The influence of the 1991/92 drought on the woody vegetation of the Kruger National Park

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All observations and data related to the impact of the 1991/92 drought on the woody vegetation, excluding the riverine vegetation of major rivers, are summarised. This includes data from a visual estimate of damage from aerial photographs, surveys on selected sites, and general observations. Despite lower rainfall, the area north of the Olifants River (excluding the far-northern part) was less affected than the area south of it, suggesting that the woody vegetation in the north is more adapted to drought. A characteristic of the drought was the localised distribution pattern and variable intensity of damage to the same species in the same general area. Information on 31 species are presented briefly. Although a large number of woody species was to some extent damaged, when the woody vegetation is considered as a whole, the influence of the drought was not very severe.

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Key words: Drought, Kruger National Park, woody vegetation, mortality.

Introduction

The occurrence of wet and dry climatic cycles in the Kruger National Park (KNP) has been well documented (Gertenbach 1980). During the dry cycles, a few periods with extremely low rainfall result in droughts, for example, during 1982/83 and recently during 1991/92 (Zambatis & Biggs 1995). The climatic conditions during these droughts are generally well recorded, but documentation on vegetation during drought conditions is often limited.

The objective of this report is therefore to summarise observations and data concerning the impact of the 1991/92 drought on the woody vegetation up to the end of the growing season in 1993, though it is realised that the influence of the drought on the woody vegetation may continue for an extended period. The drought impact on the riverine woody vegetation of the major rivers is documented by Deacon (in prep), and the herbaceous vegetation is documented by Viljoen & Zambatis (1995).

Various approaches to determine the extent of the influence of the drought on the woody vegetation were followed. Field surveys of selected woody plants were conducted on sites where damage to plants was specifically observed. The aim of these surveys was not only to quantify drought damage, but also to identify sites where the drought had an obvious impact. These sites can be used for further long-term monitoring. Aerial photographs, which are taken annually for long-term vegetation monitoring purposes, were used to obtain an unbiased overview of damage to woody plants. Direct visual observations were additionally made during the drought period, and specifically during the 1992/93 growing season.

Methods

Visual estimate of damage from aerial photographs

Large-scale (1:4 500) false-colour infra-red photographs have been taken annually since 1984 for the monitoring of the woody component of the vegetation in the KNP. One hundred and twenty-one selected strips, each covering approximately 1 200 x 500 m, were photographed during April 1993. To obtain a general impression of drought damage to the woody vegetation, all photographs were visually inspected using a stereoscope. Damage on each strip was estimated and classified into damage classes. The following damage classes and criteria were used:

- None - No individuals appeared to be dead.
- Very light - Only a few individuals appeared to be dead.
- Light - More than a few but less than five percent of the plants appeared to be dead.
- Moderate - Between five and 10% of the woody plants appeared to be dead.
- High - More than 10% of the plants appeared to be dead.

It is not possible to distinguish from the photographs whether a woody plant which appears to be dead is actually dead or only severely stressed. It has, however, been possible to distinguish healthy plants from plants that appear to be dead due to the drought. Experience with the interpretation of false-colour infra-red photographs, as well as knowledge of the vegetation, is essential. The classification into damage classes is subjective, but the purpose was to compare drought damage between strips, rather than to quantify damage.

The localities where aerial photographs were taken had been selected before the onset of the drought, and were not selected as sites where the drought specifically had an influence. Analysis of these photographs, therefore, reflects an unbiased image of damage to the woody vegetation for a large part of the KNP. This excludes the riverine vegetation as well as the area north of Punda Maria, the Lebombo Mountains and the Malelane area for which no photographs are available.

Field surveys of damage to woody species

Field surveys were made on selected woody species at specific sites, using a belt transect method. Whilst walking in a predetermined direction, all individuals of selected species within a predetermined distance at both sides parallel to the walking direction were evaluated. The area where the dead plants occurred as well as the growth form of the particular species determined the transect layout. For example, at one site a single, long transect followed the bank of a stream, while at another locality the transects were three parallel strips, 200 m long and 50 m apart. Depending on the species and growth form, transects of variable width were used. For most of the species a minimum height was selected and only larger plants were included in the survey. This procedure was followed because of the flexibility it offered—assessments had to be made of a large variety of species, of different growth forms, at localities of variable size and nature. A detailed description and locality sketch of the location of the site as well as the transect layout were made. Whenever a plant was rooted within the limits of the transect, it was recorded, plant height estimated and it was allocated to one of the following classes:

- L: Canopy 90 - 100% alive or without damage (plant appears normally healthy).
- 3: Canopy 50 - 90% alive or without damage.
- 2: Canopy 10 - 50% alive or without damage.
- 1: Less than 10% of the plant appears to be alive (eg. coppice or only a single branch

is alive or a shrub sprouts from its roots but otherwise dead)

D: Dead (plant shows no signs of recovery).

The surveys were undertaken by game rangers. The selection of sites was left to their discretion, because of their intimate knowledge of the areas they control. Each ranger received a set of guidelines, a description of the method, and standardised field data sheets. Field surveys were undertaken during May 1993, at the end of the growing season, to allow the woody vegetation as much time as possible to recover and to show signs of life after the impact of the drought during 1992.

