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The monitoring of density and utilization of two tree species in the Etosha National Park, Namibia

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ABSTRACT

This paper provides a method for monitoring two tree species in a semi-arid environment to assess degrees of utilization, density, and height structure at desired levels of precision. *Colophospermum mopane* occurred in densities of 189-381 plants/ha, revealed a healthy height structure and light utilization. At a density of 5,8-13,8 plants/ha, more than 70% of the *Boscia albitrunca* trees were less than 1 m in height. The high degree of utilization to which this species was subject may, in the future, result in a change in the height structure of the population. Recommendations are made for the extension and refinement of the monitoring method.

INTRODUCTION

One of the primary objectives in the management of Etosha National Park, Namibia, is the maintenance, and in special cases, the increase of biotic diversity (Anon 1986). This objective is translated into operational goals. The prime concern is the maintenance of *alpha* heterogeneity (Peet 1974) within permissible limits of change. It is aimed at maintaining these forms of diversity within structural limits. Although it might be true that species diversity may be maintained within permissible limits of change, dramatic changes in structural dimensions may occur, thus modifying habitats to something quite different to those recorded in baseline surveys. This is especially so in the presence of large herbivores (e.g. elephant, giraffe and rhino) and as a result of fire.

The aim of this paper is to describe the development of a monitoring technique whereby the density of two key tree species can be assessed at a desired level of precision. Follow-up surveys can then be conducted and the possible problems identified. The monitoring technique described in this paper focuses on providing a format for follow-up surveys. Also, it provides baseline data to which follow-up surveys can be compared.

STUDY AREA AND METHODS

Three study sites were chosen, each comprising a different vegetation type (Le Roux *et al.* 1988). These were situated in the western part of Etosha National Park (hereafter referred to as Etosha), an area which has been subject to intensive management during the past 10 years, e.g. the introduction of artificial waterpoints, a burning programme and the removal of large ungulates.

The first study site (A) is situated within the Renostervlei *Colophospermum mopane/Combretum hereroensis/ Sesamathamnus querichi* shrubveld (Le Roux *et al.* 1988). The study site is confined to the Otjovasandu basin which forms the main catchment for the Otjovasandu river and comprises an area of 17,6 km² (Figure 1).

The second site (B) within the Otjovasandu hilly mopane savanna (Le Roux *et al.* 1988), is restricted to 11,8 km² north of the Kaross fence excluding the Otjovasandu mountain.

The third site (C) is within the *Acacia reficiens / C. mopane/ Terminalia pruniodes* thorn scrub (Le Roux *et al.* 1988), and is restricted to an area of 75,8 km² south of Dolomietpoort between Renostervlei and Aasvoëlbad.

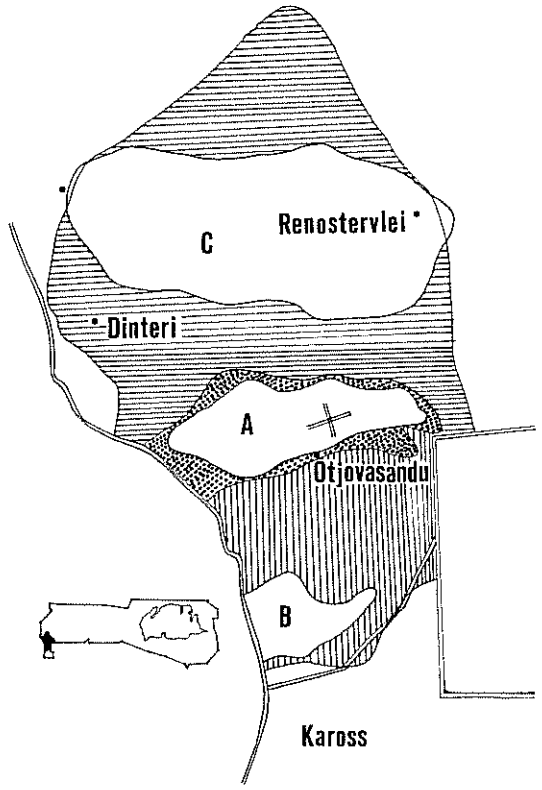

FIGURE 1: Map of the Otjovasandu area in the Etosha National Park showing the study sites and the main vegetation types (Le Roux *et al.* 1988). Study site A is situated within the Renostervlei *Colophospermum mopane/Combretum hereroensis/ Sesamathamnus querichi* shrubveld, site B within the Otjovasandu hilly mopane savanna, and site C is within the *Acacia reficiens/ C. mopane/ Terminalia pruniodes* thorn scrub.

