the entire reserve are presented in Table 4. Also presented in Table 4 are the data obtained for transects classified according to their distances from the nearest permanent water supplies, i.e. nearer than 1 mile, 1 to 5 miles and more than 5 miles, as well as those obtained for the special transects in the few preselected, badly damaged areas.

Transects with poor grazing normally fall within the one-mile zone, but in a few cases such conditions prevail in areas further away. No positive correlation could be established however between the areas further removed from water and the prevailing state of the pasture. In spite of this non-correlation, a very close resemblance exists between the figures obtained for the two factors (Table 4). Utilisation of woody plants by elephant is inversely proportional to distance from water and the state of the grass-cover.

Tree utilisation for the three distance zones is 28.8% (12.3% destroyed), 21.7% (10.4% destroyed) and 13.9% (5.4% destroyed). Corresponding figures for grazing condition zones are nearly the same viz. poor 36.3% (14.7%), fair 21.4% (10.8%) and good 15.0% (6.7%).

Destruction of big shrubs is negligible, the highest being 3.7%, but browsing is from 8-16% higher than for trees, viz. 33.1%, 27.1% and 16.4% in the distance categories and 39.8%, 28.2% and 18.0% for the different pasture conditions.

The results attained from the special transects are disturbing in comparison. Of all adult trees 77% were utilised and of these 26.7% were killed or very badly damaged. The shrub position resembles that of overgrazed areas (43.5%).

When compared with the only other data available on this subject i.e. a preliminary report by Glover (1965) on conditions in the Serengeti woodland, the position in the Kruger Park would appear to be very sound indeed. 79% of the trees counted by Glover were less than 6 ft. and only 2% more than 25 ft. in height. Of the latter, 68.6% were utilised in some way or other and 32.2% were killed outright or so badly damaged that they would not survive. Only in the special transects does the local situation approximate the results of this worker, which was obtained from plots laid out at regular intervals over a distance of about 50 miles, thus probably covering all grazing conditions (Figs. 4 and 5).

An interesting phenomenon was brought to light by this treatment of the data. Both trees and shrubs which died of "natural" causes (other than elephant action) show a gradual increase with distance from water, as well as towards better quality grazing. This may be directly attributable to increased competition by the more virile grass cover, but it may also be due to the fact that the elephant removes some plants in the overgrazed areas near water which would have died in any case.

Also presented in Table 4 are the number of living plants (browsed and undamaged — *all categories*). Despite increased utilisation of shrubs on poor grazing land (difference 23%), the total number of shrubs per transect is considerably higher than under good grazing conditions (difference ± 150 plants/transect). Trees in general do not exhibit the same trend but the number of trees under bad pasture conditions are nevertheless higher than under the best conditions. Bush encroachment under overgrazed conditions is a common and well-known consequence of degraded range in the absence of fire and the above findings serve to confirm this.

With distance from water as the basis, increased scrub growth is also prevalent nearest the water and decreases away from it, but in the case of trees it is reversed. The reason for this is not clear.

As will be remembered, analysis of the results for areas A to F (high elephant concentrations in the dry season) apparently suggested a non-correlation of biomass of other herbivores with utilisation of the upper strata by the elephant. In those instances a particular area included all possible grazing conditions and the preponderant zones of good quality grazing in each of these areas most probably overshadowed the results.

Although some doubt still remains after the above more specific assessment, the evidence favours the implication of excessive utilisation by the associated ungulate grazers in an area as the primary reason for stimulating increased browsing activity and destruction of the upper strata by elephants.

The findings of a number of workers in other parks such as Buss (1961), and Napier-Bax and Shelldrick (1963), indicate that grass forms the bulk of an elephant's diet (75 to 90%). Preliminary observations in the Kruger Park point to a more proportionate contribution to stomach contents by grasses and woody growth (50/50), even under the very best of pasture conditions. This would lead one to think that under failing grazing conditions the upper strata would receive even more attention in the Kruger National Park.

Disregarding the relative importance of the various factors in determining increased utilisation of woody plants, it is nevertheless clear from the results presented that a shortage of permanent watering points and the poor dispersion of existing water leads to excessive concentration in and destruction of relatively small and isolated areas of the Park by elephants. (Vide Figs. 4 and 5). In terms of available grazing and browse in the Park as a whole, the area could potentially support a much higher biomass than at present, but in the determination of permissible population ceilings the protection of these vulnerable areas must enjoy priority.

Several workers in other parts of Africa — Glover (1963), Burton (1963) and others — have already attempted to determine the carrying capacity of particular vegetation types for elephant. The general consensus of opinion appears to be 1 to 4 per sq. mile, depending on vegetation, size of the area and availability of permanent water. From the evidence obtained in this survey, it would appear that the highest possible overall figure to be permitted in the Park should not even reach the lowest in other parts of Africa, but rather suggest a conservative maximum figure of 0.5 to 0.75/ sq. mile, if the total destruction of the vulnerable areas near water is not to be experienced.

OTHER FACTORS AFFECTING UTILISATION

(a) *Man-made roads*

It has been mentioned that the individual transects were subdivided into 3 equal sections, in an attempt to check the validity of a locally held theory that the utilisation of trees and shrubs close to man-made roads is higher than further away. According to the theory, elephants, particularly lone bulls, would spend much time on the roads and found them particularly convenient as routes of movement. This would lead to concentrated browsing of plants in the immediate vicinity of the roads.

