Overview of the fire management policy of the Kruger National Park

H. C. BIGGS and A.L.F. POTGIETER

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New developments in fire management policy in the Kruger National Park are sketched against the background of changing attitudes towards ecosystem management. The experimental burning plots established in the mid-1950s are discussed briefly, as is the almost forty-year era of rotational block-burning. The lightning-driven fire policy initiated in 1992 and currently aimed at by park management is discussed, with comments on its early performance. More recent revision of the management plan stressed maximisation of appropriate research benefits from the experimental burning plots, condoned the lightning approach for the present, but stressed the absolute necessity of the park not finding itself in the 1992 position again, where a major change in policy has to be made with no comparative evidence from other systems. To this end, a major landscape-scale fire management trial has been planned for implementation starting in April 2000. It is sheduled to run over a twenty-year period, and will be placed at four localities representing different major landscapes in the park. It will compare the effects of three different fire systems (lightning, patch mosaic, and range condition burning systems) on biodiversity elements crucial to the park's mission. The rationale for, layout of, and criteria for deciding on the outcome of the trial are discussed, as well as the trade-offs that were made to enable the trial to be of such a large scale and still fit into overall park planning. The impact of the trial on the park's monitoring programme is discussed.

Key words: fire, management, landscape-scale trial, policy, lightning, patch mosaic, range condition.

H. C. Biggs and A.L.F. Potgieter, Scientific Services, Kruger National Park, South African National Parks, Private Bag X402, Skukuza, 1350 Republic of South Africa.

Background and intention

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). 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.

Much thought and discussion, and several recent research publications, have focussed on various issues relating to fire pattern and management in or relevant to the Kruger National Park (KNP). A reasonably comprehensive listing of appropriate literature, almost exhaustive with regard to detailing work linked to the experimental burning plots referred to below, is contained in an unpublished report (Trollope *et al.* 1999). In this paper, we provide an overview of the history and thinking that has led to the current fire management policy. We build on earlier research, and on a recent paper that has, in addition to commenting on fire research, fleshed out the concept of thresholds of potential concern as applied to fire management in the KNP (Van Wilgen *et al.* 1998). We suggest that our paper be read in conjunction with this one. We also provide an overview of a proposed landscape-scale fire experiment currently being set up to test three major approaches to the management of fire regimes in four landscape types in the park. The way in which fire management, especially that of the proposed landscape-scale fire management blocks, is to be integrated with overall management in the KNP, is discussed.

History of fire management in the Kruger National Park

The early history was described by Brynard (1971), though a short summary with an update is in order 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 1900s till the mid-1950s, 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 discussed in the next section. 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 override 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) 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.

In 1992, the forces within park management supporting notions of wilderness ecosystem management, and to an extent those striving to promote landscape patchiness, were able to obtain an overwhelming majority decision to alter the nearly forty-year run of rotational burning to an intended system of lightning-induced fires. This was documented as a formal modification to the then current Management Plan (Joubert 1986). An important ancillary issue arising during those discussions was that point ignitions (as would happen with lightning) were deemed far more desirable than perimeter ignitions which had been employed till then for the rotational block burns. The decision to change to a lightning-driven policy was taken in the face of an available alternative range condition burning system which had been developed for the Kruger National Park in 1991 (Trollope *et al.* 1995). This alternative system is based on the condition of the grass sward as described by its botanical composition and the standing crop of grass that will result in the maximisation of the species diversity of perennial grasses in the herbaceous layer. This system was to resurface in the new management plan as the basis for one of the treatments for the landscape-scale fire trial designed in the late nineties.

The experimental burning plots (EBPs)

As stated above, recognition of the need to understand the effects of fire prompted the decision-makers in the 1950s to set out a replicated trial of twelve treatment combinations of frequency and season in seven-hectare plots, in each of the four major vegetation types in the KNP. Although faithfully carried out for a half-century, very little was done until recently to analyse data from the trial. However, a serious re-think about the relevance of the trial is leading to a spate of activity on these plots, in terms of the new biodiversity objectives of the KNP. The future of the trials beyond 2003 (when the present "wrap-up" phase co-ordinated by KNP will be over) is currently uncertain, although all opportunities will be given to interested parties to feed into the final decision and to help share responsibilities if continuation is deemed desirable. In spite of the fact that 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. The full history, scientific production and current view of the future of the trials is described in a detailed report by Trollope *et al.* (1999). Figure 1 shows the locations of these EBP plots as well as the proposed larger-scale fire experiment described later in this paper.

