PROPOSED POLICY FOR THE ECOSYSTEM MANAGEMENT OF FIRE IN THE KRUGER NATIONAL PARK

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Table of Contents

Page

Summary

The fire management system being proposed for the Kruger National Park must satisfy the Park's recently revamped ecosystem objectives, which stress heterogeneity over space and time. The current intended lightning-driven system meant to achieve this, but proved to be dominated instead by fires caused by illegal immigrants. This led to revision, which was well underway before the tragic fire of 4 September 2001, an event, which served to help unify relationships between this and KNP fire security policies.

Areas of continuing debate include understanding the implications of the role of early man in shaping the landscape with fire, as contrasted with justification behind demands for "hands-off" wilderness management. Cognisance has to now also be taken of the reality of concession areas and their need for smaller-scale fire heterogeneity patterns and lower levels of risk appropriate to their geographically more confined operations. The experimental burnplots (EBP's) operated since the mid-1950's are discussed, including recent initiatives which are making these results more valuable to our current objectives.

Despite these challenges, much has been definitively learnt, for instance that point ignitions are preferable, that there should be limits on total extent allowed to burn, and that the system employed must include enough cautiously thought-through variants to allow us to learn. The strategic adaptive approach is embedded in the proposed system by TPC's[1] being built into the proposed operations, two of the most important ones being measured and evaluated by rangers directly.

Consequences arising from fire policies during the era during which fire management was intended to be dominated by lightning (1993-2001), are reviewed, as is the LASHFIRE trial, a planned experiment to realistically review practical alternatives to lightning fire systems. Reasons for dissatisfaction with the intended lightning system are highlighted, the main one being that the system in practice turned out instead to be driven largely by illegal transmigrants setting fires on their way through the park. Apart from proposing an alternative system, we also recommend the planned LASHFIRE trial now be shelved, for reasons of our having outgrown its philosophical base, and having integrated most proposed variants that would have been tested in isolation, into the newly proposed fire system anyway. The basis for a healthy relationship between the ecosystem fire management policy, and the KNP fire security policy (designed to protect humans and infrastructure) is considered, threats posed by fire to animals also being discussed. The need for training, and the emergence of Fire Protection Associations, are mentioned.

An innovative and seemingly practical way of uniting the best available components of patch mosaic fire philosophy with range condition and lightning fire philosophy, and embracing the reality of transmigrant burns, is proposed. It involves setting annual and monthly burn targets based mainly on vegetation measurements taken at the start of the season. Each month from early in the fire season, patch fires are put in by rangers, towards a target also influenced by transmigrant fires. Adaptive "catching-up" or "slackening-off" is practised as the season progresses, to try to keep somewhere near target. Rangers will generally stop setting fires at the onset

[1] TPC's are Thresholds of Potential Concern, which are monitoring endpoints based on objectives describing the desired state for the Park. They are a variation on Limits of Acceptable Change (LAC's) and are discussed extensively in Box 3 page 14 of the Revision of the KNP Management Plan (Braack, 1997).

of the lightning season to then allow lightning a chance to contribute as a natural source. Slight variations, to enable learning while managing, are imposed for wilderness areas, non-wilderness areas and concession areas, and other variations (such as amount of lightning influence in different areas) will arise over time as a natural contrast.

In this way, lightning has the best safe chance of burning significant areas, instead of these areas being pre-empted earlier in the season by (often rampant) transmigrant fires. Generally, all fires are point ignitions. Wilderness areas are allocated the least invasive form of fire management, and concessions are given maximum safeguards permissible within a biodiversity management philosophy. Rangers will once again feel a sense of empowerment in fire management, and develop fire-setting skills.

At all times during the learn-as-we-manage process described above, the central suite of TPC's operated in the KNP will act as the "referee's rules" for the desirability or otherwise of these systems. Systems exceeding TPC's will be discontinued or adapted. Certain focussed research projects may need to be solicited to answer particular questions not amenable to resolution using the regular monitoring programme, whose scope should in any event be scrutinised to make it as simple and practical as feasible in future.

Practical ways of transferring the technology, and the overall way forward, are discussed.

Introduction and Background

Fire management practices in conservation areas have remained contentious for decades, for three basic reasons. Fire is an obvious ecosystem driver (Walker 1987), there are important gaps in our understanding about the actual effects of fire including the interactive effects together with other factors such as herbivory (Bond 1997), and multiple practical fire management options appear to be available to managers (Bradstock *et al.* 1998). These three factors imply that managers realise the importance of fire, feel the need to choose between options to manage it, but acknowledge that the decisions are currently being taken on imperfect knowledge. Ongoing research into fire management thus appears important (Braack 1997), as does the learning-while-doing operating principle stressed in Vol. VII of the management plan.

Our mandate to derive a fire policy rests on the belief that certain fire management systems will better than others "maintain biodiversity in all its facets and fluxes" as stated in our vision. Braack, in the 1997 management plan revision, states

"The intent is to adopt a fire policy which tries to approximate the frequency, seasonal distribution, intensity and extent of fire which has shaped the Lowveld savanna and with which the biotic components have co-evolved. Modern human impact has grossly affected the historic "natural" fire pattern, or pattern which could reasonably be expected to prevail had human population growth and cultural practice not changed so rapidly and dramatically".

This raises a currently unanswerable question which bedevils fire ecosystem management debates – namely, what role did early man play? Apart from the

knowledge that early man in Africa has been setting veldfires in some or other manipulative way for up to a million years, little is known of the extent to which this happened and likely patterns which prevailed. Some preliminary work done in the region (Connor, pers comm), investigating the role of human-induced fires over the last two thousand years, was unable to come up with definitive evidence except that such fires were present, and probably at greater intensity at least during the militant *Difequane* period.

One strict interpretation of the wilderness ethic seeks to eliminate the effect of man completely, believing lightning constitutes the only valid ignition source in the region. The fact that a footnote to the mission statement of the KNP (Braack, 1997) acknowledges "the integral part which pre-industrial man in low densities had in the Park, existing as a harmonious component of ecosystem diversity", suggests that anthropogenic fire needs to be condoned in some way at least. The "fire shortfall argument" states that a certain number of human-ignited fires, which might escape control, are acceptable for the following reasons:

(a) Early humans resident centuries ago in low numbers in the area, which is now the Park, would probably have burnt fires, contributing to the architecture of the landscape.

(b) The high boundary: perimeter ratio of the long, narrow KNP, with in recent times very few fires ignited outside, or (if ignited) almost none spreading in from outside the Park, has certainly led to a reduction in the number of fires that would have otherwise spread to inside the park area.

There is no guarantee, however, that those human-ignited fires now arising within the borders of the KNP (currently due mainly to illegal transmigrants) and which cannot be extinguished immediately, cause fires similar in area, frequency, seasonality or intensity to fires caused by the two historical sources mentioned above. The policy proposed here reflects the inability of concerted efforts over the last decades, to reduce the flow of illegal transmigrants across the park to a level where their fires are not a problem for management, and at this time this level of ignitions by them is considered a given. It may, however, be possible (Trollope, pers comm) to influence their fire-setting behaviour, something which has never been attempted in practice in this region. In essence, this proposal arose as a direct response to illegal transmigrant fires, and it will be reasonable to consider possible changes to it, if and when such pressure abates.

