CHAPTER 4

The response of *Phragmites australis* to harvesting pressure in the Muzi Swamp of the Tembe Elephant Park, South Africa

J.A. Tarr[1], M.W. van Rooyen[2] and J. du P. Bothma[1]

[1] Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa, 0002

[2] Department of Botany, University of Pretoria, Pretoria, South Africa, 0002

Short title: Response of *Phragmites australis* to harvesting pressure in the Muzi Swamp

Published in: *Land Degradation and Development* 15: 487-497 (2004)

[1] Correspondence to: J. A. Tarr, Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa, 0002.
E-mail: s9611163@tuks.co.za
Tel: +27 12 420-2338
Fax: +27 12 420-6096

ABSTRACT

Phragmites australis (Cav.) Trin. ex Steud. has been harvested in the Muzi Swamp in Maputaland, South Africa for generations. Over the last 10 years, however, a flourishing trade in this reed has developed. Concern has now been expressed that at the current levels of utilisation the ecological integrity of the Muzi Swamp is being compromised, and that the current harvesting rates are not sustainable in the long term. The hypothesis was put forward that a degradation gradient exists with the most severe degradation occurring the closest to where community members enter the park, and the least degradation the furthest from this point. The results of this study, however, show no distinct degradation gradient. Yet the overall condition of the reeds in the harvesting area is poorer than in the non-utilised area. Expansion of the current harvesting area, coupled with adaptive harvesting systems and yearly monitoring will improve the quality of the reeds within the harvesting area without affecting the harvesting quotas.

KEY WORDS: Conservation, degradation gradient, Muzi Swamp, *Phragmites australis*, resource utilisation, sustainable utilisation

INTRODUCTION

Natural resource utilisation within South Africa's protected areas has become a sensitive issue. Increasing demand by communal rural communities for access to the renewable natural resources in protected areas has come about through a total degradation of these resources outside the protected areas, and an increasing demand for a specific resource within such an area. The occurrence of these natural resources within protected areas is often a result of total protection, or of the correct and prudent management of the resources.

When the Tembe Elephant Park was proclaimed in 1983, it was agreed that controlled harvesting of the natural resources within the park by the neighbouring communal rural communities would be allowed. The common reed (*Phragmites australis* (Cav.) Trin. ex Steud.) is currently being harvested in the Muzi Swamp within the Tembe Elephant Park under this agreement, because it is no longer readily available outside the park.

University of Pretoria etd – Tarr J A 2006

The harvested reeds are used in hut-wall construction, craftwork, and for thatching material (Cunningham, 1985; Begg, 1988; Browning, 2000; Tosh, 2000). The reed beds generate a substantial income for the neighbouring Sibonisweni community members, because most of the harvested reeds are sold elsewhere for use as building material. These reeds are often the only source of income for many of the community members, a development that was not originally planned for. The reed bundles that are not sold, are used by the Sibonisweni community themselves as building material, and in socio-cultural activities such as burial ceremonies (Browning, 2000).

Ezemvelo KwaZulu-Natal Wildlife is responsible for managing the Tembe Elephant Park and has raised the concern that the *Phragmites australis* dominated Muzi Swamp is being overutilised because the reeds are now also being harvested for commercial sale, and not just for subsistence use as was originally intended (Kyle, 2001 *pers.comm.*[1]). The Sibonisweni community members are in turn concerned that the quality of reeds that are being harvested within the area allocated to them, is deteriorating. Since the proclamation of Tembe Elephant Park in 1983 up to and including 1995, no harvesting quotas existed. In 1996, a harvesting quota was implemented to reduce the volume of reeds harvested from approximately 16 000 bundles per year, to the current quota of some 8 000 bundles per year (Kyle, 2000).

The most heavily utilised reed beds within the Muzi Swamp are those harvested by the Sibonisweni community. The proximity of this community to the tar road has lead to a flourishing trade in this reed resource. Members of the Sibonisweni Reed Cutting Association enter the park at KwaMsomi Gate in the south, and harvest the reeds northwards from there for approximately 1.7 km. Reeds of the desired quality are selected and are harvested by using a machete. Each harvester is allowed to cut a single bundle of reeds per day, sometimes weighing up to 64 kg, which must be carried out of the park. The reed bundles are then sorted into smaller, more manageable bundles at KwaMsomi Gate, before being taken to the tar road for sale.

Many factors have been regarded as being detrimental to reed growth, but it has been difficult to quantify this negative effect (Granéli, 1989; Ostendorp, 1989). One of the

[1] Dr. S. Kyle, Ezemvelo KwaZulu-Natal Wildlife, Resource Ecologist Maputaland. P. O. Box 43, KwaNgwanase, South Africa 3973.

most obvious factors affecting reed growth is that of harvesting. Both the intensity and temporal range of harvesting have an effect on the degree of regeneration and rehabilitation of the reeds (McKean, 2001). Persistent nutrient loss from the above-ground parts because of harvesting during the growing season, causes a decline in the amount of nutrients returned to the rhizomes (Mook and Van der Toorn, 1982). Removal of aerial parts during the growing season prevents full recovery and regrowth in the spring (Čižková *et al*., 2001).

The hypothesis that is tested here is that the utilisation pressure on the reeds of the Muzi Swamp in the Tembe Elephant Park will show a gradient of use, starting with the highest utilisation pressure close to the entrance gate, followed by a gradual reduction in utilisation pressure the further away from that point. If such a utilisation gradient were present, it should be reflected in changes in the measurable properties of reed quality, such as reed height, diameter, density and biomass per unit surface area. These aspects are examined here to test the above hypothesis.

STUDY AREA

The study area is situated in the eastern portion of Tembe Elephant Park in KwaZulu-Natal, Maputaland, South Africa (Figure 1). It forms a polygon between the following coordinates: 26º 53’ 08’’ S and 32º 34’ 58’’ E, 26º 53’ 04’’ S and 32º 34’ 59’’ E, 27º 01’ 25’’ S and 32º 29’ 54’’ E and 27º 01’ 24’’ S and 32º 29’ 44’’ E. The Muzi Swamp extends northwards from KwaMsomi Gate in the south to Muzi Gate in the north, from where it continues into Mozambique (Figure 1).

