two small leaflets that resemble a butterfly. Mopane grows at around 15–20° S in southern Africa (Fig. 1). The mean annual precipitation in mopane vegetation areas ranges from 200–1,000 mm/y (Werger & Coetzee, 1978: 352–363) and is concentrated in a rainy season around December to March. Mopane often dominates the alluvial plains of large rivers, and is also found on clay-rich soils (Werger & Coetzee, 1978: 352–363). The geographical distribution of mopane vegetation is controlled by several factors, including temperature (Stevens et al., 2014; Henning & White, 1974), day length in the dry season (Stevens et al., 2014), soil moisture availability (Harrington, 1991), and shade and competition with grass (Mlambo et al.,

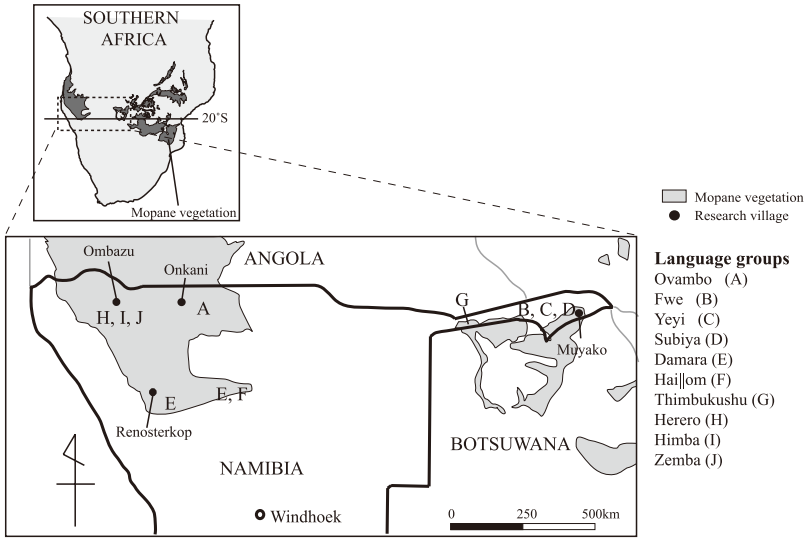

Fig. 1. The distribution of mopane vegetation and people.
Mopane distribution data compiled from Mapaure (1994).
Distribution of language groups and major dialects compiled from Mendelsohn et al. (2002). Showing only the language groups distributed in mopane vegetation.
Distribution data of Otjidhimba (Zemba) group compiled from Gordon (2005).

2005; van der Waal et al., 2009).

In Namibia, mopane vegetation is found in the northern part of the country (Giess, 1971). Its distribution can be roughly divided into two regions, the northwestern to north-central and the north-eastern (Fig. 1), with no mopane trees found between these two regions due to the occurrence of frost (White, 1983: 94). Northwestern Namibia is mountainous, with an escarpment running from north to south. The north-central and north-eastern areas are plains covered by Kalahari sand, which is widely dispersed in southern Africa and contains little organic matter or nutrients (Thomas & Shaw, 1991). The human population and livelihoods in the mopane vegetation area of Namibia are heterogeneous. A few pastoralists live in the northwestern mountainous areas, while many agro-pastoralists live in the north-central plain area. Language groups in the mopane areas include Ovambo, Fwe, Yeyi, Subiya, Damara, Hai||om, Thimbukushu, Herero, Himba and Zemba (Fig. 1).

The four research sites selected in northern Namibia are inhabited by different language groups (Table 1). The first site, the Renosterkop settlement, is located in the Kunene Region in the mountainous area (Fig. 2a; 900–1,400 m asl) and is inhabited by approximately 40 Damara people, who can be found from the northern Erongo Region to the Kunene Region in the southwestern mopane zone. Khorixas town near Renosterkop has a mean annual precipitation of about 220 mm with large year-to-year fluctuations (unpublished data provided from the Namibia Meteorological Service). The population density in this area is low at 0.6 individuals/km^2 compared with the average of 2.1 individuals/km^2 for Namibia as a

whole (Central Bureau of Statistics, 2003). The low precipitation hinders crop growth, and raising goats and cattle is the main agricultural activity. Although the people have led a nomadic life in the past, they are now settled and well established (Steyn & Pisani, 1984).

The second research site, Ombazu village, is also located in a mountainous area of the Kunene Region (Fig. 2b; 1,200–1,600 m asl), 300 km north of the Renosterkop. Opuwo town, about 40 km south of Ombazu, has a mean annual precipitation of less than 350 mm (unpublished data provided from the Namibia

Table 1. Characteristics of the study sites

Village Name	Renosterkop	Ombazu	Onkani	Muyako
Region	Kunene	Kunene	Omusati	Zambezi
Altitude (m)	900–1,400	1,200–1,600	1,100	1,000
Annual Rainfall (mm)	220	350	400–600	600
Language Group	Damara	Himba/Herero/ Zemba	Ovambo	Subiya
Population	40	200	670	1,800
Land Unit	Plain/Hill/Mountain	Hill/Mountain	Plain	Plain
Sub Land Unit	—	—	Grazing Land/ Crop Field	Termite Mound/Off the Termite Mound

