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THE CHALLENGES OF WILD GAME ON FOREST PLANTATIONS MANAGEMENT OBJECTIVES IN FOREST ECOSYSTEMS IN KENYA

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ABSTRACT

Forests in Africa and Asia host various wildlife populations that cause varying levels of damages to forest resources. The economic damage is more severe in forest plantations meant for timber production that require huge financial outlays. Like many countries most forest ecosystems in Kenya contain many forest plantations and wild game conservation units. Despite the heavy losses to plantation crops by wild game, the extent of the loss as well as existence of a balance between wild game conservation and plantation forestry remains unknown. The study therefore attempts to deepen the knowledge on the impacts of game damage on forest ecosystems in particular plantations and also provide some option to forest managers to counter minimize damage levels. To minimize wild game damages in Key ecosystems of Mt. Kenya and Aberdares in Kenya game moats were constructed. Recently, electric fences were introduced into parts of the Aberdares to keep away wild animals from plantations and farms. The use of physical structures has been successful in reducing damage from large game such as elephants and buffaloes but controlling smaller game mostly monkeys, porcupines, and moles remain a challenge. This paper focuses on the benefits and challenges of restricting wild game movement in forest plantations management as well as the ecological and economic impacts in Mt Kenya and Aberdare ecosystems. The study was carried out through assessments of the damage intensity of foliage, tree limb breakages and bark damages of major plantation species in the age cohorts 5-10, 11-20 and > 20 years old. Damage attribution by specific group of game was evaluated to establish their overall contribution to forest plantation damages. The study results show that individual site damages were statistically different ($P < 0.05$) but had a weak Pearson correlation ($r_s = 0.46$, $n = 8$, $P = 0.05$). The Duncan Multiple Range Test (DMRT) showed significant statistical differences in the two ecosystems but exhibited a strong negative correlation ($r_s = -0.97$, $n = 8$, $p < 0.05$) in the prevalence of the causative animals . The Spearman Correlation Analysis on the prevalence of damages across the species showed a strong positive correlation ($r_s = +0.88$, $n = 8$, $P < 0.05$). The economic production of plantation forests was found not to be compatible with wild game conservation but degree differed within the two ecosystems. In Mt Kenya, where plantations are not well protected from wild game, damage was widely prevalent as compared to the well-protected Aberdares ecosystem where it was minimal. The fencing off approach significantly reduced elephant damage in the Aberdare ecosystem but the restriction caused an increase in pressure on other critical forest resources resulting in overgrazing. The electric fence has been successful in restricting large wild game in Aberdare forests and hence the need to replace non-functional game moats with electric fences in Mt Kenya. Concurrently, carrying out habitat enrichment with preferred diets and other fallback resources in buffer zones between production units will provide the much-needed critical resource to destructive wild game. Other strategies explored include well-designed animals migration corridors and culling measures. The study was limited in scope to physical damage to plantation forests and hence there is need widen studies to cover economic losses and impacts on natural forests to enable development of best strategies of controlling destructive wild game in forest ecosystems.

KEYWORDS: Wild Game Damage, Forest Plantation, Electric Fencing and Excavated Moats

INTRODUCTION

Studies in Africa and Asia have shown that agricultural and forestry projects undertaken in traditional habitats for wild animals have forced them to modify their movements and feeding behaviour. Degradations and financial losses occurred when animals have high reliance of feedstock from the project areas (Seidensticker, 2008). Similarly, primates such as *Colobus* and blue monkeys have been reported to cause extensive damages to conifer plantations through debarking (UNO, 1994). Some of the management procedures for destructive wildlife game populations have been through culling and development of counter measures (Mutiso *et al*. 2008). The counter measures include development of physical structures to facilitate or block game movement hence creating buffer zones to separate game and productive areas while ensuring that game such as elephants are not pocketed in such areas (Seidensticker, 2008). This is because large game such as elephants and buffaloes are dangerous and destructive (Mutiso *et al*. 2008; Seidensticker, 2008) The restriction structures have been successful in restriction of large wildlarge wild game especially with the electric fence but have not been effective in keeping away destructive smaller wild game out of forest plantations. The damage by *Colobus guezeras* to forest plantations of *C. lusitanica*, in Mt Kenya ecosystem is currently beyond economic threshold limit (Mutiso *et al*. 2008). In Malaysia, Bandaratillake, (2008) reports that primary porcupines (*Hystrix branchyura*) damages resulted in major species to suffer 90% loss from secondary effects of insect pest and pathogenic attacks that reduced wood quantity and quality.

