

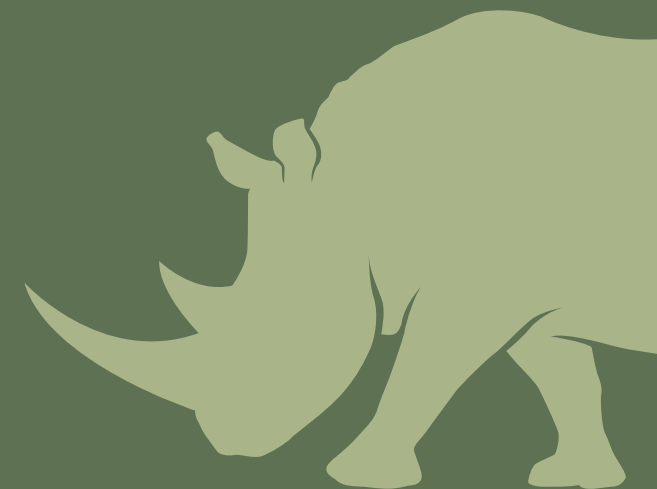
Savannah Science Network Meeting 2025



SABI SAND
NATURE RESERVE

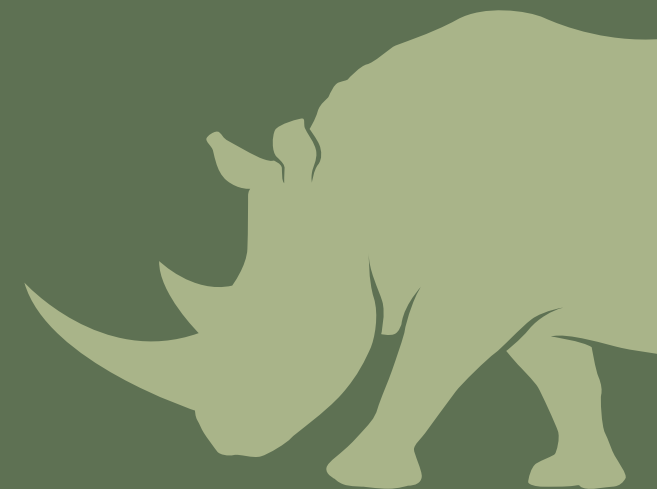
COLLUDING RHINO POACHERS EXPLOIT SPACE-TIME VARIATION IN OPPORTUNITY & RISK