The section of the Muzi Swamp that lies within Tembe Elephant Park is approximately 560 ha in size. It lies on Holocene peat deposits that are controlled by the topography of the underlying Pleistocene KwaBonambi coastal dunes (Grundling, 1996). The Muzi Swamp is an elongated interdune valley that is orientated parallel to the present coastline. This interdune peatland and isolated wetland are fed by groundwater from perched aquifers within the sand dunes (Grundling, 1999). The entire Muzi Swamp is dominated by *Phragmites australis* that is sparsely interspersed with open water, higher lying islands and hygrophilous grasses (Matthews *et al*., 2001).

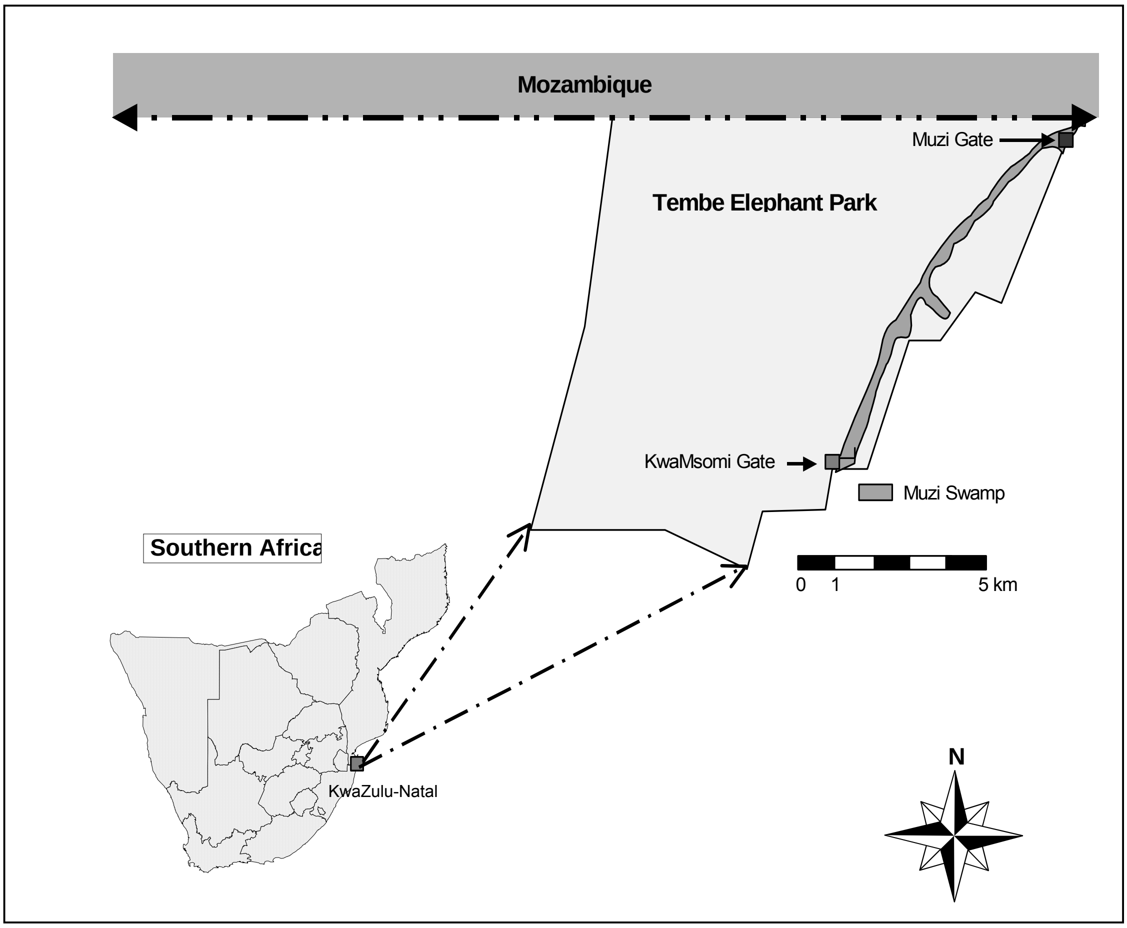

Figure 1: The location of the Muzi Swamp in the Tembe Elephant Park, South Africa.

The mean annual rainfall is 721.5 mm. The minimum recorded annual rainfall is 245.0 mm, while the recorded maximum is 2 105.0 mm. The temperature in Tembe Elephant Park ranges from an extreme minimum of 4ºC to an extreme maximum of 45ºC (Figure 2). The proximity of Tembe Elephant Park to the coast and its low-lying topography result in a high relative humidity of the air (KwaZulu-Natal Nature Conservation Service, 1997).

METHODS

The reed beds in the southern section of the Muzi Swamp were sampled from south to north. Experimental sites were set out approximately every 100 m, starting 300 m from the fence near KwaMsomi Gate (Table 1). Thirteen sites were selected and were referenced by using a Global Positioning System (GPS). Site 13 was considered to be representative of natural areas within the Muzi Swamp where no harvesting is allowed. To ensure uniform sampling of the *Phragmites australis* community, experimental sites were set out approximately 30 m away from the ecotone of the *Phragmites australis* community and the hygrophilous grassland community (Matthews *et al*., 2001).

At each experimental site six replicate quadrates were harvested by using a 1 m^2 frame. All the reeds within the square frame were cut with secateurs at water level, or at ground level in the absence of water. The stem diameter (mm) and reed height (m) were measured for each cut reed within the quadrate. The basal stem diameter was measured by using callipers. The reed height was measured with a tape measure from the stem base to the outstretched apical-leaf blade. To correct for water depth, the water level at each site was added to the mean reed height to obtain total reed height. The number of reeds harvested per sample quadrate was counted to determine the reed density per m^2. The total mass of all the reeds harvested within each sample quadrate was measured in kilogrammes by using a spring balance.