The data were entered into a database. Height classes were selected and the percentage drought damage was calculated for the different species for all sites.

Visual observations

Visual observations, of damage to woody plants that could be ascribed to the drought, were made by field and research personnel continually during and just after the 1992/93 growing season. These observations were recorded and reported by means of memo's, reports, ranger diaries and verbally. This information was confirmed where necessary by visiting specific sites or by discussion with the reporter.

Results

Visual estimate of drought damage from aerial photographs

The distribution of the aerial photograph strips in the KNP as well as the classification of damage to the woody vegetation is presented in Fig. 1. Damage was detected in about 50% of the transects. On the transects where damage occurred, 21% showed minimal damage, 36% light damage, 20% moderate damage, and 23% severe damage. South of the Olifants River damage occurred at 76% of the sites, and north of it at only 20% of the sites.

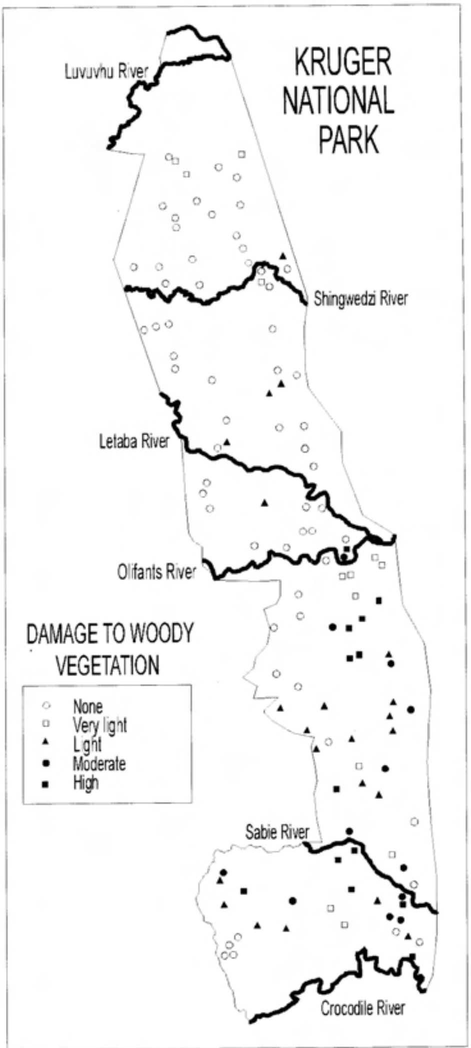

Fig. 1. The distribution of aerial photography transects in the Kruger National Park and an estimation of damage to the woody vegetation at these sites.

Drought damage to selected species

Quantitative data for 18 woody species were collected at 22 sites (Fig. 2). Observation data for a further 13 species which showed signs of drought damage, are presented

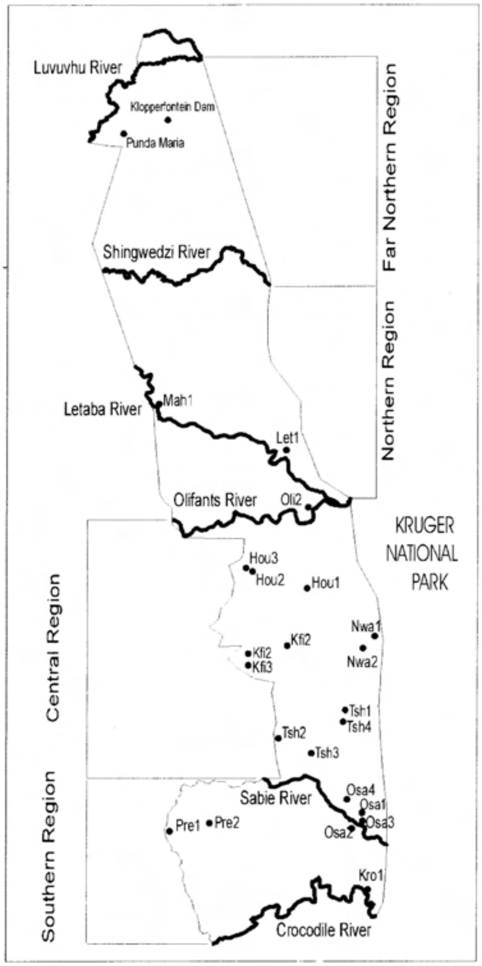

Fig. 2. The distribution of sites selected for the assessment of damage to the woody vegetation in the Kruger National Park.

briefly. No information on soils was collected at the sample sites and with the exception of *Terminalia sericea* no attempt has been made to relate damage to habitat preferences of specific species.