Unfortunately, the transects were all laid out to leave the roads at an obtuse angle, and no significant difference could be detected between our results obtained for each of the three 333 yrd. sections. In order to finally prove or disprove the theory, a number of sampling areas will have to be completed which run parallel to the roads, as the possibly greater utilisation by elephants will be reflected only in the relatively narrow strip of a few yards along either side of a road.

If this theory holds good, it will become a decided factor to be borne in mind when planning new roads through special plant associations or in close proximity to very rare plant species.

(b) *Botanical composition*

During the surveys in the *Combretum/C. mopane* veld, it was noticed that tree destruction was very closely correlated with botanical composition. The two dominating species in this vegetation type sometimes occur in almost homogeneous stands. It became evident that wherever *Combretum apiculatum* occurred in relative abundance, there was a sharp rise in the number of trees that were pushed over. This was very obvious when the destruction was compared with adjoining areas, especially those with a high percentage of scrub mopane. The final data do not elucidate this phenomenon as well as they should. The different associations form such a closely integrated mosaic that each transect usually included all vegetation types and could not be subdivided to provide separate data.

Because of the very low fire-resistance of *C. mopane,* scrub forms of this species are normally burned back almost one hundred per cent by even moderate fires. As this shrub forms a vital part of the elephant's diet removal thereof, even temporarily, will probably induce abnormal utilisation of *C. apiculatum*. If this phenomenon can be demonstrated beyond doubt in the present case, and also in other plant communities (vide Central district), it will have to be seriously considered in future burning policies. Browsing of shrubs in all areas is much higher than utilisation of trees. For the entire area, browsing of shrubs (both categories) by elephant amount to ± 16% (i.e. 85 individuals/transect) and for trees to ± 10% (31 individuals/transect).

It is obvious that the lower plant strata (grasses, shrubs and herbs) constitute the bulk of the elephant's nourishment — a fact which is of the utmost importance in the application of sound pasture management.

GENERAL

(a) *Species preferences*

A detailed list of plant species utilized by elephant in the Kruger Park is not yet available. A preliminary list has been published (Brynard & Pienaar, 1960). In this section only species which receive special attention from elephant, as evidenced by the present survey, will be dealt with.

North of the Olifants River, in the area with the highest biomass, a greater variety of species is obviously better utilised than in the southern areas. Of these, only a few commonly receive close attention from elephant. *Colophospermum mopane* is, on account of its dominance, the most important source of food, even in the burnt stage, when the charred tips are eaten. Browsing is generally rather light and only in exceptional cases such as overgrazed areas, was it observed to be heavy.

Common species which are regularly severely damaged are the shrubs *Dalbergia melanoxylon*, and just about all the *Grewia* species such as *G. bicolor, G. hexamita, G. microthyrsa, G. kwebensis, G. flavescens, G. flava* and *G. monticola*. Elephants appear to be very partial to the subterranean portions of *D. melanoxylon* as it was frequently found uprooted. This habit of elephants serves a very beneficial purpose to the habitat, since the species in question tends to form almost impenetrably dense shrub thickets unless it is burned back regularly. *Commiphora africana* occurs less frequently, but is also uprooted.

Of the trees, *C. mopane* and *C. apiculatum*, because of their dominance, are pushed over more than any other species, and the former is also heavily browsed.

It is not yet evident whether trees are preferentially uprooted, but the structure of the root system of a species seems to be important in this context. All the dominant tree species in the Park such as *Combretum apiculatum, Combretum zeyheri, Acacia nigrescens, Terminalia sericea*, and, to a lesser extent, *C. mopane,* belong to the group with shallow root systems which may be pushed over with relative ease. On the other hand, species such as *Sclerocarya caffra, Acacia tortilis* and *Combretum imberbe* are usually only browsed — sometimes severeley — and in comparison with the others less often completely uprooted or destroyed.

High elephant concentrations may in this manner be responsible for the shifting of the dominance in a vegetation type towards a sub-domiant.

Other shrubs which are heavily browsed on occasion include, amongst others, *Dichrostachys cinerea* ssp. *africana var. africana* and *Mundulea sericea*, as well as shrub forms of the tree species *C. apiculatum, Strychnos innocua, Hyphaene crinita* and *Pterocarpus rotundifolius*. Typical tree forms of *Albizia harveyi, Lannea stuhlmannii, Pseudolachnostylis maprouneifolia, Diplorhynchus condylocarpon* and *Croton megalobotrys* are also heavily browsed as a rule.

Less frequent heavy browsing was also noticed in species like *Maytenus senegalensis, Ozoroa insignis, Terminalia prunioides, Acacia xantophloea, A. nilotica* var. *kraussiana, A. gerrardii, Lonchocarpus capassa, Bolusanthus speciosus* and *Cassia abbreviata* var. *granitica*.

In the central region (Olifants to Sabi Rivers), fewer species are involved in heavy utilisation, the most important being *Colophospermum mopane, Pterocarpus rotundifolius, Acacia nigrescens, Albizia harveyi, Dichrostachys cinerea* ssp. *africana* var. *africana, Dalbergia melanoxylon* and all the *Grewia* species in the area.