Two species were monitored, namely *Colophospermum mopane* and *Boscia albitrunca*. *C. mopane* is evenly distributed and is the dominant tree species in all three study areas. It is extensively utilized by large browsers, especially elephant (de Villiers 1981).

B. albitrunca was considered as it is the only fairly abundant evergreen woody plant in the western parts of Etosha. It is

therefore an important food source for browsers from July to December when most other trees are leafless. Furthermore, this species is suspected of being excessively utilized, to the extent that the replacement and survival of large trees is doubtful (T. Nott and K. Nott 1989 unpubl. data; Le Roux *et al*. 1988)

Fifty points were randomly allocated to each of the three sites using 1: 50 000 topographical maps for sites A and B, and 1:100 000 maps for site C. Each random point was located with the aid of a compass. The direction of a 500 m transect was chosen randomly from this point. Plants were assessed in 10 m intervals. All *C. mopane* plants within 5 m on either side of the transect lines were assessed. *C. mopane* less than 2 m in height, were recorded for the first 200 m in area C and thereafter ignored. This was due to the relatively high abundance of these plants. *B. albitrunca* plants were assessed and recorded within 10 m on either side of the transect lines.

All individuals of both species were recorded within one meter interval height classes, starting with <1 m and ending with >4 meters. A collapsible measuring pole with 1 m intervals of different colours was used. The plant height was recorded as the vertical height of the highest living part of the plant. Any stems of the same species closer than 0,5 m were regarded as a single plant and the plant height recorded as the highest living point in the cluster. This was particularly applicable to *C. mopane* which form dense clusters.

TABLE 1: Degrees of utilization of *Boscia albitrunca*

Utilization	Condition of plant
0	*Tree and shrub* No utilization of any part of the plant
1	*Tree and shrub* Utilized to the extent that the canopy is still intact, the height not affected and the remainder of leaves are borne on soft terminal branches
2	*Tree* Utilized to the extent that a part of the canopy is destroyed and the remainder which is intact is not available to the giraffe. *Shrub* Utilized so that the height has been reduced to not less than half the potential height.
3	*Tree* Utilized to the extent that the canopy is no longer intact and the majority of new leaves are borne on thick hard branches. *Shrub* Utilized to the extent that the height has been reduced to less than half the original height.
4	*Tree and shrub* Plant dead, either upright or lying down.

The degrees of utilization of *B. albitrunca* were divided into five classes (Table I) based on knowledge from a previous survey of the same area (T. Nott and K. Nott 1989 unpubl. data). *C. mopane* was assessed using six utilization classes (Table 2). All plants were individually assessed. No distinction was made between utilization by different animal species or the effects of fire and frost, although brief notes were made.

TABLE 2: Degrees of utilization of *Colophospermum mopane*

Utilization	Condition of plant
0	No utilization of any part of the plant.
1	Utilization but height not affected.
2	Height reduced by utilization to more than half the original height.
3	Height reduced by utilization to less than half the original height.
4	Plant pushed over but still alive and height reduced to less than half the original height.
5	Plant dead, either upright or lying down.

The density of each species within different height classes showed asymmetrical distribution curves (typically Poisson) for transect lengths of 100, 200, 300, 400 and 500 m. The data were transformed using square root transformation (i.e. $y = x + 0,5$). A level of precision was set at 0,95 confidence limits of 20% of the mean (Green 1979). The required number of transects necessary to estimate the species population density was calculated for different height classes at the different transect lengths (Appendix 1) .

Graphs were plotted depicting the height distribution of each species and the percentage of the population within height classes having different degrees of utilization. Within each height class, at least 20 individuals were assessed for the degree of utilization. This is slightly more than that recommended by Walker (1974). When data could not be normalized, nonparametric statistics (Siegel 1956) were used. All tests were two-tailed.

RESULTS AND DISCUSSION

Density

C. mopane densities (plants/ha) calculated from data from all 500 m transects at each site, are presented (Table 3). The densities of *B. albitrunca* plants <1 m were 8,0 plants/ha for site A, 9,8 for site B, and 3,2 for site C. While no degree of precision could be calculated for other height classes, the density was however, lower than 3 plants/ha. The combination of all *B. albitrunca* height classes occurred at densities of 10,7 in site A, 13,8 in B, and 5,8 plants/ha in site C.