Dichrostachys cinerea

Surveys were made on six different sites where drought-induced damage to *Dichrostachys cinerea* was apparent. Results are shown in Fig. 3. Only plants >1 m were considered. The largest die-off (78%), was found in the area north-east of and close to Lower Sabie Restcamp, along the tar road to Skukuza (Osa2, Fig. 3). At another nearby site only 8% was dead (Osa1, Fig. 3). This clearly shows the variable impact of the drought on *Dichrostachys cinerea*. Several other observations also indicated that this species was variably damaged in areas where it occurs commonly, especially in the central and southern regions of the KNP. Occasional damage was also reported in the far-northern region on the basaltic plains and in the vicinity of Klopperfontein Dam.

Strychnos madagascariensis

The results from two sites are presented in Fig. 4. Plants of all heights were included. Both sites are located in the granite landscapes in the western part of the KNP where this species commonly occurs. The largest die-off was 72% on a site south of Orpen Dam. Observations of damage to and die-off of this plant were frequently made in the western part of the KNP between Satara and Skukuza. The impression is that this is one species which has been damaged to a large extent.

Terminalia sericea

The survival of *Terminalia sericea* was determined at three localities in the central region of the KNP (Fig. 5). This species is commonly found on the relatively wet seepage zones between the sandy uplands and the clayey bottomlands of the undulating granitic landscapes (Gertenbach 1983). Due to its association with this wetter sandy habitat, this tree is not well adapted to drought. At a site south of Tshokwane, 38% of the trees were recorded as dead, with a further 50% severely damaged. Near the western boundary along the Ripape firebreak, however, only 10% died, with a further 12% severely damaged. Various other observations of damage of different intensities were made in the southern and central regions. Limited

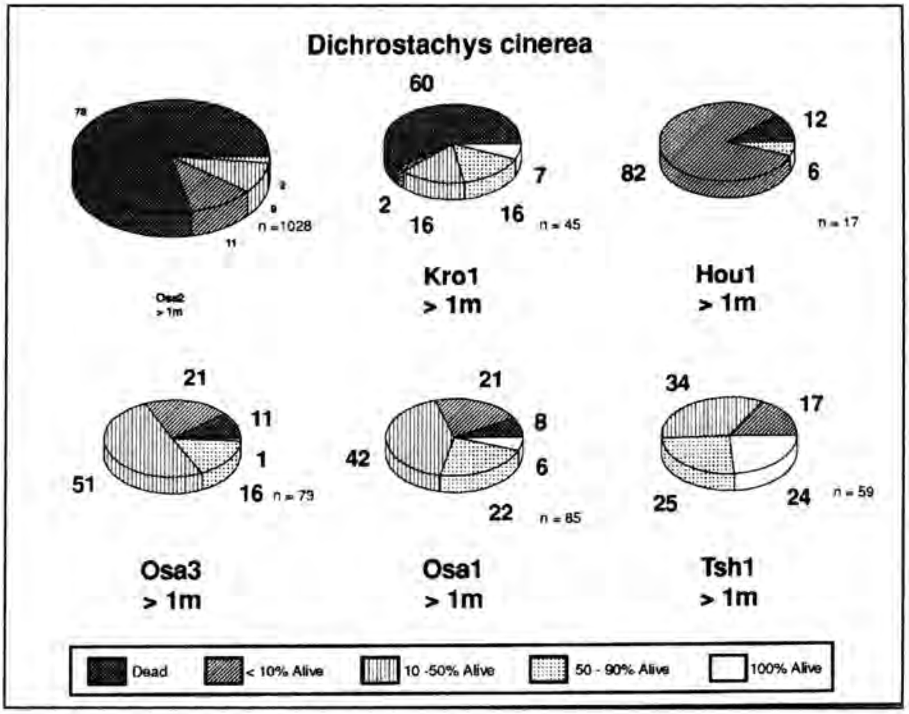

Fig. 3. Percentage plants (*Dichrostachys cinerea*) per damage class at selected sites.

mortalities were also observed in the far-northern region.

Pterocarpus angolensis

This species occurs in the south-western part of the KNP, mainly in the Pretoriuskop and Napi areas. It was severely affected by the drought, especially in the Napi area. Although only 16% of trees >8 m were classified as being dead, a further 80% showed damage of more than 90% (Pre2, Fig. 6). Most of these harmed trees coppiced only poorly and it appears that they will not recover. On a second site, north-west of Pretoriuskop Restcamp, survival was considerably better. Only 21% of the trees was classified with 50% or more damage.

Colophospermum mopane

The results for two sites are presented in Fig. 7. Both sites are situated in the western part of the KNP, just south of the Olifants River. This is the southernmost distribution of this species in the park. No plants with a shrub growth form were observed as dead at these localities. Only trees larger than five metres were therefore taken into account.