Other species involved, which have not been mentioned for the northern region, include *Combretum hereroense, Combretum mechowianum, Gardenia spatulifolia, Sterculia rogersii, Pavetta schumaniana, Acacia senegalensis* var. *restrata, A. delagoensis, Albizia evansii, Ormocarpum trichocarpum, Rhigozum zambesiacum, Cordia gharaf, Pappea capensis, Commiphora mollis* and *Rhus spinescens*.

Severe utilisation is very limited in the southern region and only a few species are involved. The most important of these are the variety of *Grewia* species which normally suffer severely wherever they occur. Other species utilised in this area include *Pterocarpus rotundifolius, Dichrostachys cinerea* ssp. *africana* var. *africana, Combretum apiculatum, Dalbergia melanoxylon, Terminalia prunioides, Acacia nigrescens, Strychnos innocua* and *Sclerocarya caffra*.

In general the species suffering most severely through elephant feeding activity are therefore: *Colophospermum mopane* (browsed and pushed over), *Combretum apiculatum* (mainly pushed over), *Grewia* spp. (severely browsed) and *Dalbergia melanoxylon* (shrubs uprooted).

In certain species, such as *C. apiculatum* and *C. imberbe*, pushed-over trees mostly suffer no ill-effects and continue to grow, seemingly undisturbed. On overgrazed areas, such trees perform a very useful function in providing a permanent source of food for smaller browsers, and protecting seedbeds of grass by their branches.

General observations revealed that by far the greater percentage of uprooted trees are not at all well utilised by the culprit in question, and also that the solitary trees in the scrub mopane vegetation are normally left unhindered. As has been pointed out previously, the present tempo of utilisation, although the figures represent the cumulative effect over many years, appears to be abnormally high judging from present elephant biomass.

(b) *Fire*

Whereas there appears today to be general agreement about the major importance of fire and of elephants as factors which are capable, singly or in combination, of effecting drastic changes in the vegetation of a region, it is necessary here to include a few remarks on the effect of fire on the indigenous flora.

Fire and elephant depredation are both natural ecological factors which, since time immemorial, have played significant parts in the realisation of certain plant communities, and are thus indispensable to their maintenance and survival.

The present three-year rotational burning policy applied to the Kruger Park is aimed at removal of excessive combustible material in such a manner and at such a time as to provide, in the highest possible degree, for the protection of all plant strata. This implies generally that veld is only burned after good spring or early summer rains and only during moderate climatic conditions, sometimes at night.

When considered in this context, fire appears not to be the utterly destructive phenomenon which it is sometimes made out to be.

Most indigenous species have acquired over the years some resistance or at least tolerance to fire — hence the particular associations and dominances which develop in the presence of fire.

Only three areas in the Park show evidence of permanent destruction of adult trees by fire.

(i) Large *Acacia xantophloea* specimens were exterminated by successive veld fires in the very heavily-grassed Shawu valley, north of the Letaba, before preventative steps could be taken.

(ii) In another instance (Nwambiya sandveld) annual dry-season fires, spreading from neighbouring Portuguese East Africa over a number of years, burned a unique floristic association back into scrub thickets. Only charred stumps of one rare species, *Baphia obovata*, remain today as evidence that this shrub once occurred as big trees. Other species also suffered severely, but in all cases tree forms survived.

Adjoining vegetation types *(C. mopane — C. apiculatum)*, although subjected to the same treatment, show no conspicuous damage.

(iii) In another case a hazardous veld fire in 1953 destroyed a large precentage of the adult trees of the species *Burkea africana* and *Afzelia cuanzensis* in the Punda Milia sandveld. Today, most of these blackened stumps still remain as witnesses of the event. No other species suffered the same fate and apart from the above, only partially charred boles of other living species are found.

The Pretoriuskop area, on the other hand, illustrates what may happen in the absence of fire. Before, and even after, the establishment of the Park, this area was burned annually. Old photographs and the evidence of persons who knew the area in former times confirm that it used to be open grassland savanna, with only scattered trees and shrubs. During a period when fire was outlawed from this area, and in the absence of elephant, it changed from grassland savanna, teeming with wildebeest and zebra, into typical bushveld with fast expanding impala and kudu populations.

The veld-burning experiments which commenced 13 years ago are conducted in all the major veld types and indicate, in preliminary surveys, that the direct influence of fire, as far as woody species are concerned, is mainly limited to the regular burning back of smaller individuals without destroying them outright. Whether this will eventually lead to the total destruction of certain species remains to be seen. Small *C. mopane* and *A. nigrescens* plants are definitely kept in check, but are not yet destroyed completely by successive treatments.

Big trees are normally only killed by a succession of serious fires. Once a wound is created in the bole of a tree, successive fires will enlarge it and eventually — after many years — the specimen is killed either through direct action of the fire, or by insects penetrating the exposed wood.

Indirectly fire may be responsible for vegetation changes by (i) preventing seed production or (ii) destruction of seeds or (iii) forcing the elephant to overutilise certain tree species by destroying shrub species that are less susceptible to elephant damage.