TABLE 3: The density of *C. mopane* (plants/ha) within different height classes for all transects of 500 m in length (* no confidence attached to density estimate).

Height class	Site A	Site B	Site C
<1	156	84	193
>1<2	69	42	112
>2<3	36	34	29
>3<4	17	21	11
>4	3*	8	3
All	381	189	348

The height distribution of *C. mopane* (Figure 2) depicts a healthy population. Up to 50% of the population is within the height class of less than 1 m. The percentage of the population in each height class decreases evenly with increasing height.

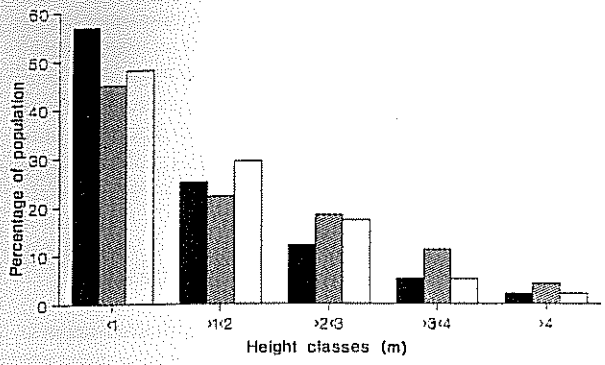

FIGURE 2: Height distribution of *C. mopane* for site A (n=7118), B (n=4694) and C (n=4494). Site A is indicated by the solid bar, site B by the shaded bar, and site C by the open bar.

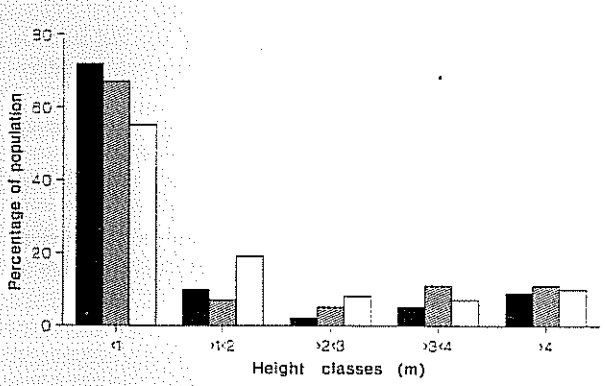

FIGURE 3: Height distribution of *B. albitrunca* for site A (n=549), B (n=705) and C (n=276). See Figure 2 for key

The height distribution of *B. albitrunca* for the three sites shows that up to 70% of the population is below 1 m in height (Figure 3). The remaining height classes are less prominent although replacement into subsequent height classes may be possible.

Utilization

The examination of the height structure of each species may provide an indication as to the "health" of each population. This would be incomplete without some assessment of "utilization" which provides an indication of the combined effects of browsing, fire and frost. Few plants showed no signs of utilization.

Utilization of different height classes for *C. mopane* were combined as there were no significant differences between the degrees of utilization in the different height classes for site A ($X^2_{12} = 284,8$; $P < 0,001$), site B ($X^2_{12} = 222,3$; $P < 0,001$), and in site C ($X^2_{12} = 220,9$; $P < 0,001$) (Figure 4).

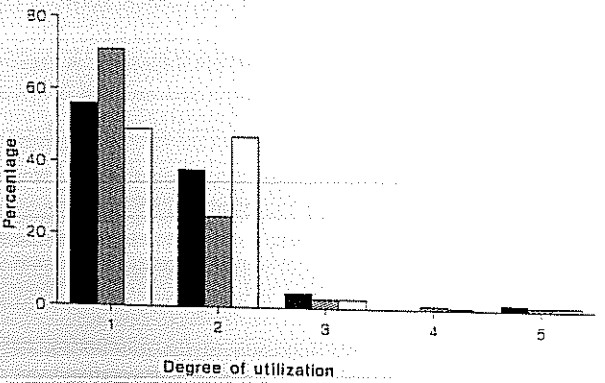

FIGURE 4: Degrees of utilization for all height classes of *C. mopane* for site A (n=5288), B (n=3657) and C (n=3183). See Figure 2 for key.

