Determining the Effectiveness of Exclosure Zones on Preserving Acacia Saplings for Rhinoceros Consumption at the Lewa Wildlife Conservancy

C. ESPINOSA, K. KAUFMAN-GIBBONS, K. MARSHALL, D. SHEPLEY

Abstract. Great emphasis has been placed on protecting the black rhinoceros, a critically endangered species, in Kenya. At the Lewa Wildlife Conservancy, a system of exclosure zones was implemented to protect vegetation for rhino browsing by excluding elephants. We tested the effectiveness of these electrified, wire fences by counting the number of acacia saplings available as a food source for rhinos inside and outside of the exclosure zones. We hypothesized that the number of acacia saplings would be greater inside the exclosures, with the greatest number found inside upgraded fences. Our results were partially consistent with our hypothesis, and our findings support the continued use of exclosure zones to protect vegetation for rhinos. However, our findings show that upgraded fences did not have a higher number of saplings than non-upgraded fences, meaning upgraded fences are not more effective in preserving acacia saplings for rhinos to eat. The results from our study demonstrate that the exclosure zones at the Lewa Wildlife Conservancy can serve as a model for other protected areas, and therefore could have larger implications for the conservation of endangered species.

1. Introduction

Due to their large size, megaherbivores occupy a distinct niche in tropical African savannas (Owen-Smith 1988). Instead of facing top-down regulation from predators, they experience bottom-up regulation from the availability of food (Sinclair 2003). Therefore, in efforts to conserve these species, we should pay particular attention to diet niche and competition for resources between species. One such example of this type of interaction is between elephants (*L. africana*) and black rhinoceros (*D. bicornis)*.

At the Lewa Wildlife Conservancy (LWC) in Kenya, elephants and black rhinos coexist in an acacia-dominated savanna landscape composed of both red sand and black cotton soils. Both are primary browsers that feed on acacias as well as forbs and other woody plants, although rhinoceros are known to browse on shorter vegetation, typically under two meters in height. A study at Addo Elephant National Park in South Africa showed apparent competition between the two species for browse in which elephants outcompeted rhinos, resulting in rhinos grazing less nutrient-efficient grasses (Landman 2013). The black rhino is an important conservation concern at LWC due to its critically endangered status (IUCN 2012), thus this competition with elephants is not desirable.

A common method for controlling elephant forage is herbivore exclosure fences (Agra 2018). At LWC, there are two kinds: those fortified with electrified, protruding wires and those that are electrified but do not have additional fortification or consistent electrical power. One of the goals of the fences is to create more suitable browsing for black rhinoceros by blocking intrusion at elephant height to mitigate elephant damage. However, the effectiveness of these fences for browse recruitment has yet to be examined. In this study, we plan to assess the effect of varying exclosure zones on acacia saplings, a common source of food for rhinos, in the Lewa Wildlife Conservancy. We hypothesize that the upgraded fences, given their bolstered infrastructure, will contain higher numbers of acacia trees within the 0-2 meter range and that, overall, the presence of a fence will have a positive effect on the availability of rhino browse by partially excluding elephants.

2. Methods

2.1 Description of Study Area

This study took place from March 4-6, 2019 in the Lewa Wildlife Conservancy in Isiolo County, Kenya. The study sites were inside and outside of 13 electric-wired exclosure zones. The study site included two types of exclosure fences: upgraded and non-upgraded. We sampled inside and outside six upgraded and seven non-upgraded exclosure zones.

2.2 Sampling and Data Collection

Two groups of seven researchers walked along 300 meter transects, one on the inside and one on the outside of a chosen exclosure. Each group lined up along the fence and maintained three meters of space between each person throughout data collection. The group walked in an agreed upon direction, directed by compass. Each researcher was responsible for counting trees within three meters of their right side, including the following species: *A. drepanolobium, A. mellifera, A. seyal, A. nilotica, A. tortillis, A. etbaica, and A. xanthaflora*. Although rhinos browse other types of vegetation, we decided based on scope and time limitations that we would survey only acacias as a proxy for general browse. Acacia trees were recorded under three categories: 0-1 m, 1-2 m, and >2 m. Each person had a mark on their arm that indicated 1 m and 2 m to quickly determine the height of the acacia trees.