After first giving a historical overview, this proposal suggests a policy modification arising after nearly ten years of experience with a fire management system which attempted to maximise lightning-induced burns and suppress fires from all other causes. This lightning policy itself could be seen as having been built partly on experience in the forty years before. The current policy attempts to also take into account what has been learnt from the cumulative research and experience over the last half-century (after van Wilgen, pers comm):

- That a diverse composition - enhancing carrying capacity - can be expected if the veld is burnt according to veld condition assessment criteria[2].

[2] Although an important realisation, it can be overinterpreted relative to objectives in large natural systems, where the desired "natural" heterogeneity does not necessarily imply maximising carrying capacity throughout, or even maintaining one suite of diverse grasses at as many points as possible in space and time

- That point ignitions are preferable to perimeter ignitions around blocks
- That variability in regime is desirable
- That there should be limits on the total area allowed to burn (based on the year's biomass production).
- That density and morphology of woody plants can be influenced by fire regime, in certain reasonably understood ways.

We have also learnt some institutional lessons:

- That we should not at this (or perhaps any future) stage proceed with a single fire management method over the whole area - thus precluding the opportunity to learn by comparing different actions.
- That the threshold for potential concern (TPC) approach adopted in the KNP management plan is highly suited to the adaptive management we strive to practice.

Apart from the sound foundation laid by many pioneers (as reviewed by Trollope, 1998), changes in perceptions of how ecosystems function (Peel et al, 1998) requires that our approach also support multiple views of these possible functional pathways. To this end, a good basis of recently analysed fire data and proposed alternative practical fire systems is available, as exemplified by publications such as van Wilgen et al (2000), van Wilgen et al (1998), Trollope et al (1996), and Brockett et al (2001). The Kruger Park, with the assistance of acclaimed fire ecologists, is thus in a leading position to now answer many questions needed for further guidance in biodiversity management.

Without placing value judgements onto any philosophical underpinning, fire management policies in conservation areas have tended at various times to be influenced by one or more of four basic beliefs or goals. These were: creation of desired (and previously usually fairly fixed) endpoints in vegetation structure and composition, sometimes contrasted (Trollope *et al.* 1996) with the second one, a belief in a wilderness-based ecosystem philosophy; thirdly, a heterogeneity paradigm, supporting enhancement of patchiness (Wiens 1997), and finally, a conviction that early man may have strongly influenced the evolution of savannas in Africa by using fire in ways we might choose to emulate (Bond 1997). No final agreement has currently been reached on the correct choice or blend of these choices, though this proposal attempts to take elements emanating from all the above foundation belief systems into account, and integrate them in a way not achieved before.

History of Fire Management policies, with special reference to the recent intended lightning-driven system

An early account was given by Brynard (1971). Fire management history was reviewed again by Braack in the fire chapter of the 1997 management update, and in summary by Biggs and Potgieter in 1997. The latter account is repeated here:

"Little is known about fires up to the present century, other than that early inhabitants made at least some use of fire to manipulate the range. From the early 1900's till the mid-1950's, there was a period of what has been referred to as an era of uncontrolled burning (somewhat of an oversimplification) with very low numbers of staff in the early years and large tracts of land with no firebreaks. Fire

suppression towards the end of this period led inadvertently to some very large fires, the organisation's Board then committing themselves to the appointment of their first research officer and to the initiation of long-term experimental burning plots. At the same time, a so-called triennial burn policy began, with rotational burning of burn blocks delineated by firebreaks, to be continued in various forms till 1992 (a description of the variations is available in Trollope *et al*. 1996). Although the initial intention was to burn three-yearly, the later variants of the policy allowed prior field visits with overrride options i.e. the field evaluation might result in the block not being burnt for several more years. For this and other reasons such as the one explained below, the mean fire return periods turned out far closer to six years (Trollope *et al.* 1994). Van Wilgen *et al*. (*in press*) evaluate the 55-year fire pattern history till 1996 in detail, showing that because of the shape of the cumulative fire probability curves (a pattern which needs to be understood clearly by fire managers[3]) the median fire return period was indeed three to four years, even though the average was far longer, as Trollope had shown. Overall, however, the frequency was shorter than is generally being judged in the late nineties to be desirable, and, as a result, allegations of possible homogenisation of the landscape due to "overburning" and its interactive effects with herbivory, are being made (Trollope *et al*. 1998). The intensity of fires is now also believed to have been uniformly too high due to the fact that perimeter burning was employed."

The lightning-fire era (or what it transpires should be called the intended lightning-fire era) began in 1993, 1992 having been year of such severe drought and low production that, for all practical purpose, no fires burnt. This policy supplanted the nearly forty-year run of rotational burning, and was documented as a formal modification to the then current Management Plan (Joubert 1986). This nearly amounted to a reversal, with the previous rotational burn policy being to set management fires and suppress lightning and "refugee fires", this policy now allowing lightning fires and suppressing all others. The underlying reasons for this radical change were to be found in the roots of wilderness fire philosophy (Kilgore, 1994), highlighting the belief that lightning was the only non-human or "natural" ignition source in this ecosystem. The perceived consequence was thus that this source would then lead to a rich "natural" mosaic, with point fires burning at different intensities over different areas under different conditions. Support was also given by certain opinion-formers not necessarily fully aligned with wilderness philosophy, but who believed lightning must at least be allowed to play its partial role, and from those who saw an opportunity to now generate more patchiness in this way. An important ancillary issue arising during those discussions was that point ignitions (as would occur with lightning) were deemed far more desirable than perimeter ignitions, which had been employed till then for the rotational block burns. An explicit stipulation was that all lightning fires should burn to their fullest natural extent, with rangers lighting them across man-made barriers, such as roads. In practice, this "natural extent" clause proved hopelessly idealistic. A cursory examination of any burn outlines (also after the attempted implementation

[3] The pattern can be understood by imagining say 3 patches (typically burnblocks, in the rotational system) having had the following inter-fire periods making up (say, for simplicity) an exact 21 year fire history – in other words if they all burnt in the first and last years as well, the interfire years would total 20 for each:
Block A: 2yr, 9yr, 4yr, 3yr, 2yr; Block B: 8yr, 1yr, 11yr; Block C: 1yr, 5yr, 3yr, 3yr, 8yr.
Aggregating all interfire periods from short to long gives: 1, 1, 2, 2, 3, 3, 3, 4, 5, 8, 8, 9, 11 yrs
The **average** interfire period is 60 yr/13 interfire periods = **4.61 yr** while the **median** (middle value) is **3 yr.**
If the fires were all equally sized, there would thus be 2/13 (15%) of land burnt within 1 yr since a previous fire; 4/13 (30%) of land within 2 yrs, 7/13 (54%) of land within 3yrs, but then far smaller increments after that. Persons interested in plotting all the points on a graph with x-axis (time since last fire) and y-axis (cumulative % burnt) will see a graph typical of inter-fire behaviour of savannas.

of these guidelines) shows that the commonest reason a fire stopped was that it ran up against a road or firebreak. With the subsequent removal of many firebreaks (discussed below) this remained true, but with larger fires being burnt. Another less common reason for larger fires was extreme weather (high winds, high temperatures and low humidity), which caused fires to jump roads or firebreaks. Through all this, man-made boundaries formed the commonest end-of-fire delineation.