(c) *Accumulation of dead material and its influence on the data*

One aspect of the survey which merits careful scrutiny to obviate possible false impressions concerns the visibly high number of dead trees which have been destroyed by elephant as well as by other causes. The percentage of dead trees rises very sharply from the small, through the young to the large tree category and then drops off in the outstanding group to about the same level as for the young.

It is significant that the figures for both trees killed by elephant and killed by other causes, follow exactly the same pattern. This immediately rules out increased elephant action as a factor which could have been responsible for the increased damage in the upper strata. This leaves only one possible factor to be considered. viz. greater accumulation of dead material with increase in size of the tree. All dominant tree species are hardwood types and take a very long time to rot away, even in the presence of fire. In the absence of fire, this process must continue for at least a few decades, depending on the size and the species.

At present about 50% of the Kruger Park is theoretically — temporarily or permanently — withdrawn from the burning programme. During the drought period, even the normal rotational burning programme were largely suspended. A network of special firebreak and tourist roads also diminishes the possibility of devastating fires which would remove dead, combustible material. On denuded, overgrazed areas — precisely those in which the worst destruction is experienced — fires do not occur. Elimination of the dead material consequently being entirely a function of insects and lower organisms, decomposition takes even longer. The very important part played by this factor in over-emphasizing the damage to the flora — *even through browsing* — cannot be stressed too strongly.

The situation in the largest group of trees must probably be attributed to transects being too small to provide reliable data — an average of only 1.9 trees/transect (dead and alive) was encountered.

Dead material derived from the small tree and shrub categories normally disappears rapidly and the data will therefore reflect the accumulation of only, at most, a few precedings years.

(d) *Present botanical composition of the Kruger Park — living plants in the upper strata*

A proper evaluation of the condition or trends in a plant community is only possible from comparison of data on the composition of the living components as derived from successive surveys.

The number of living (undamaged and browsed) trees and shrubs in the different areas, under different grazing conditions, is presented in Table 5. Lack of information regarding the composition of a fundamentally sound natural plant community renders the data of little value. In order to assess the implications of the present situation as shown in Table 5, the data therein are compared with the only comparable data available for woody plants, i.e. those for artificial forests of Natal (an area of higher rainfall).

In artificial forests, a degree of density absolutely undesirable in a natural bush/grass association prevails. It will therefore be necessary to strive towards a much more "open" vegetation in natural savanna or woodland, with consideration of species differences, in order to maintain a proper balance. It has been recommended that the density of trees in the Natal forests should be from ± 500-900/acre for various species at planting time. With regular thinning out, this number is diminished to between 60 and 110 after a period of 25 years. In a natural association numbers such as 150-300 small or 20-50 large trees per acre would be far more realistic.

TABLE 5

NUMBER OF LIVING TREES AND SHRUBS/ACRE UNDER VARIOUS GRAZING CONDITIONS IN THE KRUGER NATIONAL PARK

AREAS	PLANT CONDITION	TREES				SHRUBS		TOTAL		GRAND TOTAL
		Small	Young	Large	Outstanding	Small	Large	Trees	Shrubs	
Special transects	Undamaged	46.8	23.1	2.8	1.0	94.0	172.8	73.7	266.8	340.5
	Browsed	9.3	41.8	2.8	0.4	40.6	164.0	54.3	204.6	258.9
	Total	56.1	64.9	5.6	1.4	134.6	336.8	128.0	471.4	599.4
Poor grazing	Undamaged	106.1	63.0	11.4	1.2	207.6	111.9	181.7	319.5	501.2
	Browsed	12.1	29.9	2.7	0.2	49.2	119.0	44.9	168.2	213.1
	Total	118.2	92.9	14.1	1.4	256.8	230.9	226.6	487.7	714.3
Fair grazing	Undamaged	139.0	75.7	10.9	1.0	244.2	122.7	226.6	366.9	593.5
	Browsed	14.2	16.1	1.6	—	17.8	55.3	31.9	73.1	105.0
	Total	153.2	91.8	12.5	1.0	262.0	178.0	258.5	440.0	698.5
Good grazing	Undamaged	123.7	64.9	8.8	1.1	179.0	143.2	198.5	322.2	520.7
	Browsed	7.3	8.6	0.9	0.1	8.8	34.3	16.9	43.1	60.0
	Total	131.0	73.5	9.7	1.2	187.8	177.5	215.4	365.3	580.7
Average for K.N.P.	Undamaged	131.4	72.9	11.3	1.1	224.0	120.6	215.7	344.6	560.3
	Browsed	11.5	15.7	1.6	0.1	23.6	59.6	28.9	83.2	112.1
	Total	142.9	88.6	12.9	1.2	247.6	180.2	244.6	427.8	672.4

In comparison, the Kruger Park's density/unit area of large trees generally does not appear to be excessive, but this group is definitely not in danger of extinction. The tree population (large and outstanding) under the different grazing conditions varies from 7/acre in badly damaged areas (special transects) to 15.5, 13.5 and 10.9 as grazing improves.

When the number of young trees, viz. 65, 93, 92 and 74/acre respectively, of which the majority are in the 15-20 ft. range, as well as those in the small category (from 56-153/acre) are added, it becomes apparent that the density tends to approach an undesirable level. It must also be borne in mind that the average numbers of trees are greatly reduced by including data derived from the vast, almost treeless scrub mopane flats. Shortage of replications unfortunately rendered comparison of specific plant communities impossible.