2.3 Data Analysis

For our analysis, we removed data from one exclosure due to its irregular fence that excluded rhinos in addition to elephants. We log transformed our data to normalize the distribution. We analyzed our data in JMP using a General Linear Mixed Model (GLMM) with the following fixed effects: inside, outside, upgraded, and non-upgraded. “Plot” was used as a random effect to control for differences between plots. We also analyzed the data using Student’s t posthoc test to examine the significant differences between the sampling sites. We created a box-plot and linear regression graphs in JMP. Finally, we did not include age in the final model because age did not greatly change the number of saplings at different aged exclosures.

3. Results

There was no difference in the number of acacia trees at upgraded and non-upgraded exclosures, but the fences themselves did preserve the acacia saplings (Figure 1). There was a difference between the number of saplings inside and outside exclosures. Additionally, the number of saplings did not change significantly inside an exclosure relative to the age of the exclosure (Figure 2a and 2b).

The Number of Acacia Saplings (0-2 m)
Inside or Outside of Upgraded or Non-Upgraded Exclosures

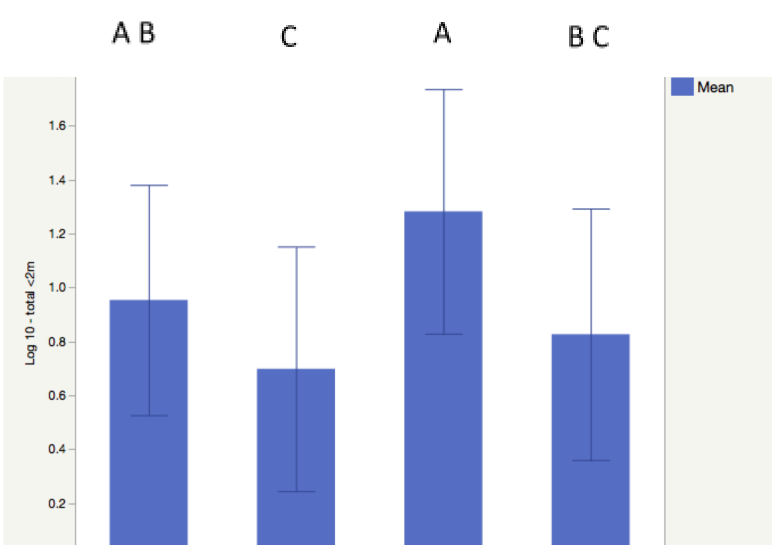

Figure 1: This graph shows the number of saplings (0-2 m) found inside and outside of upgraded and non-upgraded exclosures. There is insignificant difference in the total number of saplings between upgraded and non-upgraded exclosures. There is a significant difference in the number of saplings inside and outside any type of fence. There is a significant difference among all combinations of study sites. The letters indicate

The number of acacia saplings differed inside and outside at both the upgraded and non-upgraded exclosures (F = 101.73, df = 1, 152, p<0.0001). The total number of acacia saplings did not differ at upgraded and non-upgraded exclosures (F = 0.66, df = 1, 10, p<0.43). The number of saplings differed when we individually examined the different interactions: inside/upgraded, inside/non-upgraded, outside/upgraded, and outside/non-upgraded (F = 8.90, df = 1, 152, p<0.033).