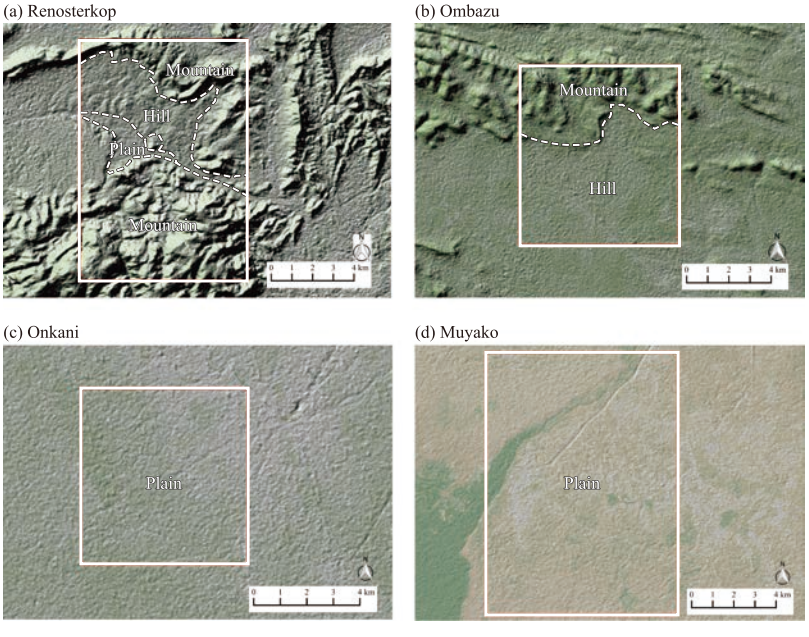

Fig. 2. Distribution of land unit in four sites.
Data source: Aster G-DEM and Landsat 8.
White square shows the area with research quadrats.
Dashed lines represent the border of each land unit.

Meteorological Service). Approximately 200 people belonging to the Herero speaking group live dispersed in the village and are composed of sub-groups, the Himba, Herero, and Zemba people. They are generally pastoralists, but the Zemba engage in crop farming (Carlos & Gibson, 1981). In Ombazu village, Zemba people live mainly on livestock farming and crop farming, and Himba and Herero people make their living raising cattle and goats.

The third research site, Onkani village, is located in the Omusati Region on a flat plain, the Cuvelai Basin (Fig. 2c; 1,100 m asl). The mean annual rainfall is 400–600 mm (Mendelsohn et al., 2000). The population density is relatively high for Namibia (8.6 individuals/km^2 in Omusati Region in 2001; Central Bureau of Statistics, 2003), and about 670 Kwambi people, a sub-group of the Ovambo group, live in this village (Uno, 2005). A unique geographic feature of the area is the distribution of many seasonal rivers (Marsh & Seely, 1992), where water remains until the mid to late dry season and riverbeds are covered with grass, with only a few trees. The main forms of subsistence among the Kwambi people are crop farming and raising livestock. Onkani village was founded in the 1970s. The local people have heavily over-utilized the forested areas of this village. The landscape of the forest is largely divided into two types by land use and tree density: crop fields and grazing lands. Although most trees are removed from the crop fields that are ploughed every year, few trees remain inside the field wide apart. In contrast, trees and grasses densely cover the grazing lands.

The fourth research site, Muyako village, is located in the Zambezi Region (former Caprivi Region) on a flat plain (Fig. 2d; 1,000 m asl). The mean annual rainfall is more than 600 mm (Mendelsohn et al., 2002). About 1,800 people live in this village, and the main ethnic group is Subiya. The population density here was relatively high for Namibia (5.5 individuals/km^2 in Caprivi Region in 2001; Central Bureau of Statistics, 2003). The main forms of subsistence in this village are crop farming and fishing, although some people keep livestock. This site is within the community forest, established in 2008, covering over 12,000 ha around the village. In the community forest, villagers need permission to cut trees for building material. In this area, large termite mounds of *Macrotermes* species (Uys, 2002) form a distinct landscape. The density of the mounds is one to two per hectare, with diameters a few to several tens of meters, and heights of several meters. Compared with the surrounding savanna, tree density and species variation are apparently higher on these mounds (Yamashina, 2014).

METHODS

I. Classification of Land Unit

A land unit is designated by a combination of landform, soils, and climate condition, which results in a kind of homogeneity within terrain units (Zonneveld, 1989). The land unit is the main concept in landscape ecology and is widely used in land system surveys. In this paper, land unit was especially characterised by the geomorphological landform, which generally regulated the diversity of the

landscape of the site. Land units recognized in the four sites were the mountain, hill, and plain areas. Mountain areas were characterised by steep slope angles and outcrops of bedrock. Hill areas had relatively gentle slopes (< 10°) with a shallow soil layer, sometimes defined as pediment. Plain areas were flat zones that ranged from small alluvial plains to the vast Cuvelai Basin. Additionally, we defined the sub land unit as the detailed category of land unit based not only on the classification of fine-scale landforms, but also the local land use, which is an important factor to the difference in landscape. Sub land units were grazing land and crop field in Onkani, on the termite mound and off the termite mound in Muyako, respectively.