Total plant population (trees and shrubs — all categories) amounts to 599 (special transects), 714 (poor grazing), 699 (fair grazing) and 581 (good grazing) per acre.

Apart from this alarmingly high population of woody plants, another disconcerting fact regarding the composition of the tree community is also illustrated by the data. At present the tree community contains 5.7% really large (large and outstanding), 36.1% young and 58.2% small trees. The smaller categories are probably more vulnerable to natural disasters and a fair number will die off or will, particularly in the small group, be kept back by fire. At this stage however, there seems to be no reason to believe that the majority of these plants will not reach maturity.

If this argument holds true, then the Kruger Park suffers, with the exception of a few relatively small abused areas, rather from general bush encroachment than from denuding of woody growth by the elephant (and or fire).

SUMMARY

(1) Severe drought conditions in the Kruger Park revealed a number of vulnerable areas with over-utilisation of all plant strata taking place.

(2) This situation necessitated a project to determine the existing relation of the ± 2,400 elephants to plant communities in their habitat.

(3) For this purpose 165 transects, each 6 x 999 yards, were laid down at regular intervals throughout the entire area and all woody plants included therein were counted and tabulated according to physical condition viz. (a) *undamaged*, (b) *browsed* (i) by elephant, (ii) by other animals and (c) *dead* (i) by elephant action and (ii) from other causes; and according to size viz. (a) *trees: small* (crown height less than 6 ft.); *young* (crown height mor than 6 ft. but not yet adult); *large* and *outstanding*, (b) *shrubs: small* and *large*.

(4) Heavy utilisation of particular species, botanical composition and general grazing condition were recorded in all transects.

(5) A short discussion of the Park's vegetation and the developmental history of the local elephant population is presented.

(6) The data compiled from the survey suggest that:

(a) There is a well-balanced overall vegetation with a tendency towards bush encroachment — the average living tree and shrub population/acre was 245 trees (of which 143 are less than 6 ft. high) and 428 shrubs, of which 248 are small.

(b) Utilisation is generally low to moderate and only in a few small areas does it reach alarming proportions.

(c) Utilisation of small trees and shrubs is negligible except where areas were over-utilised.

(d) Utilization of the woody strata is positively correlated with elephant biomass. Utilization of adult trees: at 436 lbs./sq. miles = 8.9%, at 887 lbs./sq. mile = 22.3% and at 3,726 lbs./sq. mile = 29.2%; that of large shrubs = 7.0%, 29.7% and 37.9% for the respective biomass figures.

(e) The most severe damage by elephants occurs in areas utilised by large concentrations of elephants during the dry season (total utilisation of adult trees and large shrubs = 31.9% and 41.4% respectively), followed by areas utilised by low concentrations of elephant in the dry season (17.7% and 17.6% respectively) and is least in the customary summer ranges (13.9% and 14.9%; 17.3% and 4.5% respectively for the two groups of areas distinguished).

(f) Except for the Pafuri area (A) where over-utilization takes place, the average total utilization in high-biomass winter ranges is on about the same moderate level (27 to 32% for trees and 21 to 46% for shrubs) in spite of relatively large biomass differences, (± 1,200 to 7,700 lbs./sq. mile) and necessitates no immediate action against the elephant.

(g) Winter ranges, linked with the only available permanent water supplies, are the most vulnerable and impose definite limits on the potential carrying capacity of the entire area.

(h) Utilisation is inversely correlated with the distance from a water supply and decreases with distance. (28.8 tot 13.9% for adult trees).

(i) Pasture condition and distance from water are closely correlated and utilisation will therefore follow the same pattern (36.3% in case of poor grazing to 15.0% in good grazing).

(j) Eventually the condition of the vegetation in the zone ± one r from water sources will have to be considered in determining carrying capacity of the entire area.

(k) Shrubs are generally more frequently utilised (mainly browsed) t trees.

(l) Trees are more frequently used in ranges with low shrub c centrations.

(m) The central region of the Park appears to be very vulnerable c result of the above-mentioned fact, and elephant biomass will h to be adjusted accordingly.

(n) Temporary removal of the shrub stratum may result in abnor tree utilisation — the role of fire in this respect is discussed.

(o) The number of trees killed by causes other than elephant ac exceeds that killed by elephant (average of 2.8% for K.N.P.), the difference markedly increases with distance from water —0 to 8.9%) and improvement in pasture condition (—2.9% to 7.8

(p) Some species are, owing to dominance or palatability, more quently utilised than others A list is submitted which includes most important heavily-used species.

(7) Root structure and/or bole flexibility renders some trees less vulner to uprooting than others.

(8) The life of certain species does not end with uprooting, but may tinue for the benefit of smaller browsers, and at the same time pro shelter for plants and smaller animals, especially on denuded arec

(9) The possibility of increased browsing in the close vicinity of roac discussed.

(10) The role played by the accumulation of dead material in over-em sizing the browsing and destruction rates is discussed.

(11) From this survey, it would appear that the highest number of elept which could be carried in the Park, would be 0.75 animals/sq. if the total destruction of the vulnerable areas near water is nc result.