The only other area where damage to *Colophospermum mopane* has been reported was in a strip two to three kilometres wide, extending form east of Klopperfontein Dam to north of Punda Maria in the Shantangalani area. Although no quantitative data are available, it is estimated that 30% - 40% of trees and shrubs were killed in this

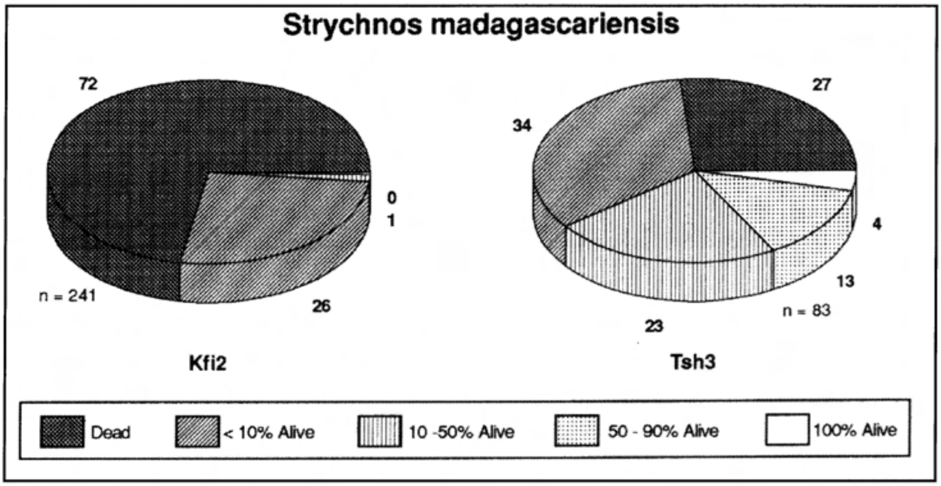

Fig. 4. Percentage plants (*Strychnos madagascariensis*) per damage class at selected sites.

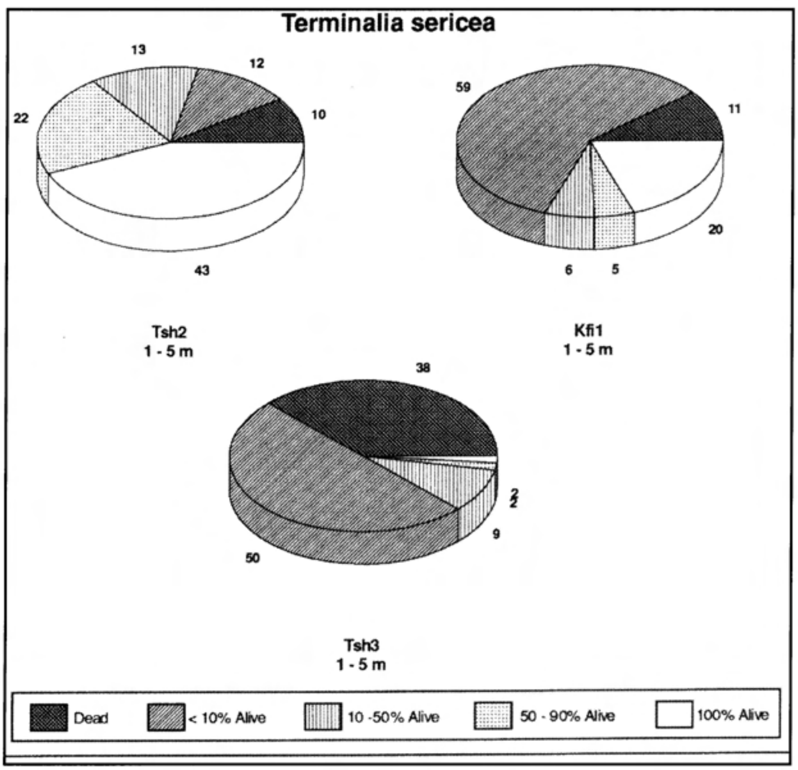

Fig. 5. Percentage plants (*Terminalia sericea*) per damage class at selected sites.

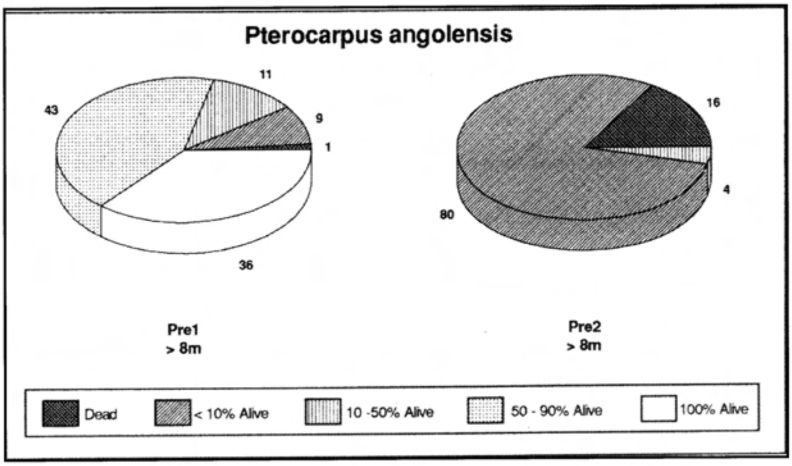

Fig. 6. Percentage trees (*Pterocarpus angolensis*) per damage class at selected sites.