In Renosterkop, there are three land units around the village (mountain, hill, and plain areas), with huts in the plain area (Fig. 2a). The hill area is commonly used as grazing land for domestic animals, whereas the mountain area is not. The land units around Ombazu were the mountain and hill areas (Fig. 2b). Huts are sparsely located on the hills, within an area of 3 km^2, in small, confined and relatively flat areas, such as found on the plains and hills. In contrast, Kwambi homesteads are widely dispersed over hundreds of meters to a few kilometres in Onkani, and located away from the riverbed area (Fig. 2c). Because the distance between homesteads is large, there are many mopane trees on the land between homesteads and in the nearby fields. Muyako is located in a totally flat area (Fig. 2d), with Lake Lyambezi on the west side of the village. Part of the area is flooded seasonally, with floodwaters arriving from the north.

II. Vegetation Surveys and Observations of the Daily Livelihood

Field surveys were conducted at the four sites, from Aug. 2006 to Mar. 2007 in Renosterkop, Aug. 2006 to Feb. 2007 in Ombazu, Jan. 2003 to Oct. 2004 in Onkani, and Sep. to Dec. 2009 in Muyako. The authors surveyed the structure of vegetation stands at the four sites (including diameter at breast height (DBH), tree height, scientific name, and stem numbers), and targeted trees with a DBH of more than 1 cm. Names of tree species were recorded in each local language, and the corresponding scientific names identified, using textbooks (e.g., Curtis & Mannheimer, 2005; van Wyk & van Wyk, 1997). The NBRI (National Botanical Research Institute, Namibia) identified the scientific names for some specimens of leaves.

The authors set quadrats (20 × 20 m) for the vegetation surveys in Renosterkop: 27 quadrats in an area of 5 × 10 km around the village, 9 near huts on the plain (0.36 ha), 9 on the hills (0.36 ha), and 9 in the mountainous area (0.36 ha). In Ombazu, we set 13 quadrats and 8 transects in 2 × 3 km plots around the village, 8 quadrats and one transect in the hilly area (0.56 ha), and 5 quadrats and 7 transects in the mountainous area (0.15 ha). In Onkani, we set 6 plots in an area of 5 × 5 km around the village, 3 in the grazing lands (4.6 ha) and 3 in the crop fields as sub land unit (4.8 ha). Species other than mopane are dispersed both on grazing lands and crop fields of this area, so that the authors set large sized plots for both lands. Villagers used fences for each piece of land that belonged to one household for both grazing and raising crops, and the authors

chose 3 of these fenced-in lands including 3 grazing lands and 3 crop fields as research plots, with the fences as plot boundaries. In Muyako, 28 quadrats (20 × 20 m) were set around the village (10 × 10 km), 14 on termite mounds (0.56 ha) and 14 quadrats off the mounds (0.56 ha). The authors selected 14 termite mounds with a diameter wider than 20 m for the survey. The remaining 14 quadrats were at least 50 m away from the mounds.

The authors also made observations of the livelihoods and daily activities of the residents at the sites, and interviewed them to determine their tree use. We selected two to three persons at each site for interviews: two men (in their 50's and 60's) in Renosterkop, a man and woman (in his 60's and her 50's) in Ombazu, two men and a woman (in their 80's and 60's, and 60's, respectively) in Onkani, and two men and a woman (in their 30's and 40's, and 40's, respectively) in Muyako. If the respondents used plants and trees, we asked how they used them, showing them samples of flower, leaves and twigs collected from the field. We also asked them the species that they used for daily tools, firewood, food, medicine and livestock farming. After the interview, we confirmed the information with more than two other villagers.

STAND STRUCTURE OF MOPANE VEGETATION AT THE FOUR SITES

I. Structure of Mopane Populations and Tree Shape

Although mopane was the dominant species at all four sites, the structure of the mopane population and the shape of mopane trees differed substantially among the sites and within a site by land unit. The two mountainous areas (Renosterkop, Ombazu) had relatively low mopane density, from 217.1 to 450.0 individuals/ha compared with the two plain areas (Onkani, Muyako), at 831.3 to 868.7 individuals/ha (Table 2). The mopane density of the plain area land unit in Renosterkop was low at 238.9 individuals/ha.

The mopane tree survey found variation in terms of tree height (tallest at aprox. 10 m) and stem number (single or multiple). Table 2 shows the mopane population divided by tree height and stem number, and the proportion of trees in each category. The dominant category varied by each land unit and site. In Renosterkop, mopane in hilly and mountainous areas accounted for 82.1 to 85.8% of the 1–3 m height category, and most (73.5% in hill areas, 70% in mountain areas) had several stems originating near ground level. There were mopane of various heights in the plain area and also many single-stemmed trees. In Ombazu, mopane of various heights and shapes were found in both hilly and mountainous areas. In hilly areas, the proportion of single and multi-stem mopane trees was similar, while more single-stem mopane trees were found in mountainous areas. Tall trees (> 5 m in height) were relatively abundant compared with the other three sites, accounting for 44% and 30% of all trees in hilly and mountainous areas, respectively. Onkani and Muyako, both plain areas, had shorter trees 1–3 m high (99.8 and 71.3% of all trees in Onkani and Muyako, respectively), but the stem number varied, predominantly multi-stemmed in Onkani and single-stemmed in

