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Vegetation changes in the Hluhluwe-Umfolozi Game Reserve Complex from 1937 to 1975

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ABSTRACT

The structural changes that have occurred in the vegetation of the Hluhluwe-Umfolozi Game Reserve Complex have been quantified using 1937, 1960 and 1975 aerial photographs, and related to the management history. A progressive increase in both tree and shrub cover has occurred. In the short term, both intensive woody plant removal operations and controlled burning applications appear to be effective in retarding the rate of encroachment by shrubs and trees. However, neither was effective in the long term. Significant reductions in tall grass cover attributed to sustained overgrazing have occurred.

INTRODUCTION

A number of qualitative and semi-quantitative accounts of the vegetation of the Hluhluwe Game Reserve Complex have indicated that gross structural changes have occurred since proclamation (Henkel, 1937; Cowles, 1959; Deane, 1966; and Downing, 1972; 1980). This study was carried out in order to quantify these changes and to investigate their relationship to management practices.

THE STUDY AREA

The Complex (Fig. 1) is situated between latitudes 28°00' and 28°26'S and longitudes 31°43' and 32°09'E, the area comprises the Hluhluwe Game Reserve, the Corridor and Umfolozi Game Reserve and is 900 km^2 in area. It is divided into 34 game control blocks which form the framework for a continuous programme of ungulate population management. Five of these blocks were selected for this study (Fig. 1). Their environmental details are shown in Table 1. The general biogeographic features of this area have been described by Moll & White (1978). Acocks (1953) defined two major veld types present in the Complex, namely the Zululand Thornveld (type 6) which is a Coastal Tropical Forest type, and the Lowveld Tropical Bush and Savanna (type 10). The woody plant communities have been detailed by Whately & Porter (1982).

METHOD

The 1937, 1960 and 1975 aerial photographs (respectively Jobs 117/37; 442 and 752 of the Trigonometrical Survey) of the five study blocks were adjusted by photographic transfer to a common scale of approximately 1: 20 000. Transparent sheets with a low light reflectance and super-imposed with a grid frame of 10 mm^2 units were placed over the photographs. A TOPCON stereoscope and a parallax bar were used to identify the vegetation at every grid point. The mean sample density for each block in all three years was one point for every 1,99 hectares.

The textural classes used were: (i) tree; (ii) shrub; (iii) tall grass and (iv) short grass and bare ground. Vegetation was identified principally on the basis of canopy height, e.g. woody components with canopies greater than 2 m in height were classed as trees, and those less than 2 m as shrub. Where vertical estimates were precarious because of poor

