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The Impacts of Elephant Grazing on Plant Succession in Tropical Forests of Africa

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INTRODUCTION

Community structure within an environment is timely and dynamic, changing in response to environmental conditions and causing a shift in species dominance and diversity. The term "succession" is used to describe this temporal change in community structure, and the rate of succession can be influenced by the level of environmental disturbance as species fight to establish themselves in a reviving environment. In this manner, species diversity is also affected by the ability and success of organisms capable enough to carve out a niche for themselves within an environment's changing habitat and community. However, succession can also be arrested as continual disturbance prohibits change and suppresses species establishment. Causes of arrested succession can be due to physical changes in the environment, or even actions by animals. For example, continual browsing by species can influence or reshape plant communities in an ecosystem.

One dramatic example is the affect that African elephants (*Loxodonta africana*) are having on the tropical forests in national park areas in Uganda and Tanzania. As the elephants are being confined to protected areas, their abundance within these locations are also increasing. Although this situation cannot be avoided due to the elephants' endangered status, it also is causing detrimental circumstances in terms of biodiversity conservation. In terms of foraging behaviors, elephants can cause serious damage to trees: small trees are oftentimes pushed over or uprooted and killed, while larger trees can be debarked or have their branches snapped or removed, reducing survival rates (Omeja et al. 2014, Ssali et al. 2012). Although elephants are considered unspecialized feeders, some plant species appear to be preferred in forests and woodlands, which has serious implications for habitat composition and dynamics (Ssali et al., 2012).

Elephant impact is thus amplified due to their increase in population. Likewise, with no natural or anthropogenic forces to regulate their population, they often become overabundant in forests and savannas (Ssali et al., 2012). This selectivity may disadvantage some tree species over others, and can differ between forests in different parks. In the following review, four separate case studies are being addressed to evaluate the environmental impacts elephants have on natural park ecosystems. Research studies were conducted in three different national parks, including Lake Manyara National Park, Tanzania ('Manyara'), Bwindi Impenetrable Forest National Park, Uganda ('Bwindi'), and Kibale National Park, Uganda ('Kibale'). Although these

studies were completed in different areas in Eastern Africa and within different time frames, the impacts caused by elephants are similar..

FORAGING ON FOREST COMMUNITIES

BWINDI IMPENETRABLE FOREST NATIONAL PARK

In both Kibale and Bwindi, elephant population density was determined by trails that were clearly distinguished within the dense herbaceous undergrowth. Series of plots were established in order to evaluate the damage caused by elephants while browsing. In the study conducted at Bwindi (Ssali et al. 2012), an analysis of vegetation density was determined by using GIS database references and calculating a "preference ratio" (PR) of each species. General linear models were generated to predict the probability of stems being damaged. Four areas of the park were monitored as elephants were known to be frequently inhabiting those regions. These included the Bamboo forest, the forest near Mubwindi Swamp, the forest near the Nshongi River, and the forest between the Bamboo forest and Mubwindi Swamp. Focusing on these areas resulted in 122 sample plots. Tree and shrub species that were impacted by elephant foraging were determined by tusk marks, broken branches, and toppled vegetation. Physical characteristics of the four sites were also taken into account when generating the models. The results indicated larger trees were more likely to be debarked, whereas smaller trees were more frequently toppled or had branches broken (Ssali et al. 2012). Additionally, elephant damage was more common in open areas rather than closed, dense, heavily-forested areas. These open areas also contained vigorous pioneer growth, which can prevent slow growing tree species from establishing themselves in the region and effectively changes elephant diet there (Ssali et al. 2012).

Increase in pioneer growth could be due to the area already being disturbed, and as the elephants frequent the area for foraging, tree species that are fast-growing and damage tolerant would most likely dominate – which in turn could also cause the elephants to favor the area for the quicker rate of tree regrowth. However, the study in Bwindi showed that elephants did not prefer the pioneer tree species despite the aforementioned reasons, instead favoring mid-successional species. This preference created a selective disadvantage for these species, which included *Newtonia buchananii*, *Myrianthus holstii* and *Chrystophyllum albidum* (Ssali et al. 2012). The elephants' selection would then benefit other early and late-successional species.