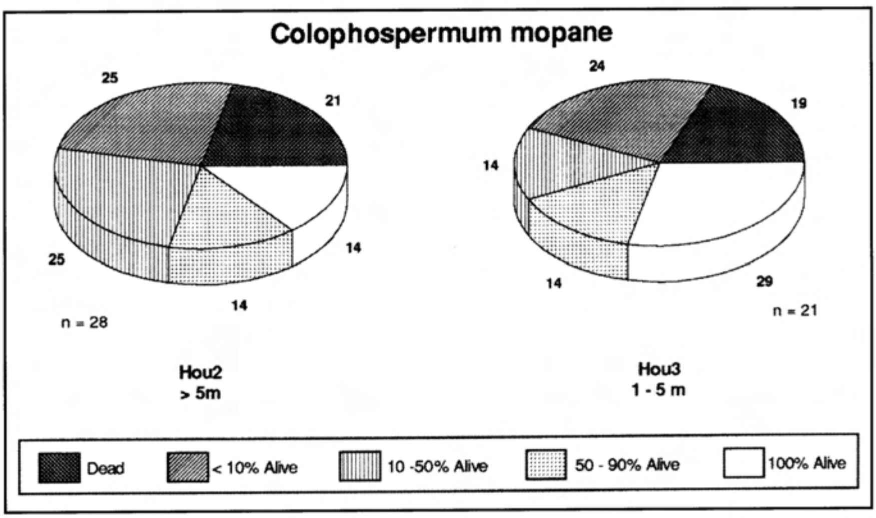

Fig. 7. Percentage plants (*Colophospermum mopane*) per damage class at selected sites.

area. Many of these were large *Colophospermum mopane* trees.

Acacia tortilis

In an area along the Crocodile River between the Dzuweni and Mpanamana streams, *Acacia tortilis* was severely damaged and at a specific site 93% of all trees >2 m died (Fig. 8). This exceptionally high mortality occurred only locally. At various other localities in the central and southern regions, damage of variable intensity was observed.

Terminalia prunioides

The results from one site showed that 44% of this species died on a foothill west of Olifants Restcamp (Fig. 9). This is the only quantitative data available for this species

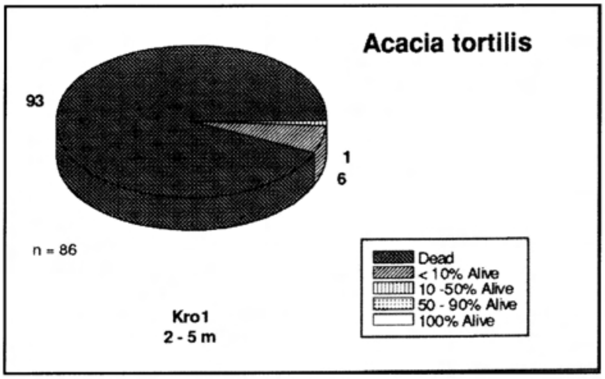

Fig. 8. Percentage plants (*Acacia tortilis*) per damage class at a selected site.

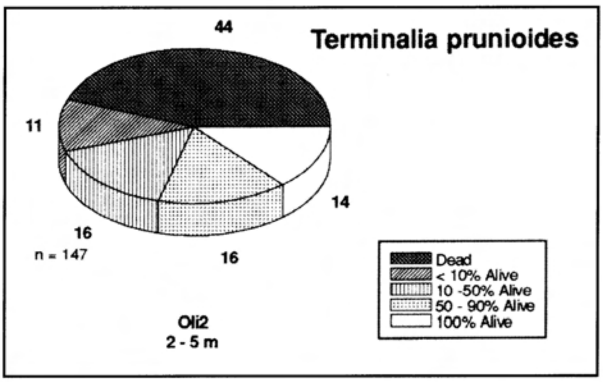

Fig. 9. Percentage plants (*Terminalia prunioides*) per damage class at a selected site.

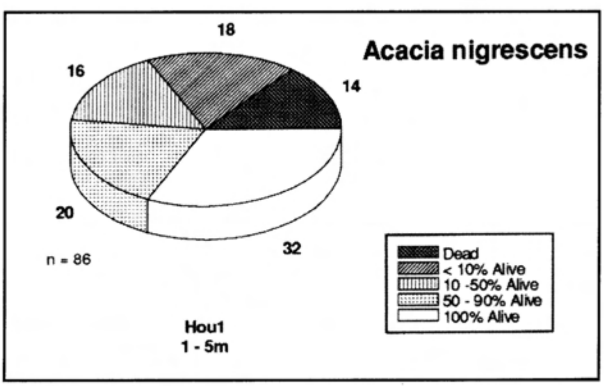

Fig. 10. Percentage plants (*Acacia nigrescens*) per damage class at a selected site.

and the only area where large die-offs were observed. Except for mortalities reported in the Klopperfontein Dam and Shantangalani area, damage to single plants were occasionally observed.