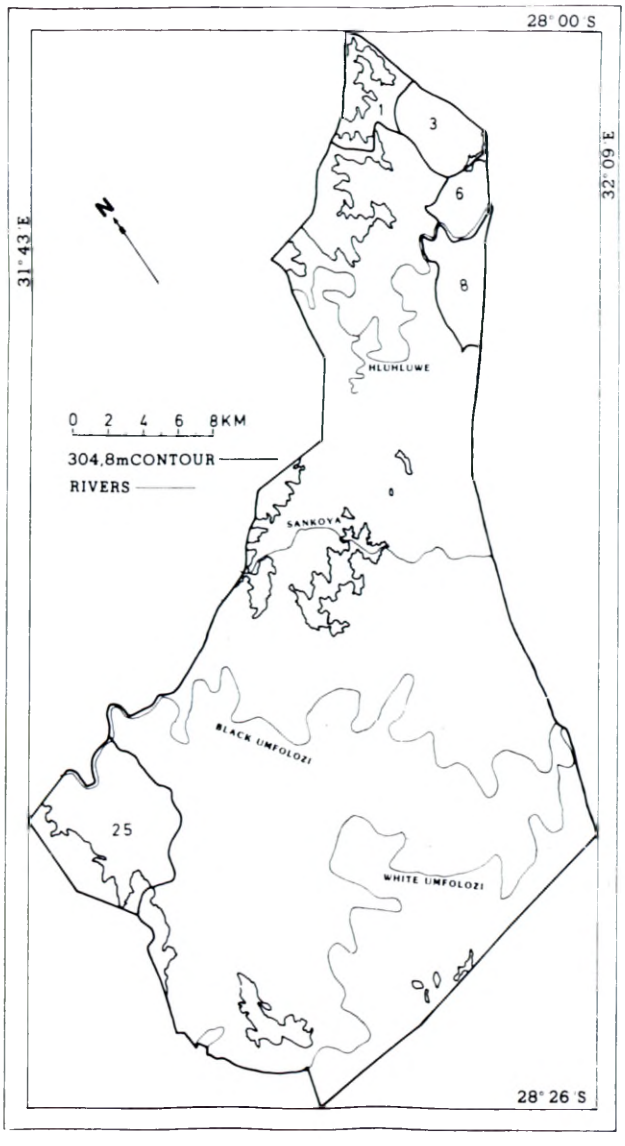

FIG. 1.—The location of the game removal blocks studied in Hluhluwe-Umfolozi Game Reserve Complex.

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TABLE 1.—Environmental features of study blocks

Game control blocks	1	3	6	8	25
Geology-listing in order of prevalence	Sandstone Shales	Basalt Sandstones Shales	Shales Sandstones Dolerite	Shales Sandstones Dolerite	Shales Sandstones Dolerite
Altitudinal range in m	122 to 495	122 to 390	82 to 390	152 to 497	122 to 598
Mean annual rainfall in mm	900	850	850	750 to 800	650 to 750
Bioclimatic subregions (Phillips, 1973)	9A, 9C	9A, 10B	10B	10B	9C
Total area in ha	1750	1656	965	1740	4960

photo resolution, identification was made on the basis of lateral canopy spread and similarity to other components of the same textural class previously identified on the basis of canopy height. The grass cover in areas identified on the photographs as having been recently burnt was classified as short. The percentage of each block occupied by each class was obtained by dividing the total number of points intercepting each class by the total number of grid intercepts examined, multiplied by 100, within each block.

Each group of ten adjacent points was treated as a sample unit. The number of points in each vegetation class was computed for each sample unit. The differences in this variate between the years studies were tested for statistical significance using the Standard Students t Test.

Summaries of the burning and intensive vegetation management histories for each block were extracted from annual maps lodged in the Hluhluwe Research Centre. The total area burnt each year within each block was measured for the period 1955 to 1974. Records prior to 1955 are not available. The 1975 fires occurred after the aerial photographs for that year had been taken. The burning data were summarized as the mean percentage of the area of block burnt per annum for the periods 1955 to 1959 and 1960 to 1974. The intensive vegetation management was of two main types: in block 25 a large strip was cleared of all woody vegetation as part of the anti-Tsetse fly campaign during the period 1942 to 1949 (Du Toit, 1954); in blocks 3 and 6 shrub invading areas of grassland and open savanna was selectively removed using a range of approaches over the period 1957 to 1969 (Ward, 1962). The areas treated were measured from maps and summarized as mean percentage of the area of each block treated per annum for the periods 1955 to 1959 and 1960 to 1974.

RESULTS

The results of the vegetation cover determinations are presented in Table 2. Derived parameters of vegetation change together with data on burning and intensive vegetation management within each study block are presented in Table 3.

The relationship between the rate of change in woody plant canopy cover and the mean percentage of the area burnt per annum is illustrated in Fig. 2. This relationship was shown to be significant at a 95% confidence level.

