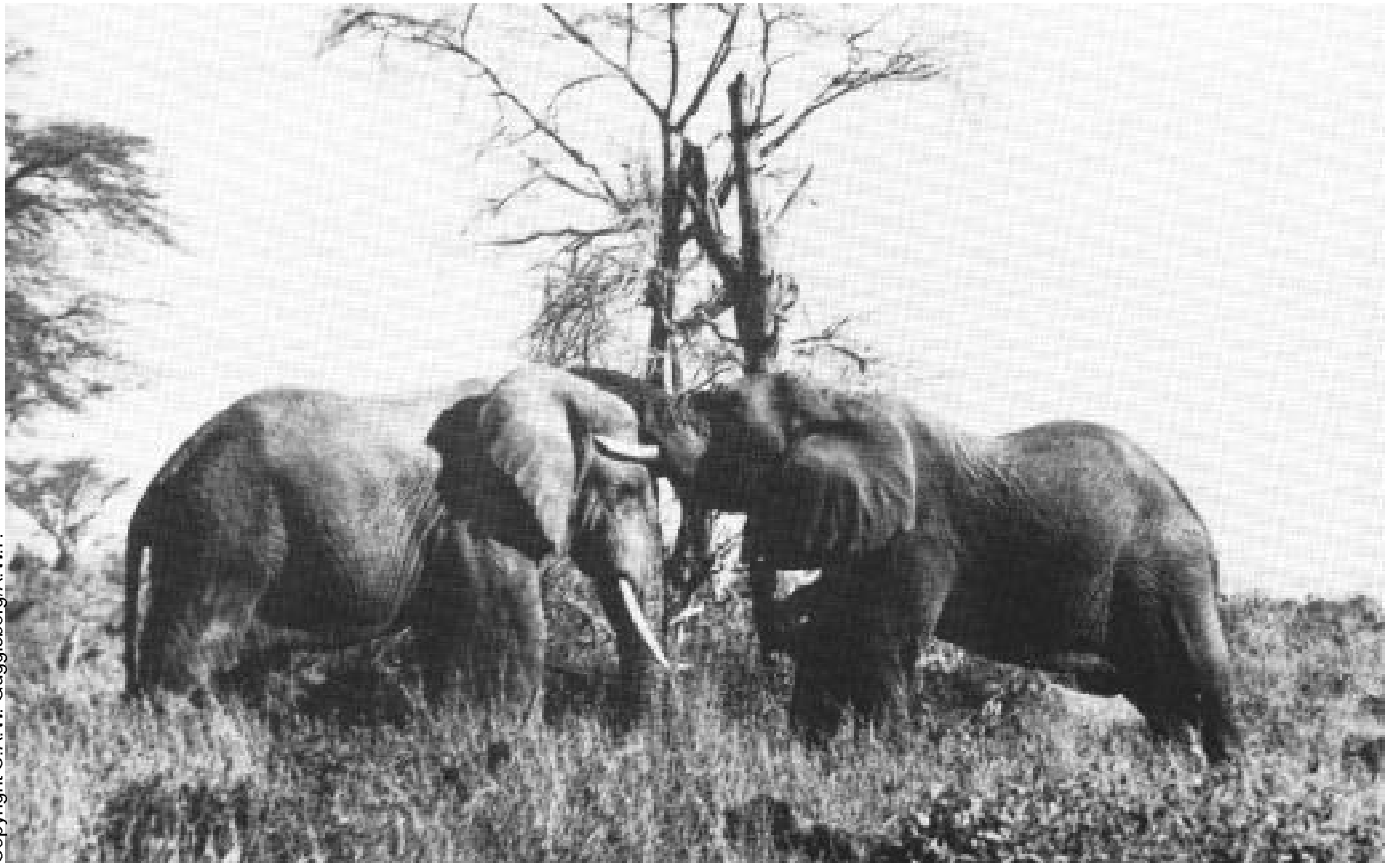


Some Preliminary Results of the Relationship Between Soils and Tree Response to Elephant Damage

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Elephants fighting in Amboseli, Kenya.

Introduction

Extensive studies of how elephants affect woody vegetation have produced the standard models of elephant-woodland interactions (Laws, Parker & Johnstone, 1975; Caughley, 1976 and Barnes, 1983). These models assume that elephants reduce tree density and therefore reduce their own food availability. The interaction of elephants and woodlands is therefore thought to be cyclic (Caughley, 1976) or to reach equilibrium at low densities of elephants and trees (Law *et al.*, 1975).

