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ELEPHANT IMPACT ON *SCLEROCARYA CAFFRA* TREES IN *ACACIA NIGRESCENS* TROPICAL PLAINS THORNVELD OF THE KRUGER NATIONAL PARK

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Abstract – A survey of elephant impact at various distances from roads was conducted in June 1978 for *Sclerocarya caffra* (marula) tree populations in *Acacia nigrescens* Tropical Plains Thornveld in the Kruger National Park, Republic of South Africa. Data from scar recovery indicate that widespread scarring of *S. caffra* trees by elephant commenced in 1973, coinciding with a wet climatic phase. Elephant impact, old and fresh and irrespective of kind, decreased with distance from roads. Substantially higher impact was also recorded along *S. caffra* population boundaries. The most recent impact on some populations was higher than expected from the established relationship between elephant impact and tree density.

Introduction

The survey reported here was initiated following reports of high recent elephant damage to *Sclerocarya caffra* trees along the main road between Satara and Mazithi Dam in the Kruger National Park (KNP), Republic of South Africa (Fig. 1).

Elephant are culled in the KNP to maintain the population at a stable number. This population limit was imposed to ensure the perpetuation of viable populations of all large mammal species in the KNP and to minimise possible elephant damage to the vegetation.

Less competitive animal species are protected through alleviating excessive elephant utilization of available food and water. Furthermore, vegetation structure favourable to elephant and other animals is maintained by limiting elephant impact on habitat.

Elephant impact on vegetation is known to be selective, though a wide variety of woody plants may be involved. In the KNP elephant utilization has been recorded for numerous woody species (Van Wyk & Fairall 1969). The consequences of elephant impact on any particular plant species depends on the nature of the scars, the ability of the plant to recover, its demography and role in various plant communities and the interrelationships between the latter and other ecosystem components.

Many factors, therefore, contribute in a complex manner to determine the effect of elephant impact on any particular plant species and/or plant community and the management of elephant numbers. These interrelated factors still require considerable study. However, *ad hoc* studies of isolated aspects are necessary from time to time. The present study deals with one aspect of the problem that has been causing concern and could influence management decisions but is not enough in itself to determine culling policy.

The primary purpose of this study was to inventorize elephant impact of various kinds on *S. caffra* trees, covering different stands of the type of vegetation from which unusually high damage was reported.

Climate, physiography and vegetation

The survey was restricted to *S. caffra* populations on the clayey basalt plains of the Central District, KNP and was conducted at the end of June 1978 (Fig. 1).

The climate of the study area is Tropical and Semi-Arid in Thornthwaite's System, with a normal annual rainfall of 500 mm – 650 mm of which less than 25 mm falls during the cool winter months June–August (Schulze & McGee 1978; Weather Bureau 1957). Mean monthly minimum Stevenson Screen temperatures for June and July at Skukuza and Letaba, KNP, are below 3°C indicating frost at ground level but both these localities are in major river valleys, where cold air accumulates (Weather Bureau 1954). Winter frost therefore, occurs occasionally in low areas but is known to be a rare phenomenon in slightly elevated terrain.

Sclerocarya caffra has a warm-temperate to tropical distribution and is frost sensitive (Palgrave 1977; Van Wyk 1974). In the KNP the species occurs widely on sandy granitic soils but on the drier, clayey basaltic soils, is largely restricted to moister climates with normal annual rainfall exceeding 500 mm (Coetzee & Nel 1978; Gertenbach 1978).

Within the study area *S. caffra* stands typically occupy the mesic sites. These are predominantly the convex upper parts of the gently undulating basalt plains, where soils are leached with comparatively low clay content (*cf.* Noy-Meir (1974) and Werger & Coetzee (1978) for a summary of the arid properties of clayey soils and their effect on vegetation). Common boundaries of *S. caffra* stands with other communities on basalt are with:

(a) Stunted *Acacia nigrescens* communities on plateaux and low terrain with much montmorillonite clay;
(b) Spiny Arid Bushveld on the dry, shallow, calcareous soils near major drainage lines towards the 500 mm rainfall isohyet; and
(c) *Acacia gerrardii* – dominated communities of poorly drained topography above the 600 mm isohyet (Coetzee & Nel 1978).