DISCUSSION

1. *Changes in tree and shrub cover*

A progressive increase in tree canopy cover over the period from 1937 to 1975 is apparent in each of

TABLE 2.—Vegetation cover percentages measured from aerial photographs

Game control blocks	1	3	6	8	25
Years	37 60 75	37 60 75	37 60 75	37 60 75	37 60 75
Tree	31 42 45	22 23 25	16 18 30	31 45 51	18 23 34
Shrub	14 25 27	41 56 55	44 61 58	12 30 37	51 44 30
Tall grass	30 12 18	37 21 18	39 20 12	35 15 7	29 31 33
Short grass + bare ground	25 21 10	0 0 1	1 1 0	22 10 5	2 2 3
Total woody plant cover	45 67 72	63 79 80	60 79 88	43 75 88	69 67 64
Trees as % of woody cover	69 63 63	35 29 31	27 23 34	72 60 58	26 34 53

TABLE 3.—Derived parameters of vegetation change together with data on burning and intensive vegetation management

Block	1		3		6		8		25	
Period	37–60	60–75	37–60	60–75	37–60	60–75	37–60	60–75	37–60	60–75
Vegetation:										
Change in % cover of woody plants/annum	+0,96	+0,33	+0,70	+0,70	+0,83	+0,60	+1,39	+0–87	−0,09	−0,20
Change in % cover of tall grass/annum	−0,78	+0,40	−0,70	−0,20	−0,83	−0,53	−0,87	−0,53	+0,09	+0,13
Fire:										
% of block burnt per annum	17	26	12	24	3	13	9	12	48	20
Intensive management:										
% of block cleared per annum	0	0	0,74	2,00	0	0,80	0	0	2,2	0

the blocks studied including the Umfolozi block where woody vegetation was completely cleared from 51% of its total area during the period 1942 to 1949. The range in tree canopy cover increase excluding block 3 is from 14% to 20%. The relatively small increase in block 3 of 3% may possibly be attributed to the woody plant removal operations which covered 17% and 30% of its area during the periods 1957 to 1960 and 1960 to 1969 respectively. These trends indicate that burning is not effective in the long term retardation of tree invasion.

Shrub invasion is effectively retarded by burning in the short term (MacDonald, 1980; 1981). However, the net increases in shrub cover over the period 1937 to 1975 in all four Hluhluwe blocks suggests that this control, even where it is supplemented with intensive techniques, is not effective in the long term.

The observed reduction in shrub cover over the period 1937 to 1975 in block 25 may possibly be attributed to the 1974 burn of 52% of its area following five years of virtual fire exclusion and an above average rain season. Such a burn may be expected to have reduced a large proportion of the shrubs to a ground level coppice (MacDonald, 1980) which would not have been detected in the 1975 photographs.

2. *Effectiveness of fire in limiting woody plant encroachment*

Burning is the major management tool employed in the Complex to arrest the encroachment of woody species as logistic considerations have always limited the extent and frequency of intensive operations (Table 3; MacDonald, 1980; 1981). Despite the repeated use of fire since the Complex's early history, there have been no previous quantitative evaluations of its long term effects.

In the Umfolozi block, a net decrease in the total woody plant cover over the entire study period occurred. This decrease was more pronounced during the 1960 to 1975 interval, presumably because of the large 1974 fire. Controlled burning within the Hluhluwe blocks over the study period did not effectively arrest or reduce the woody plant components. It may, however, have been instrumental in retarding the rate of woody plant encroachment (Table 3; Fig. 2).

The frequency of control burns appears to be too low for effective long term arrestment of the woody components. From 1955 to 1978 encroachment occurred throughout the Complex, although a mean of 23% of the total area was burnt each year (MacDonald, *et al.*, 1980).

This study indicates that in order to maintain woody cover at existing levels the mean percentage of the area that has to be burnt per annum is approximately 33%. This is equivalent to a burning frequency of once every three years. This estimate should however be regarded with caution, as it is