It has recently been suggested that under certain conditions elephants cause coppice regrowth of damaged trees, thus increasing browse density within preferred height ranges (Bell, 1981; Jachmann & Bell, 1984 and Bell, 1985). Under such conditions, the outcome of the elephant-woodland interaction may be different from that of the standard models, reaching stable equilibria at relatively high densities of elephants and trees. Results presented here indicate that elephant-woodland interactions may be more site-specific than previously thought.

Vwaza Marsh Game Reserve (VMGR), Malawi, exhibits a variety of conditions ranging from sandy well-drained sites where soil-water dynamics generally favour plant biomass production to clayey poorly-drained sites where soil-water dynamics do not favour plant biomass production (cf. Bell, 1986). This paper examines preliminary data on the relationship between the range of these soil-water conditions in VMGR and how trees respond to elephant damage.

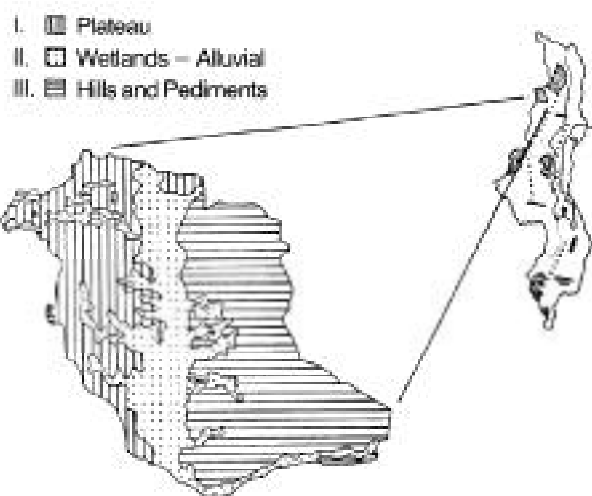


Fig. 1 The geographical distribution of landscape categories in Vwaza Marsh Game Reserve, Malawi.

The area

VMGR occupies 986 sq km of diverse terrain in northern Malawi. It lies on the Central African Plateau on the watershed between Lake Malawi and the eastern lip of the Luangwa rift at

Table 1: Relationship between landscape categories and woodland coppice

Landscape category	Total stems	Stems used	Coppice	%
Plateau		18328	9	32.1
Hills & Pediments	1534	421	14	17.6
Wetlands-Alluvial	487	223	29	13.0

Table 2: Relationship between landscape categories and woodland mortality and woodland coppice

Landscape category	Total stems	Stems used	Coppice	%
Plateau	410	35	1	2.8
Hills & Pediments	4367	525	66	12.6
Wetlands-Alluvial	1742	236	38	16.1

Fig. 2: Plot of log soil-water infiltration rate against 5s% coppice of total elephant used stems in VMGR, Malawi.