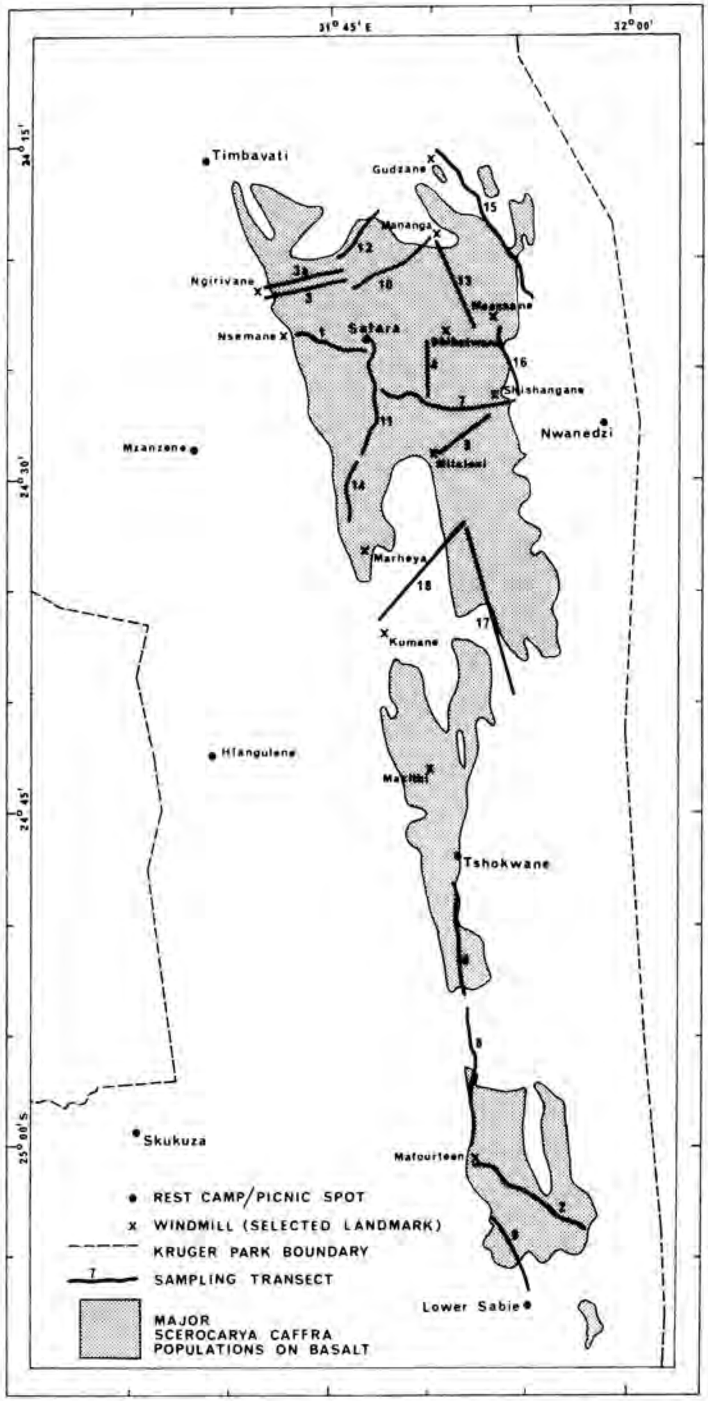

Fig. 1. *Sclerocarya caffra* populations on the clayey basalt plains of the Central District, Kruger National Park and sampling transects (After Coetzee & Gertenbach, Unpubl.).

The *Acacia nigrescens* Tropical Plains Thornveld (Werger & Coetzee 1978), to which the *S. caffra* stands in the study area belong, is deciduous Bushveld. Trees shed their leaves in the cool dry season and this winter phase is expedited by low humidity, low soil moisture and low temperatures (cf. Coetzee *et al.* 1976). The climate is presently well advanced in a wet phase of a series of wet-dry cycles lasting approximately 20 years each (Dyer 1976). During the above normal rainfall years the autumn aspect is markedly prolonged. At the time of survey tall trees, including members of the *S. caffra* population discussed here, had shed their leaves whereas low trees and shrubs still retained the autumn aspect. The grass stratum was dormant.

The *S. caffra* stands surveyed occur in vegetation with a taller than six metre tree layer, completely dominated by dormant *S. caffra* with a typical density of 2,3 individuals per hectare. Smaller trees are inconspicuous and relatively few below the 600 mm rainfall isohyet but 3 m–6 m tall *S. caffra* trees become more abundant in the higher rainfall zone. The tall tree stratum is followed by an open 1 m–3 m tall shrubby layer of varying density, dominated mostly by *Acacia nigrescens* and *Dichrostachys cinerea* in autumn foliage. Dominant grasses are *Themeda triandra, Digitaria pentzii, Panicum coloratum, Panicum maximum* and *Bothriochloa radicans* and these were all unburnt, mature and dormant.

Above average rainfall over a number of preceeding years has resulted in seepages, flowing water and numerous pools in watercourses that have little or no water during the dry season. The distribution of surface water at the time of survey was documented in a concurrent routine aerial survey (Joubert 1978).

Characteristics of elephant impact

Age

Freshly pushed over, ringbarked and otherwise scarred *S. caffra* trees have a bright pink colour where the bark has been damaged. Somewhat older scars have a darker but equally conspicuous red colour, which changes to reddish brown and then to blackish and successively lighter shades of grey with age. The pink stage was observed to last less than a week. Revisiting road-building sites where scars could be dated revealed that the red to reddish-brown stage lasts approximately between two and a half to nine months.

Felled trees

Some trees are partially uprooted and others are broken when pushed over and in both instances trees may continue to grow, the broken ones coppicing from the remaining stump (Fig. 2) and new trunks emerging

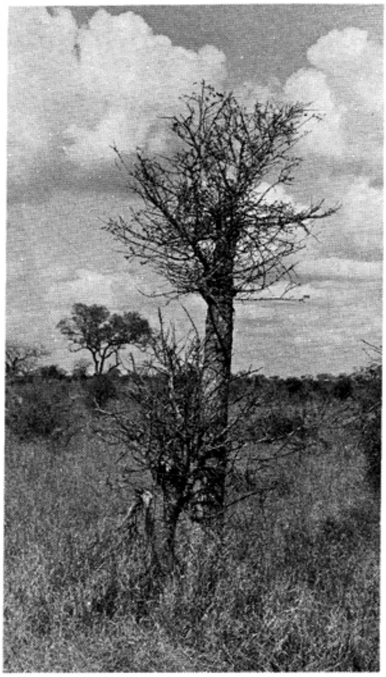

Fig. 2. Coppicing trunk of a broken *Sclerocarya caffra* tree.

from the partially uprooted trees. Occasionally all but the main trunk and stumps of large secondary branches of pushed over trees are devoured by the elephants (Fig. 3.)

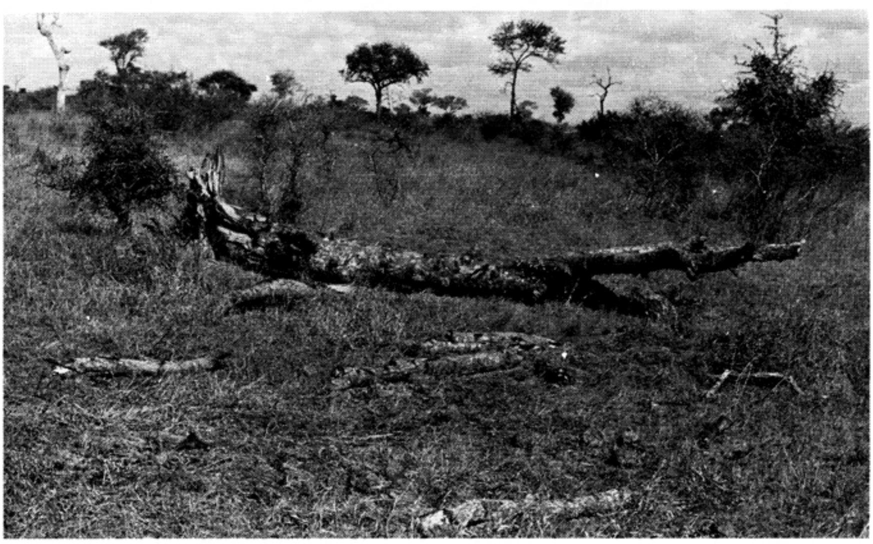

Fig. 3 Remnants of a felled *Sclerocarya caffra* tree. All but the main trunk and stumps of large secondary branches had been devoured.

Broken branches

Branches may be broken off by elephants, strong winds, or under their own weight after dying on the tree. Bark around such scars gradually grows inwards (Fig. 4) until the damaged area is covered by a smooth knob of healthy tissue. Wood is formed on the inside.