The lightning fire system currently in use and its early performance

As stated above, wilderness, and to an extent patch, considerations influenced decision-makers in 1992 to support the change to a proposed lightning fire regime. It was believed this would produce the correct "natural" mosaic required in a conservation area. There appeared to be an underlying belief that early man had contributed relatively little in the way of fire-based manipulation of the lowveld system, a belief that was strongly challenged by a minority.

Policy wording

The core policy wording of the current lightning fire system (Braack 1997) is as follows [with explanatory comments in square brackets]:

- that fire is an essential and positive agent contributing to biodiversity within the lowveld savanna;
- that as a long-term aim, lightning fires should be allowed to burn undisturbed and to their full extent [this implies lighting fires across roads if the road serves as an unnatural barrier to the spread of the fire]. However, in the short term and as an interim policy for the next five years to allow the system to recover from the perceived excessive burns arising from historic policies, only 50 % of any major fire management block will be allowed to burn due to any one particular lightning fire. A lightning fire moving into an adjoining major fire management block (there are 17 such blocks making up the

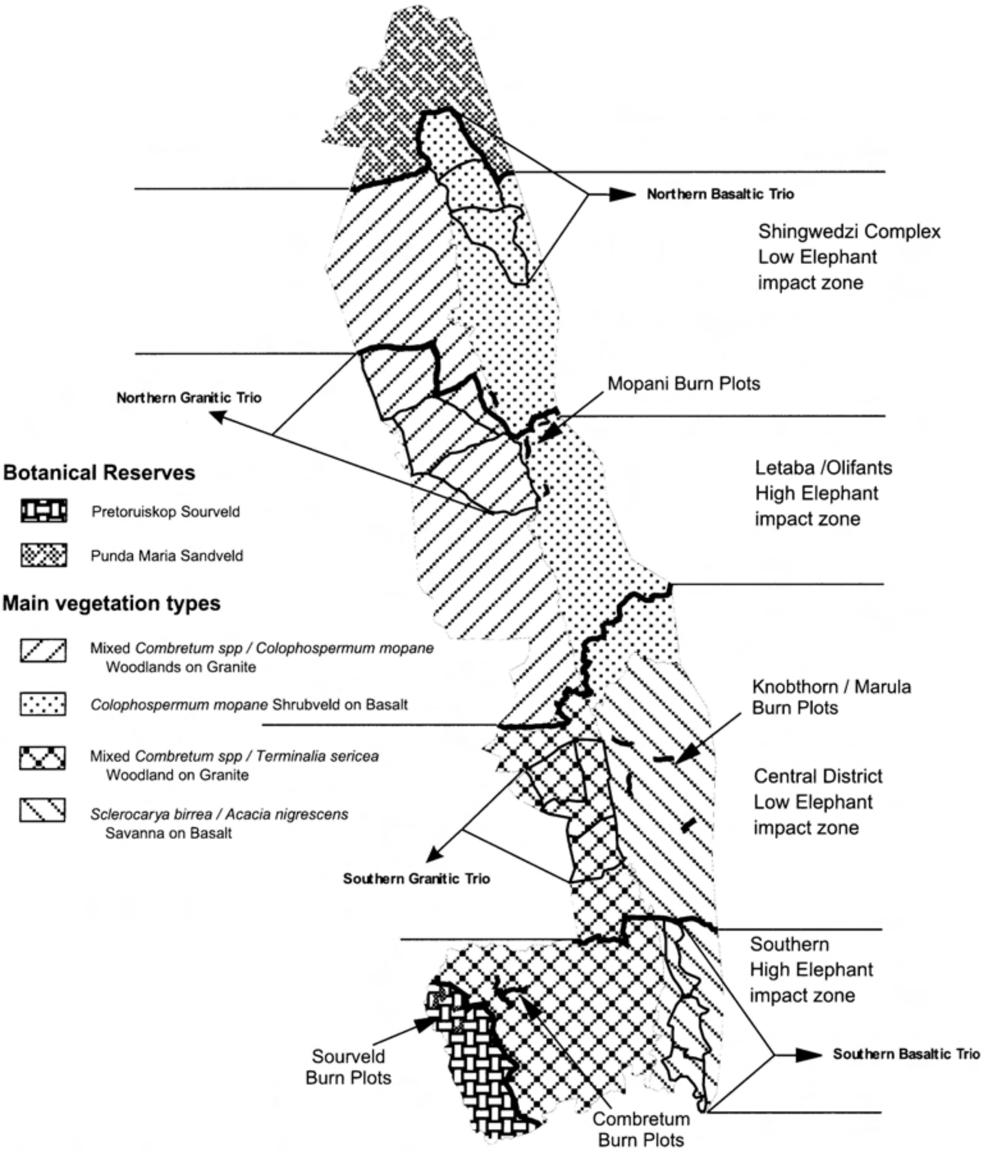

Fig. 1: The position of the LASHFIRE experimental trios and of the experimental burning plots (EBP's) in the Kruger National Park.

KNP) will also be allowed to burn up to 50 % of such block [This "lid-on-fire" clause, effectively modifying the "undisturbed and to their full extent" aim, was brought in after the large fires of 1996];

- human-ignited fires should be actively prevented or contained to the smallest possible area. The extent of human-ignited fires which will inevitably arise each year due to accidental causes or arson may be viewed as some kind of compensation for the fires which historic humans initiated in the area [see the "fire shortfall argument" under the heading "human influences historic and current" below];

- that different fire regimes should be implemented as large-scale experimental blocks so as to provide some means of comparison of the long-term effect of the proposed lightning fire policy applied in the remainder of the KNP.

Early performance

Eight years of this intended lightning fire regime have shown that, compared to a period of equivalent low rainfall in the mid-eighties, the area burnt per year had been more or less halved (Van Wilgen *et al.* in press), though the point is made that its performance during wet cycles is as yet unknown.