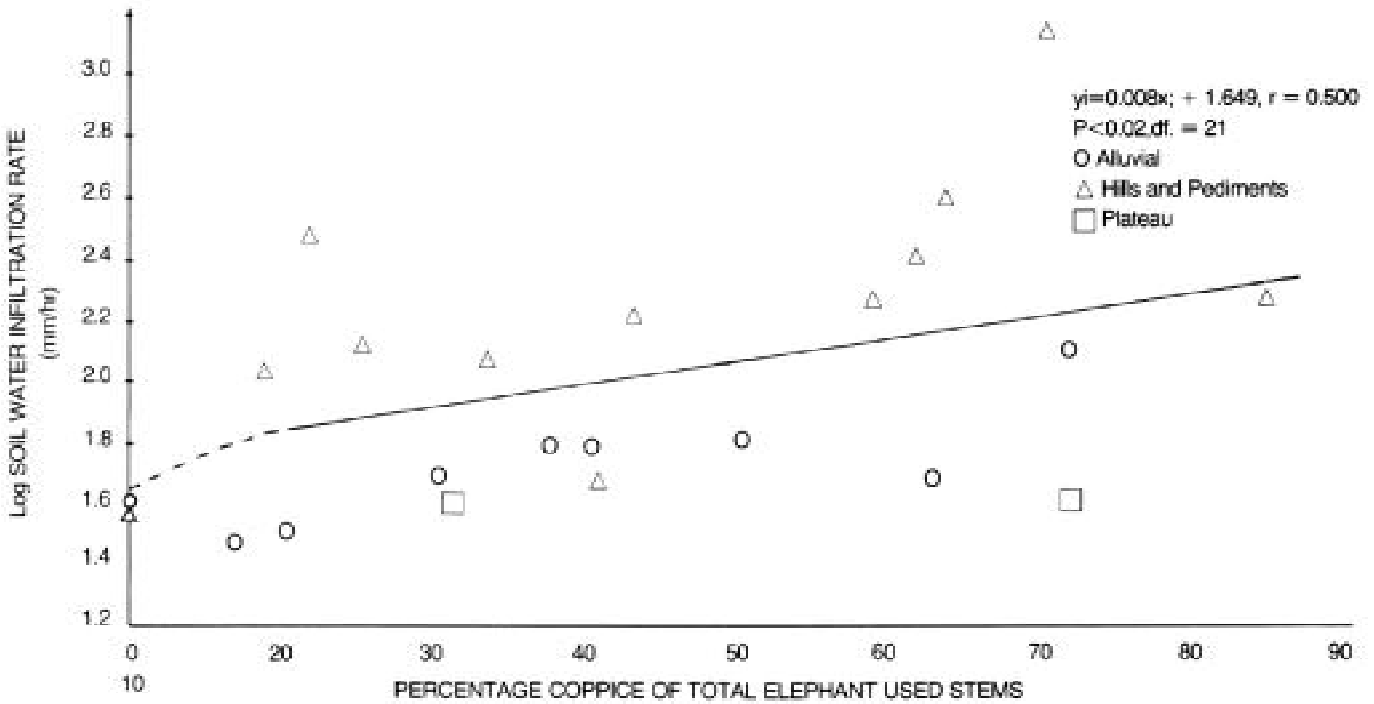
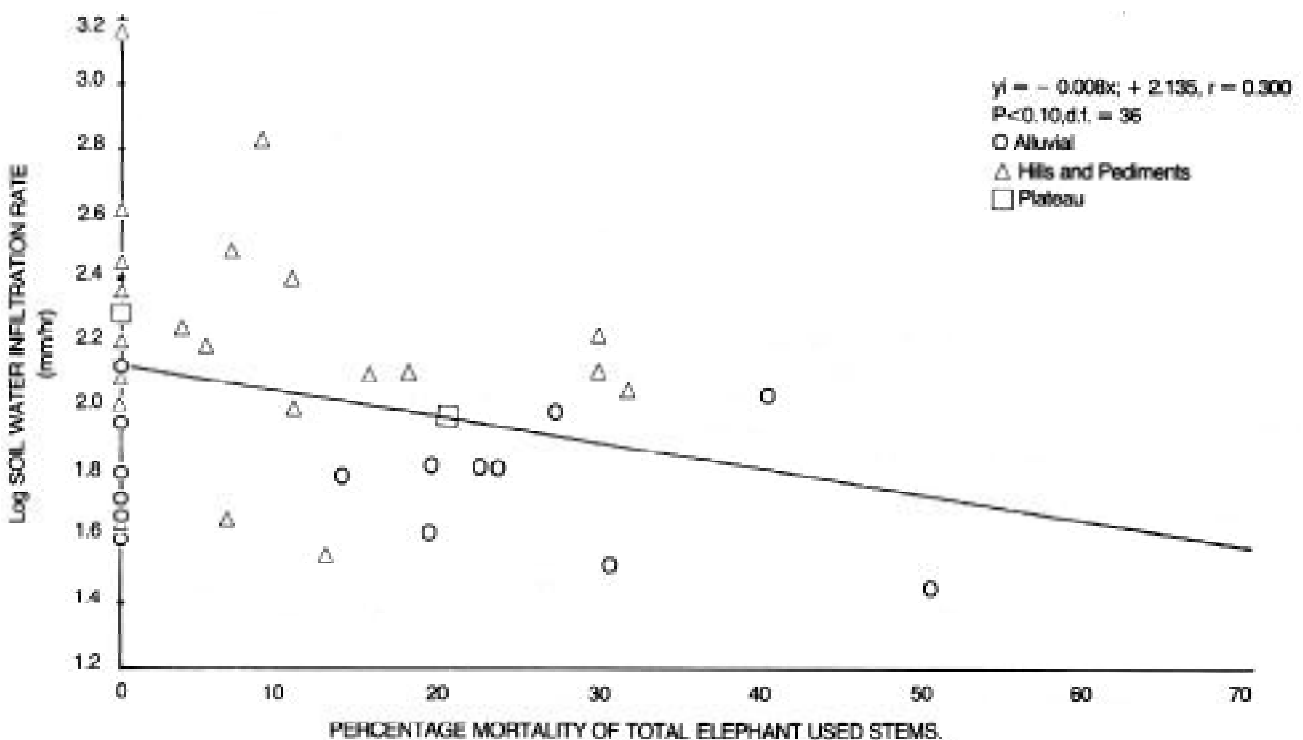


Fig. 3: Plot of log soil-water infiltration rate against %mortality of total elephant used stems in VMGR, Malawi.



about 1000 m. Annual rainfall averages 900 mm across the reserve. The reserve contains the most extensive wetlands on the plateau area of Malawi. The western half of the reserve consists of plateau *Brachystegia* woodland on well-drained sands, clay flats dominated by *Colophospermum mopane* and alluvial marshes.