Acacia nigrescens

On the basaltic plains north of Satara Restcamp patches of vegetation occurred where *Acacia nigrescens* was damaged by the drought. *Acacia nigrescens* frequently occurs as a shrub (<5 m) on these plains and damage occurred mainly in this height class. Results from a survey west of Timbavati picnic spot—which can be regarded as almost representative of the areas where damage occurred — are presented in Fig. 10. Fourteen percent of plants had died and 18% were severely damaged. Quantitative data is not available but it was reported that large die-offs also occurred near Mapetane drinking trough. This large die-off can probably also be related to a very hot veldfire in this area just before the drought. Die-off of a few large *Acacia nigrescens* trees were also observed. It is, however, incorrect to ascribe these losses to the drought alone, as these trees were partially ringbarked by elephants and already under stress.

Survival of species associated with perennial streams

Results of surveys of species associated with perennial streams are presented in Fig. 11.

Large *Ficus sycomorus* trees occur at relatively low density along the streams where surveys were conducted, though except for the strip along the N'waswitsontso stream where only five percent died (Tsh4, Fig. 11), considerable die-offs occurred. Observations of single large individuals that died or were severely damaged were frequently made at perennial streams in the KNP.

Lonchocarpus capassa trees >5 m were not severely affected but die-offs did occur (Nwa2, Fig. 11). Along the Ntlhomorwana stream at Mafortini Windmill, an area was identified where 50% of plants died and a further 25% was severely damaged. All plants were 1 - 5 m tall. Mortalities were also reported in the Klopperfontein Dam area, while a few large trees died near Mooiplaas ranger post. Other die-offs were observed in the southern and central regions. It was also observed that elephants utilised *Lonchocarpus capassa* more during the drought than in non-drought years.

The only quantitative data available for large *Diospyros mespiliformis* trees are from a small sample at a site along the Sweni stream where 15% of plants died (Nwa2, Fig.11). A few other observations of die-offs were made in the southern and central regions.

It was found that 28% of *Spirostachys africana* trees of >5 m died at a site along the Nwanedzi stream (Nwa1, Fig. 11). Damage to this species was frequently reported in the central and southern regions, and to a much lesser extend in the far-northern region.

Mortality of *Acacia xanthophloea* was high in both the 2 - 5 m and >5 m height classes (Fig. 11).

At a site along the Nwanedzi stream, 33% of *Acacia robusta* plants >5 m was recorded as dead (Nwa1, Fig. 11).

Other species

The results for *Sclerocarya birrea*, *Combretum hereroense*, *Euclea divinorum* and *Albizia harveyi* that were not severely damaged by the drought and for which quantitative data from specific sites are available, are presented in Fig. 12.

Observations made on other species for which no quantitative data are available, are as follows:

Dalbergia melanoxylon - Moderate die-offs and damage to this species was observed where it occurs on the basaltic plains north of Shingwedzi Restcamp.

Androstachys johnsonii - In the Punda Maria/Pafuri area deaths and damage occurred at places especially against the northern mountain slopes.

Acacia gerrardii - Mortalities on the basaltic plains from the central and southern regions were reported.

Acacia welwitschii - A few mortalities were reported from the central region.

Aloe marlothii and *A. chabaudii* - Deaths occurred in places in the Lebombo mountains, particularly after the plants were uprooted by elephants and damaged by kudu.

Aloe sessilifolia - It was reported that large patches died in the lower N'waswitsontso area.

Securinega virosa - Plants of this species died especially in the Klopperfontein Dam area in the north.

Trichilia emetica - Except for mortalities along the large rivers only single individuals died along streams such as the N'waswitsontso.

Combretum apiculatum - With the exception of the area around Klopperfontein Dam and north of Punda Maria Restcamp where