Studies have observed that major destruction to forest plantations occur due to resource switching in times of seasonal scarcity of preferred diet that force wild game to rely on fallback resources (Fashing, 2004, Chapman and Chapman, 2002 and Oates, 1994). Though it has been rational to allow wild game to access critical forest resource to overcome seasonal feedstock scarcities, however, there is need to minimize resultant economic damages (Seidensticker, 2008; Muiruri, 2004). This is because plantation forestry is founded on economic purposes and damage beyond economic thresholds will drastically reduce returns to investments. At global level, more efforts have been focused on human-wildlife conflict but little attention to plantation forests destruction by wild game that is of paramount importance to the forestry sector (Omondi *et al*. 2008; Okello *et al*., 2008; Sitati *et al*. 2008 and Birdlife International, 2008). This study explores the damages in terms of plant part, frequency, and age classes in order to highlight forest plantations destruction by wild game movement in the Mt Kenya and the Aberdare ecosystem. It also evaluates the benefits and challenges on wild game restriction to forest plantation management in Kenya.

MATERIALS AND METHODS

Study Sites Selection and Assessments

The study was undertaken between April-July 2011 in Mt Kenya and Aberdare ecosystems. This study was restricted to the lower sites of the two ecosystems where forest plantations are located. In each ecosystem some forest stations were selected as potential study sites. In Mt Kenya, Nanyuki, Hombe, Rangati, Chehe, Gathiuru, Naromoru and Kabaru were identified in the reconnaissance survey while in Aberdare, Zaina, N. Kinangop, S. Kinangop, Thuti, Muringato, Kabage and Kiandongoro were identified. The study site selection in each of the two ecosystems were generated by use of random numbers. In Mt Kenya, Gathiuru, Nanyuki, Naromoru and Kabaru were selected as the study sites while Zaina, Thuti, Muringato and Kiandongoro were selected in Aberdare.

For plantations in the two ecosystems to qualify for the study selection it must have been 10ha and above in size. For each species under study, three plantations were randomly selected to represent the three age classes 5-10, 11-20 and >20 years. Global positioning System (GPS) was used to collect coordinates of each of the selected plantations. The UTM coordinates were used to map the plantations on topographic maps. The maps were then transferred to 30cm by 30cm grid sheets at a scale of 1:10000. A 120cm by 150cm systematic grid at a scale 1:10000 was used to place the plots on the grid sheets. Three plots were selected for assessment for each age class in each plantation.

Circular plots of 0.04ha with a radius of 11.28m were used to assess wild game damage in the 11-20 and >20 years age classes while 0.02ha with a radius of 7.98m were used for 5-10 years age class. All trees in the plot were assessed for either foliage or bark damage. Under foliage damage, data was collected on trees pushed-over or uprooted, entire crown destroyed, major limbs broken, branches broken and browsed with little damage. Ring barked trees or otherwise dead, >50% bole stripped and <50% bole stripped were assessed under bark damage.

Data Analysis

Data was tabulated and Ms Excel used to generate frequency tables and graphs. Results of different sites were subjected to Duncan Multiple Range Test (DMRT) to detect statistical differences. Damage types prevalence was subjected to Test of Homogeneity of Variance and Pearson correlation analysis to establish relationships. Damage type occurrences and causative animals were subjected to One-way ANOVA and Spearman Correlation Analysis to detect existence of significant differences and correlations. Damage occurrences among studied species and across the age classes of the species were subjected to Pearson Correlation Analysis.

RESULTS

The results are of the study are presented in terms of the key issues in terms of sites, plant parts, prevalence of game damage across plantations in the two forest ecosystems. On the game damage Nanyuki forest had the highest prevalence of game damage compared to Gathiuru, Naromoru and Kabaru with bark damage accounting for 74.4% and 25.6% of recorded damages. The same trend was observed in

Aberdares with bark and foliage accounting for 78.4% and 21.6% respectively (Fig.1). When the results were subjected to a Spearman Correlation Analysis, a strong positive correlation existed in the occurrence of the two damage types across the eight studied sites. Test of Homogeneity of Variances showed significant statistical differences (P<0.05, 95% confidence level) in the occurrence of the two damage types in Mt Kenya and Aberdare ecosystems. Muringato site in Aberdares ecosystem had the least damage occurrence in all the studied sites (Fig. 1).

