Ecological predictors of risk areas for carnivore predation on livestock in agricultural landscapes around Makgadikgadi/Nxai National Parks, Botswana

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Abstract

Predictive spatial risk models (PSRM) for large carnivore predation on livestock are critical in managing costs associated with carnivore conservation and promoting coexistence among carnivores, wild herbivores and livestock. Development of PSRM involves understanding of site and carnivore specific ecological predictors for predation and help prioritize conflict areas where appropriate mitigation efforts should be directed. PSRM are also potentially useful in advancing strategic endeavours in adaptation to climate change and land management. However, research in developing PSRM models is still limited in Botswana and Africa at large. This study indicated that lion (*panthera leo*) mainly killed large livestock (cows & mares) **86.9%** (n=345) while leopard (*panthera pardus*) usually killed small livestock (goats & calves) **79.2%** (n=76) and wild dog (*lycaon pictus*) killed both large and small livestock (cattle (**47.44%**, n=37) (goats (**35.90**%, n=28). We then mapped risk of lion, leopard and wild dog using number of livestock killed at cattle posts. Then we incorporated ecological (vegetation and topographic features and species abundance) variables and compared risk categories of the maps. For all the species, incorporation of variables decreased %area of minimum risk classes whereas %area of maximum risk classes were increased. The visual maps also depicts that lions concentrate on areas closer to the National park boundary compared to leopard and wild dog.

Introduction

- Human-carnivore conflict (HCC) is a concern to conservation and livelihoods because of carnivore predation on key livestock, especially near protected areas.
- Lethal retaliation has lead to global population decline of carnivores (Hemson et al. 2009).
- Development of PSRM advances knowledge on site and species specific ecological determinants of predation, and it is necessary to alleviate the problem (Treves et al., 2011; Treves et al., 2017) .
- Nevertheless only 2 published studies are from Africa (South Africa: Shrader et al. (2008) & Tanzania: Abade et al. (2014)) and none in Botswana (Miller, 2015)
- Hence this study determined ecological factors influencing risk of lion (*panthera leo*), leopard (*panthera pardus*) and wild dog (*lycaon pictus*) and mapped the risk.

Objectives/aims

a. To determine livestock types killed by different carnivores species

b. To determine potential risk of predation based on past predation incidents

c. To determine the influence of ecological factors on potential risk of predation

Materials and Methods

Study area

- Approximately 6159.53 km^2 (fig 1).
- Grassland and shrub savanna with scattered large trees.
- Carnivores include lion, leopard, spotted hyena, cheetah and the African wild dog.
- Livestock include cattle, horses, donkeys and goats.