The environmental variables recorded at each site were (Table 1): the distance from the gate; the time since the last harvest by the reed cutters; the degree of trampling; and the water depth. The time since the last harvest by the reed cutters was estimated in two-monthly intervals, with the most recent harvests occurring <2 months before the experimental harvesting trial, and the least recent harvest occurring >10 months before the experimental

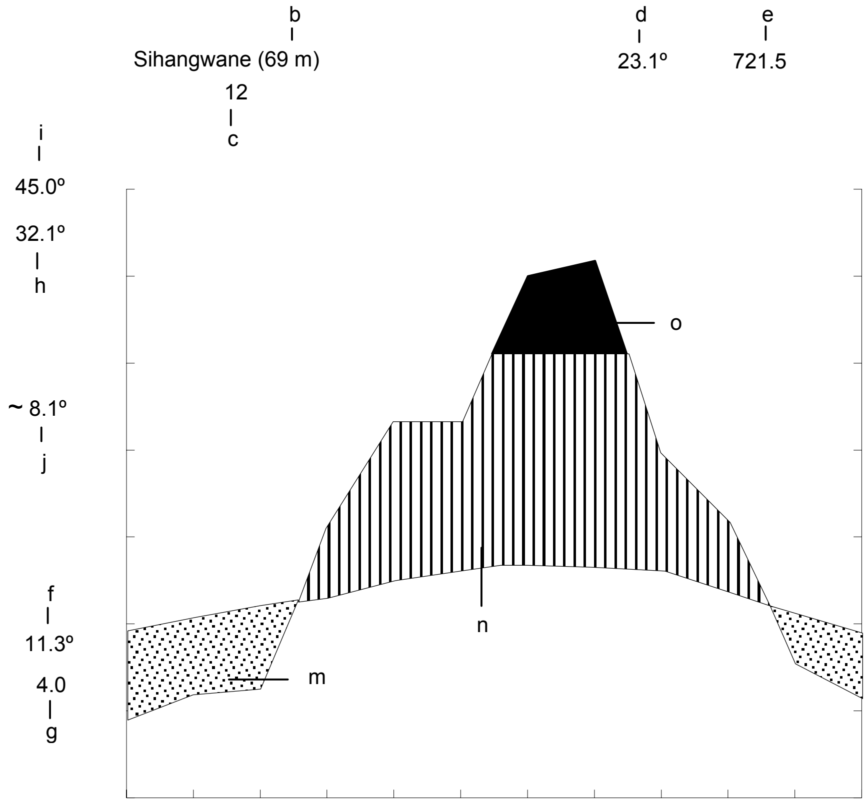

Figure 2: Climatogram of Sihangwane Weather Station, Tembe Elephant Park, following Walter and Moore, 1994). b = height above sea-level in m; c = duration of observations in years; d = mean annual temperature in ºC; e = mean annual precipitation in mm; f = mean daily minimum of the coldest month; g = lowest temperature recorded; h = mean daily maximum of the warmest month; i = highest temperature recorded; j = mean daily temperature variation; m = relative period of drought; n = relative humid season; o = mean monthly rainfall > 100 mm.

Table 1. *Environmental factors at sites in the reed bed in the Muzi Swamp of Tembe Elephant Park, South Africa. Distance from fence indicates distance away from the boundary fence at the KwaMsomi Gate, the degree of trampling by humans and animals is indicated on a 5-point sclae, time since last utilisation in months, and water depth in metres.*

Plot	Distance from fence (m)	Trampling	Utilisation	Water depth (m)
1	300	3	> 6-8	0.00
2	400	3	> 8-10	0.00
3	500	4	< 2	0.00
4	600	3	> 2-4	0.02
5	700	3	> 6-8	0.31
6	800	2	> 10	0.36
7	900	3	> 2-4	0.21
8	1 000	3	> 4-6	0.22
9	1 100	2	> 8-10	0.10
10	1 500	2	> 10	0.18
11	1 600	1	> 8-10	0.16
12	1 700	2	> 6-8	0.05
13	1 800	1	-	0.37

Trampling: high = 5, low = 1

University of Pretoria etd – Tarr J A 2006

harvesting trial. The degree of trampling at the sites was recorded on a scale of 0 to 5, with 0 being the lowest degree of trampling and 5 being the highest degree of trampling. The creation of channels and paths most often used by reed cutters, the elephant *Loxodonta africana*, buffalo *Syncerus caffer* and black rhinoceros *Diceros bicornis* had longer lasting and more visible impacts, compared with the more subtle degrees of trampling by smaller animals such as the warthog *Phacochoerus africana* and reedbuck *Redunca arundinum*. The water level was measured by using a metal dropper attached to a thin aluminium plate to prevent the penetration of the rod into the peat layer.

The mean height (m), diameter (mm), density per m^2, yield (kg per m^2) and mean mass per reed (g) were calculated for each sample quadrate. These values were used as replicates to calculate the mean values for each site. The site means were used in linear regression models to test for correlations between reed characteristics and environmental variables. An Analysis of Variance (ANOVA), and *post hoc* Bonferroni tests of the Statistica 6 computer package (StatSoft Inc., Tulsa, Oklahoma, U.S.A) were used to determine statistically significant differences between the reed characteristics at the various sites. The frequency distribution of reeds encountered in various height and diameter classes was plotted against the distance away from the starting point.

RESULTS AND DISCUSSION

Reed height

Reed height was not significantly correlated with the gradient of increasing distance away from the boundary fence at KwaMsomi Gate towards the northern parts of the utilisation area or with trampling (Table 2). Reed height was, however, strongly positively correlated with the time since the last harvest by the reed cutters and weakly positively correlated with water depth (Table 2). The results of the *post hoc* test are indicated in Figure 3a. Site 3 that had been harvested by the reed cutters less than 2 months before the experimental trial, had the shortest reeds (mean ± se: 0.32 ± 0.05 m), while site 13 had the tallest reeds (mean ± se: 2.04 ± 0.10 m). There was a significant difference in reed height ($p<0.01$) between site 13 and the rest of the sites. The disparity between site 13 and the rest of the sites can be attributed to its location in the non-utilised area where reeds have never been harvested, implying that