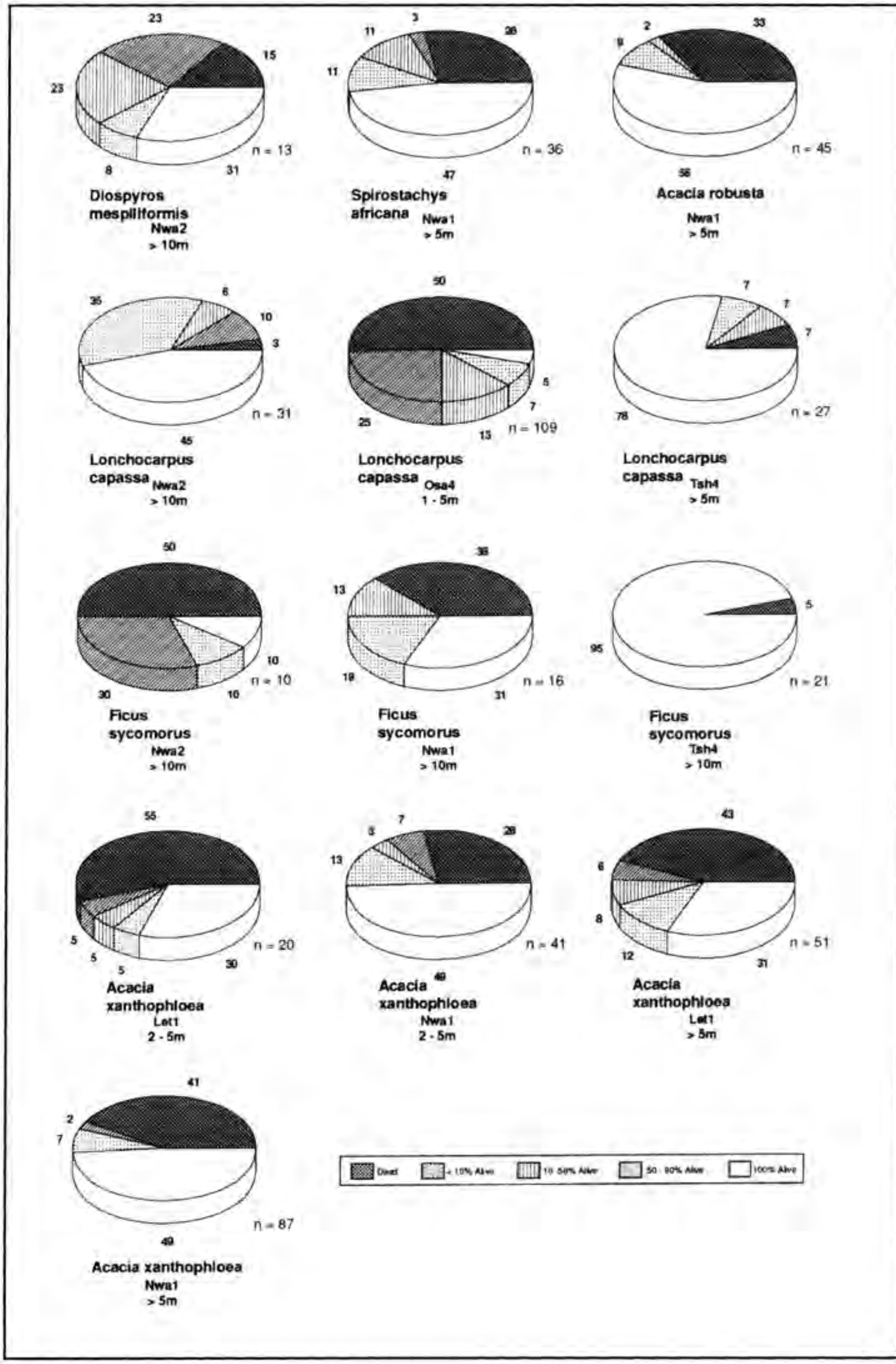

Fig. 11. Percentage plants (species associated with perennial streams) per damage class at selected sites.

considerable mortalities occurred, only very sporadic deaths of single individuals from the southern and central regions were reported.

Combretum imberbe - Deaths of large trees was reported for the Klopperfontein Dam and Shantangalani areas.

Ekebergia capensis - Mortalities of single individuals along streams especially in the southern and central regions were observed. Deaths along the Shisha stream in the far-northern region were also reported.

Euphorbia cooperi - Mortalities were recorded in the Lebombo Mountains in the southern and central regions. In the far-northern region mortalities were recorded at Dzundwini kop.

Discussion

According the classification of Zambatis & Biggs (1995) in the area south of Punda Maria and north of the Olifants River moderately severe drought conditions (31 - 45% of mean annual rainfall) occurred during the drought. With the exception of the Malelane and Lower-Sabie regions, the area south of the Olifants River experienced only moderate drought conditions (46 - 60% of mean annual rainfall). Damage to the woody vegetation as estimated from the aerial photographs, however, indicates that the woody vegetation more-or-less south of the Olifants River was affected more than the northern area (Fig. 1). The distribution of sites on selected localities where deaths occurred, as well as other observations, also indicate that the intensity of damage was less to north of the Olifants River. This, therefore, suggests that the woody vegetation south of the Olifants River is less adapted to drought. Long-term climatic data (Gertenbach 1980) also show that the northern part of the KNP is drier than the southern parts. It can be expected that the plant communities in the northern parts are more adapted to drought. Damage of the woody vegetation as a whole was estimated without any distinction between species. *Colophospermum mopane* is the most dominant woody species north of the Olifants River. It is well known that this species is frequently associated with areas of low rainfall and is therefore more drought resistant. The dominance of *Colophospermum mopane* probably contributed to the lesser impact of the drought on the vegetation north of the Olifants River as estimated from the aerial photographs.

The rain that occurred in the north during July 1992 (Zambatis & Biggs 1995) definitely contributed to the better survival of woody plants in the northern parts of the KNP. It was observed that species such as *Colophospermum mopane* and *Combretum apiculatum* even started to sprout after this winter rain, with some trees being covered with new leaves.

The area north and west of Punda Maria was, however, more affected than the rest of the northern parts. This area received only 16 - 30% of the mean annual rainfall and was classified as an area where severe drought conditions occurred (Zambatis & Biggs 1995). This resulted in more damage to woody plants as reflected by observations made in this area.

A characteristic of the drought was the localised distribution pattern and variable intensity of damage to the same species in the same general area. It can probably be attributed to the patchy and scattered distribution of the little rain that did fall during the drought. Local variation in some factors, such as soil depth and texture, slope, cover by the grass stratum and the burning history of the area, also played a role.