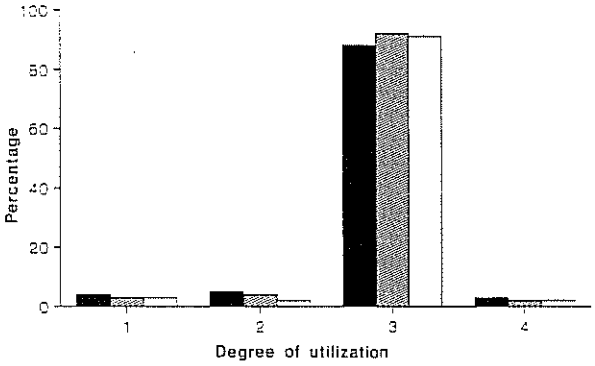

FIGURE 5: Degrees of utilization of *B. albitrunca* below 2 m for site A (n=461), B (n=530) and C (n=208). See Figure 2 for key.

In areas A and B, the majority of plants showed signs of light utilization and plant height was not affected. In area C, however, relatively more plants were utilized to the extent that their height had been reduced to about half of their original height. In the lower height classes (<2 m), this utilization was due to severe frost and particularly fire, which in the past 15 years has been more frequent in area C than in areas A and B. Reduction in height among the taller height classes (>3 m), albeit scanty, was primarily due to utilization by elephants.

B. albitrunca plants below 2 m in height showed a high degree of utilization (Figure 5). About 90% of the population in all three areas were utilized to the extent that plant height was reduced to less than half the original height. The main stems as well as the coppice regrowth were reduced to thick stunted stumps. The few plants whose height was not affected were adequately protected by other trees and therefore less accessible. Protruding leaves or branches were found to be browsed so the growth of the plant was restricted to within the canopy of the host species. Under the present stocking rate/ratio, these plants are unable to replace those within other height classes. This situation is very unlike that of *C. mopane* within the same height classes.

B. albitrunca plants between 2 and 3 m were also recorded as being highly utilized (Figure 6). Because an insufficient number of plants were recorded for area A, utilization could not be assessed. In area B, 38% of the plants were dead. Up to 19% (area C) were recorded as being utilized with the canopy only partially affected. These plants were in the protection of others. Trees between 3 and 4 m in height were intensively utilized (Figure 7). The majority of plants (up to 90%) were either dead or the canopy was completely destroyed. In area B, only 6% of the plants still had their canopies in tact. These plants occurred primarily on hill sides where accessibility to giraffe was limited. In area B, 4% of plants greater than 4 m were utilized, with their remaining canopies still in tact (Figure 8). Up to 36% (area C) of plants had grown out of the reach of giraffe although canopies within reach had been completely destroyed. Of the plants available to giraffe in area C, 58% had their canopies entirely destroyed. Areas A and B showed the most excessive utilization, with 65 and 85% respectively, of plants being either dead or having completely demolished canopies.

CONCLUSIONS

Density estimates

The approach presented here is efficient for providing density estimates at a desired level of precision for plants with a mean density of greater than 3 plants/ha. Follow-up surveys using this

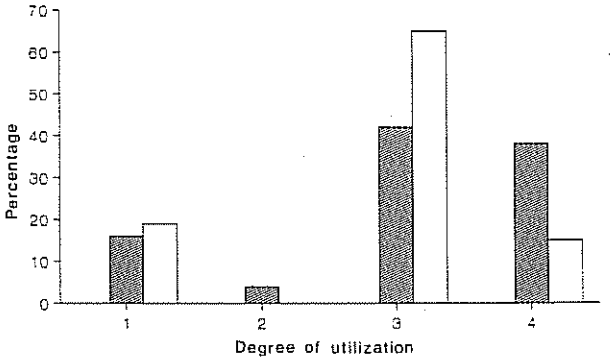

FIGURE 6: Degrees of utilization of *B. albitrunca* between 2 and 3 m for site B (n=26) and C (n=21). See Figure 2 for key.

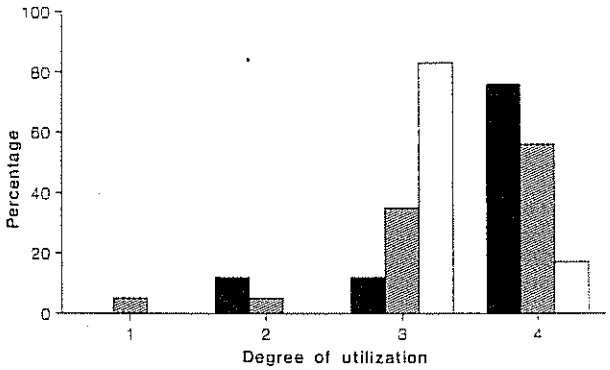

FIGURE 7: Degrees of utilization of *B. albitrunca* between 3 and 4 m for site A (n=26), B (n=74) and C (n=20). See Figure 2 for key.