(12) The urgent need for further research is pointed out.

ACKNOWLEDGEMENTS

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Plate 1: *Colophospermum mopane* woodland, far from water, in an area utilised by high concentrations of elephant during the dry season (Area B — fig. 1).

Plate 2: *Combretum apiculatum/Acacia nigrescens* veld in Area G (fig. 1). Note density and healthy condition of tree stratum.

Plate 3: Over-utilised portion of Pafuri region (Area A, fig. 1).

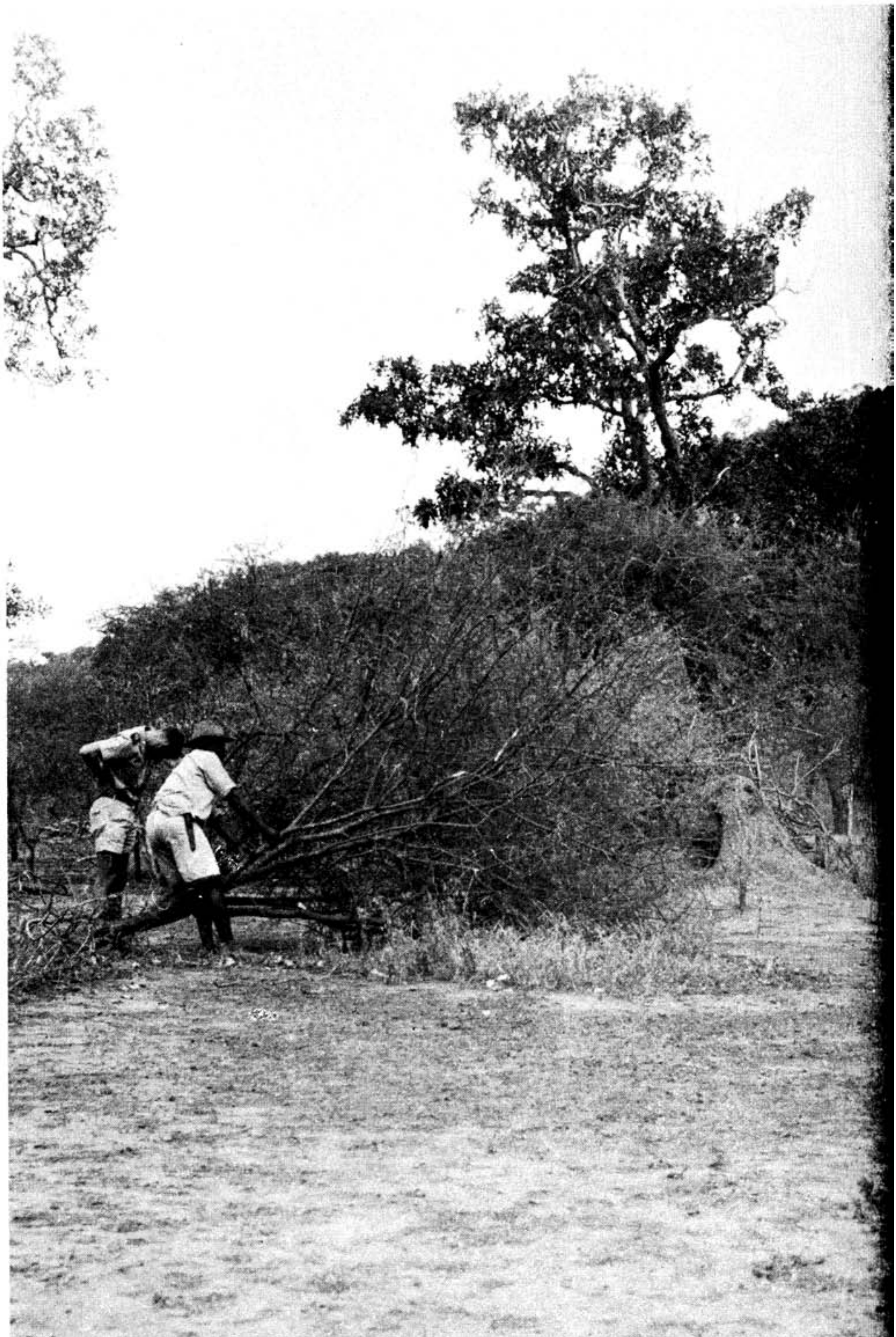

Plate 4: The beneficial function of an uprooted tree on an overgrazed area in preserving a source of grass seed.

Plate 5: Dense stand of undamaged shrub mopane (*Colophospermum mopane*) in Area (a), fig. 1.