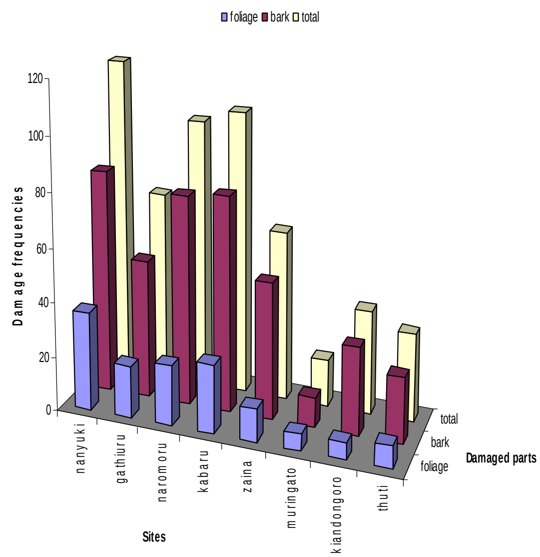

Figure 1: wild game damage prevalence in the eight studied sites of Mt Kenya and Aberdare ecosystems in 2008.

The damage intensity was assessed according to 8 damage types criteria developed for the study. The damage criteria were tree pulled up, entire crown destroyed, major limbs broken, broken branches, browsed but little damage, ring-barked, >50% bole stripped, <50% bole stripped. In the two ecosystems, trees pulled up formed 35.0% while ring-barked trees 34.5% of damage occurrences while the rest formed 30.5%. However, in Mt Kenya, debarked trees and trees pulled up had the highest prevalence whereas in the Aberdares, trees pulled-up and >50% bole strip had the highest (Fig. 2). The occurrence of individual disturbances across the studied sites was statistically different (P < 0.05) and showed relation by exhibiting a weak Pearson correlation (r_s = 0.46, n = 8, P = 0.05). The Aberdares ecosystem contributed the least in all the damage types evaluated (Fig. 2).

On the destructive wild life the study evaluated the causative animals that were categorized as elephants, monkeys, porcupines and others. In Mt Kenya, Elephants, porcupines and monkeys in the order were the most destructive animals. In the Aberdares porcupines and monkeys were the most destructive (Fig. 3).

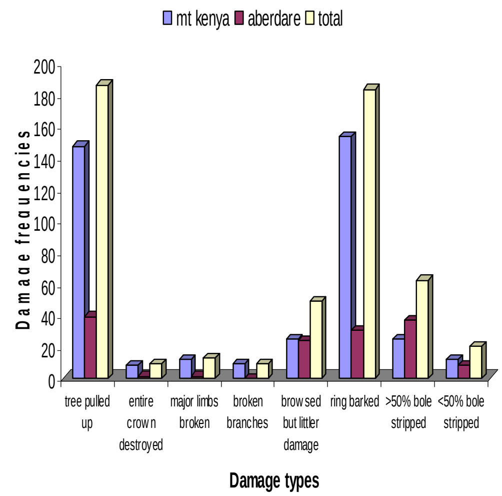

Figure 2: Damage types prevalence in the sampled sections of Mt Kenya and Aberdare ecosystem in 2008.

On large game elephants accounted for 2.6% in the Aberdares and 43.5% in Mt Kenya. To test the occurrence of the causative animals in the two ecosystems the results were subjected to a Pearson Correlation Analysis. The results showed strong negative correlation (r_s = -0.97, n = 8, p < 0.05) in the prevalence of the causative animals in the two ecosystems exists despite ANOVA showing significant statistical differences in the two ecosystems.

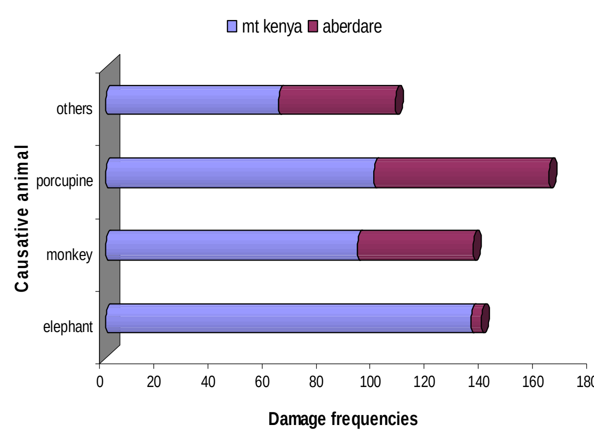

Figure 3: Contribution of each causative animal to the overall damage frequencies in sampled sections of Mt Kenya and Aberdare ecosystems in 2008.