Tim Kuiper, Iain Olivier, Julie Olivier



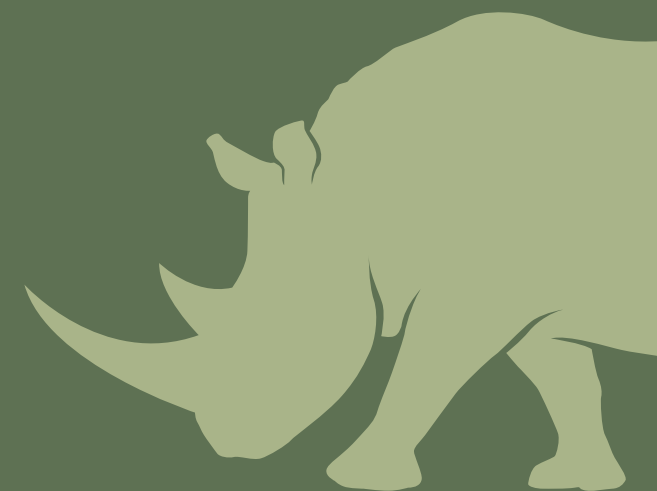
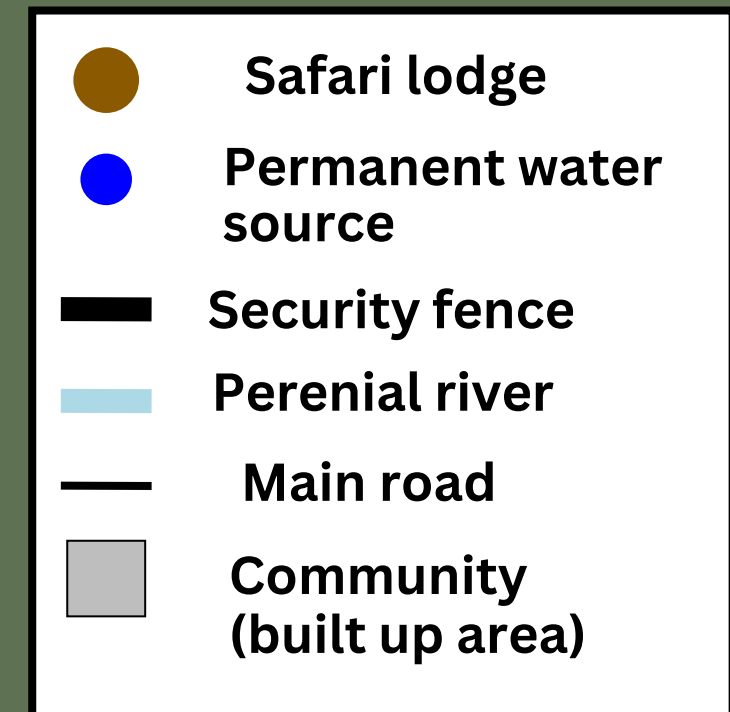
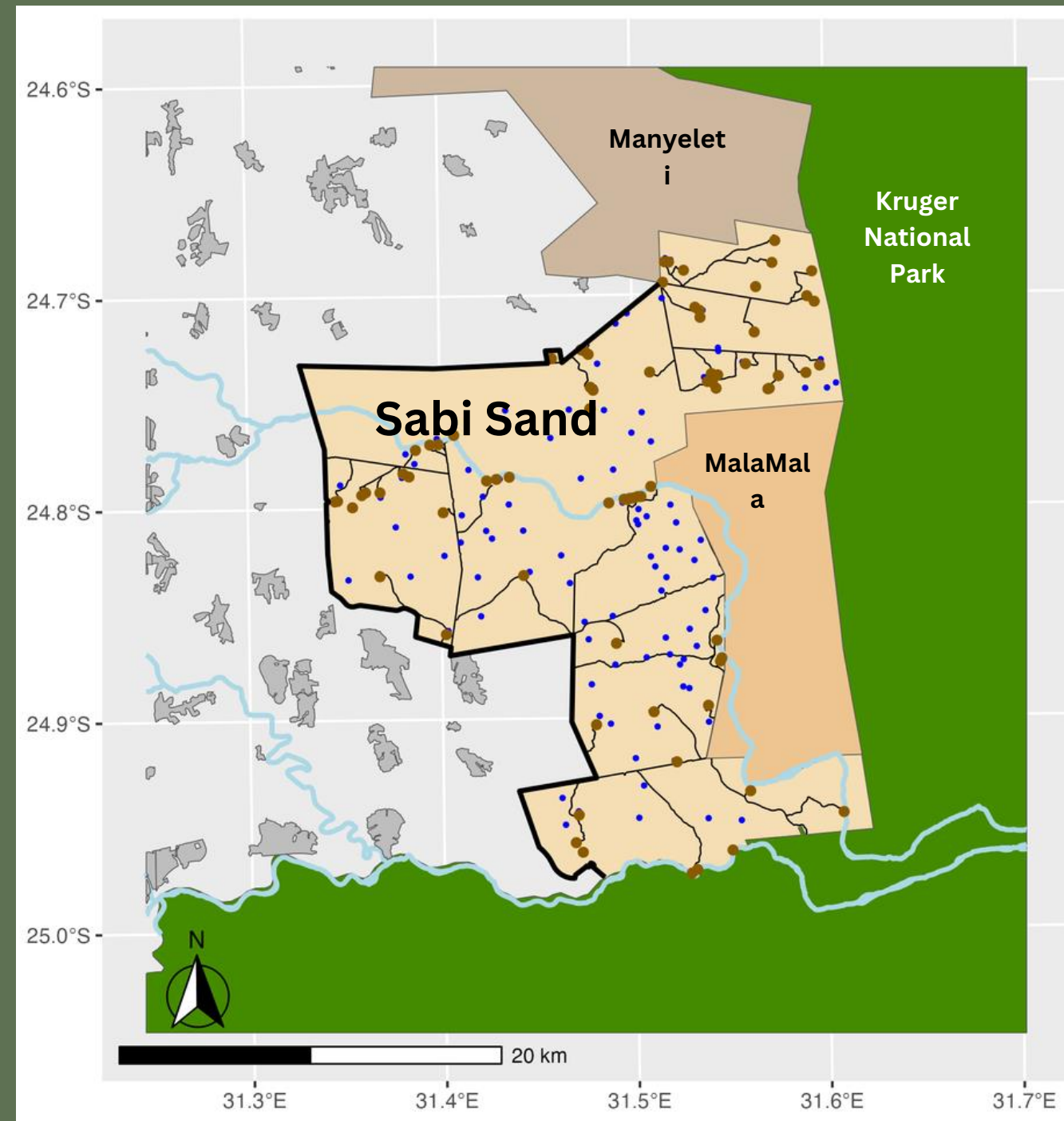
THEORETICAL BACKGROUND