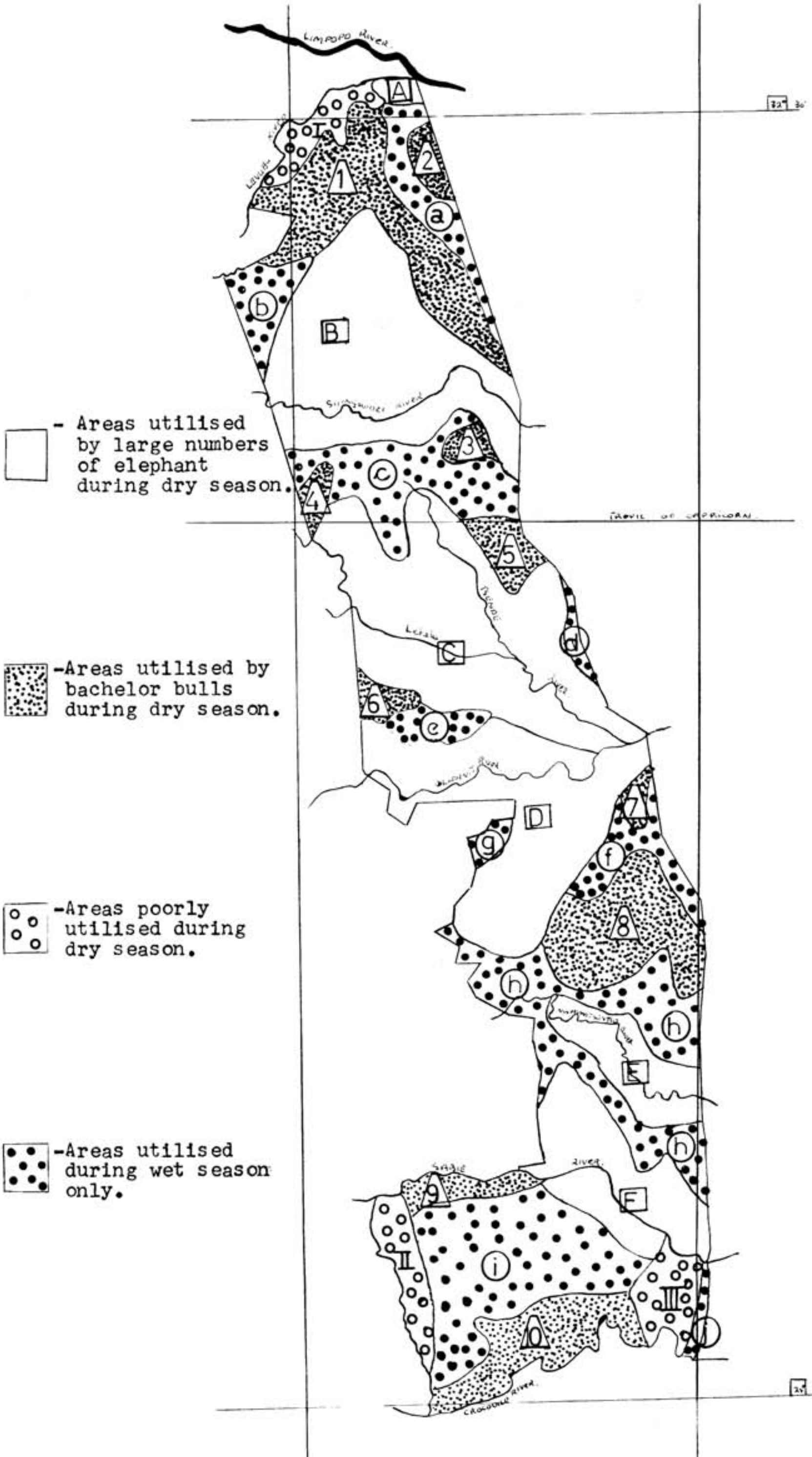

Fig. 1. Differentiation of seasonal feeding grounds of elephants in the Kruger National Park (Reproduced from Pienaar *et al.*, 1966).

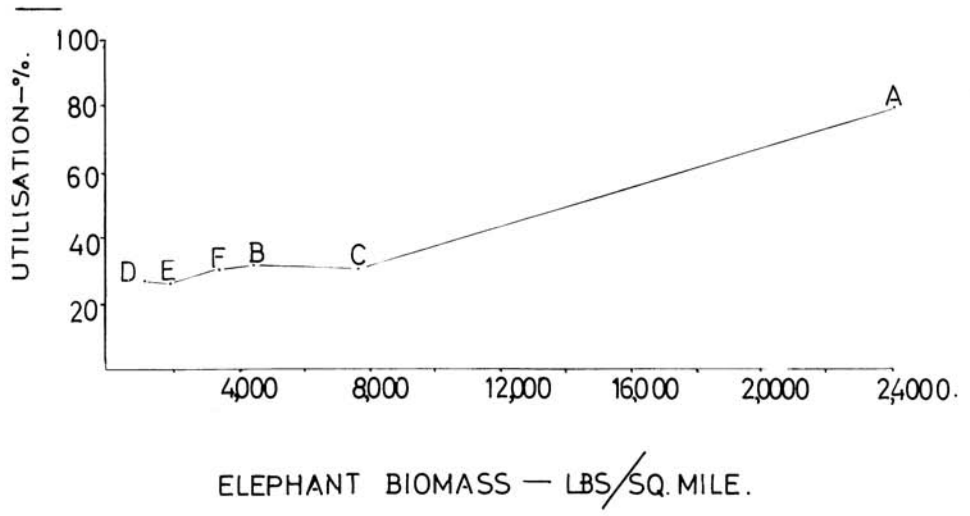

Fig. 2. Percentage utilisation of trees (browsed and destroyed) in the areas used by high concentrations during the dry season.