The Relationship between the number of Acacia Saplings (0-2 m)
Inside Upgraded Exclosures and the Established Year of the Exclosures

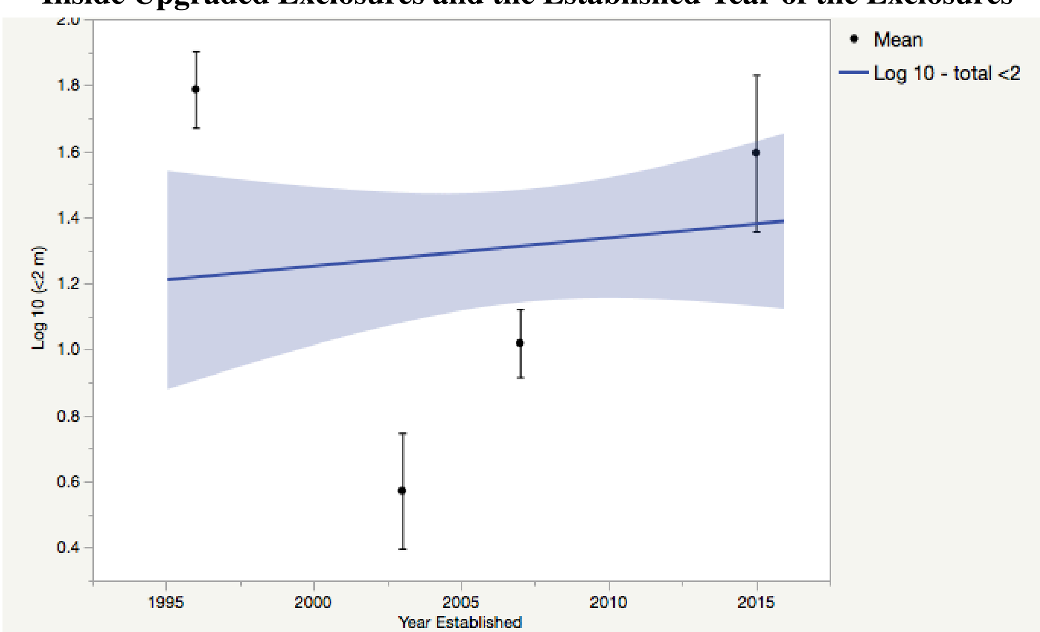

Figure 2a: This linear regression shows the number of saplings (0-2 m) inside upgraded exclosures based on when the exclosures were established. Age does not have an effect on the number of saplings inside upgraded exclosures. Error bars show one standard deviation from the mean.

The Relationship between the number of Acacia Saplings (0-2 m) Inside Non-Upgraded Exclosures and the Established Year of the Exclosures