Table 2. Distribution of the shape of mopane trees around four villages

Name of Settlement		Renosterkop						Ombazu				Onkani				Muyako			
Land Unit		Plain		Hill		Mountain		Hill		Mountain		Plain		Plain		Plain		Plain	
Sub Land Unit		—		—		—		—		—		Grazing Land		Field		Termite Mound		Off the Termite Mound	
Mopane Density (individual per ha)		238.9		450.0		333.0		217.1		251.8		868.7		2.1		846.2		831.3	
Stem Number (Single/Multi)		S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M	S	M
Tree Height (%)	1–3 m	5.8	7.0	8.6	73.5	15.8	70.0	15.3	6.8	31.8	9.1	2.0	97.8	50.0	40.0	58.3	13.0	47.7	18.8
	3–5 m	15.1	23.3	6.2	12.3	7.5	6.7	13.6	20.3	18.2	11.4	0.1	0.1	10.0	0.0	7.1	14.6	7.0	15.8
	5–7 m	9.3	7.0	—	—	—	—	16.9	13.6	6.8	6.8	—	—	—	—	1.8	4.3	0.8	5.0
	7 m <	22.1	10.5	—	—	—	—	8.5	5.1	6.8	9.1	—	—	—	—	0.5	0.5	2.3	2.5
Total % (individual)		100% (86)		100% (162)		100% (120)		100% (59)		100% (44)		100% (3,996)		100% (10)		100% (439)		100% (398)	
Type of Mopane Shape		TS/TM		SM		SM		TS/SM		SS		SM		SS/SM		SS		SS/SM	

Types of mopane shape: TS, tall and single-stemmed; TM, tall and multi-stemmed; SS, short and single-stemmed; SM, short and multi-stemmed.

Muyako. In Onkani, about one third of mopane (34%) had cut marks, suggesting that most had regenerated from shoots after cutting at this site. In contrast, more than half of the mopane found in the crop field in Onkani were single-stemmed (60%). This implies that people kept the single-stemmed mopane inside their crop field, rather than cutting them down.

The mopane tree shape could be divided into four types by tree height (short/tall) and stem number (single/multi): (1) tall and single-stemmed (TS), (2) tall and multi-stemmed (TM), (3) short and single-stemmed (SS), and (4) short and multi-stemmed (SM) types (Fig. 3). The four types were identified in the mopane vegetation in each land unit. Mopane in the plain area in Renosterkop and the hilly area in Ombazu were predominantly the TS type, but each land unit was also characterised by the TM and SM types. The mountainous area in Ombazu and the plain area in Muyako were predominantly SS type. The hilly and mountainous areas in Renosterkop and the plain area in Onkani were predominantly the SM type. Although all four sites were mopane vegetation areas, the mopane tree type differed.

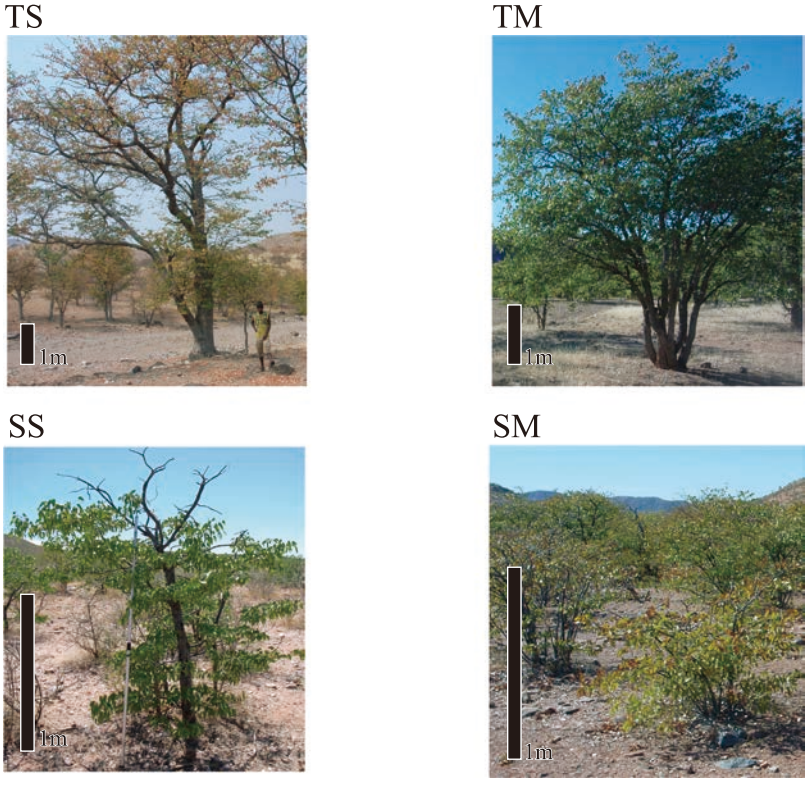

Fig. 3. Four types of mopane at Renosterkop (2008–2009, photographed by Teshirogi).

II. Tree Species Composition in the Four Sites

Mopane dominated the vegetation at all sites, but the ratio of other species to mopane varied among the land units and sites (Table 3). The ratio in mountainous areas in Renosterkop and Ombazu was relatively high, at 0.575 and 3.295, respectively. In contrast, the ratio was low in the plain areas of Onkani and Renosterkop, at 0.006 and 0.198, respectively. Exceptionally, the other species ratio in the plain of Muyako was higher than in other plain sites, with different species composition, probably caused by higher rainfall in this area. Various species also grow on termite mounds in Muyako, and therefore the presence of termite mounds can introduce variety in the local ecosystems.