Prevalence of Game Damage across Plantations Species

On the game damage prevalence across the plantations species by the four categories of causative animals Figure 4 show that Cypress had the highest damage prevalence at 59.3% and 60.4% in Mt Kenya and Aberdare ecosystems respectively. Pines were mildly damaged while damage inflicted on Eucalyptus, Vitex and other species was negligible

(Fig. 4). A Spearman Correlation Analysis on the prevalence of damages across the species in the two ecosystems showed a strong positive correlation (r_s= +0.88, n = 8, P = 0.05) and ANOVA showed significant statistical differences on occurrence of the damages across the species (P < 0.05).

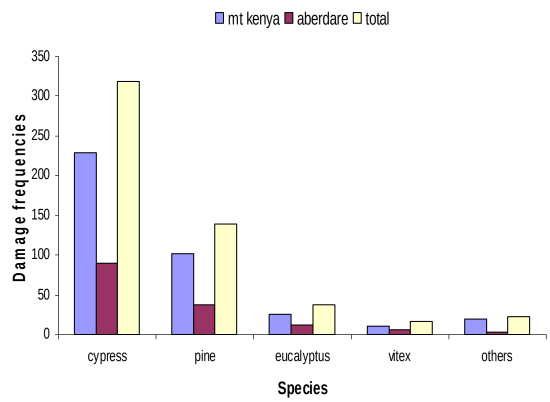

Figure 4: Damage prevalence across the studied species in sampled sections of Mt Kenya and Aberdare ecosystem in 2008.

Wild Game Damage Occurrence across Different Age Cohorts

Further, on game damage occurrence across different age cohorts Figure 5 shows that the damage was more prevalent in age cohort >20 years (41.3%, 43.2%) followed by 11-20 (34.8%, 36%) then 5-10 (23.8%, 20.9%) in Mt Kenya and Aberdare ecosystems respectively. Duncan Multiple Range Test showed significant statistical differences (P = 0.05) in the occurrence of damages across the three studied age cohorts. Damage occurrence correlated positively across the age classes (Spearman correlation, r_s = 0.79, n = 3, P < 0.05).

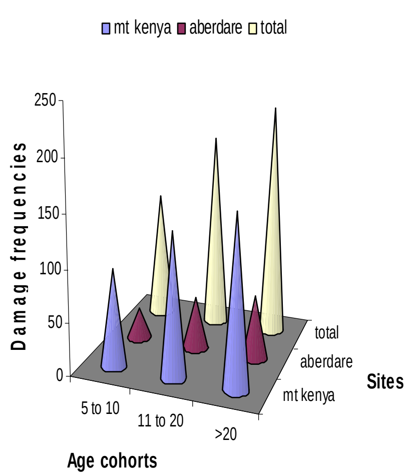

Figure 5: Damage prevalence across three age cohorts of all studied species in sampled sections of Mt Kenya and Aberdare ecosystems in 2008.

DISCUSSIONS

The discussions are presented in terms of the key results on the game damage occurrence, type of destructive game and game damage across plantations in the two forest ecosystems. The study found out that unlike in Aberdare, the plantations in Mt Kenya were not well protected from wild game movement from the upper to lower parts of the ecosystem. Studies have confirmed mass exodus of wild game from the upper regions of Mt Kenya and existence of plantations that have been turned into isolated pockets inhabited by elephants (Mutiso *et al.* 2008). The study showed that trenches or game moats excavated in the colonial period (1920-1950) were the only protective devices in Mt Kenya that have since become non-functional owing to years of siltation and lack of maintenance as compared to Aberdare ecosystem where electric fence has been erected around the plantations. Thus, in Mt Kenya, elephants and buffaloes damage can be traced to ineffective moats that allow large game easy access to plantations. The elephants were the major cause of plantation forest damages while buffaloes were the least destructive. The same observation was confirmed by studies done in northern Tanzania that found elephants to cause severe damage to forest plantation crops in Kilimanjaro forest reserve (Afolayan, 2007). Similarly, elephants damage was reported to cause major financial losses when they are allowed to enter and feed in the production forest areas (Seidensticker, 2008). While buffaloes were found to cause negligible damage to plantation crops, their presence in plantation forests in Mt Kenya ecosystem was found to cause a major managerial problem because they were "pocketed" in plantation areas that they fiercely protected as their territories. Elsewhere, studies found out that isolated wild game "pocketed" in production forests were very dangerous and destructive (Seidensticker, 2008).