Routine Activity Theory
(environmental
criminology)



STUDY SITE & QUESTION

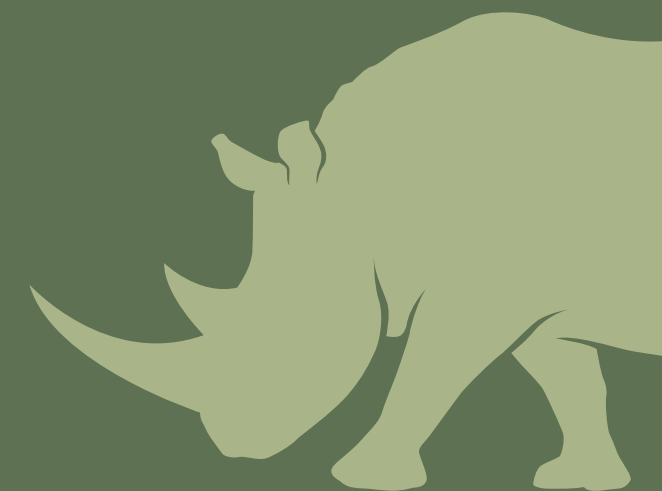
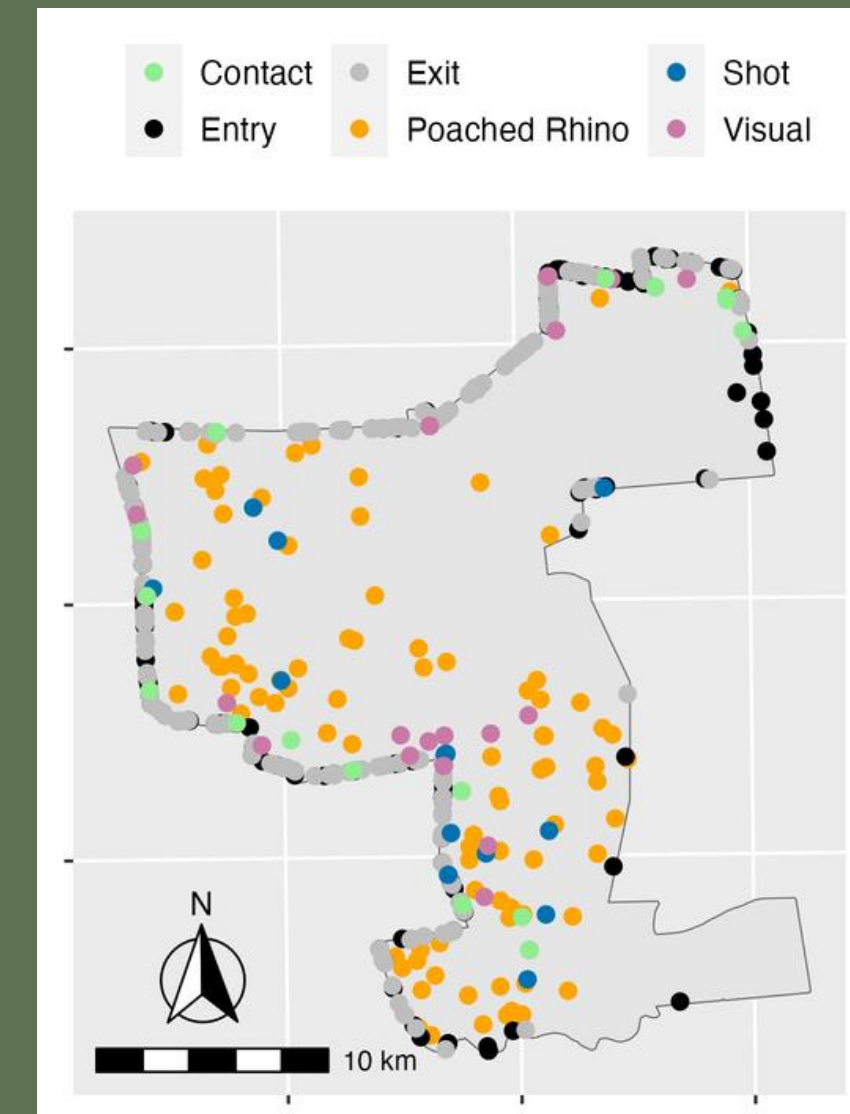
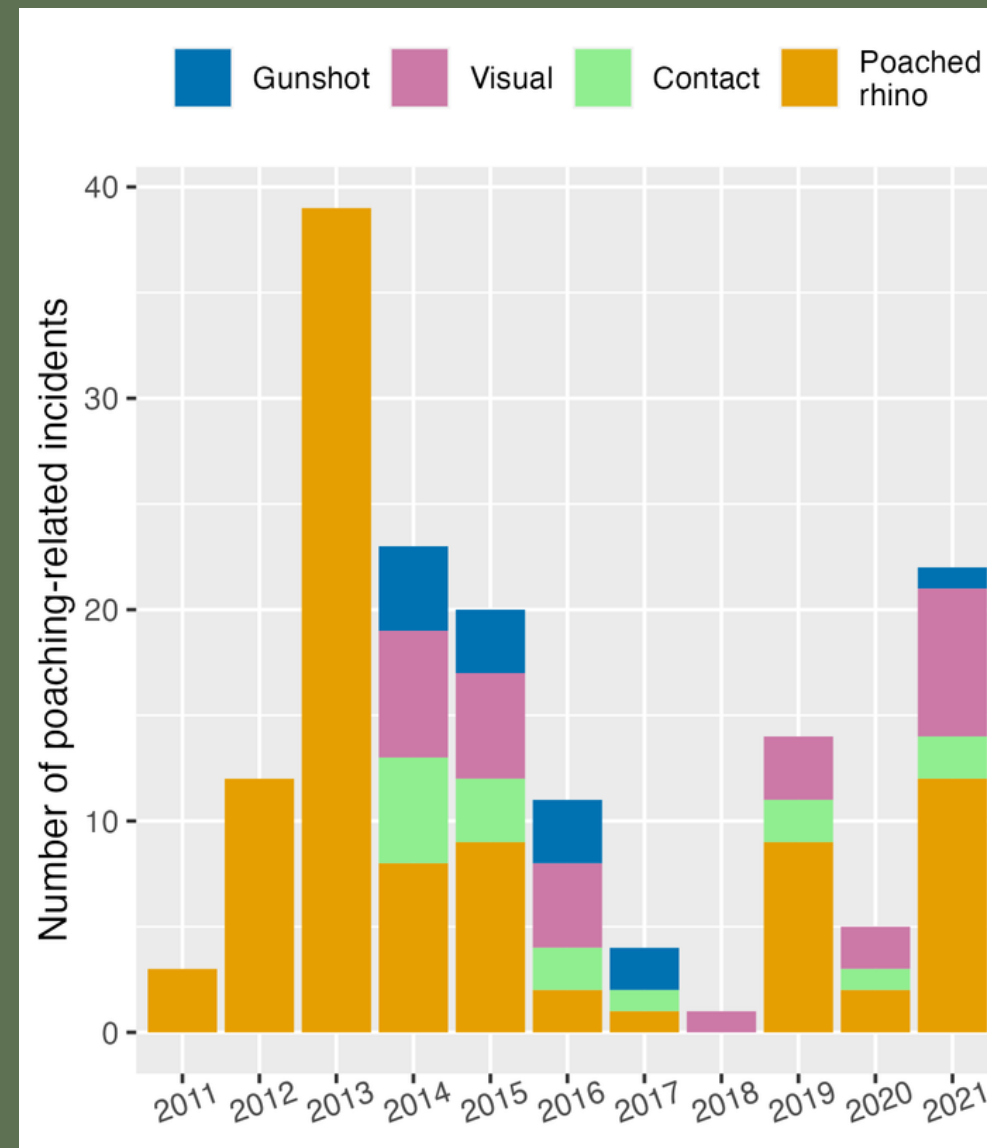
What do space-time patterns in rhino poaching reveal about the interacting behaviours of poachers and rangers?



DATA

We used data from 2011 to 2021:

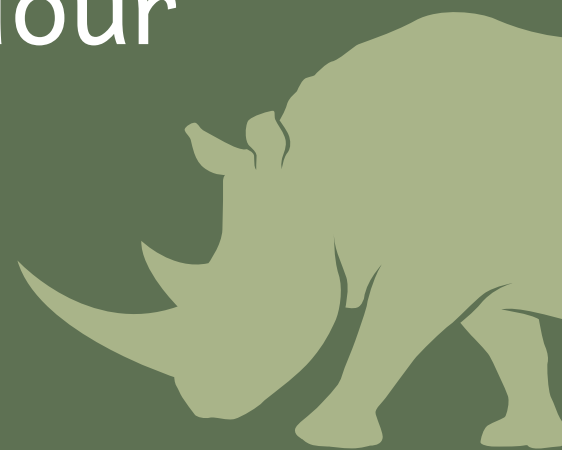
- 104 poached rhino carcasses
- 28 visuals of poachers
- 16 contacts between poachers and rangers
- 13 detected gunshots
- 164 detections of poacher fence entries
- 235 fence exits