According to Zambatis & Biggs (1995) the 1992 drought was preceded by seven years with below-average rainfall. This long dry period and the resultant cumulative soil water deficit certainly contributed to the woody vegetation damage which occurred during 1992/93.

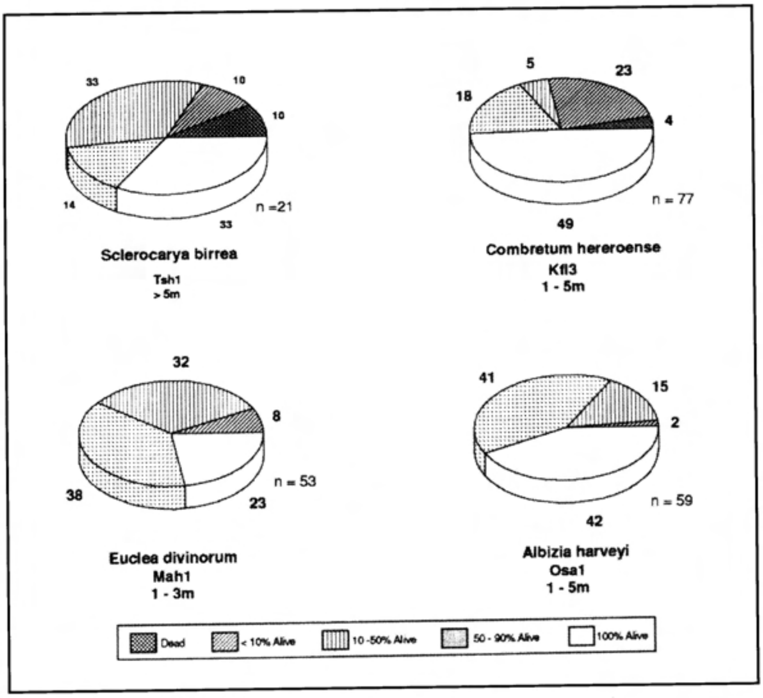

Fig. 12. Percentage individuals per damage class at selected sites.

The drought not only damaged the vegetation but also influenced it in other ways. In some species, for example, sprouting was delayed after the first summer rain at the end of 1992 and beginning of 1993. Prominent in this regard were species such as *Spirostachys africana, Schotia brachypetala* and *Diospyros mespiliformis*. It was also conspicuous that during the spring of 1993 species such as *Lonchocarpus capassa, Schotia brachypetala, Sclerocarya birrea, Acacia nigrescens, Terminalia prunioides, Combretum imberbe, C. hereroense, Rhigozum zambesiacum, Mundulea sericea* and *Hexalobus monopetalus* flowered extremely well. It can be speculated that this reaction and the subsequent large seed production could be a possible mechanism to ensure survival after a plant has been subjected to severe water stress. The same tendency was observed and recorded in ranger's diaries after the 1982 drought.

Damage that occurred was not always negative. *Dichrostachys cinerea*, a species that is regarded as a potential encroacher (Bredenkamp 1986) was highly affected by the drought. Drought may be a natural mechanism to prevent encroachment by this species.

Conclusions

The 1992 drought clearly affected the woody vegetation in the KNP. Damage was localised and differed in intensity at different localities. A large number of woody species was to some extent damaged but when the woody vegetation of the KNP is considered as a whole, damage was not severe. Some species, at specific localities, were severely damaged but no large areas with high mortalities were observed. It must be emphasised that the sites where surveys were made were specifically selected for

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damage and that the results in most cases reflect the worst conditions.

Mortalities certainly did not only occur because of water deficiencies but also in combination with other factors such as old age, diseases and utilisation by elephants. A long-term detailed study of these interactions (also during normal rainfall periods) will be necessary to fully understand the influence of drought on these ecosystems.

Finally, it must be born in mind that the fate of individual plants which just survived the drought will only be determined by the rainfall of the next few years. The possibility also exists that individuals of various species which were initially classified as dead may coppice again and survive if good conditions prevail. Future monitoring is therefore important, not only to confirm mortalities but also to follow succession at localities where plants died.

Acknowledgements

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References

BREDENKAMP, G.J. 1986. Ecological profiles of potential bush encroacher species in the Manyeleti Game Reserve. *South African Journal of Botany* 52: 53 - 59.

GERTENBACH, W.P.D. 1980. Rainfall patterns in the Kruger National Park. *Koedoe* 23: 35 - 44.

GERTENBACH, W.P.D. 1983. Landscapes of the Kruger National Park. *Koedoe* 26: 9 - 121.

VILJOEN, A.J. AND N. ZAMBATIS. 1995. Short-term effects of the 1991/92 drought on the herbaceous layer of the vegetation in the Kruger National Park. National Parks Board Internal Report.

ZAMBATIS, N. AND H.C. BIGGS. 1995. Rainfall and temperatures during the 1991/1992 drought in the Kruger National Park. *Koedoe* 38(1): 1 - 16.