Braack makes the point in the management review that "the courage represented by this policy was put to severe test during the spring of 1996, when large accumulations of grass resulting from the exceptionally wet season of late 1995/early 1996 enabled several massive fires in the central and southern KNP, causing considerable public concern and enquiries. Nevertheless, no mammal mortality attributable to these fires could be found despite several helicopter and fixed-wing patrols during and immediately after the fires, and good follow-up rains resulted in rapid regeneration of grass. Some wildlife managers nevertheless felt that had good follow-up rain not fallen at such an opportune time, the consequences could have been dire, and this resulted in a re-appraisal during mid-1997 of the "Wilderness Fires" policy". By 2001 it was clear that 1996 was the only year on record in the "lightning-fire-driven era" when lightning fires actually burnt a larger surface area than anthropogenic fires, although the perceived threat of drought following very large fires of transmigrant origin is equally (or, because of their "unnaturalness" from some viewpoints, even more) worrying. The re-appraisal mentioned led to the so-called "lid-on-fire" argument, which, although originally intended as a safety measure for five years, is now widely thought to be permanently required. The specifications of this "lid-on-fire" clause strive basically to restrict the area burnt in one season to under 50% of whatever (larger-scale) fire management unit is in place, whatever the circumstances.

The change to a lightning-driven fire policy in 1993 took place before the current revision of the KNP management plan in 1996/97, and it was with great interest that the fire management policy was scrutinised during the revision. The basic elements of the new management plan include maintenance of biodiversity and wilderness qualities, while providing human benefits in keeping with the organisation's mission (Braack, 1997). A clearly traceable objectives hierarchy was generated under this overarching objective, to make clear, at different levels of detail, exactly what was being aimed at. The review team, which had to flesh out details of policy for fire-related issues in this plan, felt it necessary to co-opt several local fire ecologists to assist in this endeavour. The result was a series of workshops during which the principles of the plan were presented to workshop participants, who were asked to formulate fire policies compatible with these. The outcome was a series of recommendations:

(1) That whatever studies could be undertaken on the 45 year experimental burning plots to feed into of the new research and management objectives, should be encouraged.
(2) That the SANP should not find itself in the position again, as it did in 1992, where a major change in policy needs to take place, and no comparison with any other system is possible. To avoid this, it was eventually decided that realistic alternative and continuously adaptive policies should be tested on a landscape scale and probably for at least 20 years. This led to the plan for the LASHFIRE trial, which is described below.

(3) That the "default" policy of allowing lightning fires to burn could in the meanwhile serve as a likely route to achieve lower fire frequencies and richer landscape mosaics.

The LASHFIRE trial as planned

The trial design is described in detail in Biggs and Potgieter (1999) and summarised here.

Four large experiments, each occupying about 5% of the surface area of the Park, would be placed in the four main vegetation-soil combinations in the Park (combretum on granite; knobthorn-marula on basalt; mopani on granite; and mopani and grassland on basalt). Two were placed in the intended high-impact elephant zones, and two in the low impact zones. Each experiment would have three treatments –

- A patch mosaic system (Parr and Brockett 1999; Brockett et al 200). In such a system, an estimate is made at the beginning of the fire season (in most years taken as April) of the target percentage to be burnt by the end of the season, based on grass biomass at the end of the growth season (also April). This is divided into monthly steps, the earlier months with large numbers of small fires, fire size increasing and monthly fire number decreasing as the fuel dries with seasonal progression. All origins of point fire are allowed, as long as within the numbers and area guidelines. In practice, most early fires are set by ranger staff, usually at random locations, and simply left to burn. The underlying idea is to create an ecologically rich mosaic, and in so doing break up the fuel bed as the season progresses, thus reducing the risk of large fires. The system has been practised with some success in several southern African conservation areas.
- A range condition burning system (Trollope et al 1995). In this system veld condition assessment (quantity and composition) is undertaken in April and used as a basis for deciding which areas to burn. The objective is to only set fires in areas with vegetation characteristics, which are known to respond in a way, which produces "equally good or better" veld condition, and thus avoid veld "degradation". As stated in an earlier footnote, this is often (but possibly not universally) helpful in maintaining a range of diversities in large conservation areas. As adapted to the LASHFIRE plan, up to five point ignitions were to be allowed per block designated to be burnt, with no full perimeter ignitions being allowed. Again, other point ignitions (such as lightning) would be allowed as long as the rules were met.
- A lightning-driven system (the same as the rest of the Park outside the experimental area) as described in the previous pages. The only reason to have a specific similarly sized block adjacent to the other two treatments – rather than simply use any other area in the Park – was for rigour of comparison.

Each experimental subunit would be managed in a practicable way (meaning that if selected later as the default for the Park, that if it could easily be employed more generally over wider areas in a practical and cost-effective way). Each would be allowed to make adaptive changes to the system, and in fact, some level of eventual convergence between systems was anticipated. A more intensive suite of monitoring themes would be implemented in these LASHFIRE areas, allowing close ecological tracking. The "refereeing" between systems would be carried out over

the anticipated 20-year span, simply by applying standard Park TPCs. This would include not only fire pattern TPCs (as in van Wilgen et al, 1998) but also all the other TPC themes in the KNP monitoring programme (Braack, 1977). Any system consistently outside the "desired state" represented by the joint envelope of the TPCs, would be discontinued or adapted. If two or even all three stayed within the envelope, the choice between systems would eventually then be made on the basis of practicality (mainly cost-effectiveness and safety criteria) and not on ecosystem criteria. This trial reached an advanced stage of preparation, many additional monitoring transects for several biodiversity themes having already being put in by 2000. In 2000 a fair amount of prototyping of fire management systems took place, particularly of patch mosaic burns in certain of the designated areas.

If the proposal presented below is accepted, the LASHFIRE trial will however, be shelved, and some of the questions it sought to answer, addressed in other ways through but now in the normal course of management proposed in the new plan.

The Experimental Burn Plots (EBPs)

The recognition of the need to understand the effects of fire prompted the decision-makers in the 1950's to set out a replicated trial of twelve treatment combinations of frequency and season in 7 ha plots, in each of the four major vegetation types in the KNP. This trial and its products were thoroughly reviewed by Trollope at al (1995). Although the experimental treatments were faithfully carried out for a half-century, very little was done until recently to analyse data from the trial. The fact that what little information was available in 1992 was not directly used to influence the policy change at that time indicates a disconnection between research and management systems in this particular case. Although the trials have been variously considered to have been "conducted at too small a scale", "based on a regular regime" and "confounded by herbivory", much can be learnt from them in terms of results from the rigorous field experimentation and resultant solid inference. An assertive such initiative is currently underway, and the plots have recently attracted so much national and international interest (and are producing so much novel and useful science) that KNP needs to consider whether the designation "wrap-up" – as applied to the five year period granted to complete work on these plots is appropriate. The plots represent a unique set of interventions, which can shed important light on, *inter alia*, vegetation response to global climate change. The fact that KNP's (historically strong) research stature will be an even more important part of its overall portfolio in a globalising world indicates that we take any decisions on downscaling or closure of the EBPs with care, outside involvement and great discretion. The EBP trial, in spite of the original intentions of it designers, should no longer seen as a realistic management experiment, but rather as a rigid scientific trial for promoting understanding of fire-herbivory interactions, potentially useful in understanding basic relationships in the ecosystem, and for assisting in the calibration of TPCs.