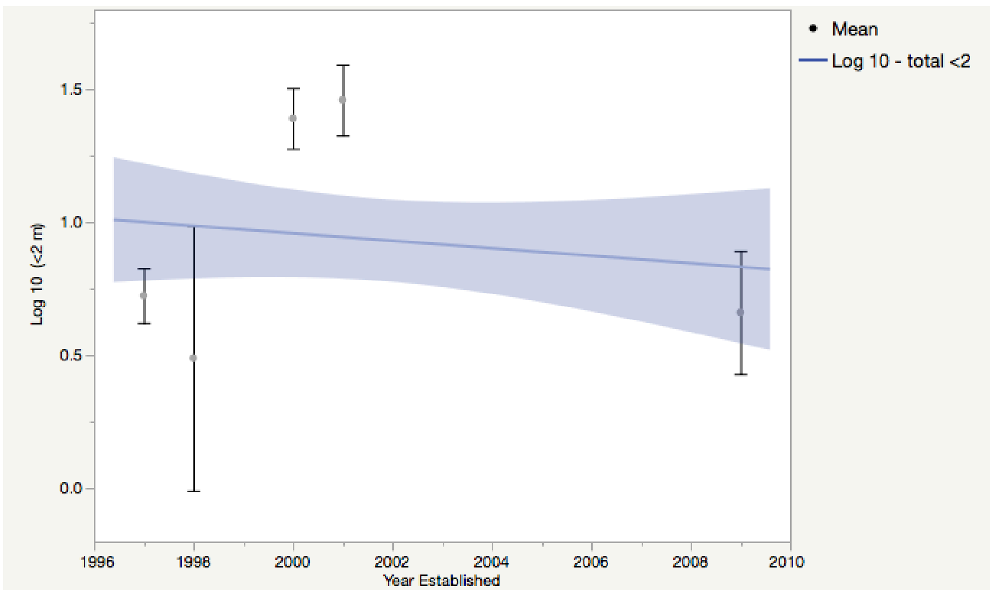

Figure 2b: This linear regression shows the number of saplings (0-2 m) inside non-upgraded exclosures based on when the exclosures were established. Age does not have an effect on the number of saplings inside non-upgraded exclosures. Error bars show one standard deviation from the mean.

Inside upgraded exclosures, we did not see an effect between the year that the exclosure was established and the number of acacia saplings (R^2 = 0.016, p = 0.46). Inside non-upgraded exclosures, we did not see an effect between the year that the exclosure was established and the number of saplings ($R^2 = 0.021$, $p = 0.40$). Therefore, since age did not have an effect on the number of saplings inside the exclosures, we did not include age in the final model and analysis.

4. Discussion

This study aimed to provide insight to the management of the Lewa Wildlife Conservancy on the effectiveness of elephant exclosure zones in protecting acacia saplings for rhino consumption inside the conservancy. To understand the impact of the exclosure zones on the protection of vegetation commonly eaten by rhinoceros, we counted the number of acacia trees along transects both inside and outside of thirteen exclosure zones. We also compared the number of rhinoceros-accessible acacia trees in upgraded and non-upgraded exclosure fences, and examined the effect of the age of the exclosure in relation to the number of acacia saplings. We hypothesized that the number of acacia trees found within exclosure zones would exceed the number outside, with the greatest number found within upgraded exclosure zones. Our data partially supports our hypothesis, showing a greater number of acacia saplings inside the exclosure zones than outside. However, we found the number of saplings in upgraded compared to non-upgraded exclosures to be insignificant.

Our study can provide insight to the management of LWC for practical use. We recommend that management continue their practices of using exclosure zones in order to preserve food sources for the black rhinos as our study demonstrated that they are effective. However, since there was difference between upgraded and non-upgraded fences, we would suggest using the non-upgraded fences for all exclosures and investing money allotted for additional fortification elsewhere. We also recommend conducting further studies to obtain a more comprehensive understanding of the state of the landscape, including investigating differences in soil, plant type, and water sources in the various exclosures. Since rhino diets extend beyond acacia saplings, it would be useful to conduct a study similar to this one that includes all potential rhino vegetation to fully assess the efficacy of the exclosure zones.

Additionally, it would be prudent to analyze what the state of the land was in each of these, and any future, exclosure zones at the time of fence installment. It is possible that each area was specifically chosen due to its high volume of acacia saplings rather than the reverse relationship being true. This is an important piece of additional information necessary to consider the full picture.

With the constantly changing environment and frequent loss of animal habitat, it is crucial to take measures to protect the endangered species left in our world. Protected areas, like the Lewa Wildlife Conservancy, are not only beneficial for growing ecotourism and the local economy, but for conserving the biodiversity of the savanna landscape. With improving conservation methods in protected areas, the health of the endangered animals as well the landscape can be prioritized. However, the complex implications of human intervention on an ecosystem must be considered.

Sources

Agra H., Schowanek S., Carmel Y., Smith R.K. & Ne'eman G. (2018) Forest Conservation. Pages 285-328 in: W.J. Sutherland, L.V. Dicks, N. Ockendon, S.O. Petrovan & R.K. Smith (eds) What Works in Conservation 2018. Open Book Publishers, Cambridge, UK.

Emslie, R. 2012. *Diceros bicornis*. *The IUCN Red List of Threatened Species*2012: e.T6557A16980917. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T6557A16980917.en. Downloaded on 07 March 2019.

