ELEPHANTS AND WOODLANDS IN NORTHERN BOTSWANA: HOW MANY ELEPHANTS SHOULD BE THERE?

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ELEPHANTS AND WOODLANDS

In some African reserves, elephant population densities are often a major factor in management policy concerned with conserving woodlands. The associated 'elephant problem' is a typical paradigm whereby an increase in elephant numbers is followed by a decline in woody vegetation due to over-browsing. This has been reported in several nature reserves in East and southern Africa (Barnes, 1983; Laws, Parker & Johnstone, 1975; van Wyk & Fairall, 1969). Much emphasis has been put on the role of elephants, probably because of the apparent destructive behaviour of these animals and conspicuous effects of elephant browsing on adult trees in woodland savanna habitats.

The decline in woody vegetation resulting from elephant impact could be attributed to biomass removal from living trees or the reduction of tree densities through tree mortality. However, in most semi-arid savannas, elephants are not the only agent that modifies woodlands. Other factors facilitating woodland loss include: prolonged periods of drought; intense browsing by large herbivore species other than elephants; and, a high frequency of fire. Yet, the dynamics of plant growth, rates of change in vegetation structure, and the magnitude of impacts of elephants and other factors on woody plant species, have not been assessed. As a result, the desired elephant density remains an arbitrary decision by local managers.

ELEPHANTS IN NORTHERN BOTSWANA

Northern Botswana is defined as an area of more than 80,000km^2 between l80 and 21^0 south and 21^0 and 26^0 east, but excluding the permanent swamps of the Okavango Delta. Rainfall ranges from 400mm in the south and 650mm in the north-east. Rains occur during the summer from November to April and mainly in scattered heavy storms. Temperatures vary between a monthly mean maximum of 34^{0}C (October) and a mean minimum of 6^0—7^{0}C (June) (Bhalotra, 1987). In this region, the resident elephant population is a prominent factor influencing vegetation structure because of its abundance and high recruitment potential (Calef, 1988; Melton, 1975). Northern Botswana woodlands carry between 65,000 and 94,000 elephants (DWNP, 1993). The elephant population is probably increasing, due to natural recruitment and to immigration from neighbouring countries (Calef, 1988; Melton, 1985). Moreover, the elephant population is likely to be compressed in response to habitat loss due to expanding human population and development. If elephant densities in northern Botswana continue to increase, then over-utilisation of woodland habitats are expected.

Major woodland types in northern Botswana include *Baikiaea plurijuga*, *Acacia erioloba*, *Burkea africana* and *Colophospermum mopane*, all of which have associated woody vegetation that also contributes to the diet of the elephants. Woody species that are relatively abundant and make a substantial contribution to the diet of elephants include *Baphia massaiensis*, *Combretum spp.*, *Bauhinia petersiana*, *Diplorynchus condylocarpon*, and *Terminalia sericea.* These species however, often appear as shrubs and do not dominate the cover abundance of tall tree stands. Elephant damage to woodland vegetation is widespread throughout the region. Occasional observations on woodland types along the Chobe and the Linyanti river fronts indicated severe damage to trees as a result of elephant activity (Child, 1968; Sommerlatte, 1976). The impact of fire on woodlands in northern Botswana is also apparent and there is some distinction between the effects of elephants and fire on different plant communities. Accordingly, woodland vegetation in the region can be viewed as a mosaic of three states containing: low elephant utilisation and high fire damage; high elephant impact and low fire damage; and, minor utilisation by elephants and/or minor fire damage (Ben-Shahar, 1993).

Elephants in northern Botswana tend to converge around water sources and reach high densities (7—

10 elephants/km^2), particularly towards the end of the dry season (Craig, 1990; Melton, 1985). The proximity of food sources to these localities is often detrimental to cover abundance of preferred species (Ben-Shahar, 1993). When utilising vegetation, elephants may strip the plants of leaves, break twigs, uproot and debark trees. I chose mopane plants to demonstrate the effects of elephants on woodlands because much of the elephants' range is within mopane woodlands (Child, 1968). Moreover, mopane is a principal food source for elephants in many conservation areas of southern Africa (de Villiers, Pietersen, Hugo, Meissner & Kok 1991; van Wyk & Fairall 1969).