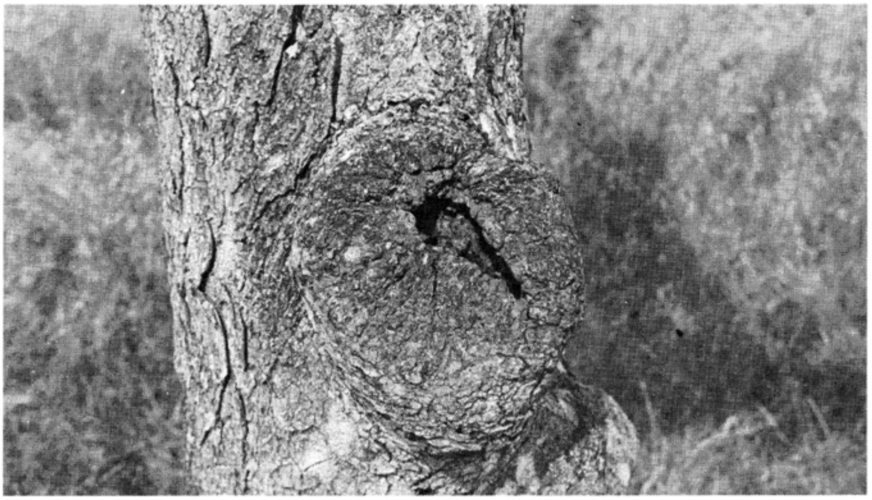

Fig. 4 Advanced stage of recovery of a scar where a branch had broken off a *Sclerocarya caffra* tree.

Debarking

When bark is stripped off a healing process similar to that described in the previous paragraph sets in. However, such bark regrowth is terminated by coarse surfaces on the exposed wood, e.g. where strips of isolated bark died and remained, wood borer holes, termite and ant activity and shallow grooves made by elephant tusks (Fig. 5).

Bark is stripped off longitudinally. Vertical ridges on lateral regrowth separate sections that apparently represent seasonal regrowth (Fig. 5). The latest season's bark regrowth can readily be distinguished by its orange-brown colour. Terminated regrowth is indicated by the absence of such a zone.

Examples where regrowth had ceased on one side of a scar only, showed the associated occurrence of less regrowth, fewer seasonal ridges, course obstructions on the underlying dead wood and the absence of an orange-brown zone of fresh regrowth.

Where dead wood is exposed in a partially healed scar, fires may be a hazard to the tree. Old wood beneath healed areas may burn or continue rotting, leaving an apparently healthy individual with a hollow trunk.

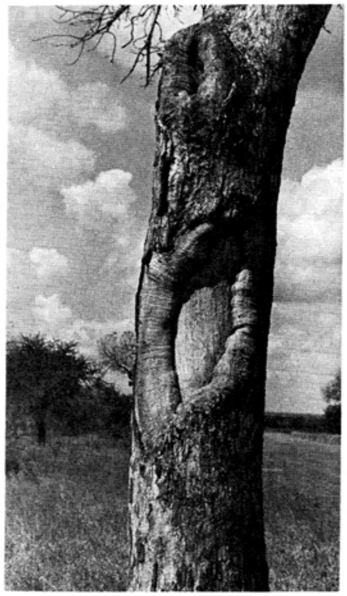

Fig. 5 Debarked area with active regrowth on a *Sclerocarya caffra* trunk. Insertions on the right side of the scar are where small obstructions inhibited regrowth.

These trunks usually snap when pushed by elephant, or may also break with heavy winds, to reveal the hollow anatomy (Fig. 6).

Fig. 6 Broken hollow trunk of a *Sclerocarya caffra* tree, which appeared healthy until felled. The effect of fire on the wood core is evident.

A narrow strip of bark is enough to keep a scarred tree alive (Fig. 7). Fresh bark is also produced *in situ* where virtually only cambium remains after debarking. However, when isolated patches of such regrowth die before being joined to other bark, the dead bark may create a coarse surface that inhibits lateral regrowth of nearby bark.

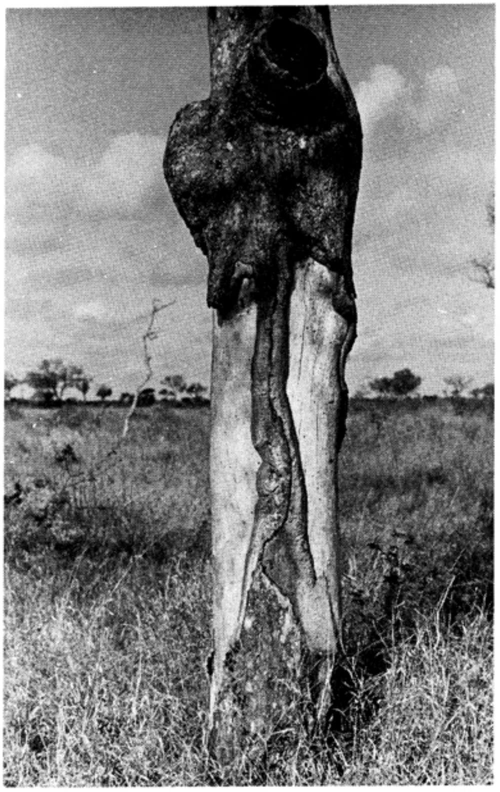

Fig. 7 Trunk of a *Sclerocarya caffra* tree that is kept alive by a narrow strip of bark, which is essentially regrowth.

Close inspection of numerous *S. caffra* trees left the impression that although scars rendered them somewhat more vulnerable, they generally showed a remarkable capacity for recovery.

Sampling methods

Degree of impact

The survey covered roads through all major stands of *S. caffra* in the study area (Fig. 1). Separate sections of road served as individual sampling transects. The length of these transects varied from 5,1 km–16,7 km with an average of 8,9 km (Table 1). All *S. caffra* trees over 5,5 m tall to a distance of 100 m on each side of the road were recorded.

In one instance a special transect, 1 km from and parallel to a road was sampled for comparison with data from a transect along the road. These two transects were through a homogeneous stand of *S. caffra* in similar topographic positions.

In the survey unscarred trees and trees with different categories of scarring were differentiated.

Unscarred trees included:

(a) those with old debarked areas completely covered by new bark; and
(b) trees with broken branches of which the scars were healing and grey, but excluding coppicing trunks, which had most likely been broken by elephants.