Guldemond RAR, Purdon A, van Aarde RJ (2017) A systematic review of elephant impact across Africa. PLoS ONE 12(6): e0178935. https://doi.org/10.1371/journal.pone.0178935

Lagendijk DDG, Mackey RL, Page BR, Slotow R (2011) The Effects of Herbivory by a Mega- and Mesoherbivore on Tree Recruitment in Sand Forest, South Africa. PLoS ONE 6(3): e17983. https://doi.org/10.1371/journal.pone.0017983

Landman M, Schoeman DS, Kerley GIH (2013) Shift in Black Rhinoceros Diet in the Presence of Elephant: Evidence for Competition? PLoS ONE 8(7): e69771. https://doi.org/10.1371/journal.pone.0069771

Owen-Smith, R. Norman. 1988. "Prologue." In *Megaherbivores: the influence of very large body size on ecology*, by R. Norman Owen-Smith, 1-5. New York, NY: Cambridge University.

Sinclair A.R.E., Mduma S., Brashares J. (2003) Letters to nature. Patterns of predation in a diverse-predator prey system. Centre for Biodiversity research.

Figure Appendix

The Number of Acacia Saplings (0-2 m)
Inside or Outside of Upgraded or Non-Upgraded Exclosures

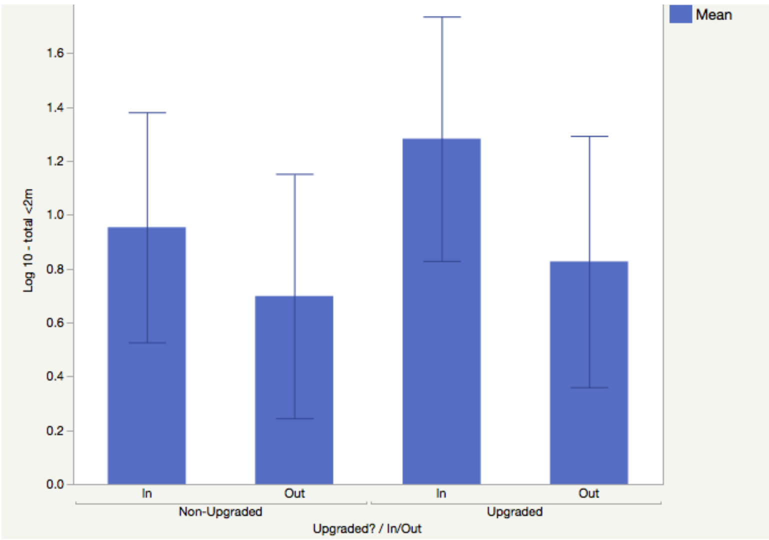

Figure 1: This graph shows the number of saplings (0-2 m) found inside and outside of upgraded and non-upgraded exclosures. There is insignificant difference in the total number of saplings between upgraded and non-upgraded exclosures. There is a significant difference in the number of saplings inside and outside any type of fence. There is a significant difference among all combinations of study sites. The letters indicate significant differences between columns. The error bars signify one standard deviation from the mean.

The Relationship between the number of Acacia Saplings (0-2 m)
Inside Upgraded Exclosures and the Established Year of the Exclosures