Additional considerations in formulating fire policy

Threats to human safety and infrastructure due to fires

Fire security issues (such as timeous burning of firebreaks round camps and round parts of the border of the Park), have traditionally been separated from ecosystem

fire management, though clearly there is an interface – the two systems should be as compatible as possible with each other (see Appendix 1). The procedures for these fire security issues has been administered and implemented by the particular line-function departments. Over many years, only isolated cases of such fire threats actually manifested, and authorities and stakeholders were probably justified, on the basis of that experience, in considering the system fairly safe. Unfortunately, a set of unusual conditions worked together on the evening of 4 September 2001 and led to the biggest tragedy in the KNP's history, in which 23 people (19 contract grass-cutters and 4 staff) died near a temporary encampment in the Pretoriuskop region. Unusual and unpreventable though the combination of circumstances may have been, the incident will leave a lasting mark on KNP's attitude towards fire security – indeed fire security guidelines are currently being consolidated (Appendix 2). The ecosystem fire management policy proposed in this document was conceptualised in July 2001, several months before this tragedy. Since the tragedy, several people have automatically but wrongly assumed that this proposal was a result of institutional response to the killer fire. Regarding changes in national fire legislation, KNP is expected to play a key role in formation and membership of the emergent local Fire Protection Association, and needs to also assert its ecosystem fire management needs at a realistic level in this forum.

Discussion in this paragraph will be restricted to the overall philosophy concerning the influence of fire ecosystem management on the fire security situation. It is contrary to our mission to manage a natural area in such a way that no or almost no fire security risks are present. There will be a certain tension between the need for appropriate fire ecosystem management, and reasonable fire security requirements. The proposed new fire ecosystem management policy, through its concern over large fires, and through its intention to explicitly create mosaics, clearly reduces fire security risks. Since the tragedy, an additional goal of re-instituting certain key firebreaks has been included, though this limits the Board's stated desire in the late 1990's of coalescing wilderness areas into blocks that are as large as possible. Current thinking on the firebreak system is based on encircling the outer boundary of the Park, encircling concessions, encircling "blocks" of contiguous pristine wilderness areas, and finally, maintaining or re-opening certain other key firebreaks in between these. The resultant landscape fragmentation is far less than that caused by the firebreak system of the rotational block-burning years.

Threats to animal safety due to fire

Animal populations can be threatened in two ways – by direct damage due to fires, and probably more importantly, through removal of grazing by fire, followed by a drought. Both these have generally been considered "natural risks", though they can become very contentious if the management policy is itself considered "unnatural", for instance, when perimeter burns often led to very hot fires in the central vortex of a block, in the rotational burn policy. Still, park managers see most fire effects as "natural", and there often exists a gap between this view and broad public perception, a gap that we should work to reduce. In spite of occasional deaths (there were as many as 20 elephant deaths associated with the same fire as led to the human tragedy, and another 20 elsewhere in another fire in the Park) animal populations generally show enormous indifference to fires – in a current study examining bird populations between heavily burnt, lightly burnt, and unburnt areas, only small differences could be detected (Mills, pers comm). This usually renders media adjectives such as "destructive" inaccurate and even grossly

misleading, though one is reminded by the recent (albeit very unusual) set of circumstances that such destruction can occasionally occur. This paradox is part of forming a mature understanding of the variation over time and space in the ecosystem, so clearly stated in our mission and objectives. Looked at over long time scales and large areas, "natural" fire effects appear to be a disturbance factor which is integral to system function, an understanding we have yet to transfer successfully to the public as a whole.

Concession Areas and fire

Concession areas, by definition, operate at a smaller scale than the whole KNP or even than the regular fire management units in KNP, and therefore run a higher risk of a single fire passing through their whole area and possibly creating game viewing and landscape conditions which are uniformly unpleasing to the visitors. Because of this concern, the contracts include a clause allowing them, under these circumstances, to use alternative areas for a period. This contingency will not be easy for SANParks to manage. The proposed policy below deals with special arrangements to minimise this likelihood.

Wilderness Areas and Fire

The intended lightning-driven system was particularly acceptable to wilderness lobbyists, as it implied minimal interference and "letting nature get on with its own burning". One variation of this opinion was that the influence of early man could validly be superimposed on the lightning regime, and in some conservation areas in KwaZulu-Natal, patch mosaic systems actually selectively choose locations near very old settlement sites, believing this to emulate the influence of early man (Blackmore, pers comm). It must be remembered that one reason why such people may have burnt, was to improve grazing conditions or attract wildlife, so that there may be justification for applying range condition type systems in wilderness areas, provided the role of early man is accepted in this way.

Reasons for dissatisfaction with the intended lightning-driven fire management system

It has proved impractical to carry out the intended lightning-driven policy, except in one year, 1996. In every other year after 1992 (except 1995, when the area burnt by lightning-ignited fires and by fires from other ignition sources was almost equal) fires started by illegal transmigrants, or accidentally by guests or staff, have dominated the fire regime. Of all the area burnt every year, lightning-ignited fires have only accounted for an average of 19%.

This led to exceedance of a threshold for potential concern (TPC) designed for exactly this purpose, viz. so that we do not fool ourselves that the system is lightning-driven. Out of all the TPC's tabled on various themes since the inception of this form of adaptive management system; this TPC is the only one that has not been acted upon in some way. Instead, it followed the alternative (allowable) route of re-calibration by the committee responsible for these decisions. After much debate and contextualisation, the re-calibration eventually specified that the same comparison would be made in 2003, after 10 years of the so-called lightning-driven

system would have elapsed. Apparent agreement was thus reached that the lightning system might need alteration if the 10-year figure (as seems inevitable now) still showed that transmigrants, rather than lightning bolts, were actually driving the predominant fire regime in the Kruger Park.

In retrospect, it now appears that this extension of the TPC should not have been entertained, as we face widespread dissatisfaction amongst ranger staff (as expressed in a presentation by them at the annual meeting at the end of 2000). This is because:

- They consider there to be too many runaway fires started by transmigrants or guests. Their impression is verified by exceedance of the TPC.
- They object to the obligation to have to go out and combat *each and every* of these fires, often under dangerous conditions. Many of these fires could be considered "desirable". Some are safest left alone, or being combated from a distance only.
- Even in 1996, the one-year in which lightning-ignited fires predominated; several of these were considered uncontrollable, leading to the "lid-on-fire" clause.
- Even knowing that fires can only be partially manipulated in conservation areas, the feeling they have is one of almost no control. The increased emphasis on wilderness management in the park has led to removal of firebreaks and thus less ability to control "runaway fires". There is a measure of acceptance of this removal, yet a feeling that some compensation has to now be made in terms of fire policy. In the same vein, because the emphasis is on leaving lightning fires and on combating other fires, rangers are no longer as well versed in fire-setting skills as they were in earlier years, thus compounding this feeling of disempowerment.
- The fact that veld is burnable from April onwards, and that the lightning season usually only begins in late spring, sets the scene for the dominance of transmigrant fires. Transmigrants presumably burn fires for reasons of warmth and security, and not for the same reasons as resident tribal communities – the result is that fires are not necessarily set for reasons of their ecological effect. Also, although widespread through the Park, they tend to an extent to occur more often on certain routes.