ANALYTICAL METHODS

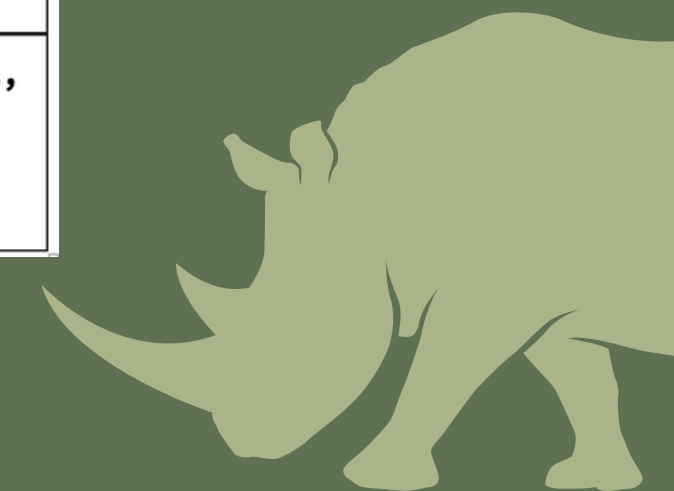
1. Spatial model to identify spatial predictors of poaching locations (logistic regression with LASSO regularization)
2. Space-time permutation models from epidemiology to identify clusters of