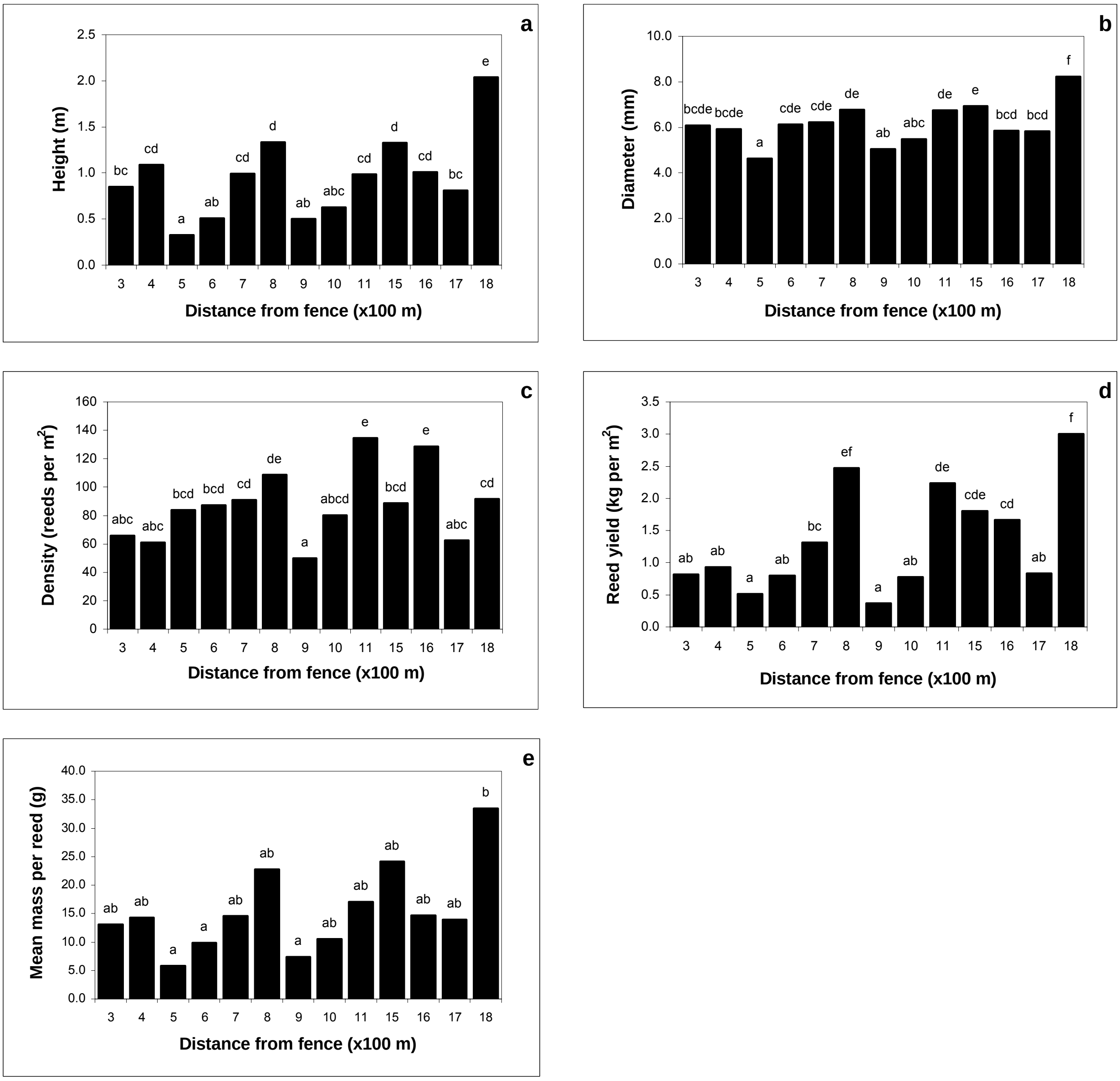

Figure 3: Reed characteristics at sites along a transect from the southern border of the Tembe Elephant Park from site 1 northwards to site 13. (a) Mean reed height; (b) mean reed diameter; (c) mean reed density; (d) mean reed biomass; (e) mean mass per reed. Bars with the same superscripts do not differ significantly (p>0.05).

University of Pretoria etd – Tarr J A 2006

Table 2. *Simple linear regression between various measures of reed quality and environmental variables. r^2 values and p-values are shown. An asterisk denotes a statistically significant relationship at α = 0.05.*

	Distance from fence		Degree of trampling		Time since last utilisation		Water depth	
	r^2	p	r^2	p	r^2	p	r^2	p
Reed height	0.269	0.069	0.020	0.640	0.885	0.000*	0.368	0.028*
Reed diameter	0.219	0.107	0.011	0.735	0.739	0.000*	0.274	0.066
Reed density	0.092	0.314	0.032	0.556	0.156	0.181	0.079	0.353
Reed yield	0.266	0.071	0.089	0.321	0.74	0.000*	0.405	0.079
Mean mass per reed	0.257	0.076	0.050	0.461	0.821	0.000*	0.379	0.025*
Degree of trampling	0.058	0.429	-	-	0.038	0.523	0.115	0.188
Time since last utilisation	0.266	0.071	0.038	0.523	-	-	0.254	0.079
Water depth	0.171	0.159	0.115	0.188	0.254	0.079	-	-

University of Pretoria etd – Tarr J A 2006

reed harvesting has a negative effect on reed height.

Sites 3, 4, and 7 that had been harvested by the reed cutters within 4 months before the experimental trial (Table 1) did not have a high percentage of tall reeds. These recently harvested sites had a significantly ($p<0.01$) higher frequency of short reeds in the >0.0–0.5 m height class, than sites 6 and 10 that had been harvested more than 10 months before the experimental trial (Figure 4a). New shoots sprouting from the cut stem of harvested reeds accounted for the high frequency of short reeds in the recently harvested sites. As the height classes increase, the frequency of occurrence of reeds in these classes in the recently harvested sites decreases. Site 13 had a significantly ($p<0.01$) higher frequency (mean ± se: 31.5 ± 5.0%) of reeds in the >2.5 m height class than any of the other sites (Figure 4f).

Reed diameter

Reed diameter was not significantly correlated with the distance gradient away from the boundary fence at KwaMsomi Gate, degree of trampling or water depth (Table 2). Reed diameter was, however, significantly positively correlated with the time since the last harvest by the reed cutters (Table 2). Site 3 had the smallest mean reed diameter (mean ± se: 4.64 ± 0.33 mm)(Figure 3b), while site 13 had the largest one (mean ± se: 8.22 ± 0.23 mm). Site 13 had significantly thicker reeds ($p<0.03$) than the utilised sites, implying that utilisation has had a negative influence on the mean reed diameter of the sites.