Of the 66 non-mopane species recorded, 56 (85%) were present at only one specific site. Some species were common in most or all sites: *Terminalia prunioides* and *Combretum imberbe* were present at all four sites, while *Berchemia discolor* and *Ximenia americana* were present at three sites. When considering the differences among land units (but not sub land units), the most abundant species was *Terminalia prunioides* (seven land units), which was present in all land units at all sites. The second-most abundant species, *Combretum imberbe* and *Ximenia americana*, were present in four land units, while the third most abundant species, *Acacia reficiens*, *Berchemia discolor*, *Boscia foetida*, *Catophractes alexandri*, and *Combretum* spp. were present in three land units.

With regard to the characteristic species at each site, at Renosterkop, 16 tree species was observed in 27 quadrats. However, some species were only found on a specific land unit. For example, *Myrothamnus flabellifolius* was found only on mountains, and *Combretum imberbe* only on alluvial plains. Apart from mopane, other species with a high level of cover (but not dominant) in all areas of this settlement were *Terminalia prunioides*, *Combretum collinum*, *Catophractes alexandri*, *Acacia reficiens*, *Boscia albitrunca*, *Myrothamnus flabellifolius*, and *Combretum imberbe*. Other species were rare, and therefore these eight species could be considered to be the key species for determining the vegetation type.

In Ombazu, 25 tree species were found around the village, and mopane was dominant in almost all quadrats. However, the density of trees and the number of species differed by location. Near huts on the hills, mopane and *Terminalia prunioides* accounted for 90% of the total tree population. Of the 20 tree species recorded in mountainous areas, 15 species were found only on mountains. In addition, *Ficus* spp. and *Faidherbia albida* were typical tree species around the springs.

In Onkani, mopane was extremely dominant (99% of all individuals) in three sites. Four other species (23 individuals) were also present in plain area: *Acacia arenaria*, *Commiphora* sp2, *Salvadora persica*, and *Terminalia prunioides*. Crop fields contained four tree species, two species bear edible fruits, such as *Hyphaene petersiana* (dum palm tree) and *Berchemia discolor*.

In Muyako, a total of 38 tree species were found in 28 quadrats. Termite mounds had a total of 34 species, and 17 species were found only on termite mounds. On the other hand, 19 species were found off the termite mounds. Only four species were restricted to off the mounds, with a large predominance of mopane (60% of all individuals).

Table 3. Species composition of trees other than mopane in mopane vegetation areas around the four villages

Name of Village	Renosterkop			Ombazu		Onkani		Muyako	
Land Unit	Plain	Hill	Mountain	Hill	Mountain	Plain	Plain	Plain	Plain
Sub Land Unit	—	—	—	—	—	Grazing Land	Field	Termite Mound	Off the Termite Mound
Other Species/Mopane Ratio (Individuals No.)	0.198	0.414	0.575	0.822	3.295	0.006	0.565	2.388	0.655
Species									
Acacia arenaria						○			
Acacia erioloba	○								
Acacia melifera									○
Acacia nigrescens								○	○
Acacia nilotaca	○								
Acacia reficiens	○	○	○						
Acacia spp.				○	○			○	○
Acacia tortilis								○	○
Adansonia digitata								○	
Adenolobus garipensis			○						
Albizia anthelmintica								○	○
Albizia herveyi								○	
Balanites aegyptica								○	
Berchemia discolor					○		○	○	○
Boscia albitrunca		○	○						
Boscia foetida	○	○		○					
Brachylaena rotundata								○	
Calicorema capitata		○							
Capparis tomentosa								○	○
Catophractes alexandri		○	○		○				
Combretum collinum		○	○						
Combretum hereroense									○
Combretum imberbe	○			○			○	○	○
Combretum sp.				○	○			○	
Commiphora glandulosa								○	○
Commiphora glaucescens					○				
Commiphora mollis					○				
Commiphora mossambicensis								○	
Commiphora sp1.			○						
Commiphora sp2.						○	○		
Cordia spp.								○	
Dichrostachys cinerea			○					○	○
Ehretia spp.								○	○
Euclea divinorum								○	
Euclea pseudebenus	○								

Table 3. (continued)

Name of Village	Renosterkop			Ombazu		Onkani		Muyako	
Land Unit	Plain	Hill	Mountain	Hill	Mountain	Plain	Plain	Plain	Plain
Sub Land Unit	—	—	—	—	—	Grazing Land	Field	Termite Mound	Off the Termite Mound
Euphorbia ingens								○	
Faidherbia albida					○				
Ficus ingents					○				
Ficus sycomorus					○				
Flacourtia indica								○	
Fockea multiflora								○	
Garcinia livingstonei								○	
Grewia flavescens					○				
Grewia spp.								○	○
Grewia tenax					○				
Gymnosporia senegalensis									○
Hyphaene petersiana							○		
Kirkia acuminata					○				
Lonchocarpus capassa								○	
Lonchocarpus nelsii					○				
Maerua angolensis								○	
Mundulea sericea				○	○				
Myrothamnus flabellifolius			○						
Pilostigma thonningii									○
Rhigozum brevispinosum					○				
Rhoicissus tridentata								○	
Rhus tenuinervis								○	○
Salvadora persica						○		○	
Sclerocarya birrea					○				
Spirostachys africana					○				
Sterculia africana					○				
Terminalia prunioides	○	○	○	○	○	○		○	
Terminalia sericea								○	
Vangueria infausa								○	
Ximenia americana	○			○	○			○	○
Ziziphus mucronata								○	○