The revision of the KNP management plan (Braack 1997) had made provision for explicitly-stated "thresholds of potential concern" or TPCs defined as "those upper and lower levels along a continuum of change in a selected environmental indicator which, when reached, prompts an assessment of the causes which led to such an extent of change, and results in either (a) management action to moderate such causes, or (b) re-calibration of the threshold to a more realistic or meaningful level". The paper by Van Wilgen *et al.* 1997 developed this idea specifically for fire regime criteria. One of these criteria states that if a situation arises where more than half the area (in the original publication it was one-quarter of the area) burnt can be shown to be due to transmigrants or poachers, that this would constitute a TPC. This undesirable eventuality arose in both 1997 and 1998, and the TPC concerned is currently being reviewed in an attempt to calibrate just how frequently such an occurrence will be considered acceptable. If the level, after review, is not considered acceptable, this is likely to lead to management action, or eventually, a change in policy. The large fires which occurred in 1996 (Braack *unpubl. data*) when an isolated very wet year co-incided with favourable fire-weather and ignition, led to a management debate on whether lightning fires should be left to burn unimpeded and in fact helped along across all artificial barriers such as roads, even under these circumstances. Currently, a "lid-on-fire" argument (see policy wording above) applies.

Human influences historic and current

A contentious topic in fire management in conservation areas is the way in which anthropogenic fires should be treated. 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 research needs to be done to establish more exactly the effect of pre-industrial residents on the fire regime in the lowveld region. The "fire shortfall argument" states that a certain (currently seen as small) 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 transmigrants and to some extent to poachers) 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. It is nevertheless hoped that they in some way compensate for this, thus making good the "fire shortfall" if lightning is the only other source. In any event, in 1997 and 1998, this allowable limit was exceeded by far (see "early performance" above) and the criterion used to determine acceptability is being reconsidered.

The attitude towards fire in the revised management plan

The change to a lightning-driven fire policy in 1992 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:

- that whatever studies could be undertaken on the 45-year-old experimental burning plots to feed into of the new research and management objectives, should be encouraged;
- 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 key recommendation was acted on by Park Management and resulted in the far-reaching planning discussed in the rest of this paper;
- 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 landscape mosaics.