Unscarred trees were counted over the entire width of the transect except for two transects where they were classified according to distance from the road.

Impact was recorded separately for each of the following ranges in distance from roads: 0 m–10 m; 10 m–30 m; 30 m–50 m and 50 m–100 metres.

It was assumed that the total number of trees were evenly spread over the width of transects and that totals for sub-zones could be calculated from totals for transects in direct proportion to the areas of sub-zones. This saved considerable time and effort in the field.

The ranges of different sub-zones were estimated after an initial period of pacing. One person carried out the fieldwork. The final procedure developed gradually so that at the end of the survey the first two transects were re-done. This ensured an even standard of distance and other observations throughout the final survey.

Few ambiguities arose in separating reddish from greyish scars and the distinction between reddish-brown and blackish-grey served as the dividing line between old and fresh impact. Observations that scars change from reddish to grey after a few months coupled with Guy's (1976) observation that trees are pushed over during the dry months, lead us to suspect that the reddish scars represented mainly the current season's impact. The following classes of impact were distinguished:

1) freshly pushed over, showing reddish marks on bark;
2) freshly ringbarked, with reddish marks;
3) freshly scarred, with bark lifted or removed and reddish marks; and
4) old grey scars, with bark removed and not completely healed as well as old scars in the form of coppicing main trunks that had been broken. Other marks of broken off branches were excluded since branches commonly die from causes other than elephant. Trees with both old and fresh scars were counted only as freshly scarred.

Trees were observed with binoculars, where necessary, for various kinds of impact. Observations were from roads while approaching and receding from trees, thus covering a large part of their circumference. A small percentage of scars hidden completely behind trees could therefore be consistently underestimated. Similarly a small percentage of trees classified as ringbarked may have had a narrow strip of bark intact in the area obscured from vision. Infrequently bark was slightly marked without being lifted. These trees were considered unscarred.

Scar size and recovery

Along routes where degree of impact was determined, 145 old scars were indiscriminately visited and the following characteristics recorded:

(a) Lateral diameter of the originally debarked area as well as the remaining uncovered area were measured. These measurements were at the level of the broadest uncovered part where normal healthy original bark occurred on both sides of the scar.
(b) At the last 102 scars an attempt was made to select typical regrowth with clearly defined growth ridges and to measure each season's regrowth. Growth ridges could be distinguished in 90 of the 102 scars.
(c) The condition of the exposed woody surface was recorded, i.e.: smooth; showing ant activity; with wood borer holes; cracked; or rotten.
(d) Regrowth was described as having terminated, or partly terminated or continuing.

Synthesis

For the 145 scars measured the lateral diameter of the uncovered area was substracted from the lateral diameter of the originally debarked area to determine the combined amount of regrowth for both sides of the scar.

The 90 scars where seasonal regrowth was discernable were classified according to numbers of seasons regrowth and the frequency of scars with continuing and ceased regrowth in each class, determined.

The significance of association between terminated lateral bark regrowth and poor condition of the exposed wood was calculated from a 2 × 2 contingency table, using the Chi-square Test, with the correction for continuity.

For 293 measurements of seasonal regrowth in the 90 scars the mean and standard deviation were calculated.

For each route sampled the total number of marked and unmarked trees were divided between parallel zones at various distances from the road, in direct proportion to the areas of these zones. Trees showing the various kinds of impact were expressed as a percentage of the calculated total for each zone. For each transect the density of trees for the entire transect was calculated.

The percentage trees with various kinds of impact at various distances from roads were plotted against tree density and regression curves fitted to these points. Four types of regression curves were calculated to find the best fit. These were (1) straight lines; (2) exponential curves ($y = be^{mx}$); (3) power curves ($y = bx^m$); (4) logarithmic curves ($y = b + m \ln x$). Low densities do not necessarily indicate homogeneous low density stands but to a large extent reflect roads alternatively leaving and entering *S. caffra* stands or occurring on their edges as the roads loosely follow the boundaries of the populations. No mathematical derivation of the best fit from biological principles was therefore attempted.

Results and Discussion

Bark regrowth and age of impact

The majority of old scars showed two or three seasons' regrowth (Table 2). Mean seasonal regrowth based on typical growth ridges was 2,86 cm

Table 2

Frequency of scars with different numbers of seasons of regrowth

Number of seasons of regrowth	Total number of scars	Number of scars with terminated regrowth	Number of scars with partially terminated regrowth	% scars with partially or completely terminated regrowth
1	3	0	0	0,0
2	24	1	1	8,3
3	30	1	2	10,0
4	17	3	0	17,6
5	14	5	0	35,7
6	0	–	–	–
7	2	1	0	50,0
>7	0	–	–	–

(S.D. = 1,04), which, doubled to include both sides of the scar, gives a total regrowth rate of 5,7 cm per season or 11,4 cm and 17,1 cm for two and three seasons respectively. Direct regrowth measurements of between 11 cm and 18 cm had the highest frequency of occurrence (Fig. 8).

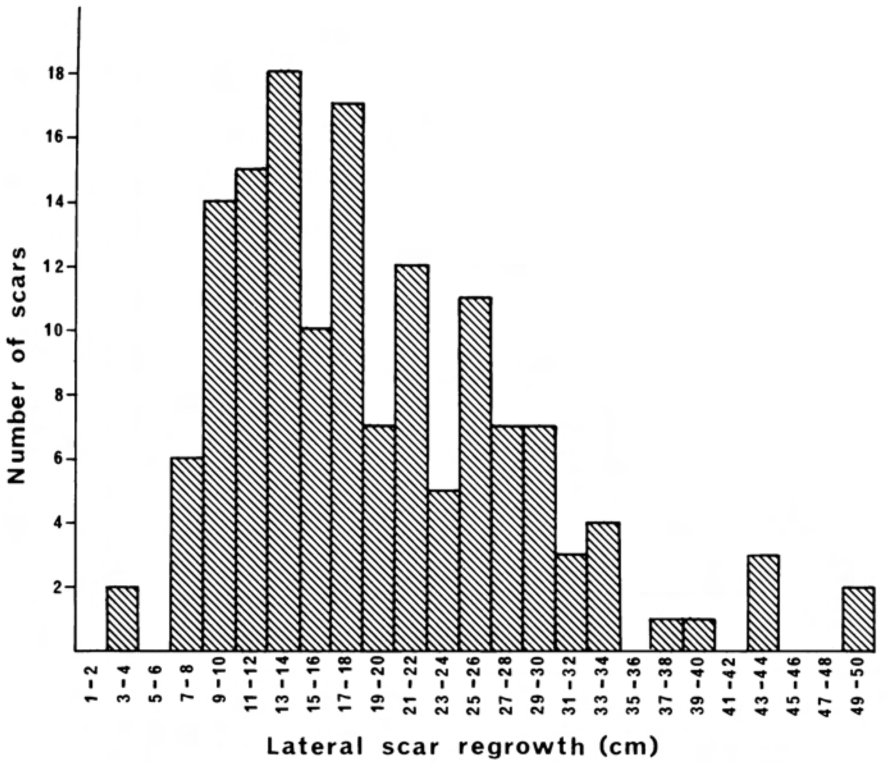

Fig. 8 Number of scarred trees with various amounts of lateral bark regrowth. Regrowth is calculated as the difference between the lateral diameters of the originally debarked area and the remaining uncovered area.