Site 13 is 1.8 km away from the boundary fence at KwaMsomi Gate and it has a significantly ($p<0.01$) higher frequency (mean ± se: 23.6 ± 2.4%) of reeds in the >10.0 mm diameter class compared with that of any of the sites that were utilised by the reed cutters less than 10 months before the harvesting trial (Figure 5f).

Phragmites australis is a rhizomatous, perennial plant, producing annual aerial shoots. The basal diameter of the emergent shoot is determined by the size of the bud on the rhizome. The rhizomatous growth habit of *Phragmites australis* also determines the reaction to damage caused by harvesting. Early damage to the emergent shoot's apical meristem results in the complete replacement of the shoot from subterranean buds. Damage to the apical meristem of the shoot late in the growing season leads to replacement by several thinner shoots from the above-ground nodes (Van der Toorn and Mook, 1982).

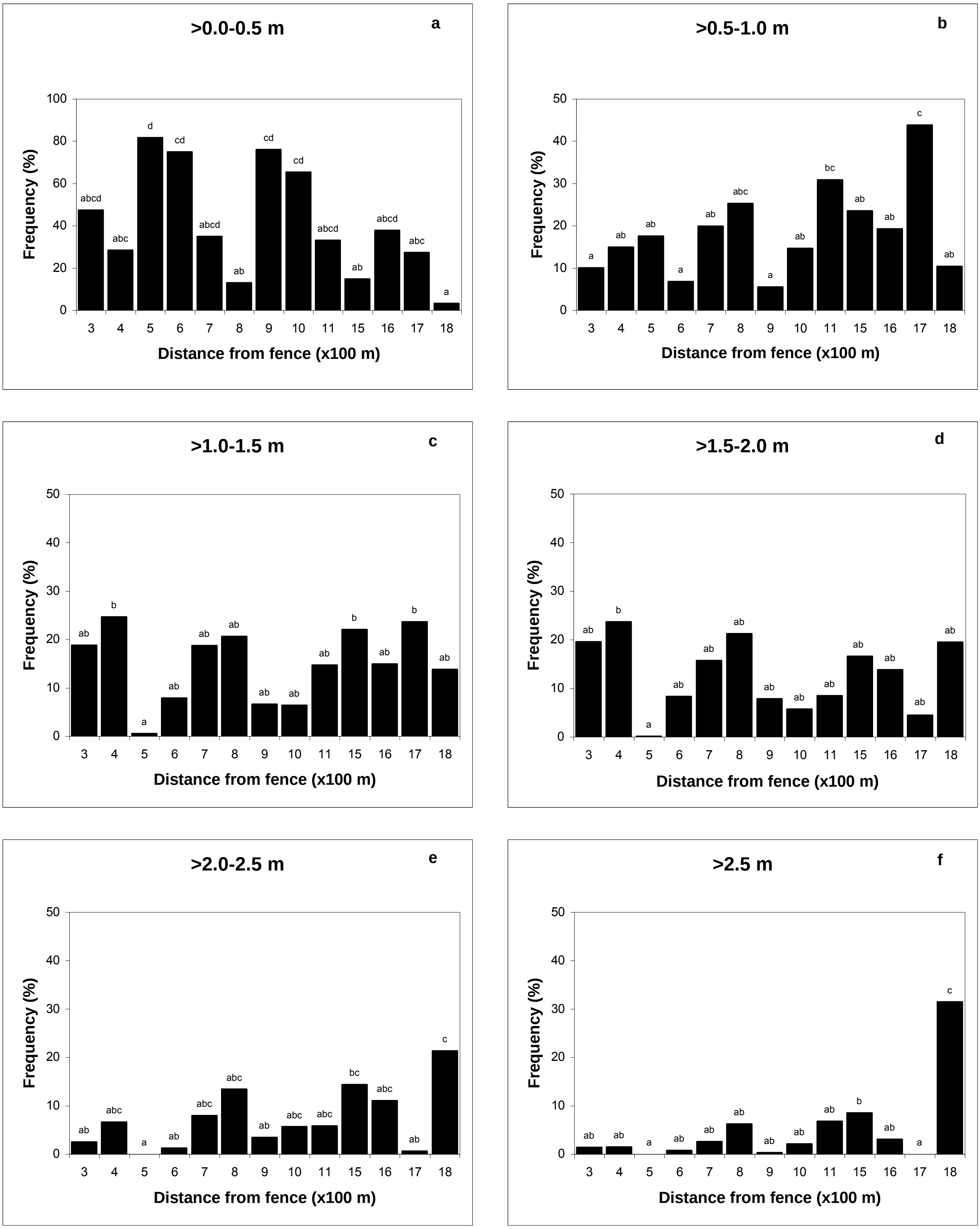

Figure 4: Frequency of height classes of reeds in sites along a transect from 300 m north of the fence at KwaMsomi Gate to 1 800 m north of the fence at KwaMsomi Gate. (a). >0.0-0.5 m height class; (b). > 0.5-1.0 m height class; (c). > 1.0-1.5 m height class; (d). > 1.5-2.0 m height class; (e). > 2.0-2.5 m height class; (f). >2.5 m height class. Bars with the same superscripts do not differ significantly (p>0.05).