This proposal argues that these objections are indeed valid, and that sufficient time has elapsed to draw such conclusions based on experience. It is true that the arguments are most relevant in wetter years and cycles, but similar conditions will occur again.

The key question that thus arises is how the intentions of the 1993 modification (giving lightning fires the best possible chance to fulfil their natural role) can be achieved in some more practical way.

Towards an Integrated Fire Management System – the approach to modification

The presence of all our South African fire advisors in Skukuza in July 2001 was leveraged to take recent ranger suggestions and existing policy intentions into account. These proposals were developed in a process of further consultation with rangers and senior management staff. The purpose of this submission is to give

lightning fire the best chance it can be given under practical circumstances (i.e. given the above problems), to play out its natural role. The rationale of the integrated system proposed is to "co-manage" the fire system together with (the reality of) transmigrants in the early season, in such a way that the following goals are reached:

- Transmigrant fires are limited in type and extent, by putting in patch burns to break up the fuel bed and by pre-empting them.
- The total amount burnt by 30th September is in most years less than (or at least roughly the same as) would have been burnt by transmigrants alone, given the runaway nature of many of their fires if no pre-empting or breaking up of the fuel bed were possible.
- The mosaic created by spring is such that massive lightning (or transmigrant) fires are less likely, even though many intermediate-sized fires totalling a large area may still be possible. Lightning will obviously vary over different years in effect.

All fires will thus generally be point ignitions, obviating what transpired to probably be one of the bigger disadvantages of the system employed in Kruger prior to 1992 viz. perimeter burns. No patch burns set by staff are allowed after a certain cut-off point (depending on the year e.g. in a wet spring, the end of September) thus leaving only lightning to "compete" with transmigrants on a safer mosaic at a time when lightning "has a chance."

Because of the special requirements of concessions, special variants of this policy are presented for use in these areas. Considering the spirit behind establishment of wilderness areas, all pristine wilderness areas (PWA's) are given less contrived human manipulation.

How will this take place? – Integrating the best of each system

Although it is recommended below that the LASHFIRE trial be shelved, the long thought processes which went into refining the two alternative systems (patch mosaic and range condition) for this trial, and the difficult experiences we had in the park as a whole with the intended lightning-driven system, have placed us in the following position: we recommend an integrated system which has a fair chance in most years of achieving the goals stated in the section above. It is believed that the hybrid elements making up the Integrated Fire Management System take the best out of each system and unify them in a practical way, meeting our 1997-biodiversity goals. Apart from differences of opinion concerning small modifications, our team of advisers and fire-knowledgeable staff could not, after several iterations stretching over months, come up with any alternative system that could compete with the one this proposal. We will probably thus need to now learn from implementation and from experience of the consequences, before we can again move on to an improved plane of thinking in fire management philosophy.

The system can be summarised as follows:

The Park is divided into at least 12 large fire management units or LFMU's (usually consisting of the area covered by a section ranger and by the assistant ranger under his guidance, see Map 1, attached here as MAP1.DOC) though differing edaphic templates in some of these may lead the section ranger to subdivide the

area into two e.g. in the south-west of the Park, a sweet- and a sourveld district. Regarding the six functioning concession areas, each of these will constitute a totally independent small fire management unit (SMFU). It is thus anticipated that there will not be more than about 20 FMU's in all, comparable to the 24 in the previous fire management systems. All FMU's, large or small, will function as a unit with regard to the criteria and actions listed in the operational plan below. Although pristine wilderness areas have different operating rules to the other parts of LFMU's, the LFMU is considered the unit[4].

At the beginning of each season, the veld condition assessments will provide the baseline for estimating the percentage of surface area to be burnt in each by the end of the season, though rangers (especially if assisted by experienced regional rangers) are allowed to modify the targets slightly according to their judgement of other influential factors e.g. possible poor representivity of VCA sites, expectation of a drier season ahead etc. Provision of a month-by-month step function helps translate the annual target into a monthly cumulative target to aim at as the season develops. (These two targets are two of the most important "interactive" fire TPCs specified in the KNP adaptive management system, and are delegated here to ranger level for implementation, monitoring and decision-making; all other fire TPCs will be centrally checked in Skukuza at the end of each fire season and feedback given per district).

Outside of concession areas

Patch fires will then be put in to account for half of each monthly target, normally leaving the other half **for transmigrants to burn, a reality**. The Ranger decides when to combat transmigrant or other accidental fires of human origin, using certain guidelines, with the targets as limits. If a ranger is then "ahead" or "behind" target by the end of any month, s/he can adjust the patch burn amount accordingly the next month and in this way align with the overall target. By a certain cut-off point (probably end of July in a very dry year and end of Sept in a very wet spring) the ranger will cease putting in patch fires, and literally leave the lightning fires (now likely as the lightning season arrives) to "compete" with the rest of the season's refugee fires, both of which will now often be limited in potential spread by the mosaic formed till then, a pattern on which the ranger at least had some influence. Till the cut-off point, all the elements follow **the patch mosaic methodology**, except that **lightning fires**, if any of these occur so early in the year, are allowed to burn further than the limit, at most as far as the "lid-on-fire". The following modification is regarded as an essential contrast: that the quality filter (consisting of a lower biomass limit and an upper Increaser II grass species compositional limit) as per the **range condition philosophy**, be strictly applied in certain areas, this system to then be compared with random burning (without a quality filter) in other areas. The reason for this contrast is, on the one hand, to spread our risks, and to learn by non-radical experimentation, on the

[4] Thus, overall annual and monthly targets are calculated over the whole LFMU, with an expectation that rangers will in practice burn to roughly the same targets both inside and outside PWA's. It is therefore not expected that they will inadvertently manipulate the system to burn far more inside or outside of these firebreak-encircled PWA's. Only in particular years and under exceptional spatial patterns will conditions arise which could lead to far different burning patterns inside and outside PWA's, and even these conditions tend to mean that more burning is then "needed" on the one side. The proposed year of inception of this system (2002) is unusual in that conditions are good for burning using range condition criteria virtually everywhere, implying no difference in approach for 2002 inside and outside PWA's.

other. The guarantee we have against "things going wrong" is the TPC suite, which, if consistently exceeded, will lead to a change in system. It is recommended for practicality that the areas where the filter is applied should be the non-wilderness areas in each fire management district. Said conversely, in Pristine Wildernesses (PWA's), quasi- random mosaics are put in without any quality filters – if it ignites, that area chosen for an ignition is burnt, irrespective of biomass or composition of the veld[5]. The point has been made that it is unlikely that the current VCA sites will provide adequate coverage to pick up such differences between consequences in wilderness vs. non-wilderness areas. The following is thus proposed: that, in the forthcoming review of the KNP monitoring system, simplification be sought for the VCA system, perhaps along the lines that a restricted (critical) set of readings be taken but at more sample points, thus giving better geographical representivity for these few crucial measurements. This restricted set must however enable the ranger to take all the immediate decisions they need to operate this system. In addition, it is suggested that a wider set of detailed readings then be taken by research staff or contracted collaborators, specifically in limited identified areas most amenable to yielding the particular answers being sought. For example, in the comparison of quality filter vs random burning, the choice of such areas for detailed measurements might be those in which illegal transmigrant fires occurred least (the quality filter thus working best).