The eastern half of VMGR consists of wooded foothills of the Nyika massif reaching a maximum height of 1660 m and dominated by *Brachystegia* woodlands on the slopes and broadleaved *Combretum* woodland and thicket in the valleys. The reserve has been classified into three landscape categories based on geology, soils and drainage pattern (Fig. 1). Correlations with vegetation were evident, though distinctive boundaries were difficult to delineate and intergradation common between categories. Specific landscape descriptions can be found in McShane (1985) and McShane & McShane-Caluzi (1987).

Methods

The formulation of a method to investigate tree response to elephant damage is described by Bell (1985) and Bell & McShane (1986). The probability that a tree will coppice or die due to breakage by elephants was related to soil conditions.

Data were collected on a series of 20x50 m quadrats located along transects running east/west through VMGR, cutting across the landscape categories (McShane, 1985). All woody stems over 1 m tall were tagged with metal tags and recorded as to species, height class, circumference class and degree of elephant damage. For each quadrat, two belt transects 4 m wide, running the length of the quadrat, were used to measure tree coppice. Measurements of soil-water dynamics were recorded using soil-water infiltration rings located at each corner of the quadrat.

Damage was enumerated from trees estimated to have been damaged within the last five years by comparing decay rates from trees with known breakage dates in an effort to reduce bias introduced by the disappearance of dead trees over longer time periods. A total of 6,519 woody stems were examined in the tree mortality set and 3,204 woody stems in the tree coppice set.

Results

The hypothesis tested in this study suggests that in some areas, particularly those where soil-water dynamics generally favour plant biomass production (sandy well-drained sites), the characteristic response of the vegetation is coppice, improving food availability to elephant. In areas where soil-water dynamics do not favour plant biomass production (clayey poorly-drained sites), the characteristic response is tree mortality, reducing food availability to elephant.

In Tables 1 and 2 broad trends between position on the catena and the amount of coppice and mortality are evident. The results indicate that woodland coppice is more likely to be encountered on the mid and upper catena levels (plateau and hills and pediments) than on the lower catena levels (wetlands-alluvial). The inverse result is recorded with regards to tree mortality.

Fig. 2 presents the results of a regression between the per cent coppice of all elephant used stems and the log of the soil-water infiltration rate. This shows a correlation between coppice and the more freely drained soils $r=0.500$, $P<0.02$, $d.f.=21$). Fig. 3 presents the results of a regression between the per cent mortality of all elephant used stems and the log of the soil-water infiltration rate. The data indicate a correlation between mortality and the more poorly drained soils ($r=-0.300$, $P<0.10$, $d.f.=36$).

Discussion

Whereas the standard models hypothesize that the effect of elephant on woodland is to reduce tree density and therefore to reduce food availability to elephants, this study indicates that woodland response due to elephant damage may differ over a

range of soil conditions. On sandy well-drained sites, trees respond to elephant damage by coppice regrowth, increasing browse density, which may result in an equilibrium of elephants and trees at relatively high densities of both. On clayey poorly-drained sites trees respond to elephant damage by dying, reducing tree density; results more in line with the standard models. Indications are that elephant-woodland interactions may be more site specific than indicated in the standard models and that the coppice response may be more wide-spread over Africa's range of soil conditions.

Coppice is a common response in the savannah woodlands of W National Park, Niger over a range of soil conditions (cf. McShane, 1987). Preliminary analysis of data collected in this park indicate this may be due to relatively uniform soil-water dynamics throughout the area, plant communities dominated by Combretaceae and plant growth patterns with a large number of stems from 2—20 cm in diameter resulting in a high resilience to elephant damage and relatively low probability of death. Christenson (1976) [quoted in Spinage (1985)] reported a very low tree mortality in Po National Park, Burkina Faso, a park occupying the same type of savannah as W National Park.

This paper has presented only one component of a considerably complex system. A full range of both biotic variables (i.e. tree species, tree size and shape, forage quality and secondary chemicals, plant competition, browse regeneration, tree recruitment, tree coppice, tree mortality, browsing competition with other animals and human influences) and abiotic variables (i.e. climate, geology, topography, soils and fire) must be considered to explain the complex dynamics of elephant-woodland interactions in the diverse habitats in Africa. As these components are examined and different responses under different conditions are described, management goals and the methods of reaching them are likely to differ from site to site.

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