MOPANE VEGETATION AS A DAILY LIVELIHOOD RESOURCE

I. Mopane Use in the Four Villages

Mopane was used in various ways in the four villages. Villagers used the logs as building material, firewood, and as tool parts. Domesticated goats and cattle

browsed on the mopane leaves. In the three villages, mopane vegetation was included in the fields for crop cultivation.

In all four villages, mopane stem parts were used in building huts, kraals, and fences (Table 4). In Renosterkop and Ombazu, one hut required about 500 and 150 mopane logs, respectively. Logs about the size of 10 cm in diameter were frequently used. In both villages, logs were cut out of standing mopane trees from the hilly areas, usually where logs of appropriate size were found, and these logs were re-used many times. In Onkani and Muyako, smaller logs of less than 5 cm in diameter were mainly used as building material. In Onkani, the homesteads had huts of complex structures, with outer and inner palisades. More than 1,500 logs were used for the outer palisade (Fujioka, 2005). In Onkani, villagers gathered logs near and far away from their homestead because thick mopane vegetation remained. The homesteads in Muyako had a number of huts surrounded by a fence. One hut required about 150–300 mopane logs, and in total, 400–500 logs were used for one homestead. In Muyako, villagers gathered logs away from their homestead, but not from termite mounds. For firewood, only dead mopane was used in Renosterkop, Ombazu and Muyako, while in Onkani villagers cut small stems from standing mopane in the dry season, then dried and used them for fuel. Furthermore, in Ombazu and Onkani, the bark and heartwood of mopane were used for rope and pestles, respectively. In addition, mortar was also made of mopane in Onkani. People in Renosterkop and Ombazu used mopane as medicine to treat coughing.

Livestock farming is important for subsistence for most people in the four villages. Livestock were fed on mopane and other tree species, as well as grass species. In Renosterkop, an interview with herders revealed that goats preferred to browse the leaves of SM type mopane (Teshirogi, 2010a; 2010b). One herder noted that, “goats eat as much mopane as we humans eat porridge, and they eat other plant species as seriously as we eat meat” (Teshirogi, 2010a). Teshirogi (2010b) reported that the grazing route of goats is determined by the availability of mopane and the other palatable species. Hilly grazing land tended to be dominated by dense, SM type mopane, and contained other species such as *Catophractes alexandri* and *Combretum collinum*.

People in Ombazu, Onkani, and Muyako engaged in crop farming, but the Damara people in Renosterkop did not. In Ombazu, the Zemba crop fields (2–5 ha) were surrounded with fences made with mopane stems on the hilly area, a few kilometres from the homestead that the Zemba call *onganda*, including huts and kraals (Yamashina, 2010). Villagers cut down trees inside the fields to begin crop cultivation, and large trees were cut to make fences, with other parts burned in the field together with the tree stumps. The ash was mixed into the soil through ploughing, and no manure was used. Large trees were left in the field to shade humans, livestock, and crops. The villagers would abandon the fields and move to another location approximately every decade. In Onkani, the Kwambi people established upland crop fields (about 2–4 ha) with many mopane trees. The trees were cut down before the fields were cultivated, but not burned to clear the fields. Some tall trees were left inside field. In Muyako, the villagers cut down and burned the trees in the field before cultivation, but left the large trees providing

Table 4. Outline of mopane uses in the four villages

Uses			Renosterkop	Ombazu	Onkani	Muyako
Use of Logs, Leaves	Building Material	Degree	+++	+++	+++	+++
		High Frequency of DBH (cm)	5–10	10–15	< 5	< 5
	Firewood	Degree	+++	+++	++	+++
		Condition of Trees	dead	dead	living (cut and dry)	dead
	Other (Tools and Medicine)	Mortar	−	−	++	−
		Mallet	−	+++	+	−
		Rope	−	+++	+++	−
		Medicine	+	++	−	−
	Cattle Farming	Degree	++	+	+	+
		Seasonal Movement of Grazing Land	B	C	C	B
	Small Livestock Farming	Degree	+++	++	++	+
		Seasonal Movement of Grazing Land	B	A	A	A
Indirect use of Mopane Vegetation	Crop Farming		−	++	++	+++
	Mopane Worm		+	++	+++	−

Seasonal movement of grazing land: A (not moved); B (moved near the village), C (moved away from village).
Degree of mopane use: + + + (highly dependent), + + (dependent), + (slightly used), − (not used).
Degree of mopane use was determined by comparing the three movement categories at each site.
Tree use for ritual purposes was rarely observed in four sites.

shade. Crops such as carrots and pumpkins were planted on large termite mounds, as locations suitable for cultivation. The villagers abandoned the fields for another location every few years.