Variation of the system as recommended for use in Concession Areas

Ideally, concession area fire policy should be seen merely as a variation of the above system (described below), though the fear of one fire changing the whole concession into a "black area almost without animals to view for several months" remains a major concern. Apart from the onset year[6] it is recommended that SANParks staff, who are contractually responsible for ecosystem fire management in all **concession areas**, exercise their discretion using the following guidelines and treating each concession's situation as a separate case treated on its merits each year:

In years and under situations where patch mosaics are seen not to be too risky, they should be implemented with the following variations:

- Ensuring that sufficient early-season patch burns are definitely set in the concession area, to reduce risks while it is still very safe to do so.
- Setting patch fires in such a way and under such conditions as to generally allow easy suppression at pre-chosen tracks, if they burn that far.
- Continuation of setting of patch fires after September as one component of the ignition sources, so that variation in greenness of patches is still promoted thereafter, and so that the risks of the aftermath of a large fire disrupting the experience of their guests on these relatively small areas, is minimised

[5] An alternative suggestion, currently not favoured, was that every second fire management unit *as a whole* should use the quality filter (even if it contains large wildernesses), thus implementing the contrast at a coarser scale. A third suggestion is the establishment of a LASHFIRE type experimental management area, regarded as the least feasible, as this then becomes seen as a research and not an operational area.

[6] At the time of this proposal being submitted and till late in 2002, only two concessions will have started tourist operations. The remaining areas have little or no internal firebreak/track structure as yet. Tall grass after the heavy rains in late 2001 is considered a fire risk for building; burning these areas would be an ad- vantage for track placement. It is therefore proposed that the non-operational concessions be burnt in 2002.

- Application of range condition (quality filter) prerequisites for burns as far as is possible, in view of the relatively intensive management in these areas. However, if conditions do not allow rangers to get anywhere near the target (because there is too little area to burn which meets the quality filter) and if there is still significant fire risk, burning should continue elsewhere to reach targets. Although the latter makes for safety, it is logical that it might promote degradation, and such areas should thus be carefully monitored. Although TPC's form a general safety net, these areas will require extra scrutiny, given the potential "vicious circle" that may arise if rangers are always burning for safety only, and degraded yet burnable veld is resulting.
- Any lightning fires should form part of the contribution to the targets, but should not be allowed to burn beyond the target, as allowed elsewhere. In fact, if the lightning fire is seen as too risky (e.g. due to weather conditions) and can be extinguished, this should be done as part of the more cautious approach in the concessions.

Under other circumstances, when patch fires represent too great a risk in the view of the ranger, the following "block-patch procedure" can be adopted:

- Identification and usage of small "burn-blocks" created by roads, tracks, rivers or adequate drainage features. Track development in most concessions should make this readily possible by 2003. (If no or hardly any such features exist, there seems little option but to revert to patch burning, even at the higher risk)
- Burning selected ones of these under safe conditions using **perimeter fires**, in such a way that the burnt blocks form a seasonal mosaic approximately meeting the targets set for the concession (SFMU) – these will be the same targets as would have been used for a patch mosaic system, a system which follows all the above (safer concession variation) specifications. All that will differ is that the ranger will have decided that patch fires are too risky in that particular year or place. Rangers should strive not to use this perimeter option too often, as the whole foundation of the 1992 decisions was to move away from perimeter fires (particularly in small areas such as these) even though occasional perimeter fires are not expected to result in the suspected deleterious landscape patterns. As long as the blocks are safely "ring-burnt" it is not necessary to burn the centres if the fire dies before then. If targets are not being met that month or later, the centre can be ignited if this seems the best option to reach targets.

These interventions are seen as a necessary compromise, given the valid concerns of concessionaires. This also provides one form of field experiment (albeit at a reduced scale than elsewhere in the Park) to compare with the late season lightning-dominated and late season transmigrant-dominated systems expected in different localities (see Quo Vadis LASHFIRE? below)

The Operational Rules of the Integrated Fire Management System

This is a two-page document to be inserted here. For field use it is printed back-to-back and laminated. Attached here as Field Guidelines.doc.

Back-burns

During the planning of this proposal, the issue of back-burns was repeatedly raised. It has become clear from experience here and elsewhere, that injudicious

placement of back-burns is responsible for many large fires. Although put in good faith because of an overriding desire to do "something to help", these back-burns often result in far larger fires than if they were not put in at all. This illustrates the following non-linear sequence:

- If conditions enhancing fire spread are unfavourable, back-burns are often unnecessary, but if put in, will probably not result in very serious consequences unless weather conditions change. Under the right conditions, they may improve chances of stopping the fire, if this extra certainty was really needed. It needs to be remembered that the risk of weather change is what can turn an (often) unnecessary back-burn under these conditions into an undesirable cause of extra danger.
- If conditions promoting fire spread are intermediate, back-burns, which are correctly put in at, *the right time* (not too soon after point-fires, else point-fire setting is useless; and not too late, when they will no longer stop the fire) will stop a fire, helping rangers to stay within target. Under this policy, these conditions should be commoner than conditions favouring rapid spread, since rangers choose the circumstances for prescribed burns.
- If conditions for fire-spread are favourable, back-burns are often counterproductive, as these fires tend to jump firebreaks and roads. Setting back-burns several firebreaks further back, under these adverse conditions, increases the chance that a very large area burns and the new fire jumps, with multiple extra heads and fronts to control. If they are not put in, and conditions change, the fire may die down and can be put out more easily, often having burnt a far smaller overall area. On the other hand, the right back-burn, if really needed, *may* on important occasions save the day. Thus great care is needed putting in back-burns, discretion sometimes being the better part of valour. Back-burns are always safer put in at night, if it is at all feasible to wait. If the decision is to not put in back-burns, that time can be used to further secure infrastructure or human safety. Seniors and the public at large should be aware of the difficulty rangers face making these decisions.

Quo vadis LASHFIRE?

The LASHFIRE trial in its original form now seems largely unnecessary, given the merging of techniques achieved by this system, and the low relevance of each pure system as an independent entity. Although we agree that running the pure systems would generate useful knowledge, we suggest the logistics and costs will be excessive given the expected outputs. We therefore propose that LASHFIRE be shelved, but point out that the preparatory exercised till now was probably the only way we would have put together the concepts behind this Integrated Fire System. However, we insist that we keep alive the spirit of LASHFIRE's aims – which we learn as much as practically possible by management.