However, it has also been noted that other interactions between animals and the environment can influence tree selectivity. Furthermore, as elephants promote more open areas due to their foraging habits, they influence vegetation and micro-habitats in the forest. As pioneer tree species are benefitting the most from elephant grazing, this in turn creates more open habitats that are conducive for other animals, including mountain gorillas (Ssali et al. 2012). However, increasing elephant density can also increase damage and competition for food sources. Similarly, as most mid-successional species are the least tolerant of damage caused by elephants, these species can be depleted in habitats frequented by elephants (Ssali et al. 2012). This selection can also stop the regrowth of the forest as only some species are able to tolerate elephant disturbance, causing the area to be dominated by shrubs and grasses.

Figures 1 & 2. African Elephants consuming browse material at Bwindi Impenetrable Forest National Park (WICE, n.d.a, n.d.b)

KIBALE NATIONAL PARK

Kibale also witnessed the growing dominance of shrubs and grasses. While the elephants in this park have not become more selective foragers, like the elephants in Bwindi, they do also favor areas that have been previously disturbed and are therefore more open. Likewise, shrubs and grasses are predominant over tree species.

Similar to the case in Bwindi, the study in Kibale (Omeja et al. 2014) was also conducted in the field by walking elephant trails to determine their density. Vegetation plots were evaluated with trees, shrubs, grasses, and ferns inventoried in the Kanywara area of the park, with their various numbers being calculated using records from 1989 when permanent vegetation plots were established. Diet plots were also created within these vegetation areas as tree species were

identified as being fed upon or damaged the most often. Tree damage was described according to a numerical scale, and tree species preference was also correlated with elephant population change in order to determine possible population decline. Despite the prediction that more favored plant species would decline at an annualized rate, study results showed that the abundance of preferred elephant foods did not decline between 1989 and 2013 (Omeja et al. 2014). This could indicate that the tree species are a good nutrient source in elephant diet, but actually this preferred food species would last as long as the elephant community does not exceed a certain threshold. Likewise, other environmental factors can influence the tree community in Kibale, which can mask the effects of the influence of the elephants.

Similar assumption in the Bwindi study, in Kibale it was thought that trees capable of resprouting and regenerate quickly after foraging would be preferred by the elephants. However, the results indicated that elephants are feeding more on the vegetative undergrowth more abundant in these areas. By feeding on the herbs and grasses that colonize disturbed areas, elephants are also preventing the forest from recovering after disturbance, and therefore maintaining areas in a state of arrested succession (Omeja et al. 2014). Likewise, seed dispersal by elephants through their fecal matter can also influence the distribution and abundancy of these plant species.

DECLINE IN *ACACIA* WOODLAND

LAKE MANYARA NATIONAL PARK

In contrast to the Bwindi and Kibale studies, the Manyara study was more concerned with a particular tree species than the overall forest community. While forest density estimates would indicate the level of succession and its relation to elephants, *Acacia* woodland was assessed using the point-centered quarter method (Vessey-Fitzgerald 1972). The woodland also has a three-tiered structure, indicating tree maturity and distribution, and regeneration was shown to be influenced by tree proximity, with grouping decreasing the impact of browsing and animal hazards. Likewise, grazing by animals reduces the amount of grass by trees, influencing young *Acacia* plant survival and reducing fire hazards for the plants (Vessey-Fitzgerald 1972). However, if grazing is excessive, death can result for the tree. Shrub density was also shown to increase as mature *Acacia* are eliminated due to foraging.

Once again, these results indicate that elephants are more abundant in open areas rather than heavily forested ones. The Manyara study also states that the decrease in *Acacia* is beneficial as it increases undergrowth diversity (Vessey-Fitzgerald 1972). However, the importance of *Acacia* being able to regenerate is also crucial to ascertain possible detrimental effects of elephant browsing.

CONCLUSIONS

While the conclusions about the relative status of elephants and food preferences differ between each study, it is apparent that plant communities are influenced by the foraging habits elephants develop within and around the forests. The relationship between the various plants and the local elephant communities are dynamic and can depend on multiple factors. Elephants' population density, the trees' susceptibility and recovery rate, and the time scale in which the damage occurs all influence forest succession (Omeja et al. 2014). While elephants do affect the composition of a forest, they do not affect old growth forests as strongly. Meanwhile, regeneration in disturbed areas is inhibited, which most often include dense overgrowth rather than an abundance in tree species (Omeja et al. 2014).

Additionally, since elephants are overabundant in areas of national parks, they have limited space within the forest they occupy. This will also affect succession as they are frequently present in these areas. Elephant numbers are still recovering from poaching and culling, which presents issues as there is not a known equilibrium state at which elephant abundance can exist in an area. Therefore, many parks are maintaining long-term studies to understand how changes in elephant population are influencing habitat and community structure, and the implications this has for conservation efforts.

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