Some by-products of mopane are also used. The villagers in Ombazu and Onkani uses the mopane worms; caterpillars of the emperor moth of two species, *Imbrasia belina* and *Gynanisa maja*, as food especially in the rainy season. Some people, especially children, eat mopane sugar produced by insects inhabiting mopane leaves.

II. Uses of Other Trees in the Four Villages

Although people who live on mopane vegetation are highly dependent on mopane for their daily needs, some other trees are also important. Table 5 shows the uses of trees other than mopane in each village. In addition to mopane, *Combretum imberbe* was used as building material in Renosterkop and Onkani, for firewood in Renosterkop, and to make tools in Ombazu. In Onkani, the petioles of *Hyphaene petersiana* were also used as building material and firewood, and their importance has increased with the reduction of thick mopane vegetation in the area. The stems of *Combretum hereroense* and *Terminalia sericea* were also used as building material in Onkani, because they were strong and resistant to termites. In Muyako, *Dichrostachys cinerea* and *Commiphora glaucescens* were used as building material. The spiny branches of *Dicrostachys cinerea* were also used for the fence surrounding the crop fields (5–10 ha) near the lake. *Terminalia prunioides* was used for firewood in Renosterkop, Ombazu, and Onkani.

In Ombazu, *Commiphora mollis* and *Combretum* sp. were used to make mortars to mill corn and sticks to stir porridge, respectively. In both Ombazu and Muyako, the wood from *Commiphora glaucescens* was used to make chairs, and *Euclea divinorum* twigs were sometimes used as toothbrush. In Onkani, people hollowed the trunk of *Hyphaene petersiana* (dum palm tree) to use as a basin used in the distilling process for palm liquor. The dum palm leaves were strewn, and dyed brown with the root of *Berchemia discolor* to weave into baskets. In Muyako, the *Euphorbia ingens* resin was used as hunting poison.

In Ombazu, Onkani, and Muyako, people were seen to eat the fruits of *Berchemia discolor* fresh or dry. In Renosterkop and Ombazu, tea was made with the leaves and twigs of *Myrothamnus flabellifolius*, a shrub with a height of 30–40 cm. The fruit of *Ximenia americana* was eaten in Renosterkop, Ombazu, and Muyako. Abundant *Ficus ingents* and *Ficus sycomorus* fruit around the springs were dried and preserved in Ombazu. In Onkani, people were seen to eat the fruit of dum palm tree (*Hyphaene petersiana*) and also used them to make palm liquor. People in Muyako often eat the baobab (*Adansonia digitate*) and *Garcinia livingstonei* fruits fresh. The marula (*Sclerocarya birrea*) juice is brewed to make local beer during the rainy season in Onkani. *Myrothamnus flabellifolius* was used as a headache remedy in Renosterkop. People in Ombazu boiled the bark of *Terminalia prunioides* to use as a stomachache remedy. The differences in tree use culture among the four areas studied reflected the available tree species other than mopane, even though mopane was the dominant vegetation.

Table 5. Trees other than mopane used in the daily lives among residents of the four villages

Species/Uses	Building Material				Firewood				Tools				Food & Drink				Medical			
	Renosterkop	Ombazu	Onkani	Muyako	Renosterkop	Ombazu	Onkani	Muyako	Renosterkop	Ombazu	Onkani	Muyako	Renosterkop	Ombazu	Onkani	Muyako	Renosterkop	Ombazu	Onkani	Muyako
Acacia arenaria	−	−	−	−	−	−	++	−	−	−	−	−	−	−	−	−	−	−	−	−
Adansonia digitata	−	−	−	−	−	−	−	−	−	−	−	−	−	(++)	−	++	−	−	−	−
Berchemia discolor	−	−	−	−	−	−	−	−	−	−	+	−	−	++	++	+	−	−	−	−
Boscia albitrunca	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−
Combretum imberbe	+	−	+	−	+	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
Combretum sp.	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
Commiphora glaucescens	−	−	−	+	−	−	−	−	−	+	−	+	−	−	−	−	−	−	−	−
Commiphora mollis	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−	−	−
Dichrostachys cinerea	−	−	−	++	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Euclea divinorum	−	−	−	−	−	−	−	−	−	+	−	+	−	−	−	−	−	−	−	−
Euphorbia ingens	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−
Ficus ingents	−	−	−	−	−	−	−	−	−	−	−	−	−	++	−	−	−	−	−	−
Ficus sycomorus	−	−	−	−	−	−	−	−	−	−	−	−	−	++	(+)	(+)	−	−	−	−
Garcinia livingstonei	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	++	−	−	−	−
Grewia spp.	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−
Hyphaene petersiana	−	−	++	−	−	−	++	−	−	−	++	−	−	−	++	(+)	−	−	−	−
Myrothamnus flabellifolius	−	−	−	−	−	−	−	−	−	−	−	−	++	+	−	−	+	−	−	−
Salvadora persica	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−
Sclerocarya birrea	−	−	−	−	−	−	−	−	−	−	−	−	−	(+)	(++)	(+)	−	−	−	−
Terminalia prunioides	−	−	−	−	+	+	+	−	−	−	−	−	−	−	−	−	−	+	−	−
Ximenia americana	−	−	−	−	−	−	−	−	−	−	−	−	+	++	−	++	−	−	−	−

Degree of use: ++ (frequently used), + (occasionally used), − (not confirmed).
Tree species mentioned in interviews on tree use omitted from the results of vegetation survey (Table 3) due to rare occurence of the species in the area, shown in parentheses.
Tree use for ritual purposes rarely observed in four sites.