Scars with one season's regrowth were largely absent from the sample (Table 2). The first year's regrowth was slow to emerge from under the freshly damaged bark and it was difficult to distinguish between the freshly damaged area and regrowth and such scars were therefore ignored.

Relatively few scars had four or five seasons of regrowth and virtually no scars had regrowth of six or more seasons (Table 2). Based on the seasonal regrowth rate of 5,7 cm the amount of regrowth for six seasons would be 34,2 centimetres. The frequency distribution of regrowth, measured irrespective of seasonal ridges, shows an almost complete breakoff at 34 cm (Fig. 8).

Whereas the results indicate only five seasons of lateral regrowth, the mean original scar width of 47,8 cm (S.D. = 33,7) allows for approximately eight seasons of regrowth at 5,7 cm per season before closing completely. Closing up of scars in the sixth season is therefore an unlikely explanation for the general lack of more than five seasons of regrowth.

Few scars with two or three seasons of regrowth had ceased growing but regrowth had stopped in a considerably larger proportion of scars with four of five seasons' regrowth (Table 2). Cessation of regrowth was strongly associated with deteriorating condition of the exposed wood ($P < 0{,}005$) and such deterioration must necessarily increase with age. Lack of regrowth after four or five years might have accounted for the absence of scars with regrowth of more than five seasons – granted that the 64% of scars with five seasons' regrowth that showed fresh regrowth possibly do not continue to close up in the sixth season. However, had impact been consistently high for more than five years, with regrowth stopping in the fourth and fifth years, the frequency of trees with such scars should increase above the frequency of trees with two or three season old scars.

The reverse is true (Table 2), suggesting that: either regrowth is a recent phenomenon; or trees with five year old scars invariably die and disappear. The majority of transects were through *S. caffra* populations that had not burned for a period including two winters and no standing dead trees other than those that had been completely ringbarked, were evident. Thus, the explanation of elephant impact being a recent phenomenon appears to be the most feasible account for the lack of scars with more than five seasons of regrowth.

Indications are, therefore, that elephant scarring of *S. caffra* became significant approximately five years ago, increased considerably three years ago and has since remained relatively high. The most recent impact also appears to be of a relatively high order since, as discussed in the next section, a typical ratio of fresh scars representing part of the current years impact, to old scars, representing four years' impact is 1:3,9.

Tree density vs. elephant impact: three classes of S. caffra *population*

In Table 1 all relevant data regarding classification of transects, transect lengths, tree densities and degree of elephant impact are given.

The power curve best fits the relationship between elephant impact and tree density for all kinds of impact at all distances from roads. This relationship and certain anomalies are best shown by the data for the entire width of the transect (Figs 9–11). The correlation coefficient is highest for old scars ($r = -0{,}80$, Fig. 9) and considerably lower for fresh scars ($r = -0{,}69$, Fig. 10) and freshly pushed over and ringbarked trees ($r = -0{,}66$, Fig. 11). However, if Routes 12, 13 and 14, which deviate strongly from the curves for fresh impact, are omitted when correlating recent impact with tree density, the correlation coefficient for both classes of recent impact is as high as for old scars, i.e. $r = -0{,}84$ for fresh scars and $r = -0{,}83$ for freshly pushed over and ringbarked trees. The anomalous Routes 12–14 represent a class of population in which recent elephant impact is higher than expected from the established relationship between impact and density (Table 1: Class B). Routes 15–18 are classified as low density population boundaries with consistently high impact (Table 1: Class C). Routes 1–11

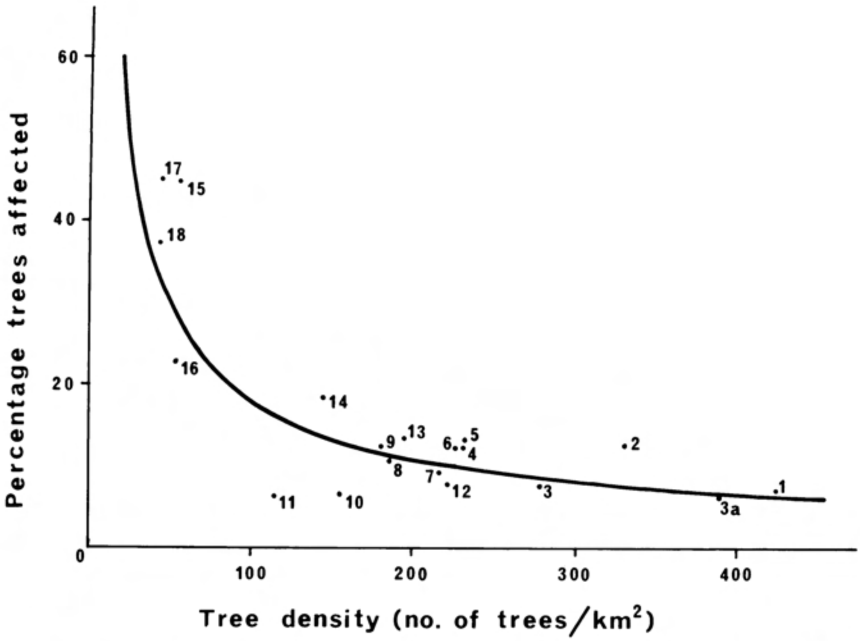

Fig. 9. Percentage *Sclerocarya caffra* trees with old scars, within 100 m from roads, for transects of varying density. A power curve of the function $y = 546{,}8\times^{-0{,}737}$ has been fitted through all points. $r = -0{,}80$.