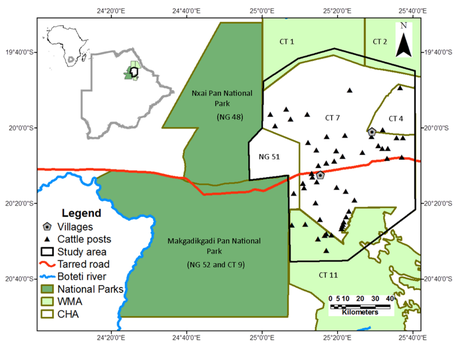

Fig 1. Map of study area showing cattle posts and the associated surroundings

Data collection and analysis

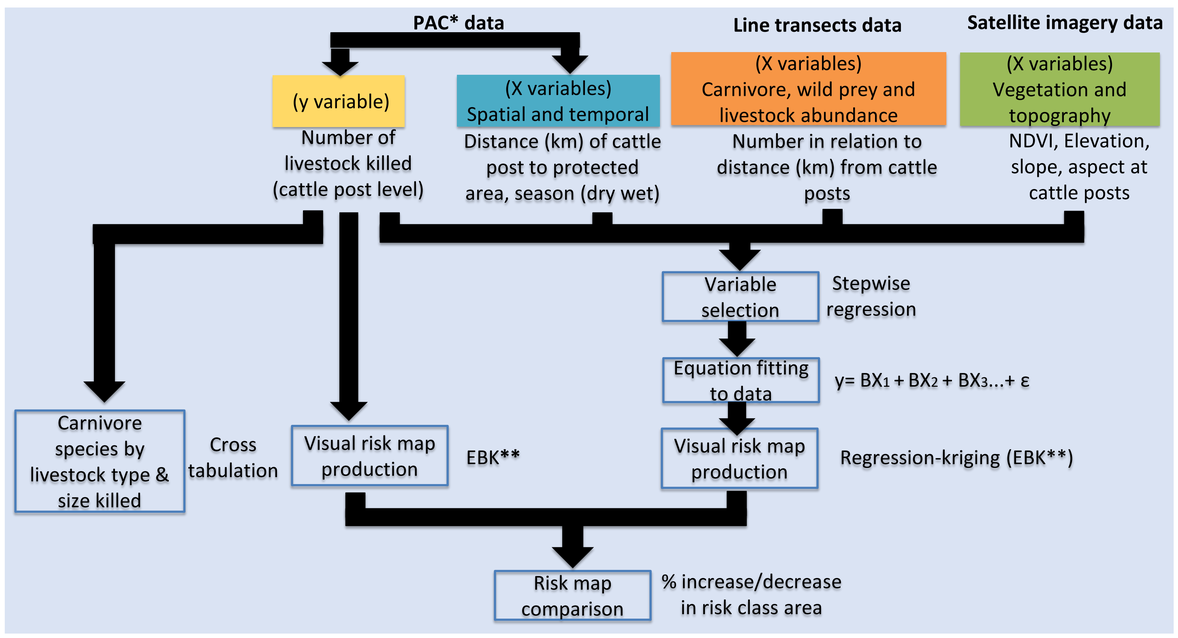

Fig 2. Data collection and analysis flowchart NB: *Problem Animal Control, **Empirical Bayesian Kriging

Results

Lion killed most of livestock 69.53% (n=397) then leopard 16.81% (n=96) and lastly wild dog 13.66% (n=78). Fig 3.

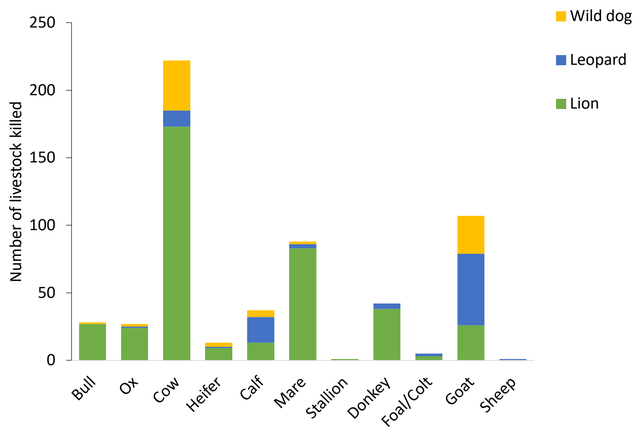

Fig 3. Number and type of livestock killed by each of the carnivores lion, leopard and wild dog.

Maps showing risk interpolated from number of livestock killed by lion (fig 4a), leopard (fig 4c) and wild dog (fig 4e). Significant ecological predictors for lion were incorporated using the formula $\boldsymbol{y = 6.93 + (37.83 * lion\ abundance) + (5.26 * TRI) - (15.48 * NDVI) + \varepsilon}$. The results mapped (fig 4b). Leopard predictors were in the formula $\boldsymbol{y = 0.21 + (0.05 * distance) + \varepsilon}$, and mapped (fig 4d). Predictors for wild dog formula was $\boldsymbol{y = 0.40 + (0.06 * distance) + (1.95 * small\ wild\ prey) + (0.004 * large\ livestock) - (0.01 * small\ livestock) + \varepsilon}$, and the mapped as well (fig 4f). Table 1 shows % increase and decrease in area covered by minimum, moderate and maximum risk classes.