How will we learn-as-we-manage, with the new system?

We suggest the most important questions we can answer within the normal operational framework of the currently proposed system, over the next decade or

two (some experts believe we may need even longer), each a key cutting-edge question in practical savanna fire management, are the following:

- Are fire and biodiversity patterns different between the concession areas (where staff-selected patch or block-patch burning will dominate, though lightning and certain transmigrant fires will be allowed) and the rest of the park? Unsatisfactory systems as judged by TPC's being consistently exceeded, will be modified. It must be remembered that there exists an inherent scale problem in this comparison (concession areas are typically around a quarter the size of the other management units). It is also thus likely in practice that many more small fires per unit area will be able to be put in there. It is nevertheless a worthwhile opportunity for comparison.

- Are fire and biodiversity patterns different between late-season lightning-dominated and late-season transmigrant-dominated fire systems (we can predict with some certainty where some of these are likely to be)? Localities representing these systems will be finally chosen for biodiversity analysis according to the unfolding history of dominant fire source. Again, Park TPC's will act as the "referee's rules", and modification considered once either system is found wanting.

- Do fire and biodiversity patterns differ if range condition criteria (biomass and veld condition) are included or excluded from the protocol? This question pits the well-researched veld condition criteria known to produce the most productive and species-rich veld, against a belief system which states that all burnable areas should burn (preferably at random locations). The latter paradigm suggest that large conservation areas need, in addition to "prime" veld, a percentage of "degraded" and a some "moribund" rangeland, important for different organisms. It is suggested that this important question can be satisfactorily answered for our scale of management by including the range criteria in certain management units, and excluding them in others, till biodiversity TPC's are exceeded.

Achieving each of the above may require, as stated earlier, wider spatial coverage of ranger sampling – something which would also improve the immediately "field-usable" part of the monitoring results – but this would have to come at the cost of an important compromise viz. rangers collecting only a few crucial items per sampling site. If this is considered when the monitoring programme is reviewed later this year, the obvious action needed to complement it is more remote-sensing (esp satellite image) analysis and more detailed groundwork by scientific teams in carefully chosen localities. The latter will bring back some of the detail planned for monitoring LASHFIRE, in the same spirit.

Finally, this report does not recommend, but wishes to nevertheless discuss the following:

- A contentious final question is: what fire and biodiversity patterns develop in a overwhelmingly lightning-dominated system? This question is regarded by some as no longer relevant, given a belief that anthropogenic fire has played a predominant role in shaping African Savannas for a million years; and that transmigrant fires can anyway not be controlled - and so will always pre-empt whatever pattern lightning will have produced on its own. Although there may yet be sense in setting up a large lightning-only block (with good fire security

round the edge, few transmigrants and high ignition rates) to clarify this perplexing question, our recommendation is again that the logistics and costs are excessive given the likelihood of even achieving lightning domination. Reasons why it may yet be worthwhile are (1) that it could act as a benchmark for simulated systems, and (2) it may indeed e.g. with the advent of transfrontier parks, be possible to control transmigrance rates. If deemed worthwhile to attempt this, feasibility will surely remain a key consideration, given the Park's poor track record to keep systems lightning-fire dominated. Because of its still restricted area, appropriate modelling will have to be used to generate rules to augment the number of fires in such a block according to how many lightning fires are calculated to have come in from outside if there had been no boundary.

Technology Transfer

The proposed system, although integrated and thus complex, can be distilled down to a few core principles, as expressed in the summary. Even the more detailed operation rules can be summarised on two pages (as per attachment). Rangers will thus need to appreciate these basic underpinning themes, and carry out the operational rules as specified. This will mean an initial round of training in the principles, and in fire-setting. André Potgieter who has a lifetime of fire experience, is still in contractual employ of the KNP for this season, and is training up a fire technician and an understudy for this person. This team will visit all rangers, probably in business unit groupings, in the next two months, and carry out this training. They will be available thereafter for advice, guidance, and for the centralised (later) part of the data analysis.

Certified training in fire safety and fire-fighting, as required by legislation in the emergent local Fire Protection Association which KNP will be assisting in founding, is essential and urgent, and will most likely require special financial arrangements which should receive immediate attention in KNP. It is important to arrange certified training in fire-*setting* in a way at least involving our own expertise i.e. which supports the principles in this document, and not only in small-scale farm block-burning.

Conclusions and The Way Forward

Thus, in the light of what we have learnt to date, we believe the above recommendations to be the most practical way of achieving our 1997-biodiversity goals, since:

- The lightning component, as far as it is possible to promote this in a practical way, will fulfil the original intentions of a varied "natural" fire regime (Braack, 1997)
- The patch mosaic component driven by us will fulfil the heterogeneity aims targeted by that system (Brockett, 2000)
- The quality filter introduced over large areas (in terms of range condition) will provide a certain safeguard against possible adverse ecological developments as a result of fire, in the areas it is applied. In all areas, changes will be monitored.

Furthermore, the system will

- Reduce fire security risks to some (in many years a considerable) extent, because of break-up of the fuel-bed. To strengthen this (but only within reason) we also recommend re-examining the network of firebreaks with a view to re-opening certain key firebreaks for extra security.
- With the special arrangements for concession areas, promote the particular interests of concessionaires, insofar as this is possible in a national park setting.

It is important to realise that fire in extensive natural settings is so varied under different circumstances, and these specifications sufficiently flexible, as to give rangers considerable freedom of judgement in implementing the intended achievement of KNP goals. Indeed, a more rigid programme is likely not to succeed in achieving biodiversity aims. Therefore, understanding the background and intention is crucial for rangers, and rangers should not be reprimanded for consequences which may arise founded on good or even reasonable judgement on their part, in the rare events when unexpected changes of, for instance, weather conditions, lead to large fires. This is inevitable at times in extensive systems, and is likely to continue to arise even more frequently if this proposal is not adopted, and the KNP continues to allow illegal transmigrant burns, set indiscriminately under any weather conditions and at any (for us convenient or inconvenient time) to predominate.

References

BIGGS, H.C. AND A.L.F. POTGIETER 1999. Overview of the fire management policy of the Kruger National Park. Koedoe 42(1):101-110

BOND, W.J. 1997. Fire. Pp. 421-446. *In:* COWLING, R.M., D.M. RICHARSON & S.M. PIERCE (eds.). *Vegetation of Southern Africa*. Cambridge: Cambridge University Press.

BRAACK, L.E.O. 1997. A Revision of parts of the Management Plan for the Kruger National Park. Volume VIII: Policy proposals regarding issues relating to Biodiversity Maintenance, Maintenance of Wilderness Qualities, and Provision of Human Benefits. South African National Parks, Skukuza. Available at http://www.sanparks.org. (Scientific Services, Management Plan)

BRADSTOCK, R.A., M. BEDWARD, B.J. KENNY & J.SCOTT, 1998. Spatially-explicit simulation of the effect of prescribed burning on fire regimes and plant extinctions typical of south-eastern Australia. Biological Conservation 86: 83-95.