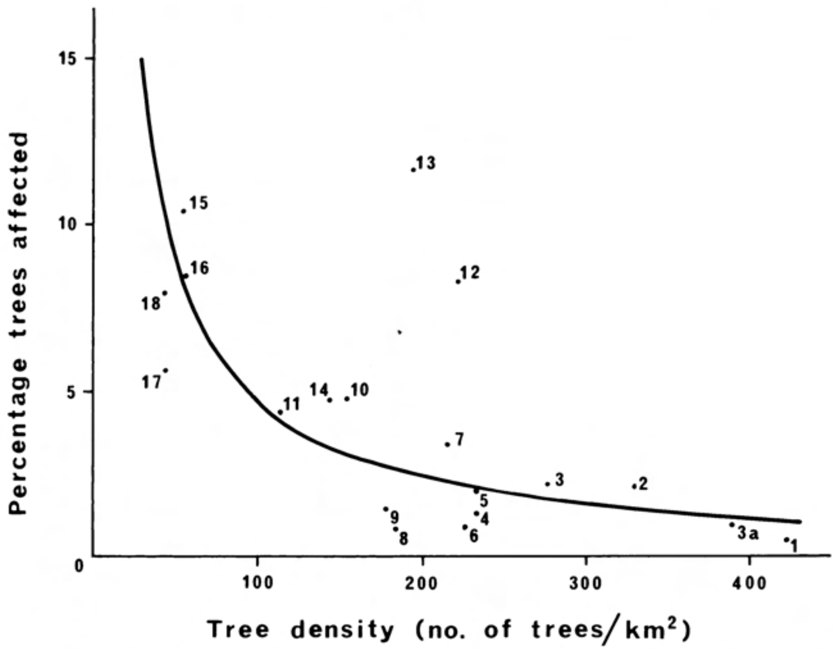

Fig. 10 Percentage *Sclerocarya caffra* trees with fresh scars, within 100 m from roads, for transects of varying density. A power curve of the function $y = 391{,}7\times^{-0{,}963}$ has been fitted through all points. $r = -0{,}69$ ($r = -0{,}84$ without Transects 12, 13 and 14).

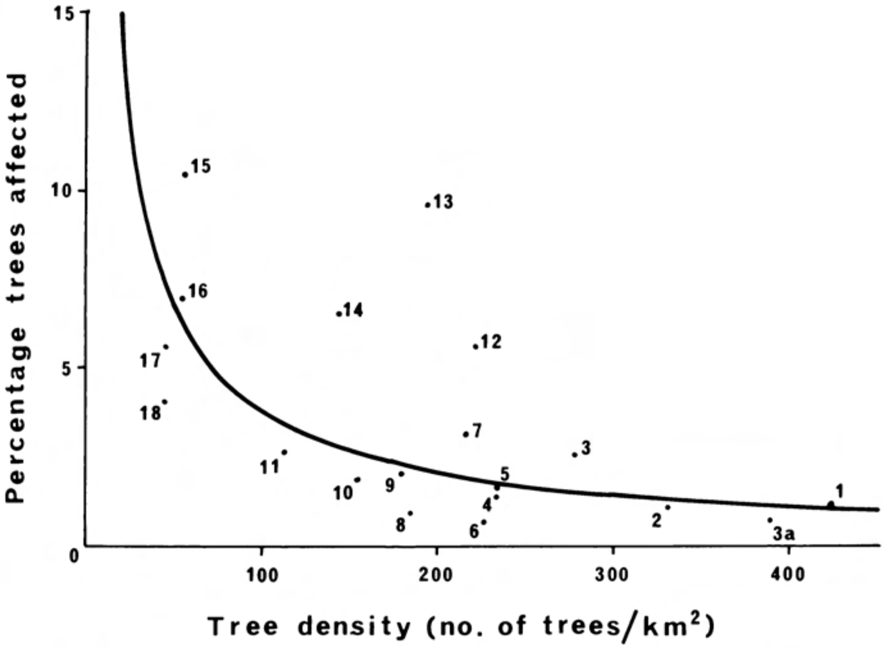

Fig. 11 Percentage *Sclerocarya caffra* trees ringbarked and pushed over, within 100 m from roads, for transects of varying tree density. A power curve of the function $y = 197{,}7 \times^{-0{,}861}$ has been fitted through all points. r = –0,66 (r = –0,83 without Transects 12, 13 and 14).

represent stands with high tree density and consistently low impact (Table 1: Class A).

Distance from road vs. elephant impact

The high degree of all kinds of elephant impact near roads, in all three classes of *S. caffra* population densities is shown in Table 1 and Figs 12–13. A zone of high impact extends 10 m on either side of the road, followed by a zone of intermediate impact between 10 m–50 m and relatively low impact beyond 50 metres. In the one instance where impact was recorded in a 200 m zone 1 km from the road, elephant impact differed little from that at 30 m–100 m from the road (Fig. 14). The higher incidence of elephant impact near roads may be ascribed to the habit of elephant bulls following roads and open tracks. Trees closest to the roads are therefore more vulnerable to the onslaughts of these bulls (*cf.* Pienaar 1968).

With this confirmation of concentrated elephant impact along roads, mentioned by Pienaar (1968) and referred to as a theory by Van Wyk & Fairall (1969), we agree with these authors that the phenomenon must be borne in mind when planning roads.