CAN A BALANCE BETWEEN ELEPHANTS AND WOODLANDS BE MAINTAINED?

Since 1991, I have been monitoring woodland habitats throughout northern Botswana and measured the extent of plant mortality and biomass loss in relation to plant utilisation through all its forms and local elephant densities. Following a preliminary survey (Ben-Shahar 1993), I chose sites that contained the range of regional spatial heterogeneity in vegetation structure of different woodland habitats. These sites are subjected to varying elephant densities, fire occurrence, large herbivore browsing and tree mortality from unknown reasons. I described the likelihood of woodland loss under different elephant utilisation rates and fire regimes through mathematical models. The models rely on records of plants from sites re-visited from 1991 to 1996.

Elephants and fire appear to have a pivotal role in the dynamics of certain woodland types in northern Botswana. Their respective effects however, are likely to differ between woodland habitats dominated by specific plant species. It appears that woodlands dominated by C. *mopane* are susceptible to elephant induced damage, whereas woodlands dominated by *B. plurijuga* are prone to fire damage and less to elephant damage.

Previous research indicated that the influence of elephants on tree density was species specific (Barnes, 1983). *C. mopane* exhibits a significant reduction in tree densities with the increase in local elephant abundance (Ben-Shahar, 1996a). However, high variation found in tree densities at low elephant densities suggest that other factors, such as soil nutrients, water drainage and fire, also control tree densities (Guy, 1989; Lewis, 1991).

Seedlings of some woody plant species seem to be particularly vulnerable to the influence of elephants, fire, flooding, and other large herbivorous species that may also damage plants by trampling. As a result, a large proportion of the seedlings that germinate are often lost before the seedlings establish themselves and persist as small shrubs. Woodlands dominated by *Acacia erioloba* are influenced through the combination of these factors in northern Botswana. Under such diverse range of oppressing factors, the recruitment rate of *A. erioloba* seedlings is low by comparison to *B. plurijuga* and *C. mopane.* Nonetheless, on a regional scale, *A. erioloba* woodlands are viable because elephant impact and fire damage are low (Ben-Shahar, 1996a).

Biomass reduction (as opposed to mortality) was examined through elephant off-take and growth rates of plants. A logistic model differentiated between sustainable utilisation and over-utilisation of C. *mopane* plants by elephants (Ben-Shahar, 1996b). Predictions were based on recorded range of above ground biomass of mopane shrubs and trees and elephant densities in sites within northern Botswana. The model suggests that *C. mopane* shrubs and trees were resilient to the impact of elephant browsing, even at lower growth rates, which are assumed to coincide with dry years. Rates of biomass production reached the maximum measured level within 10 years. The prevalence of periodic drought (50% of the maximum growth rate of plants) did not hinder woodland growth (Ben-Shahar, I 996b).

THE STATUS OF WOODLANDS AND ELEPHANT NUMBERS

Central to the argument supporting the expansion of grasslands formerly dominated by woodlands (Caughley, 1976) is the likelihood that high elephant densities over-utilise woodlands already weakened by the effects of lower than average annual rainfall. During the period of sampling, northern Botswana had a lower than average rainfall regime. Nonetheless, records from *A. erioloba, B. plurijuga* and *C. mopane* woodlands indicated healthy and potentially increasing populations of woody plant species within.

There was no substantial evidence to imply that elephants will diminish woodlands below a sustainable level if their numbers are allowed to increase considerably beyond the current estimate. Hence, elephant culling as a means to prevent woodland loss is unlikely to meet the objective.

From an ecological perspective, northern Botswana can sustain well beyond the maximum number (60,000) set in 1991 by the DWNP. But then, for the future conservation of the region management policies should prioritise, setting the desired composition and structure of indigenous plant communities, rather than maintaining a threshold number of elephants. As it is, northern Botswana can sustain many more elephants as long as people can tolerate the decline of woodlands.

The ecological aspect of the elephant problem' in northern Botswana is confined to areas of interest to people where elephants seem to have an excessive impact, such as Chobe, Khwai and Linyanti river fronts. A management policy based on the ecological balance between elephants and woodlands would best consider habitats dominated by specific woody plant species where managers perceive a desired vegetation composition and structure to be maintained. Managers should review optional combinations of the density of elephants, fire regime and densities of other herbivore species that accomplish the desired vegetation form.

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