poaching in space and time (testing for space-time dependence)
3. Analysis of poacher entry and exit pathways

Combine insights from 1–3 to better understand poacher behaviour

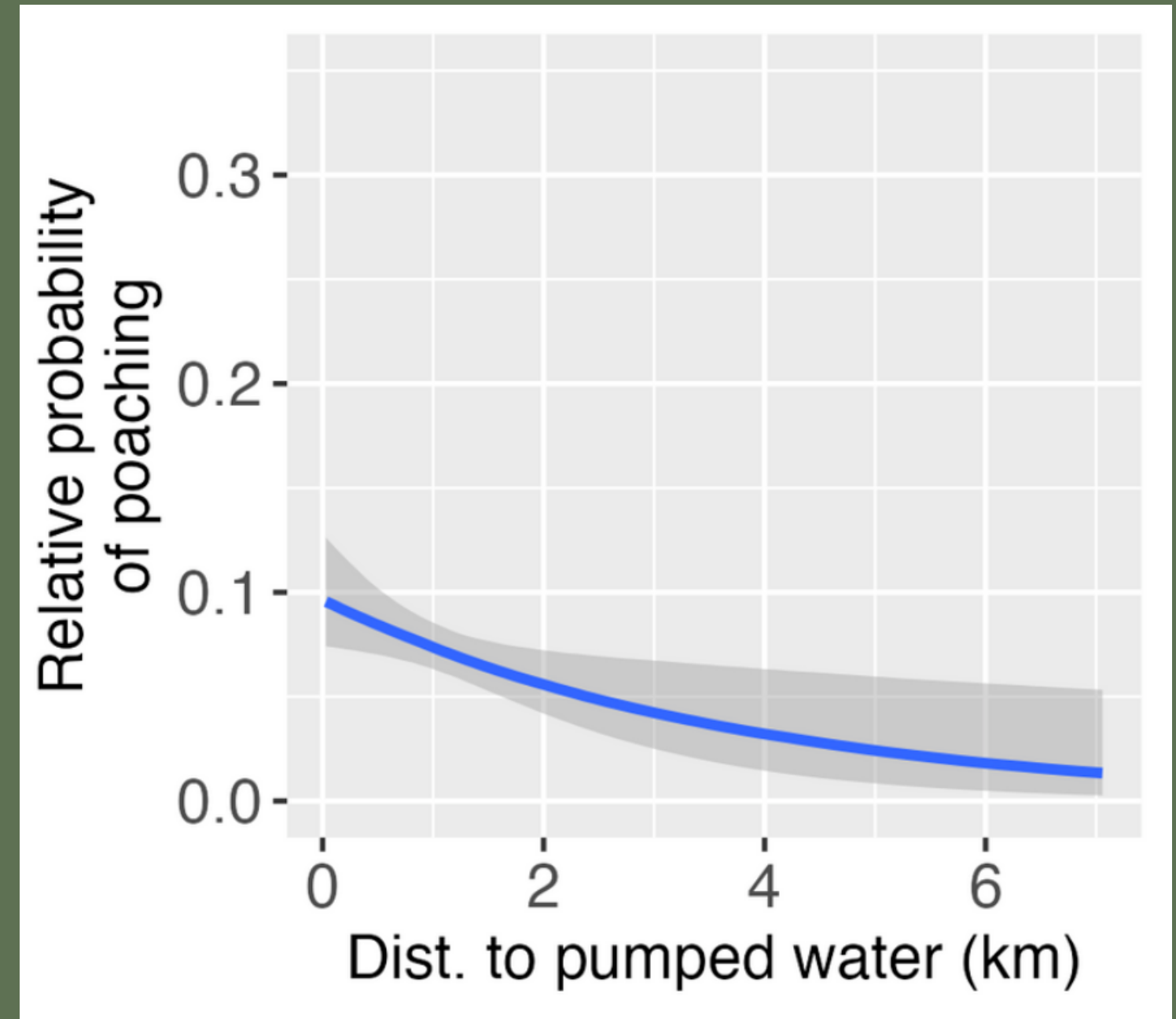
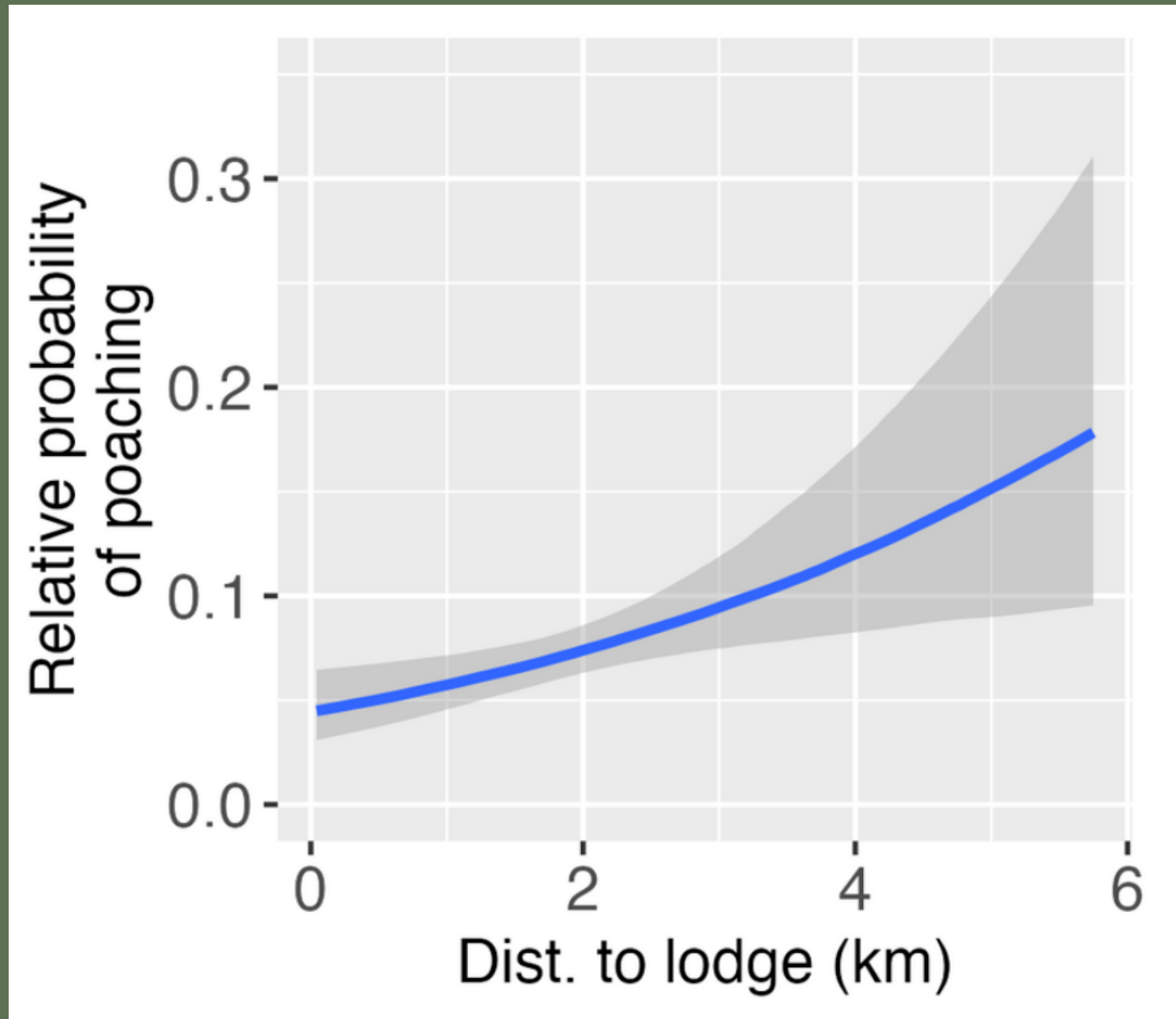