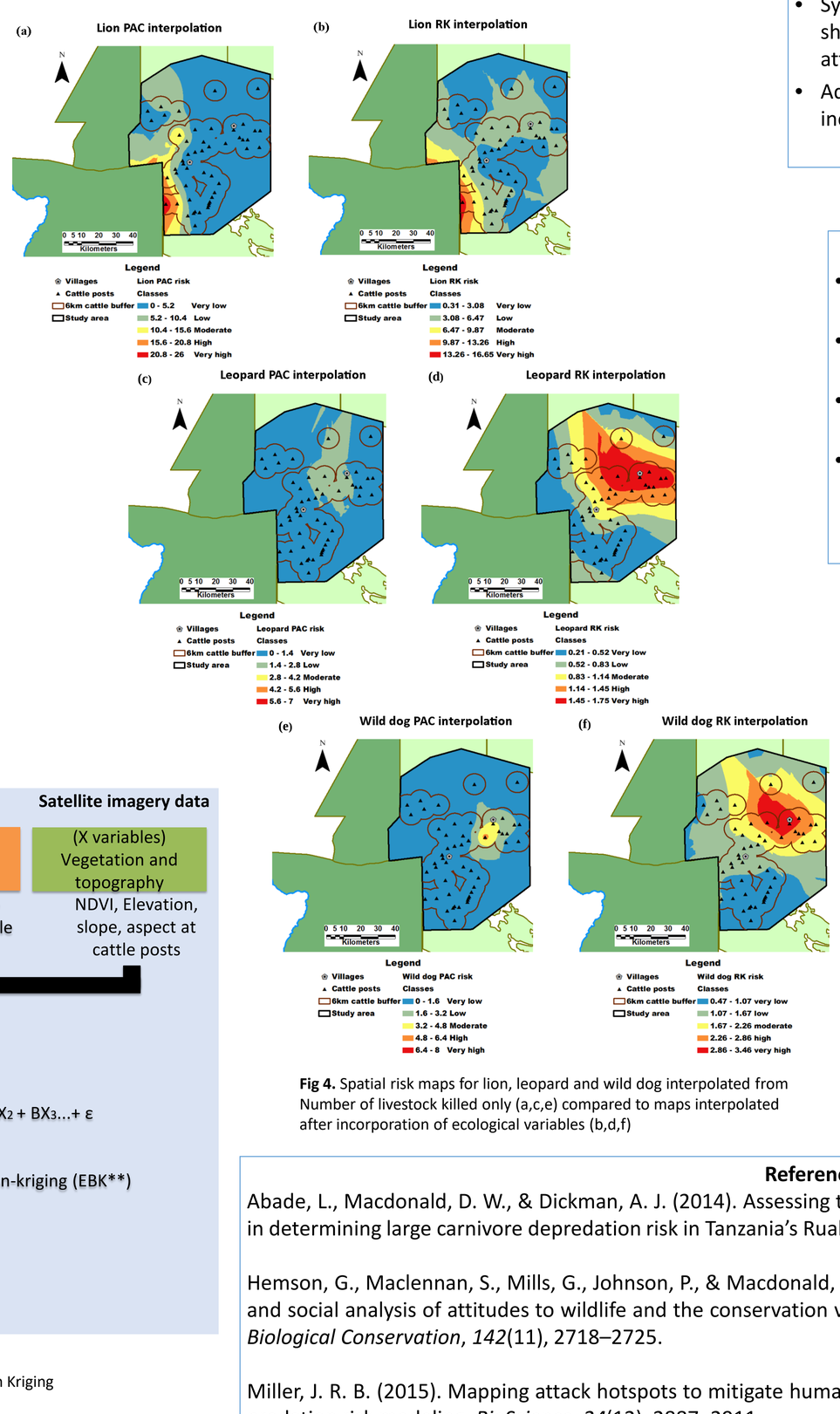

Fig 4. Spatial risk maps for lion, leopard and wild dog interpolated from Number of livestock killed only (a,c,e) compared to maps interpolated after incorporation of ecological variables (b,d,f)

Table 1. difference in % area of risk classes before and after predictors were included in mapping procedure

Carnivore species	Risk Intensity	PAC* (no predictors)	PAC* (predictors included)	Change in % area
		% area	% area	
Lion	Minimum	91.69	90.84	-0.85
	Moderate	5.48	5.90	+0.42
	Maximum	2.83	3.26	+0.43
Leopard	Minimum	100	55.53	-44.47
	Moderate	0	16.69	+16.69
	Maximum	0	27.78	+27.78
Wild dog	Minimum	98.07	64.46	-33.61
	Moderate	1.80	20.85	+19.05
	Maximum	0.13	14.69	+14.56

Conclusions

- Risk of lions, leopards & wild dogs is determined by unique set of ecological factors in various locations
- Sympatric carnivores (lion, leopard & wild dog) show spatial partitioning of areas where they attack livestock
- Addition of ecological factors to PAC data increases % area of potential high risk areas

Policy implications

- Stakeholders should understand potentially risky areas based on their ecological characteristics
- Prioritisation of decision making in mitigation should be focused relative to risk of specific species.
- This could reduce costs related to conflict mitigation and conservation
- Understanding spatial and temporal risk could advance adjustment to climate change and adaptive land use management

Acknowledgements

References

Abade, L., Macdonald, D. W., & Dickman, A. J. (2014). Assessing the relative importance of landscape and husbandry factors in determining large carnivore depredation risk in Tanzania's Ruaha landscape. *Biological Conservation*, *180*, 241–248.

Hemson, G., Maclennan, S., Mills, G., Johnson, P., & Macdonald, D. (2009). Community, lions, livestock and money: A spatial and social analysis of attitudes to wildlife and the conservation value of tourism in a human-carnivore conflict in Botswana. *Biological Conservation*, *142*(11), 2718–2725.

Miller, J. R. B. (2015). Mapping attack hotspots to mitigate human-carnivore conflict: approaches and applications of spatial predation risk modeling. *BioScience*, *24*(12), 2887–2911.

Treves, A., Martin, K. a., Wydeven, A. P., & Wiedenhoeft, J. E. (2011). Forecasting environmental hazards and the application of risk maps to predator attacks on livestock. *BioScience*, *61*(6), 451–458.