The second reason for the prevalence of wild game in Mt Kenya forests was the favorable climatic conditions characterized by mildly warmer temperatures as opposed to Aberdare ecosystem that offered a unsuitable environment to wild game. The vicinity of Mt Kenya to the national and private game ranches and parks can also account for high game damage prevalence in the ecosystem. Game damage to plantations is critical during the dry season when preferred feedstock becomes scarce. The foliage of most of the plantation species comprises of the needle-leaved conifer species that do not form a major diet among the wild game. Elephants, monkeys, porcupines among others prefer the barks of plantation species as opposed to the foliage. This explains why the bark is more damaged as opposed to foliage in the two ecosystems. Similar studies in the Atlas and Tanzania have confirmed that wild game were largely responsible for killing forest trees by strip barking to get the moist and nutrient rich living tissues underneath the bark (Ross, 2004, Afolayan, 2007).

The most practical way protecting forest plantation from large game is through erection of electric fence to reduce game damage. However, the approach is likely to confine wild game within some ecosystem niches that may also pose another ecological threat through over utilization of the vegetative resources within it. The wild game diet switching and digestive flexibility enables them to forage on wide range of species (Lambert, 2004). Though electric fencing is effective in restricting large game it is ineffective in restraining smaller destructive animals such as monkeys and porcupines.

Another approach to reduce game damage to below economic threshold in productive forests is through habitat enrichment with preferred top diet species and culling of excess animals.

Trees pulled-up and ring-barking associated with elephants, monkeys and porcupines in the two ecosystems was more severe among the young plantations. The same observation was evident in Mt Kilimanjaro (Afolayan, 2007). Debarking by monkeys, elephants and porcupines was widely prevalent in cypress plantations because it becomes a fallback resource to monkeys in times of seasonal scarcity or in absence of the more preferred *Moracea* family (Mutiso *et al.* 2008; Ross, 2004; Fashing 2001a). Sometimes monkeys try to get at the cambium tissue underneath the bark to slake their thirst and hence installation of water points may reduce bark stripping behavior by monkeys.. Since monkeys have flexible diets and their preference for *Cuppressus lusitanica* bark can become a threat to plantation in Kenya where Cypress forms bulk of the plantation species (Fashing, 2004). Strategies such as putting up of buffer zones comprising of key resource such as *Moracea* family and other fallback species such as *Prunus africana* and *Celtis africana* were found to ease debarking pressure on *C. lusitanica* plantations (Ross, 2004).

In cases of pocketed wild game where damage is beyond economic threshold limit and plantations are mature, the plantations can be salvaged and transformed into natural forests. This is because plantations found in wild game prone areas are normally unhealthy due to frequent stresses caused by game damages that predispose them to pathogenic inoculums, and make them susceptibility to insect pest attack (Kumar, 2001). It is also possible to allow the damage to proceed to certain critical levels that will lead to destruction of the plantation or transforming into natural forests as part of biological succession process. Hence salvaging and transforming such plantation into natural forests will diversify the vegetation varieties in the wild game ranges.

On the wild game damage across the species *C. lusitanica* plantations was the most affected because they were preferred by the monkeys and porcupines. The two most destructive wild games in the two ecosystems showed a strong preference to *C. lusitanica* compared to other species. Further, *C. lusitanica* was found to be easily bark-stripped compared to the others and could have contributed to the high preference of the species. High nutritive value coupled with ease to bark-strip probably made the species a key fallback resource to the wild game especially monkeys and porcupines. Preference of *C. lusitanica* by wild game is of major concern given that the species forms the major plantation crop in the country. This was made worse by the fact that the electric fence that was effective in keeping large animals out of the plantation forests were ineffective against monkeys and porcupines that easily gained access to plantation forest areas. .