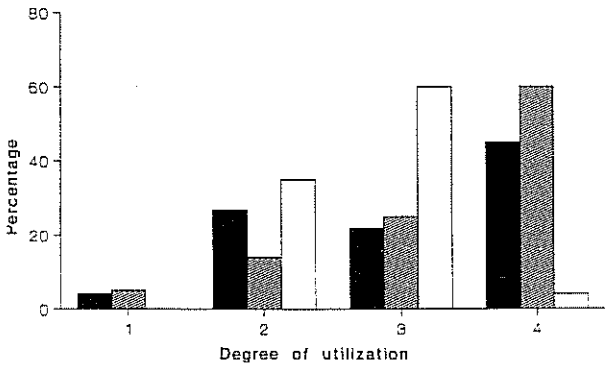

FIGURE 8: Degrees of utilization of *B. albitrunca* above 4 m for site A (n=54), B (n=75) and C (n=28). See Figure 2 for key.

approach can be easily conducted and tested statistically. These differences can be determined for individual species within different height classes. Significant differences beyond the permissible limits of change, within a particular height class, may be related to levels of utilization. These in turn may indicate the type of management to be used. Furthermore, the degree of utilization may show deviations beyond those considered desirable and this may help to identify the type of management to be applied at an early stage. This is manifested by the high utilization pressure on *B. albitrunca* by giraffe.

Utilization

Under the present pressures of fire, frost and browsing, the utilization of *C. mopane* is low. No signs of high utilization are present for any height class and all height classes are adequately represented.

Under the present browsing pressures, the survival of *B. albitrunca* trees between 3 and 6 m is questionable. These trees are being severely browsed by giraffe whose numbers in the las ten years have increased dramatically. Younger trees (below 3 m in height) are subject not only to browsing by giraffe but the combined browsing of many other species. Under these conditions, the growth of small trees is restricted. In the long term an overall decrease in the density may not necessarily result, bu a decrease in the density of plants between 1 and 6 m is likely The larger trees which have grown beyond the reach of giraffe will not live forever. Without replacement, these trees will also disappear under the present browsing pressures.

Recommendations for future monitoring in other areas

It is recommended that:

1. Density and utilization estimates of tree species be assessed within height classes of above and below 3 m.
2. More dominant plant species, within the selected area, be included for both density estimates and assessment of utilization.
3. Larger areas (than those chosen for this study) be considered for estimates of density and assessment of utilization.
4. Within each transect, levels of utilization need only be assessed for about 20 plants within each height class.
5. Initially, only 30 transects per area need be assessed to establish a baseline survey and to facilitate the calculation o levels of precision.

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APPENDIX 1: Optimal transect length and number for 0,95 confidence limits of 20% of the mean for *C. mopane* and *B. albitrunca* in different height classes within the study sites A, B and C, in western Etosha National Park.

Study site	Height class (m)	Transect length (m)	*C. mopane* Number of transects	*B. albitrunca* Number of transects
A	<1	400	28	-
		500	28	27
	>1<2	400	29	-
		500	32	-
	>2<3	400	24	-
		500	26	-
	>3<4	400	24	-
		500	26	-
	>4	-	-	-
	All	300	24	27
		400	22	24
		500	22	21
B	<1	400	19	25
		500	16	54
	>1<2	200	22	-
		300	19	-
		400	19	-
		500	18	-
	>2<3	200	14	-
		300	14	-
		400	13	-
		500	11	-
	>3<4	230	14	-
		200	13	-
		300	10	-
		400	10	-
		500	9	-
	>4	300	16	-
		500	15	
	All	100	13	-
		200	12	22
		300	11	21
		400	10	20
		500	9	19
C	<1	200	9	-
		400	-	23
		500	-	20
	>1<2	100	19	-
		200	12	-
	>2<3	200	21	-
	>3<4	200	35	-
		300	32	-
		400	28	-
		500	28	-
	>4	300	15	-
		400	16	-
		500	17	-
	All	100	7	-
		200	5	-
		400	5	23
		500	5	22