BROCKETT, B.H., H.C. BIGGS & B.W. VAN WILGEN 2001. A patch-mosaic burning system for conservation areas in southern African savannas. *International Journal of Wildland Fire* 10, 169-183.

BRYNARD, A.M. 1972. Controlled Burning in the Kruger National Park – History and Development of a Veld Burning Policy. Pp 219-231. *In:* Proceedings Annual Tall Timbers Fire Ecology Conference, Tallahassee, Florida, Number 11: Fire in Africa. April 22-23, 1971. Published by: Tall Timbers Research Station, Tallahassee, Florida.

JOUBERT, S.C.J. 1986. Masterplan for the management of the Kruger National Park. Vol VI. Unpublished memorandum, National Parks Board, Skukuza.

KILGORE, B.M. 1994. The role of fire in Wilderness: A state-of-knowledge review. Wilderness Management Course RR452/DCE 174. Colorado State University.

PARR, C.L. & B.H. BROCKETT. 1999. Patch-mosaic burning: a new paradigm for savanna fire management in protected areas? Koedoe 42: 117-130.

PEEL, M.J.S, H.C. BIGGS AND P.J.K. ZACHARIAS. 1998. The evolving use of stocking rate indices currently based on animal number and type in semi-arid heterogeneous landscapes and complex land-use systems. African Journal of Range and Forage Science 15 (3): 117-127.

TROLLOPE, W.S.W. 1994. Fire regime of the Kruger National Park for the period 1980-1992. Koedoe, 36(2): 45-52.

TROLLOPE, W.S.W., H. C. BIGGS, A.L.F. POTGIETER & N ZAMBATIS 1996. A structured vs a wilderness approach to burning in the Kruger National Park in South Africa. Proceedings of the Vth International Rangeland Congress 1995, Salt Lake City, Utah. 1:574-575.

TROLLOPE, W.S.W., A.L.F. POTGIETER, H.C. BIGGS & L.A. TROLLOPE. 1998. Report on the Experimental Burning Plots (EBP) trial in the major vegetation types of the Kruger National Park. Scientific Services, South African National Parks, Skukuza. Unpublished report.

VAN WILGEN, B.W., H.C. BIGGS & A.L.F. POTGEITER. 1998. Fire management and research in the Kruger National Park, with suggestions on the detection of thresholds of potential concern. *Koedoe* 41: 69-87.

VAN WILGEN, B.W., H.C. BIGGS, S. O'REGAN AND MARE, N. 2000. A Fire History of savanna ecosystems in the Kruger National Park, South Africa, between 1941 and 1996. South African Journal of Science. South African Journal of science 96, 167-178.

WALKER, B.H. 1987. *Determinants of Tropical Savannas*. Oxford: IRL Press.

WIENS, J.A. 1997. The emerging role of patchiness in Conservation Biology. Pp. 93-107. *In:* PICKETT, S.T.A., R.O. OSTFELD, M. SHACHAK & G.E. LIKENS (eds.). *The Ecological Basis of Conservation*. London: Chapman and Hall.

APPENDICES

Appendix 1: DRAFT: Compatibility between the Fire Ecosystem Management and the Fire Security Policies

Compilers: Biggs and Jordaan/Nobela

Background

The Fire Ecosystem Management Policy is aimed at managing fires in the ecosystems of the Kruger National Park in such a way as to maintain the natural (or at least quasi-natural) state of these systems in a sustainable way. Establishing such a policy obviously requires taking the overall system view, and as tragic as occasional deaths of individual animals or groups of animals are in fires, these will have always taken place to some extent in such systems. Indeed, complete elimination of such risk will no doubt imply extreme actions, which even if feasible, will imply that ecosystem aims cannot be met. The result is that managers have to "accept" a certain amount of apparently unnecessary "damage" as part of a wider tolerance of the natural role of fire. The level of "damage" to animals and plants in any event falls within the overall schema of the Fire Ecosystem Management Policy. Consequently, these trade-offs fall entirely within the ecosystem management objectives of the KNP, and indeed, need to be guided by higher-level objectives as stated in the *ecosystems and biodiversity parts* of the management plan.

There exist, however, higher-level trade-offs about overall fire management in the objectives hierarchy, namely, between:

- Ecosystem/biodiversity management, as enumerated above
- Human benefits, namely safety in terms of human and infrastructural risk. Minimising this risk is part of the Fire Security Policy
- Wilderness philosophy, which stresses "naturalness" in a puristic form, and hence has lobbied for removal of as many firebreaks as possible, to produce unimpacted areas of the greatest possible size

The setting of the three-way trade-offs between these sometimes opposing forces is not simple, yet common-sense should prevail, as guided by the following principles:

- It is recommended that infrastructural safety from fire, of all approved structures, *especially all inhabited buildings or encampments*, take precedence over wilderness and ecosystem/biodiversity considerations. Low-value structures or structures which cannot cost-effectively be protected against fire, may be exceptions, in that higher levels of fire risk be tolerated. It is assumed that the measures needed to protect this infrastructure (and human lives there) *do not constitute unacceptable environmental practices* (e.g. use of unacceptable herbicides) and are not carried out on a scale that significantly jeopardises ecosystem/biodiversity management. If there is doubt about any of these consequences, integrated environmental management criteria will need to be used to set the trade-off levels.
- The Ecosystem Fire Management Policy should achieve its own aims but as far as possible in such a way as to minimise risks to human life and infrastructure. Fortuitously, the currently proposed amendment to this policy, resting on patch mosaic principles, will tend to break up fuel-beds progressively through the dry

season, hence minimising the chances of very large uncontrollable fires which again pose a human and infrastructural risk. There is thus little scope for conflict here.

- Wilderness considerations may be more difficult to trade-off, as indeed, we appear to be considering re-instating some previously closed (so-called "rehabilitating") firebreaks because of the need for some extra safety lines to fall back on in the case of large fires under difficult conditions. This intention has resulted from experience following the closure of these firebreaks. Firebreaks sometimes double as patrol roads, and the indicated necessity for these is presumably justified under the "how" of biodiversity management. All in all, it is suggested that wilderness, patrol management and fire policy representatives come up with an optimal firebreak system, which presumably will never satisfy all requirements. The philosophical guidance for the level of these trade-offs should come from stated park objectives, interpreted in the light of experience. It seems to make sense that safety of humans in camps, and critical infrastructure, be given as high a level of priority as is reasonable, and that practical considerations of patrolling be given some but not complete consideration, when being weighed up against the desirability of re-instating large tracts of firebreak-free (and hence burnable) wilderness.

Appendix 2: Draft Table of Contents for Fire Security Policy: February 2002

1. Link with the ecological management system (H Biggs & W Jordaan)
2. Protection of infrastructure (M Coetzee & S Schoeman)
3. Fire fighting equipment (M Coetzee)
4. Fire fighting capacity (P Nobela & M Coetzee)
5. Preparation of firebreaks (P Nobela & S Schoeman)
6. Training (P Nobela & M Coetzee & W Jordaan)
7. Protective clothing (P Nobela & M Coetzee & P Melamu)
8. Emergency procedure (P Nobela & M Coetzee)
9. Establishment of a Fire Protection Association (P Nobela & M Coetzee)