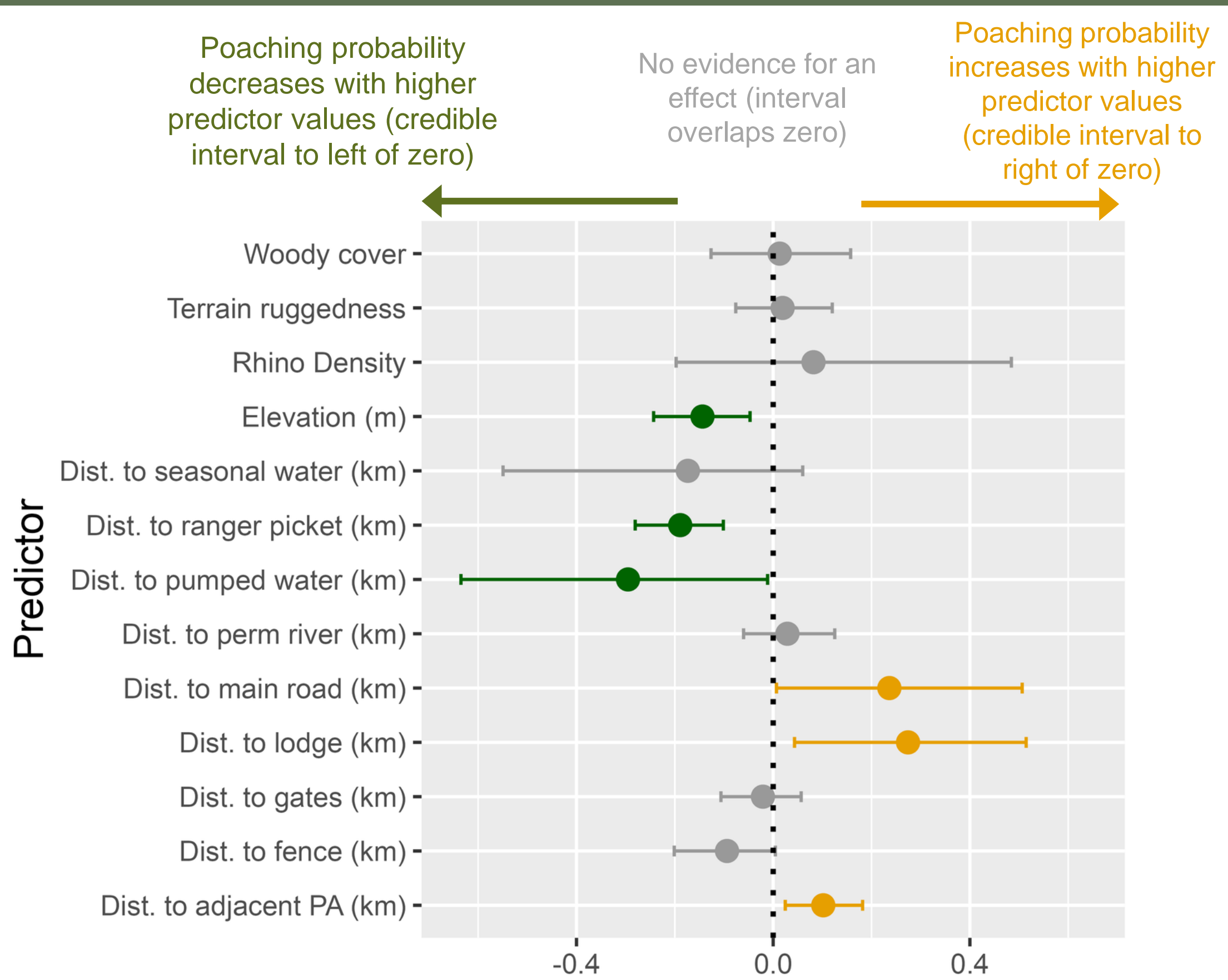
HYPOTHESIS BASED

Spatial predictor	Influences	Hypotheses (to be tested)	Direction	References
Terrain Ruggedness	All agents	Difficult to navigate for all agents. Energy and time saving to avoid.	Negative	(le Roex et al., 2020)
Distance to water source (river, pumped water sources, seasonal pans)	Rhinos, and hence rangers and poachers	Rhinos require water daily.	Negative (lower poaching as distance to water increases)	(Critchlow et al., 2015; Sibanda et al., 2015)
Rhino density	Poachers and rangers	Poachers target areas of higher rhino density.	Positive	(Critchlow et al., 2015)