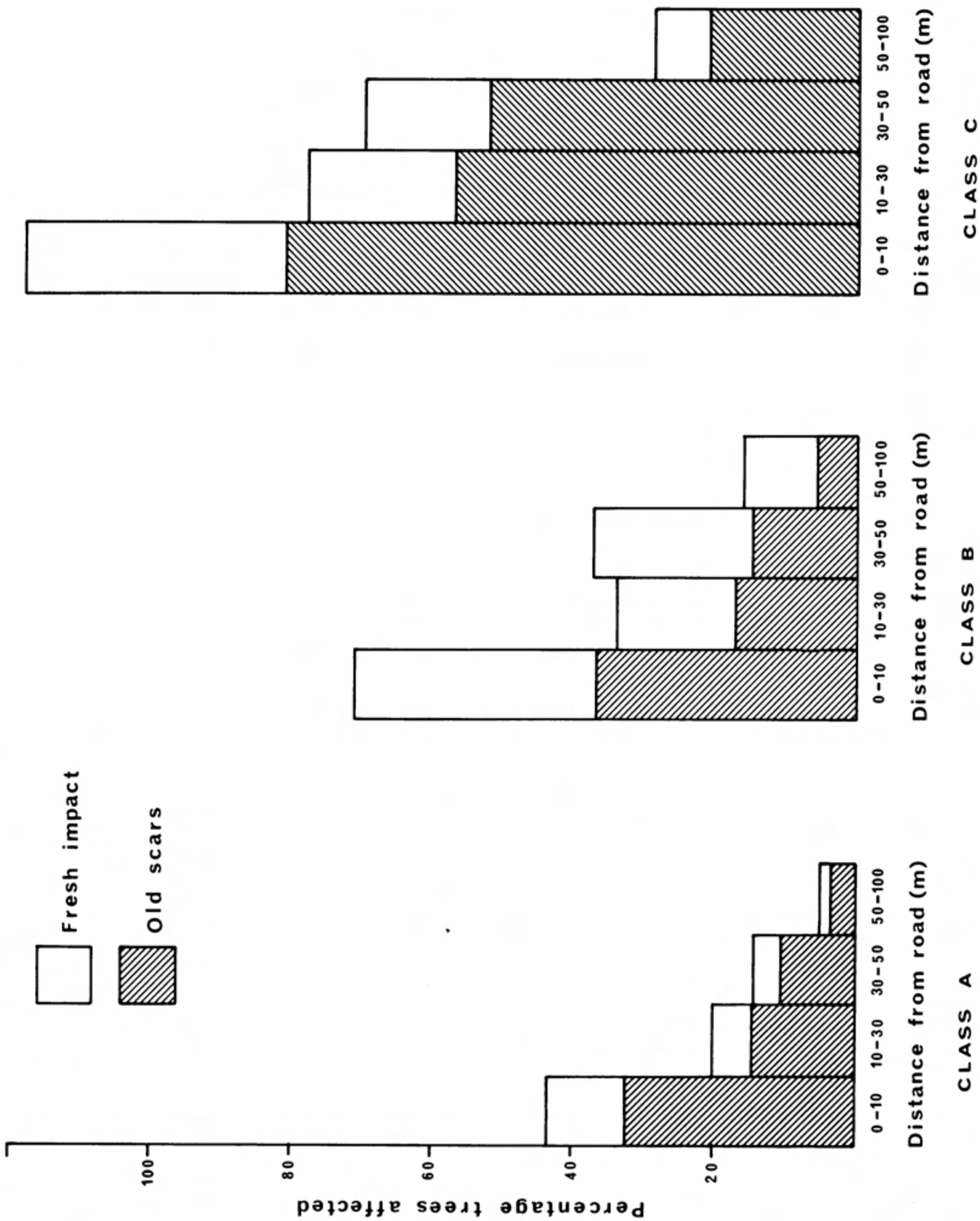

Fig. 12 Percentage trees with old and recent scars as well as pushed over and ringbarked at various distances from roads, for each of the three classes of transects through *Sclerocarya caffra* stands.

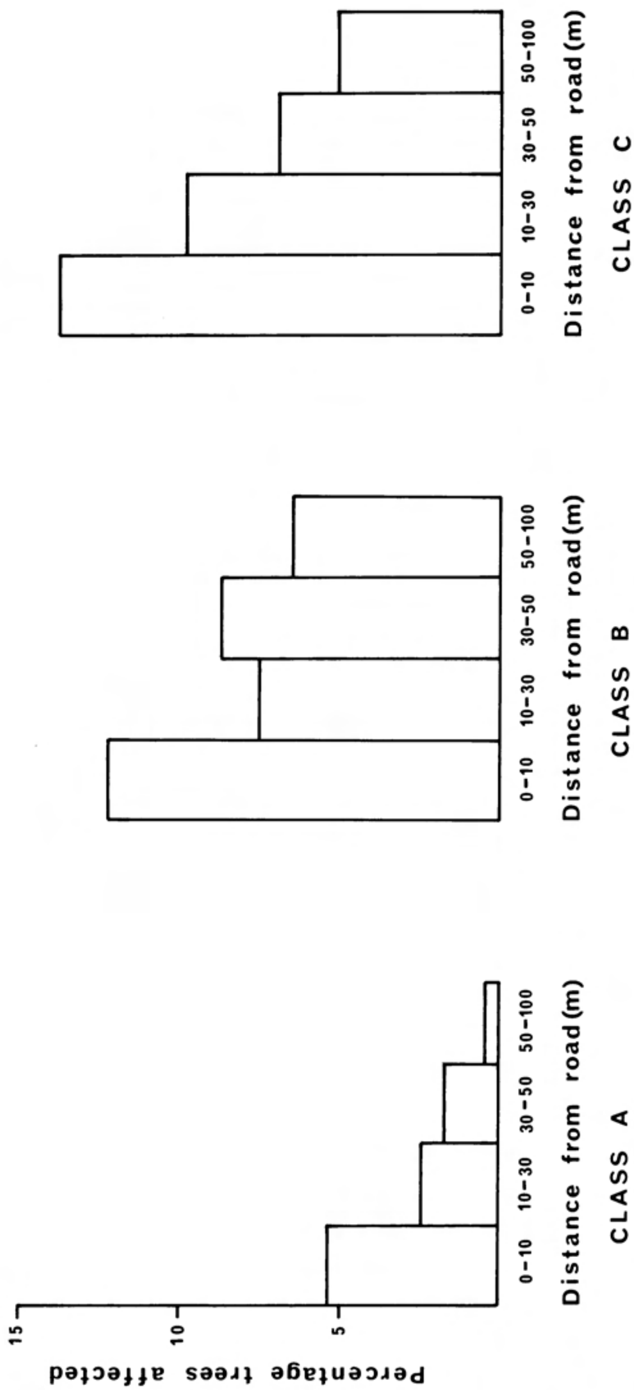

Fig. 13 Percentage trees ringbarked and pushed over at various distances from roads, for each of the three classes of transects through *Sclerocarya caffra* stands.