On damage occurrence across age classes the results showed damage prevalence increased drastically up the age classes with spearman rank test showing significant differences. This could be greatly attributed to the two most common damage types; trees pulled-up and debarking. Trees in the upper age classes provide a thick, moist, nutrient-rich living tissue underneath capable of providing the much needed nutrients to the wild game as opposed to lower age class trees. Tree at sapling stages or lower age classes provided a much thinner and tender barks unsuitable for nutrition provision. The preference for upper age classes by monkeys is supported by studies done at Shennongjia nature reserve in China that showed that snub-nosed monkeys (*Rhonipthecus roxellanae*) preferred mature forests that were negatively affected by debarking (Yiming *et al.* 2002). The damage of mature trees of *C. lusitanica* posses a major threat to plantation forestry in Kenya given that it predisposes the trees to secondary damages by insect pests and pathogens. The losses incurred by plantation owners and saw millers due to secondary effects of debarking were high because of low growth performance and log recovery due to the fact that up to 90% of previous game debarked logs had high infestation of *Oemida gahani* and multiple fungal infections. The results confirm that though wild game debarking may cause minimal losses due to stunted growth, the secondary effects can cause more economic losses. The findings are supported by studies by Wermelinger, (2007) who reported primary damages by monkeys enhanced secondary infestation by spruce bark beetle (*Ips typographus*) and fungi that caused drastic reduction in wood quality. The significance of game damage confirmed by studies done in Hong Kong by Elsa (2005) that found that plantation species suffered 90% value loss occasioned by Malayan porcupines (*Hystrix brachyuran*) and further, Bandaratillake (2008) report that porcupine damages in some cases can lead to gradual death of affected trees. Hence management strategies that protect plantation forests from wild game debarking will drastically reduce economic losses from secondary infestations.

The study findings confirms the critical impacts of wild game in forest plantations in Mt Kenya and

Aberdare range and strong arguments for keeping them out of such productive forests. The problems may not be widespread on global scale but its importance cannot be ignored because plantation forests in Kenya account for 10% of forest areas but supply 90% of industrial roundwood due to its inherent high prodicivity. Thus more efforts should be redirected towards development of measures to counter wild game damages in plantation forests in the country.

CONCLUSIONS

Plantation protection measures such as installation of electric fences are effective in restricting large wild game but ineffective in controlling smaller game that freely access forest plantations and hence the need to develop alternative strategies such as planting of preferred feed species to attract such animals away from key plantation species. . The Damages occurred highly in *C. lusitanica* plantations than in other species because it acts as a fallback resource for *Colobus* and porcupines in times of seasonal scarcity of the preferred top diets. The upper age classes were greatly preferred by wild game thus highly damaged. The preference of *C. lusitanica* plantations coupled with preference of the mature stems has significant negative impact on wood production in quantity and quality. Most of the game damages cause physical damage to trees but secondary effects of game damage especially insect pests and pathogens are magnified and drastically reduce quantity and quality of timber. There is a strong positive correlation between prevalence of game damage and secondary effects thus making a compelling case for prevention measures.

RECOMMENDATIONS

From the management perspectives there is a strong case for reviewing of policies on interaction between productive forests and wild game conservation in order to strike a balance between the economic objectives of forest plantations that ensure economic returns to investment is not diminished by the other interrelated conservation measures. In cases of overlap in management of forest plantations and wild game, strategies that will minimize primary damages should be put in place such as establishment of buffer zones enriched with preferably top diets or fallback species for specific or range of wild game.

On counter measures to restrict wild game movement, there is need to promote use of effective interventions through excavation of moats/trenches and erection of electric fences to keep away wild game from plantation forests. There is need for strong institutional collaboration between forest and wildlife agencies to ensure that wildlife migratory routes and corridors are appropriately designed to avoid plantation areas. In cases where economic or policies orientation favor wild game conservation, salvages should be undertaken and areas should be reverted to natural forests to increase the much needed critical resources for wild animals.

On further research to deepen the knowledge and scope on productive forests and wild game interactions, the study recommends more work on better approaches to keep away destructive smaller game such as monkeys and porcupines out of the plantations that cannot be restrained by the electric fence or moats. Further, there is need for more research to enable development of designs of effective game corridors that will reduce damages on existing plantations. Some studies to determine the wild game carrying capacity of specific forest ecosystems and threshold beyond which some prescribed culling can be undertaken. Similarly, studies are needed to evaluate the economic losses incurred due primary game damage and secondary infestation that diminish wood values and measures to keep such losses below stipulated economic injury levels and returns above breakeven levels.

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