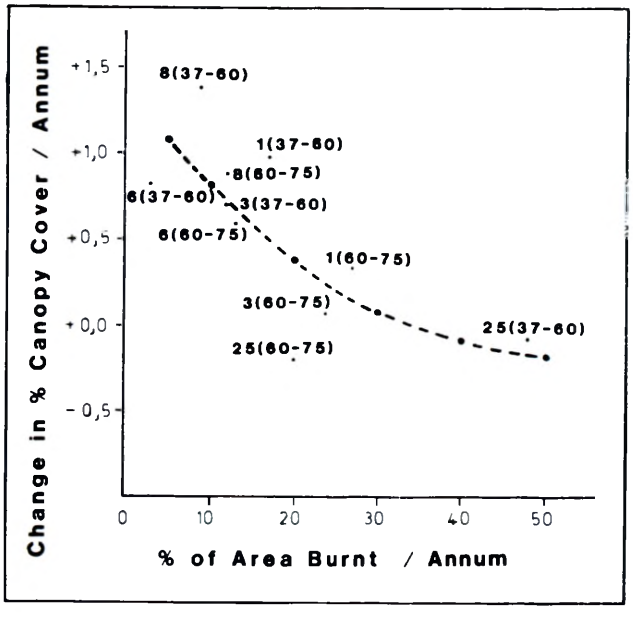

FIG. 2.—Relationship between rate of change in woody plant canopy cover and mean percentage of area burnt per annum.

derived from a period when data regarding the most effective frequency and season of burning was still accumulating. In particular many of the control burns were implemented after the first spring rains, a practice which is now considered to be deleterious to grasses and not as destructive to woody plants as a late dry season burn which is now being implemented. In addition, herbivore densities within the Complex between 1937 and 1975 exceeded the area's carrying capacity for extensive periods and therefore the fuel accumulation rates and hence fuel loads during burning, were probably too low on numerous occasions.

3. *Effectiveness of intensive operations in limiting woody plant encroachment*

During the 1940's the woody vegetation components were cleared from 51% of the area of block 25 in Umfolozi. The exact techniques employed in this area are not documented. In other areas cleared during the same campaign large trees were stumped out using a tractor, while smaller trees and shrubs were mattocked out at ground level and burnt in their felled positions. Although this clearing operation appears to have been effective in arresting the shrub encroachment, it had no long term effect on the encroachment of trees. As a result, the overall woody canopy cover on this block in 1960 was only 2% less than it had been in 1937.

The other block where large scale intensive management has been practised is number 3 in Hluhluwe. Although these operations apparently limited recruitment to the tree layer (*Acacia karroo* was the main species controlled and this species can form extensive stands of trees), the shrub cover increased considerably so that the overall woody canopy cover increased from 63 to 80% over the study period. The single large operation in block 6 when the shrub layer was removed from 12% of its area, was also unsuccessful in arresting the trend to woody plant dominance.

One of the reasons why this intensive management may have been ineffective is that the techniques used failed to kill the treated plants. This is highly likely in the case of the operations conducted in blocks 3 and 6: 408 ha were treated by cutting the plants at ground level, 328 ha by applying the arboricide 2-4-5-T to the plants and 150 ha by digging out the plant's rootstocks. Only the latter technique is likely to have resulted in anything like 100% mortality. The middle technique is influenced by such factors as concentrations, proportion of plants missed, season and method of application etc.; and has highly variable results, whereas the first technique is almost totally ineffective in killing those species treated.

4. *Changes in long grass cover*

In all the Hluhluwe blocks studied there have been signficant reductions in the extent of tall grass cover over the period 1937 to 1975. This has occurred notwithstanding the high proportion of short grass in two of the blocks in 1937 — thought to have been the result of an early dry season burn prior to the 1937 photography. The rate of decrease in tall grass cover in the Hluhluwe blocks was greatest in the 1937 to 1960 period. A possible reason for this is the fact that in Hluhluwe the first major reductions in grazer biomass were achieved in the late 1950's and 1960's.

In Umfolozi where block 25 actually registered an increase in tall grass cover over this early period, the anti-Tsetse fly game elimination campaign had reduced grazer biomass to very low levels over the period 1943 to 1953 (Du Toit, 1954). Most of block 25 was at this time outside the Umfolozi Reserve Boundaries and was a buffer zone in which total eradication of game was attempted. Game control was continued in this area over the period 1960 to 1975, and in fact large numbers of White Rhinoceros *Ceratotherium simum* were removed from the bush cleared zones due to the relative ease with which animals could be captured in these areas.