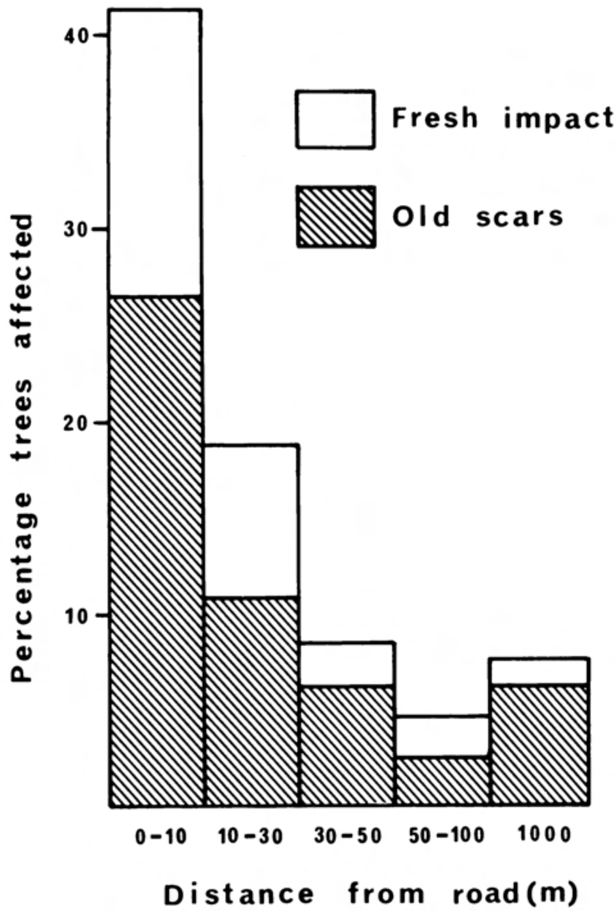

Fig. 14 Percentage *Sclerocarya caffra* trees with old scars as well as freshly scarred, pushed over and ringbarked, at various distances from the road, for Transect No. 3, representative of Class A *Sclerocarya caffra* stands.

Characteristics of elephant impact on three classes of Sclerocarya caffra *stands based on density and degree of impact*

Class A

The majority of transects were from high density populations of *S. caffra* with consistently low elephant impact (Table 1, Fig. 1). The ratio of old healing scars to fresh scars of a similar nature at 50 m–100 m from roads is 3,9:1. This ratio allows for freshly scarred trees to have old scars in the same proportion as the rest of the population. The survey took place midway through winter and the ratio would change if the rest of the current winter's impact were added.

Class A transects included 4 214 trees, which is 77,2% of the total sample (Table 1). This class represents the general picture of elephant impact on *S. caffra* stands in the Central District basalt vegetation.

The impact at 50 m–100 m from roads was 3,5% trees with old scars, 0,9% trees with fresh scars and 0,5% pushed over and ringbarked. Ninety-five percent of the trees were unmarked (Table 1, Figs 12 & 13). Within 10 m from roads the percentage old scars was nine times higher (32,7%) than at 50 m–100 m, the percentage fresh scars six times higher (5,4%) and the percentage recently pushed over and ringbarked eleven times higher (5,4%).

Class B

Transects 12, 13 and 14 represent a class of populations in which percentage recent elephant impact was higher than expected from the relatively high density of trees (Figs. 9–11). The ratio of trees with old scars to freshly scarred trees was 1,6:1 at 50 m–100 m from roads.

Class B transects included 733 trees, which is 13,4% of the total sample (Table 1). Transect 14 is part of the route which caused the concern that led to this survey.

Impact at 50 m–100 m from roads was 5,7% old scars, 3,8% fresh scars and 6,5% pushed over and ringbarked. Eighty-four percent were unmarked (Table 1, Figs 12 & 13). At less than 10 m from roads the percentages old and fresh scars were both six times higher (36,8% and 21,8% respectively) than at 50 m–100 m whereas the percentage trees pushed over and ringbarked (12,3%) was only double the figure for 50 m–100 m. The possibility exists that the zone of influence away from a road widens with a high degree of impact.

Class C

This class represents low *S. caffra* densities with consistently high elephant impact. It includes four transects from the edge of *S. caffra* populations. The ratio of trees with old scars to those freshly scarred was 6,8:1.

The transects, which included 508 trees, i.e. 9,3% of the total sample, included isolated individuals on the perimeter of the main *S. caffra* distribution range.

Impact at 50 m–100 m was 20,9% old scars, 3,1% fresh scars and 5,1% pushed over and ringbarked (Table 1, Figs. 12 & 13). The increase at less than 10 m from the road was fourfold (80,7%) for old scars, eightfold (23,6%) for fresh scars and threefold (13,8%) for trees recently pushed over and ringbarked. As with Group B the increase of recently destroyed trees towards the road was not as drastic as in Group A.

The sustained high impact along Group C transects has discriminately decreased tree density near the road. Therefore, the assumption that tree density in this zone may be calculated from overall density in direct proportion to the area of the zone is incorrect in this instance. The result is an overestimate of the differential impact, owing to the phenomenon itself. The overestimate is shown by the histogram for total impact near the road exceeding 100% (Fig. 12).

General conclusions

Widespread scarring of *S. caffra* trees by elephant is probably a recent phenomenon. Indications are that it is now in its sixth year. This coincides with the wet climatic phase, which is now in its seventh year and the possibility of a causal relationship cannot be excluded.

Destructive elephant impact over one season i.e. ringbarking or felling, was 0,5% 50 m–100 m from roads in typical stands representing 77% of the tree sample. This does not constitute an immediate threat to *S. caffra* stands. Total impact 50 m–100 m from roads affected 5% of the standing crop, which is not disconcerting either since five years of scarring are included and scars apparently have a minor short term effect and the capacity to heal.

However, in some major stands, representing 13% of the tree sample, 6,5% of all trees 50 m–100 m from roads had been felled or ringbarked in one season and total impact had affected 16% of the standing crop. Furthermore, despite the healing potential of scars, 26% of scars with four or five seasons of regrowth had stopped closing and these could possibly have a detrimental effect on trees over the long term.

In addition, all kinds of elephant impact were higher in the first 50 m from roads particularly in the first 10 m, than at 50 m–100 m. Old and fresh scars in all major *S. caffra* stands surveyed were six to nine times greater within 10 m from roads than at 50 m–100 m from roads. In the typical low impact stands, representing 77% of the tree sample, the percentage trees pushed over and ringbarked increased elevenfold (to 5,4%) within 10 m from roads, as compared to the 50 m–100 m zone.

The situation should therefore, be monitored to determine the trends of elephant impact in wet and dry climatic phases, recovery of affected trees and the replacement of those destroyed.

Impact away from roads is best studied at 50 m–100 m or, if impact is high, at greater distances from roads. The earliest signs of retrogression is expected to be decreasing tree densities towards roads. The methods used here are recommended for rapid assessments of elephant impact on *S. caffra* tall tree densities except that:

(a) unmarked trees should also be recorded per distance range from roads to allow accurate density estimates for the zones; and
(b) the 10 m–30 m and 30 m–50 m ranges may be lumped together.

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