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TECHNICAL COMMENT

The case for fencing remains intact

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Abstract

Creel *et al.* argue against the conservation effectiveness of fencing based on a population measure that ignores the importance of top predators to ecosystem processes. Their statistical analyses consider, first, only a subset of fenced reserves and, second, an incomplete examination of 'costs per lion.' Our original conclusions remain unaltered.

Keywords

Carrying capacity, edge effects, fences, lions, population size.

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INTRODUCTION

Creel *et al.* claim that fences are ineffective for lion conservation because, first, conservation should prioritize population *size* instead of the extent to which a population approaches its carrying capacity (population *status*), and, second, by reanalyzing our original data using a biased sample of fenced reserves and a cost analysis that did not control for differences in governance across Africa.

POPULATION SIZE VS. POPULATION STATUS

Creel *et al.* state that a 'low-density population of 2000 individuals has more conservation value than a high-density population of 20' and '…a population of 640 lions that is below its carrying capacity has more conservation value and potential than a smaller number of lions already at higher density.'

This philosophical distinction follows the widespread usage of population size as a conservation measure. However, lions should not merely be conserved for their own sake but as part of integrated ecosystems: by emphasizing population size rather than population status, Creel *et al.* neglect the contribution of apex predators to ecosystem processes. Furthermore, exclusively focusing on population size ignores the significantly lower population growth rates in unfenced populations compared to fenced reserves: nearly half of the unfenced reserves are likely to fall below 10% of their carrying capacity in the next 20–30 years. Thus, even if more lions *exist* in unfenced reserves, they are not better 'conserved.' Finally, population status demonstrates how well observed population densities match their expected values. In the absence of an ecological framework, how can conservation success be measured from population size alone?

FENCES ARE EFFECTIVE

In reanalyzing our data, Creel *et al.* only included populations that were at or below their predicted carrying capacities. As expected densities are only exceeded in fenced reserves, Creel *et al.* inevitably reduced any chance of finding significant impacts of fencing. If we include all populations but cap their sizes at 100% of carrying capacity to control for 'over-population,' fencing remains the strongest predictor of population status, with management budget and nearby human population density the only other significant factors (Table 1). This is, in fact, how many smaller fenced reserves are managed: a proportion of the population is removed once the

Table 1 Multimodel averages across 40 sites for the ratio of current-to-expected population densities, capping maximum values at 100%

	Estimate	SE	Adj. SE	*z* value	*P*-value	Relative importance
(Intercept)	−1.063	0.230	0.235	4.522	0.000***	1
Fence	0.431	0.086	0.088	4.880	0.000***	1
Management budget	0.107	0.026	0.027	3.935	0.000***	1
Human pop'n density	−0.123	0.058	0.060	2.033	0.042*	0.75
Method	0.123	0.107	0.111	1.111	0.267	0.32
Size of PA	0.087	0.068	0.070	1.236	0.216	0.28
Hunted	0.082	0.105	0.109	0.748	0.455	0.13
Governance	0.011	0.020	0.021	0.531	0.595	0.09
Namibia + South Africa	−0.034	0.122	0.127	0.266	0.790	0.08
State run	−0.032	0.083	0.086	0.375	0.708	0.11

Results are based on all models with ΔAIC less than 4.0. *$P<0.05$; ***$P<0.001$.

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lions are perceived as exceeding carrying capacity (see our Fig. S1)—and these costs are included in overall management budgets.

FENCES ARE COST-EFFECTIVE

Creel *et al.* reworked our data to estimate how many dollars are spent per lion and claimed that fenced reserves are more expensive than unfenced reserves. However, they neglected to control for factors that are well known to influence operational costs in different parts of Africa. After controlling for governance (corruption, purchasing power parity, etc., see Table S2 in our study), dollars spent per lion is no different in fenced vs. unfenced reserves (Table 2). Our original analysis showed that, dollar for dollar, fenced reserves achieved better conservation outcomes than unfenced reserves but that population status in fenced reserves does not vary with management budget, so we emphasized that fences can succeed on budgets as low as $500/km^2.

ADDITIONAL CONSIDERATIONS

Although Creel *et al.* argue that 'Fenced and unfenced reserves differ in ways other than fencing,' our AIC analyses explicitly controlled for these differences, and fences remained the most important factor affecting population status and trends. They also list numerous supplementary practices that are essential for managing unfenced reserves but are less important in fenced reserves. Additional new strategies for reducing edge effects—including new types of physical barriers that cannot be used to manufacture snares—may eventually prove to enhance conservation of lion populations, but their cost-effectiveness should be measured objectively against the gold standard of a good fence.

Table 2 Multimodel averages of log[(lions/km^2)/($1000 budget/km^2)] = log (lions/$1000), including the full set of independent variables examined in our original study

	Estimate	SE	Adj. SE	*z* value	*P*-value	Relative Importance
(Intercept)	0.853	0.393	0.399	2.139	0.032*	
Governance	0.097	0.045	0.046	2.106	0.035*	0.75
Hum pop'n density	−0.174	0.119	0.123	1.408	0.159	0.44
State run	0.285	0.184	0.190	1.502	0.133	0.41
Namibia + South Africa	−0.378	0.284	0.291	1.301	0.193	0.33
Size of PA	0.158	0.131	0.135	1.171	0.242	0.29
Fence	−0.191	0.207	0.213	0.897	0.370	0.19
Hunted	−0.181	0.266	0.274	0.661	0.509	0.18

Results are based on all models with ΔAIC less than 4.0. *$P < 0.05$. Note: our Table S1 contained two transcription errors (the correct management budget for Phinda is $3,452/km^2 and $204/km^2 for Ishasha); these errors would not have affected the results reported by Creel *et al.*; the analysis below is based on the correct values. Also, Creel *et al.*'s Figure 2c should read lions/$1000 rather than lions/$100 000.

CONCLUSIONS

Most lions live in unfenced reserves because of the high construction costs of fencing and the prevalent paradigm of unfenced nature. Our analysis illustrated the large economic costs of protecting unfenced landscapes and raises the issue of society's willingness to pay for unfenced conservation. While novel conservation approaches may help reduce conflicts in some areas, the ability to protect fragmented ecosystems will require extensive investigation and considerable investment.

The large-scale decline of lion populations requires urgent action. In Africa, human population is projected to quadruple to four billion people in the next 90 years (United Nations Department of Economic and Social Affairs, Population Division 2013), greatly amplifying deleterious 'edge effects' and accelerating loss of habitat both within and outside PAs. It is essential to find strategies to limit these impacts. It would be tragic if past and present resistance to enclosing ecosystems prevented the consideration of fencing as one of a suite of valuable tools for conserving African ecosystems.

ERRATA

Creel *et al.* noted an error in our text that 'less than half the unfenced reserves are likely to persist above 10%' in the next 20–40 years. The true figure is 57%. However, our abstract correctly stated that, 'nearly half of the unfenced populations may decline' over that period. They also note that we said 'lion population size' in the final sentence of our introduction; we should have instead said 'population status.'

AUTHORSHIP

All authors contributed to the writing of the manuscript; CP & AS performed the analysis in Table 1.

REFERENCE

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