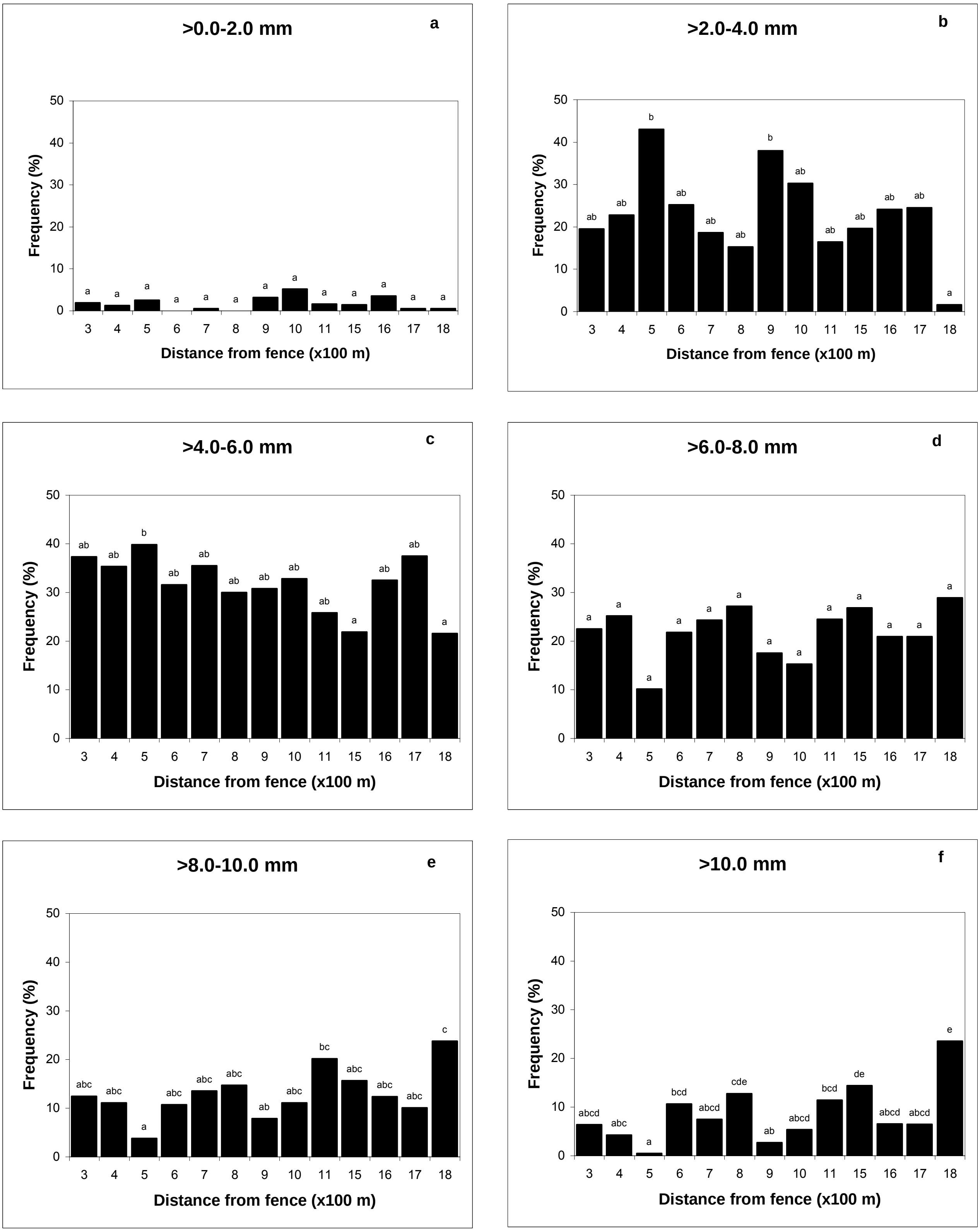

Figure 5: Frequency of diameter classes of reeds in sites along a transect from 300 m north of the fence at KwaMsomi Gate to 1 800 m north of the fence at KwaMsomi Gate. (a) >0.0-2.0 mm diameter class; (b) >2.0-4.0 mm diameter class; (c) >4.0-6.0 mm diameter class; (d) >6.0-8.0 mm diameter class; (e) >8.0-10.0 mm diameter class; (f) >10.0 mm diameter class. Bars with the same superscripts do not differ significantly (p>0.05).

University of Pretoria etd – Tarr J A 2006

The similarity in the mean diameter of reeds at the various sites can be partly ascribed to the vegetative growth pattern of *Phragmites australis*. Shoots emerging from the rhizome have a basal stem diameter that remains stable throughout the year. An emergent shoot can therefore have a large basal diameter at the beginning of the growing season and not necessarily have grown into a tall reed yet. Nevertheless, Mook and Van der Toorn (1982) found a positive linear correlation between basal diameter and eventual reed height, and reeds with a large basal diameter tend to be proportionately taller than reeds with a small basal diameter. The results of the present study do not reflect this correlation as all the shoots were harvested for the purpose of the study and not only the mature reeds.

Reed density

None of the linear regressions revealed a significant relationship between reed density and the environmental variables that were recorded (Table 2). Reed density did not show a distinct gradient with distance away from the boundary fence at KwaMsomi Gate to the northern sections of the utilisation area (Figure 3c). Site 7 had the lowest mean reed density (mean ± se: 50.00 ± 5.16 reeds per m^2), while site 9 had the highest one (mean ± se: 134.33 ± 11.43 reeds per m^2). Site 13 differs significantly from sites 7 ($p<0.01$), 9 ($p<0.01$) and 11 ($p<0.02$) in terms of reed density, but it did not differ significantly ($p>0.05$) from any of the other sites in this parameter. No predictable effect of reed utilisation on the mean reed density of the reed beds in the Muzi Swamp could be established (Table 2).

Reed yield

As was the case for reed diameter, reed yield per m^2 was not significantly correlated with the distance from KwaMsomi Gate, degree of trampling or water depth (Table 2). Reed yield was, however, significantly positively correlated with the time since the last harvest by the reed cutters (Table 2). Site 7 had the lowest mean reed yield (mean ± se: 0.37 ± 0.15 kg) while site 13 had the highest one (mean ± se: 3.00 ± 0.04 kg) (Figure 3d). There is a significant difference ($p<0.05$) in mean reed yield between site 13 and all of the other sites except for site 6 ($p>0.20$). There is a direct linear relationship between mean reed height and reed yield (Figure 6a).