The landscape scale management trial ("LASHFIRE")

The acronym LASHFIRE stands for Large-Scale Herbivory-Fire Interaction Research Experiment, an initiative which is described below.

After several fire workshops flowing out of the revised management plan initiatives described above, the only two practical alternative treatments (to the "default" lightning fire policy, which itself would be subjected to detailed measurements in the same experiment) turned out to be:

- *The Patch Mosaic System*. This system had developed partly as a result of emulating early man's fire management patterns and partly because it seemed a promising way of achieving the landscape heterogeneity which has become such an important issue in ecology recently. Working examples of the system had been developed particularly in Australia, but also for the last 10 years at some localities in South Africa (e.g., the Pilanesberg). A description of the system is contained in Brockett *et al*. (in press), in which all technical underpinnings are presented, as is pattern-based evidence of increased heterogeneity in the Pilanesberg. Because of the novelty of this system, and because it seems, at least to persons previously unacquainted with it, practically infeasible, philosophically curious, and generally unsubtantiated, persons with knowledge and experience of the system have been requested to further address these issues in a paper in the next issue of this journal.

The Range Condition Burning System. This system was developed by and is adequately described in Trollope *et al.* (1995) where it is referred to as a structured decision support approach. In Van Wilgen *et al.* (1997) the system is referred to as one utilising ecological criteria assessment. It follows a series of well-defined rules in a practical decision-support system. The proposed system initially targeted relatively fixed endpoints in vegetation state (such as decreaser-dominated swards over large areas, specified at the time by managers as desirable) from a burning system evoked by the rules based on assessments of range composition and quantity. Recent adaptation to the new biodiversity principles in the KNP has led to a proposal to effect the same general outcome but targeting a wider continuum of desired states and utilising point ignitions if at all practically feasible. The range condition burning system is easily acceptable to managers, partly because it originally arises from a similar historical paradigm of ecosystem management to that in which they were trained, but also because there is considerable substantiation from field trials for the expected responses (Trollope *et al.* 1995).

Operational prescriptions for both these systems under KNP conditions are under preparation and will be written into a formal report this year in order to be ready for the onset of the LASHFIRE trial in April 2000.

Selection of sites and characteristics of the trial

After careful consideration, it was decided to introduce a landscape-scale trial of the three available fire systems. These systems would be implemented in four extensive areas of the park. The actual localities of these four large trios (a trio is a group of three blocks, each representing one of the three treatments: lightning, range condition and patch mosaic), which vary in size but have an average area of 75 000 ha, are shown in Figure 1. This map also shows that the decision to place these trios was based on the four main vegetation types in the park, at least those types outside the two botanical reserves. Further, while it was not possible to replicate the trial, it was decided to place two of the trios in high elephant impact zones and two in low elephant impact zones (Braack 1997). Furthermore, the ROZ (recreational opportunities zonation) specified in Braack (1997) was used to, as far as possible, avoid pristine wilderness areas during selection. In one case, the lightning block is in a pristine wilderness area, which is clearly the most acceptable of the three treatments for this ROZ classification. Allocation of blocks to treatments was thus not done randomly, because of considerations of this type. The existing northern plains multidisciplinary study site (Funston 1997) acted as one of the anchoring concepts of this design. Intentional placement of a trio over this study site constrained the placement of the rest of the sites, and the "mirror-image layout" to that in Fig. 1 (which would, incidentally, have avoided the disadvantage of the narrow basaltic strip in the current south-east trio) was thus precluded. Also, the placement of the patch mosaic and the range condition treatments in that part of the northern plains where the rare antelope populations still exist, is believed to be more likely to benefit these species than the unpredictable lightning policy.

For reasons of the large scale and other considerations, therefore, there is explicit recognition of the limitations of this design, the trios each being considered as separate unreplicated management experiments. Any comparison between trios will need to be done in a loose gradient analysis sense rather than a strict statistical one. These concessions were seen as necessary trade-offs in order to make it possible to experiment at the landscape scale at all. Also, there was acceptance of the fact that the experiments would be adaptively managed with concomitant documentation i.e. it is possible that as new experience is gained, that the treatments be modified. This is in sharp contrast to the rigorous EBPs (see above). Finally, each treatment block in a trio would be large enough to represent a field ranger section realistically. In this way the management experiment, on which operation cost and feasibility data would also be gathered, could act as a technology transfer site. In the event of one of the treatments being chosen as that treatment to be used in the park as a whole, this would then be readily achievable.