Distance to tourist lodges	Poachers	<i>Detection:</i> Poachers may avoid lodges due to higher probability of detection (passive surveillance)	Positive	(Baral, 2013)
Distance to ranger picket/base	Rangers and Poachers	Detection/Deterrence: Poachers may avoid ranger bases to reduce probability of detection, which may displace or deter poaching. Conversely, rangers may facilitate poaching.	Positive or negative	(Dancer et al., 2022; Moore et al., 2018)
Distance to adjacent towns	Poachers	Accessibility: Poachers may be more likely to enter the reserve nearer towns.	Negative	(Faulkner et al., 2017)

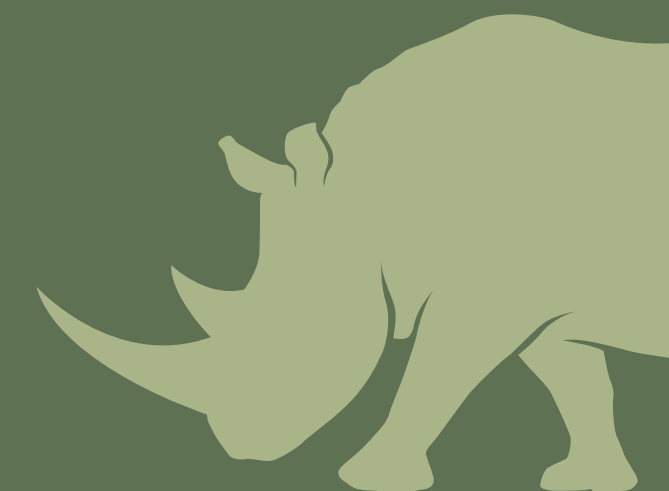


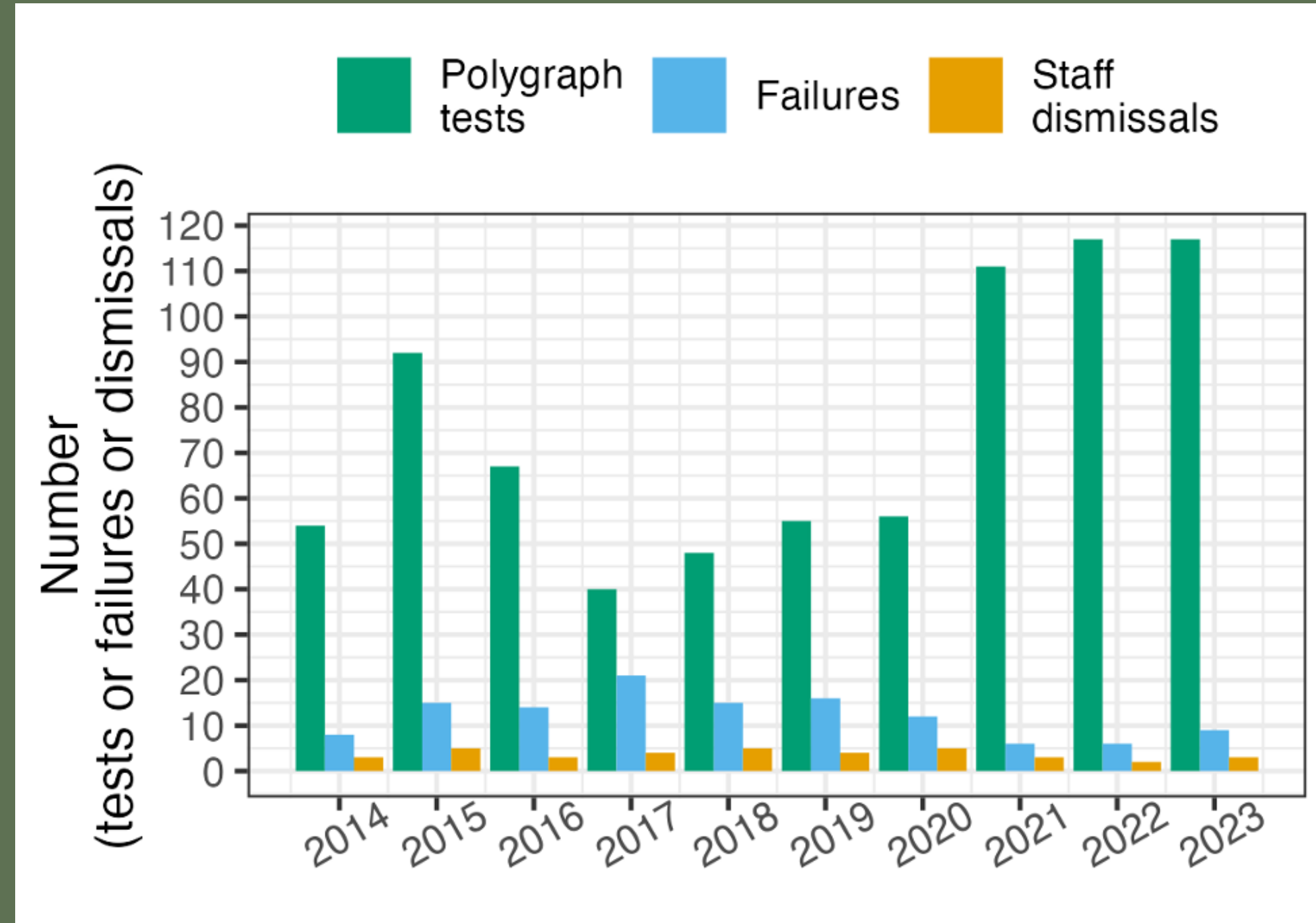
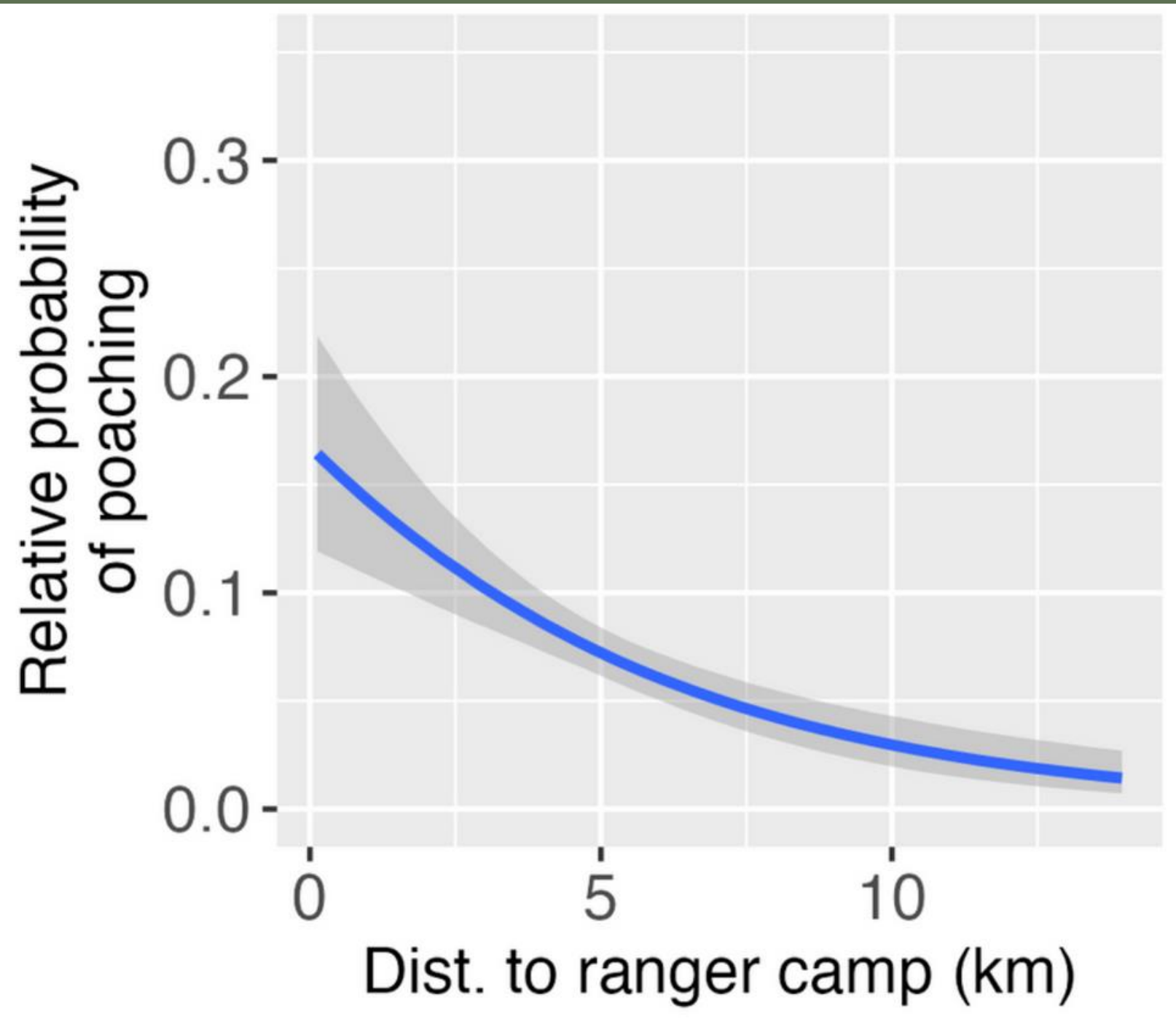
RESULTS