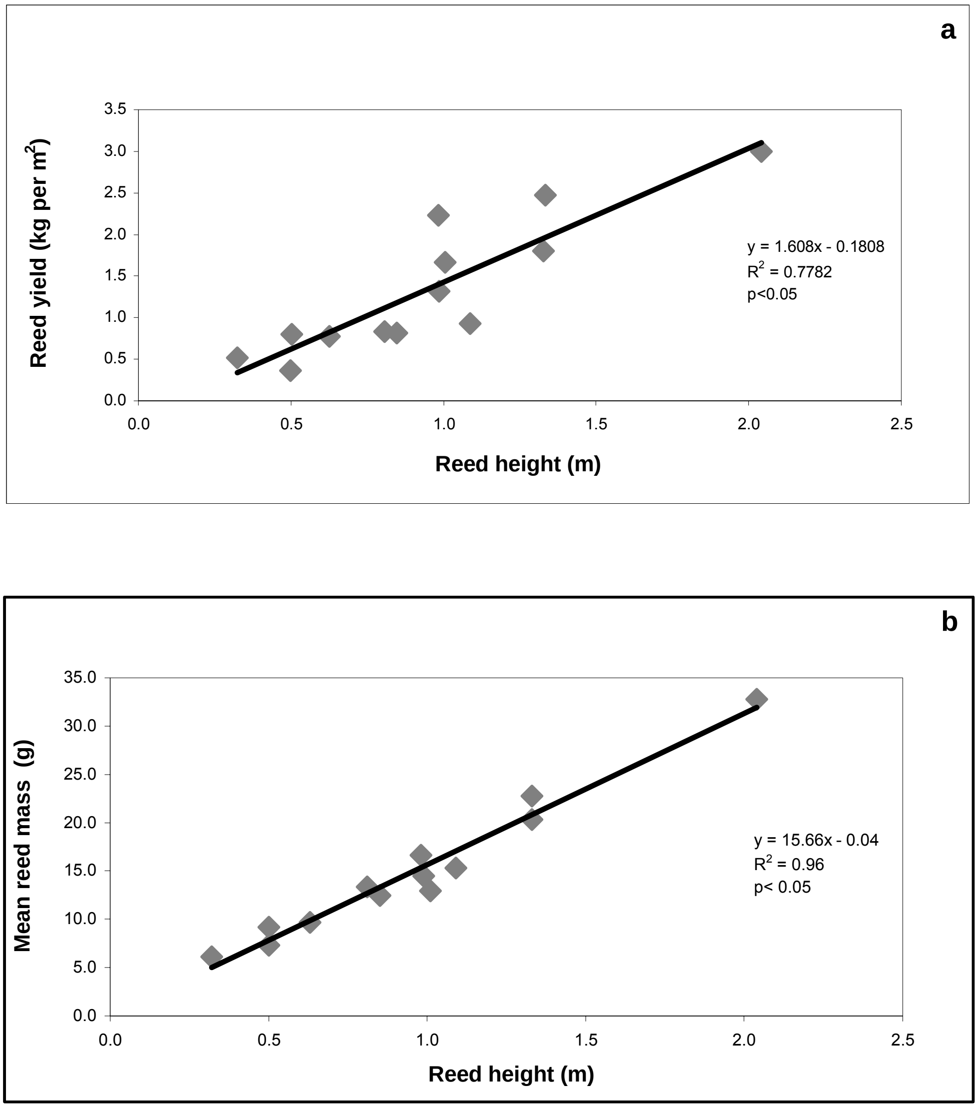

Figure 6: Positive linear relationship between reed height and (a) reed yield and (b) mean reed mass, determined along a transect from 300 m north of the fence at KwaMsomi Gate to approximately 1 800 m north of the KwaMsomi Gate.

Mean reed mass

No significant relationship between mean mass per reed and distance from KwaMsomi Gate or degree of trampling could be demonstrated (Table 2). However, mean mass per reed was strongly positively correlated with the time since the last utilisation and weakly positively with water depth (Table 2). Site 3 had the lowest mean reed mass (mean ± se: 5.77 ± 0.65 g), while site 13 had the highest one (mean ± se: 33.44 ± 2.27 g) (Figure 3e). The mean reed mass in site 13 was significantly higher only from that of sites 3 ($p<0.01$), 4 ($p<0.02$) and 7 ($p<0.01$). Mean reed mass is linearly proportional to reed height (Figure 6b), and differences in the mean reed mass are consistent with the differences in mean reed height for the same sites.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

At the current harvesting intensity the structure and size of the reeds fluctuate within the utilisable area in the Muzi Swamp. These fluctuations produce some clear and significant changes in reed quality, but there is no observed gradient in reduced utilisation pressure associated with the distance away from the boundary fence at KwaMsomi Gate in a northwards direction. The lack of such a gradient indicates that the more accessible reeds close to KwaMsomi gate are not under a higher utilisation pressure than those further away. Reed harvesting within the Muzi Swamp is not concentrated entirely to the southern sections of the Muzi Swamp near the KwaMsomi gate, as was expected, due to the limitations placed on the reed cutters' movements. The Sibonisweni reed cutters appear to be harvesting the reeds systematically by selecting areas within the reed bed where reeds of a desirable quality are found. It does also appear that the reed cutters allow a regeneration period before returning to a previously harvested area. However, reed size and structure are not reaching their full potential in the utilisable areas. Reeds outside the harvesting area display an improved quality as is evident from the data obtained in site 13, which is representative of areas where utilisation does not occur.

Areas that were harvested 10 months before the experimental trial showed significantly taller and thicker reeds with a higher reed yield when compared to reed beds outside the utilisation area. The same did not show significant differences in reed density and mean reed mass when compared with reed beds outside the allotted harvesting area. Sites that had been utilised 6 months before the start of the experimental harvesting trial, showed a significantly decreased frequency of reeds in the height class >2.0 – 2.5 m when compared with that of the unutilised site 13. The frequency of reeds occurring in the >2.5 m height class was significantly higher in site 13 than in any of the sites. The results of the frequency of reeds in the various height classes are not reflected in the frequency of occurrence of the reed diameter classes.

The basal diameter of a new reed shoot can be as thick as that of the basal diameter of a fully-grown reed. All reeds were harvested in the quadrates, irrespective of their maturity. This is reflected in the significantly similar diameter frequencies of the sites found in the individual diameter classes. The mean reed diameter at the unutilised site 13 is, however, significantly different from that of all the sites. This might indicate a larger rootstock, and thus improved shoot production, due to greater amounts of nutrient reserves accumulated over time. This is only possible in a reed bed that is allowed adequate recovery time before being re-harvested.