SUMMARY & DISCUSSION

The authors examined the variation in species composition and mopane tree shape in the mopane dominated vegetation among four sites, focusing on the land unit. Mopane dominance at all four sites had been previously noted in many studies in the area (e.g., Werger & Coetzee, 1978). However, we found variation within the mopane vegetation in terms of species composition and mopane tree shape. The ratios of other species to mopane varied among land units within each site, and there were four types (TS, TM, SS, and SM) of dominant mopane tree shapes.

Two hypotheses for the existence of shrub-type mopane has been reported in previous studies: one related to the effects of abiotic factors, such as water availability (February et al., 2007), soil conditions (Mlambo, 2007), temperature, and frost (Werger & Coetzee, 1978: 352–363), and the other related to the disturbance factors such as fire (Kennedy & Potgieter, 2003; Donald & Isaac, 2006), human activity (Sullivan & Konstant, 1997) and browsing by animals (Smallie & O'Connor, 2000; Sibanda & Ndlovu, 1992). In this study, the authors found that the land unit, including the sub land unit reflecting the abiotic factors and the natural resource use by the villagers affected the species composition and the tree shape in mopane vegetation, and that the variation in mopane vegetation conversely affected the natural resource uses among the four sites.

The mopane tree has regenerating traits, regenerating from shoots after the trees are felled, which forms the SM type of mopane (Timberlake, 1999). The authors suspect that the tree utilization by local people might also be an important disturbance factor for the variation in mopane vegetation, especially in tree shape among the four sites. Villagers at all four sites heavily depended on mopane as firewood and as building material. The predominance of the SM type of mopane in Muyako off the termite mounds and in Onkani might be due to human disturbance. In Muyako, short mopane were found on termite mounds as well, but people were highly dependent on mopane trees off the mounds for building material. Therefore, other factors should account for the short mopane on the termite mounds. In Onkani area, timber has been collected for several decades, and many cut marks were apparent on mopane stumps. This disturbance factor might have produced the extreme dominance of the SM type in the grazing land of this area. The tree population density is also an important factor in considering the effect of human disturbance on the vegetation. Although people used many short and young mopane stems in Onkani, the intensity of human disturbance was not severe, because the mopane population density was very high.

In contrast, the short mopane vegetation found in the hilly and mountainous areas in Renosterkop and mountain area in Ombazu was lightly affected by human disturbance, perhaps due to abiotic factors. It is reasonable to assume that the complex landform in the mountainous area influenced a range of environmental factors, such as soil water potential and other soil characteristics, allowing other species to grow alongside the mopane trees. Although mopane tree utilization was heavy in these areas in both villages, the intensity of human disturbance was low compared to other sites.

Geomorphological features would also affect the species composition and tree density found in the four sites. Mountainous and hilly areas and termite mounds had a higher diversity of tree species and tree density compared to plain areas. Most (86%) of all recorded species were present on only one specific site. These site-specific species were present on the sloping land units of the hilly and mountainous areas. Termite mounds were also found to be a special habitat for various species in the Muyako area.

Beside the effects of human disturbance and landform on mopane vegetation, the variation in the vegetation affected the local people's tree use. Firstly, the different harvesting practices resulted from the different structure of local mopane vegetation. Villagers in Renosterkop and Ombazu used logs with a diameter of about 5–15 cm, easily found in these areas. On the other hand, villagers in Onkani and Muyako used many smaller logs with a diameter of < 5 cm, because hardy mopane trees were not available in these areas. Secondly, the short mopane trees may be advantageous for livestock grazing. The Damara people of Renosterkop do not graze livestock in plain areas because small livestock cannot feed on the tall mopane, thus, SM type mopane in hill areas is important for browsing (Teshirogi, 2010a). Thirdly, local people have also adapted their daily and subsistence needs in relation to tree use with vegetation change over time. Some residents near Onkani now mainly use petioles of dum palm tree (*Hyphaene petersiana*) instead of mopane trunks (Fujioka, 2005), because tall and thick mopane is harder to find. Tree use by local people and local vegetation has mutually regulated each other with change over time.

The sustainability of mopane use is dependent on regeneration. In this study, the authors found that the cutting activities of local people changed the tree shape that made them adjust their tree use. It has been reported that coppicing to produce multi-stemmed trees increased the rate of mopane dieback (MacGregor & O'Connor, 2002). Moreover, some studies have pointed to the effects of physiognomy in relation to tree fruiting and reproduction. Lewis (1991) found that only mopane trees exceeding a height of 5 m produced seeds, while Styles and Skinner (2000) found that shorter mopane hedges browsed by elephants produced seeds, leading to the recruitment of new individuals. Therefore, in future work, the authors look forward to examining the future effects of cutting activities on mopane survival and reproduction capacity to assess the sustainability of mopane use in these areas. Furthermore, abiotic and disturbance factors mentioned in previous studies needed to be incorporated and examined to better understand the variation and sustainability of mopane vegetation utilization.

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