It appears then, that the long grass component of the study blocks has been reduced primarily through sustained overgrazing, a conclusion reached by other observers in the Complex namely, Cowles (1959) and Deane (1962).

5. *Consistency of results with other information*

The only previous attempt to quantify long term vegetation changes in the Complex is that of Downing (1980) who compared the 1937 and 1974 vegetation maps of Hluhluwe. However, due to differences in the mapping units used and the imprecision with which boundaries were determined these results are of questionable value. His estimate that 'grassland' areas decreased from 49 to 41% of the area during this period appears to be much too low. The comparable figures for areas covered by tall and short grass in the Hluhluwe blocks of this study are:- 55 to 28%, 37 to 19%, 40 to 12% and 57 to 12%. Most of this grass cover occurred within savanna communities. The accurate measurement of the area covered by vegetation communities in the Hluhluwe Game Reserve and northern Corridor, which is generally more open than Hluhluwe, showed that only 4% of the area was covered by grassland in 1975 (MacDonald & Phelan; in prep.).

In addition, Downing's (1980) findings that the increase in the extent of forest communities and the combined extent of woody communities of alluvial sand and lowland shrub communities over this period are 5% and 1% respectively, also appear to be gross underestimates. The results of this study and the comparison of historical photographs show an extensive displacement of lowland grassland areas by woody communities.

This study confirms Cowles's (1959) and Deane's (1966) reports of a decrease in the extent of tall grass communities and their replacement by shrubs in Hluhluwe over the period from 1925 to 1953 and in the adjacent Corridor over the period from 1954 to 1966, respectively.

Bourquin & Hitchins (1979) used the 1937, 1960 and 1969 aerial photographs to 'map apparent differences in the vegetation' of a study area in north western Hluhluwe. Although their results were not

quantified, they concluded that there had been an increase in the area covered by woody plant communities between 1937 and 1969. From inspection of historical photographs, they concluded that 'Rapid development of encroachment in Hluhluwe started taking place after 1949'.

Ward (1962) views the open grassland in Hluhluwe as a seral stage of the vegetation which may be prevented from progressing towards its climatic and edaphic forest climax by being subjected to the periodic retarding influence of fires. Downing (1972), likewise, views the Umfolozi grassland as a subclimax community which is part of the Deciduous Woodland Formation.

Hall (1977) and Feely (1978) have proposed that the increased frequency of vegetal firing associated with human occupation which dates back to Palaeolithic times, served initially to reduce the proportion of woody communities present within the Complex, and thereafter to maintain the dominance of grassland communities.

Weisser (1978a; 1978b) and Weisser & Marques (1979) have indicated the duration of the seral stages towards the forest climax of the Coastal Belt of Northern Natal once human influences such as burning, clearing, shifting cultivation and cattle-grazing were prevented.

From the results of this study, it is apparent that grassland areas, particularly those created by clearing established woody vegetation, are rapidly invaded by woody plants. The reduced frequency with which the vegetation was burnt and the removal of other human influences following the reserves' proclamation is seen as a fundamental factor responsible for the recent increase in the Complex's woody plant communities.

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UITTREKSEL

Strukturele veranderings in die plantegroei van die Hluhluwe-Umfolozi Wildreservaatkompleks is bepaal deur lugfoto's van 1937, 1960 en 1975 met mekaar te vergelyk. Hierdie gegewens is gekorreleer met bestuurspraktyke in die reservate. 'n Toename in sowel boom- as struikbedekking het voorgekom. Op die korttermyn skyn dit asof die verwydering en beheerde brand van houtagtige species die uitbreiding van hierdie veldtipe voldoende vertraag. Op die langtermyn nie een was doeltreffend nie. 'n Aansienlike afname in langgrasbedekking het voorgekom wat kan waarskynlik aan voortdurende oorbeweiding toegeskryf word.

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