The production potential of the reeds over the entire harvesting area appears to be uniform, but it does not reach the production potential of the areas outside the harvesting area. Reed quality in the harvesting area consistently differs from that of the reed beds outside the harvesting area.

Reed harvesters do appear to be allowing for the regeneration of reeds after harvesting, but the current period of rest between the harvests is not long enough. This can be attributed to the small area within the Muzi Swamp in which the reed cutters are allowed to harvest at present. By increasing the size of the current harvesting area while maintaining similar quotas will allow for the implementation of a rotational resting system. Such a system will allow for a longer recovery period between successive harvests. The extension of the recovery period will result in a healthier rootstock in the long term, and should produce reeds that are comparable in quality to those found outside the utilisation areas.

The expansion of the harvesting area by 30%, or 540 m in a northerly direction, and division of the entire area into three equal sectors for a tri-annual harvest is suggested to allow sufficient time for the recovery of the reed beds to their full potential. Harvesting of these three sectors should only occur in the winter, once the growing season and the nutrient transfer to the rootstock has been completed. The first year's harvest should take place for the larger part in the previously unharvested area, between 1 600 m and 2 400 m north of the fence at KwaMsomi Gate. The second year's harvest should occur in the sector between 800 m and 1 600 m north of the fence at KwaMsomi Gate. The third year's harvest should occur in the sector between the fence to 800 m north of the fence at KwaMsomi Gate. Easily distinguishable posts or markers dividing these sectors should be put in place to avoid any confusion as to the location of the areas. Harvesting quotas should be maintained at their current level, with the focus being to harvest the yearly quota within the winter months, and not to spread the harvest over the entire year as was previously done. Yearly monitoring of the size, number and structure (basal diameter, height and reed density) of the reed bundles being harvested is essential. Non-destructive monitoring of the reed bed structure in the sectors to be harvested in the following years should also be implemented. As an alternative to overutilisation, other sources of building material may also have to be developed. Rehabilitating the degraded reed beds outside Tembe Elephant Park, and developing these for sustainable commercial utilisation will also reduce the harvesting pressure on the reed beds occurring within the park.

The results have shown that the hypothesis put forward at the beginning of the study is incorrect. Reed quality in the Muzi Swamp shows no degradation gradient in a south to north direction in the harvesting area north of KwaMsomi Gate. The study has proved, however, that there is a general reduction in reed quality in the harvested areas.

ACKNOWLEDGMENTS

The authors would like to thank Ezemvelo KwaZulu-Natal Wildlife (Tembe Elephant Park) for their logistical support, the Sibonisweni Community, Prof H Els and the former Centre for Indigenous Knowledge, of the University of Pretoria. This material is based upon work supported by the National Research Foundation under Grant Number 2047386.

REFERENCES

Begg GW. 1988. The Wetlands of Natal. Natal Town and Regional Planning Commission, Pietermaritzburg

Browning TC. 2000. Preliminary study of the socio-economic value of *Phragmites* reeds to the people neighbouring Tembe Elephant Park, KwaZulu-Natal. BA (Hons) APL 770 Project Report. University of Pretoria: Pretoria.

Čižková H, Istvánovics V, Bauer V, Balázs L. 2001. Low levels of reserve carbohydrates in reed (*Phragmites australis*) stands of Kis-Balaton, Hungary. *Aquatic Botany* **69**: 209-216.

Cox CB, Moore PD. 1994. *Biogeography: an ecological and evolutionary approach.* 5thedition. Blackwell Scientific Publishing: Oxford.

Cunningham AB. 1985. The resource value of indigenous plants to rural people in a low agricultural potential area. PhD (Botany) thesis, University of Cape Town: Cape Town.

Granéli W. 1989. Influence of standing litter on shoot production in reed, *Phragmites australis* (Cav.) Trin. ex Steudel. *Aquatic Botany* **35**: 99-109.

Grundling P-L. 1996. The implication of C^{14} and pollen derived peat ages on the characterisation of peat lands of the Zululand-Mozambique Coastal Plain, South Africa. Report no. 1996-0119. Council for Geoscience Geological Survey: Pretoria.

Grundling P-L. 1999. Some characteristics of the Muzi Peatland, in the Tembe Elephant Park, northern KwaZulu-Natal, South Africa. Report no. 1999-0066. Council for Geoscience Geological Survey: Pretoria.

Kyle S. 2000. A summary and some comments on resource utilisation in the Tembe/Ndumo Game Reserve Complex during 2000. Unpublished report. Ezemvelo KwaZulu-Natal Wildlife: Pietermaritzburg.

KwaZulu-Natal Nature Conservation Service Protected Area Management Plan. 1997. Part B: General description of the Tembe Ndumo Complex and key references. Unpublished Report. KwaZulu-Natal Nature Conservation Services: Pietermaritzburg.

Matthews WS, Van Wyk AE, Van Rooyen N, Botha GA. 2001. Vegetation of the Tembe Elephant Park, Maputaland, South Africa. *South African Journal of Botany* **67**: 573-594.

McKean SG. 2001. Productivity and sustainable use of *Phragmites* in the Fuyeni reed bed - Hluluwe-Umfolozi Park – Management guidelines for harvest. *South African Journal of Botany* **67**: 274-280.

Mook JH, Van Der Toorn J. 1982. The influence of environmental factors and management on stands of *Phragmites australis* II. Effects on yield and its relationship with shoot density. *Journal of Applied Ecology* **19**: 501-517.

Ostendorp W. 1989. 'Die-back' of reeds in Europe - A critical review of literature. *Aquatic Botany* **35**: 5-26.

StatSoft, Inc. 2300 East 14th Street, Tulsa, OK 74104.

Tosh C. 2000. The effect of human harvesting on the height and diameter of *Phragmites australis* in Tembe Elephant Park. Botany project, University of Pretoria: Pretoria.

Van Der Toorn J, Mook JH. 1982. The influence of environmental factors and management on stands of *Phragmites australis* I. Effects of burning, frost and insect damage on shoot density and shoot size. *Journal of Applied Ecology* **19**: 477-499.