Because the four patch mosaic and range condition treatment blocks, when totalled, each constitute around 5 % of the area of the park, there is 90 % of the park outside of this area. This 90 % employs the standard current management practice of a lightning fire policy. A principle decision was taken to allocate four comparable blocks under lightning treatment, and adjacent to the patch mosaic / range condition "duos", to thus make the trios described above, which together constitute 15 % of the park's surface area. The lightning treatment blocks formed in this way would then be allocated the same (increased) density of sampling sites as the two other treatments, and more than the general landscape in the remaining 85 % of the park outside the LASHFIRE experiment. Although expensive to place the higher intensity monitoring in the third (lightning) block, this was seen as preferable to making comparisons between the candidate alternative treatments in 25000 ha blocks and the lightning treatments in a vegetation zone about ten times the size. Apart from the higher intensity of sampling sites and attempted comparability/contiguity with the "duos", there is no other intended difference between the lightning treatment blocks and the other 85 % of the park under the lightning fire regime.

It is important to note that the three treatment blocks in each trio were checked using geographical information systems techniques for comparability in terms of several criteria (usually over a 10 year period): mean annual rainfall and its coefficient of variation, biomass of herbaceous vegetation, percentage decreaser grass species, mean fire return period (over 50 years), occurrence of lightning-induced burns, occurrence of transmigrant-induced burns, and distance-to-water classing. Because the trios are being seen as separate experiments, no attempt was made to "balance" the values of these criteria between trios – we only examined whether they were similar between blocks within each trio. In most cases the matching was found to be adequate, except for distance-to-water classing, which was seriously skewed between blocks in two of the trios. In order to correct this, and so make roughly the same percentage of each block in a trio the same distance from permanent water, certain waterholes in or near the blocks will be closed before the onset of the experiment in April 2000.

Deciding on the outcome of LASHFIRE

At the outset, thresholds of potential concern (TPCs) for fire characteristics and patterns (Van Wilgen *et al.* 1998) have been agreed upon as an ecological basis for judging the performance of these three systems. Any treatment which consistently produces results outside of the acceptable "window" will be rejected as not meeting KNP objectives – following the normal process for TPC handling in the organisation - and discontinued. If either two or all three of the treatments fall within acceptable windows, the treatment of choice will be selected on grounds of cost-effectiveness, monitoring of which will also be undertaken for each of the treatments. In the long run, the best alternative/s will act as the basis for implementation throughout the park.

The LASHFIRE sites as foci of monitoring and experimentation

An interesting consequence of the LASHFIRE planning was that the largest concentration of planned monitoring initiatives in the park (including more detailed aerial census initiatives) have now tended to cluster on these areas. Although not universally relevant in the monitoring programme (documentation of which is scheduled to be released as Volume IX, a follow-up of the Braack (1997) series referenced here), the most common brief in any of the specified themes is to ensure that biologically meaningful differences, if these develop, will be detectable between high and low elephant impact areas, and between the three fire treatments. This has normally led the designers of these programs to use these sites to carry out their most intensive monitoring. This then has the additional effect of overlapping multidisciplinary effort, and is likely to enhance system understanding sooner at these trio localities.

Conclusion

Fire management in the KNP is entering an interesting experimental era, in which implementation of the intended lightning-driven fire system will continue, but now alongside a major management-orientated adaptive experiment testing the lightning system and two alternatives. The layout for this experiment has taken many other planning factors into account, such as the proposed high and low elephant impact areas, wilderness zonation and the northern plains study area. The result is that the new monitoring programme currently in the process of planning and implementation, makes heavy use of the four experimental areas (trios) described in the paper. Criteria to judge the performance of the three candidate systems have been decided on prior to the planned onset in April 2000. It is expected to take up to 20 years or longer before the outcome can be finally evaluated.

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