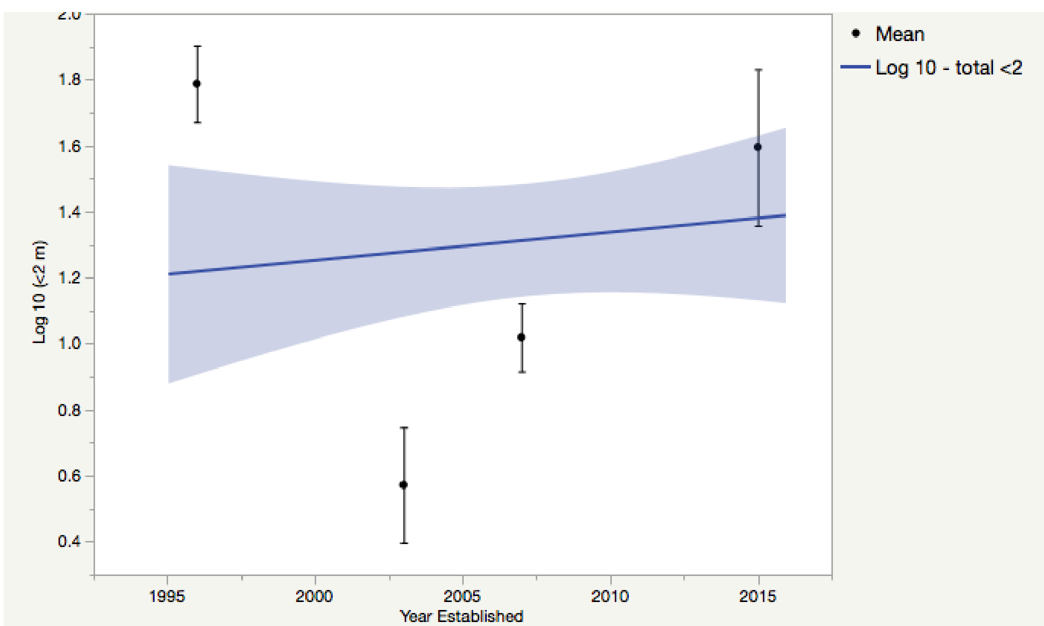

Figure 2a: This linear regression shows the number of saplings (0-2 m) inside upgraded exclosures based on when the exclosures were established. Age does not have an effect on the number of saplings inside upgraded exclosures. Error bars show one standard deviation from the mean.

The Relationship between the number of Acacia Saplings (0-2 m)
Inside Non-Upgraded Exclosures and the Established Year of the Exclosures

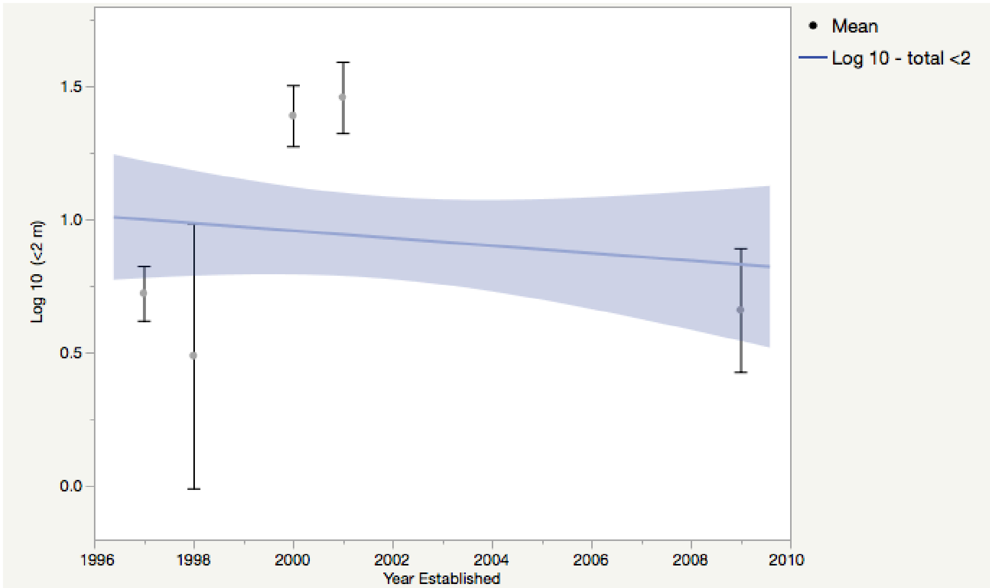

Figure 2b: This linear regression shows the number of saplings (0-2 m) inside non-upgraded exclosures based on when the exclosures were established. Age does not have an effect on the number of saplings inside non-upgraded exclosures. Error bars show one standard deviation from the mean.