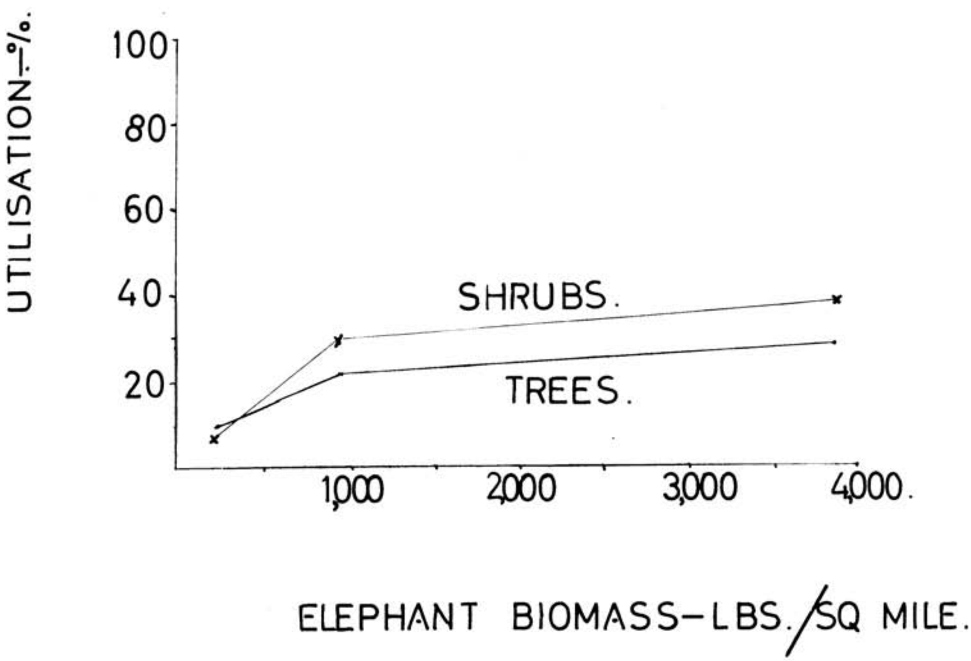

Fig. 3: Percentage utilisation of trees and shrubs (browsed and destroyed) at different elephant biomass levels.

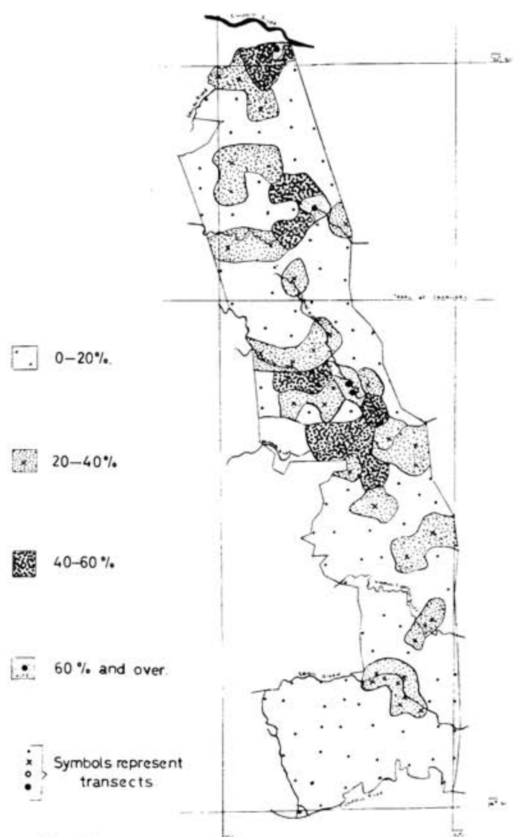
0–20%.
20–40%.
40–60%.
60% and over.
Symbols represent transects

Fig. 4

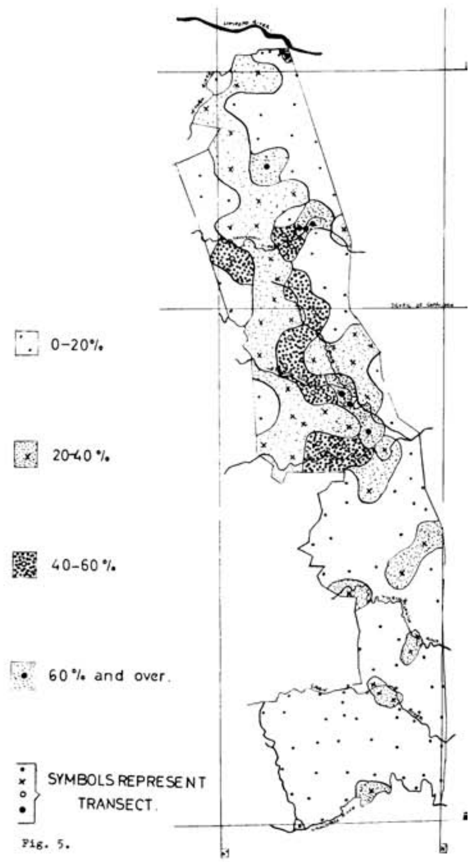
0–20%.
20–40%.
40–60%.
60% and over.
SYMBOLS REPRESENT TRANSECT.

Fig. 5.

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