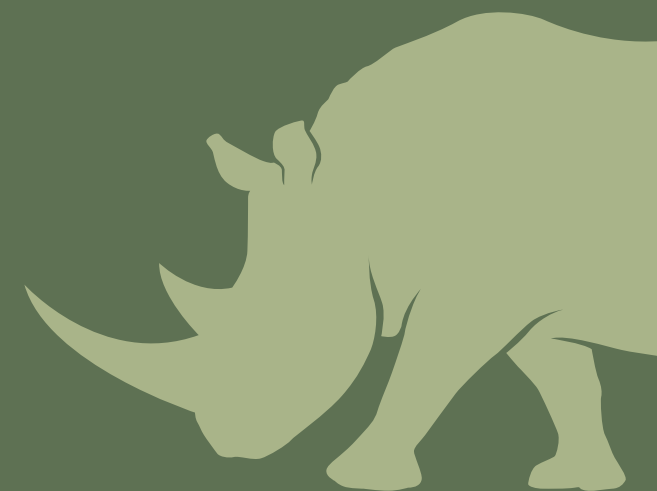


Effect on poaching (mean and 90% credible interval)



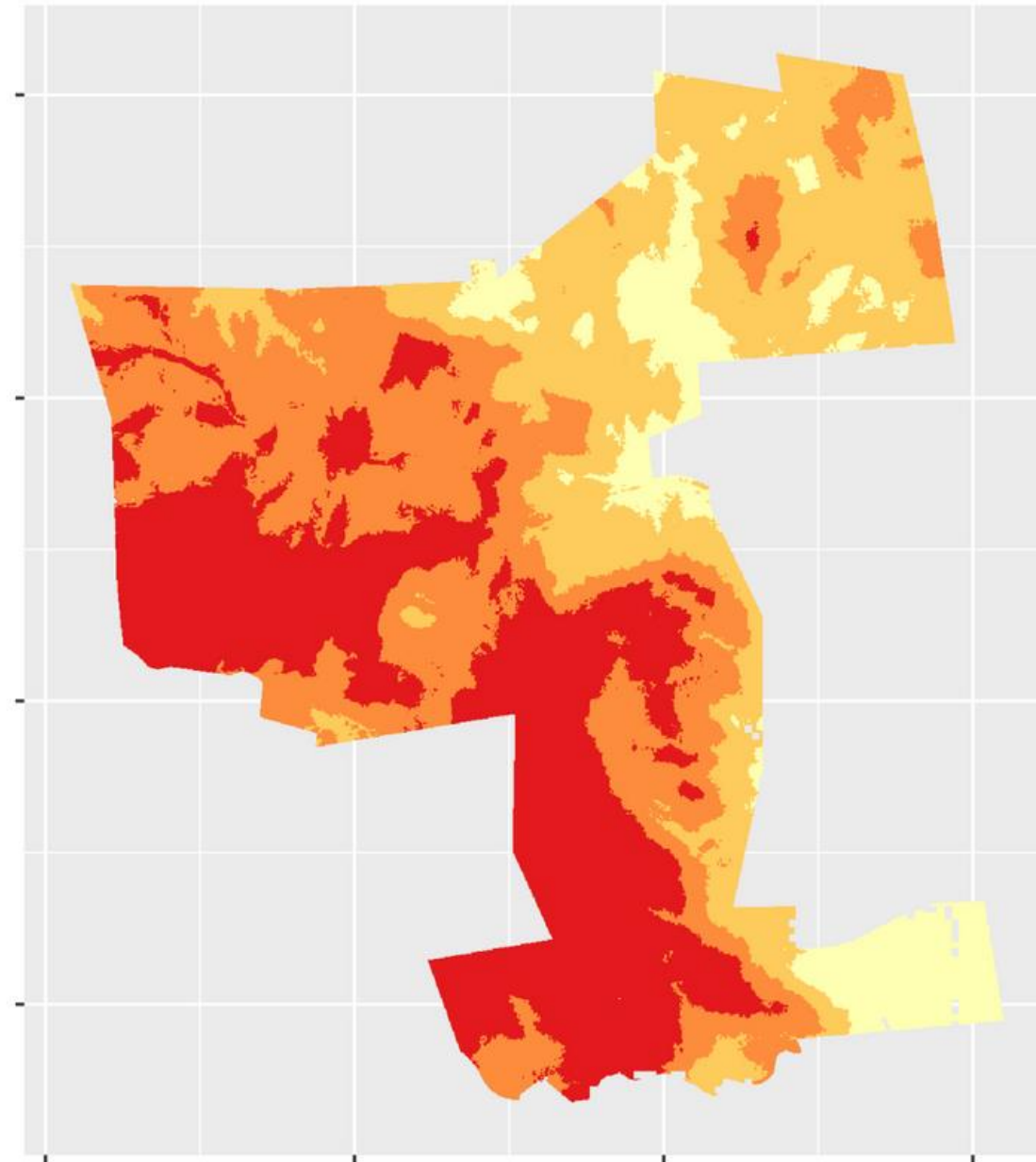
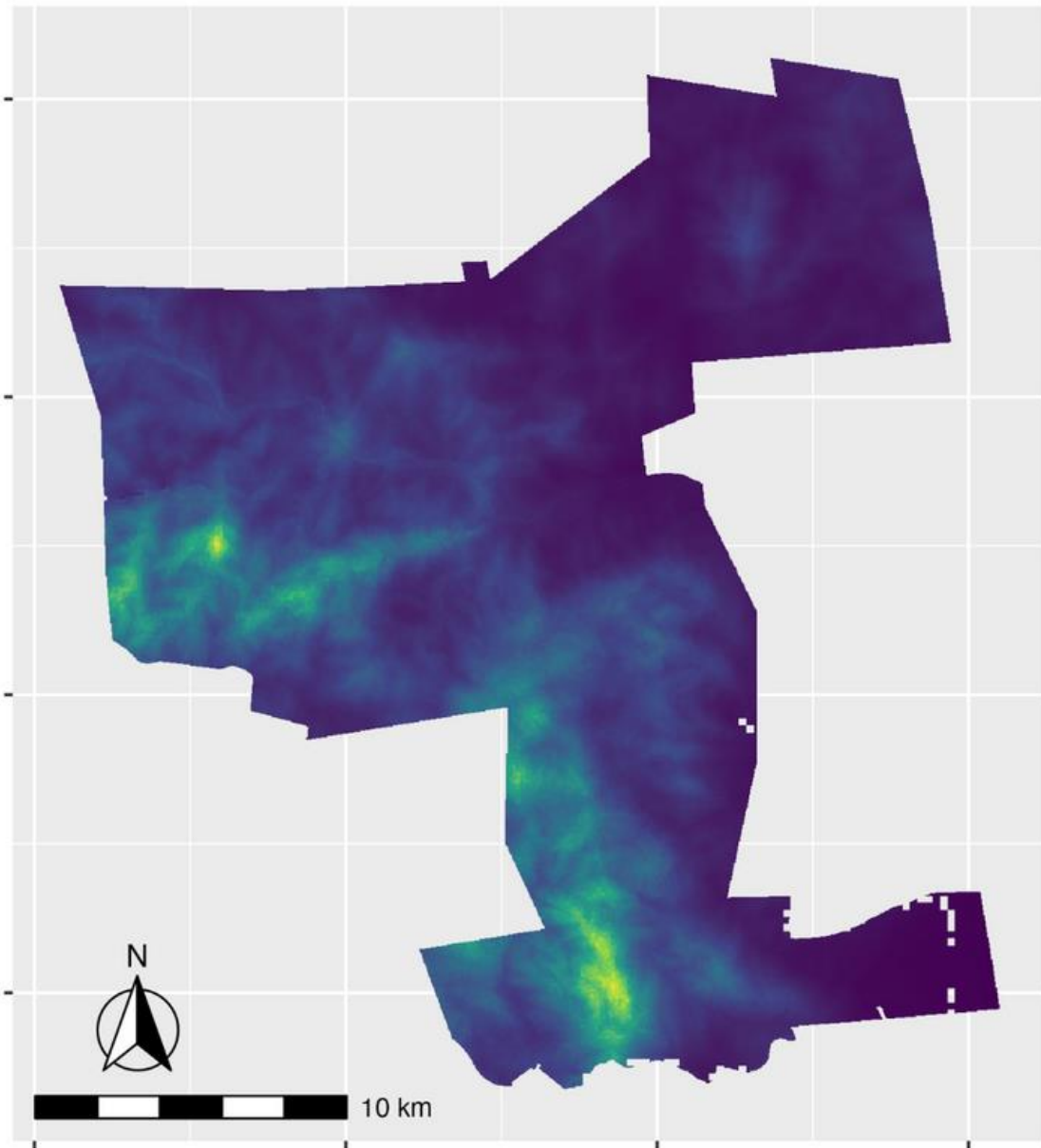
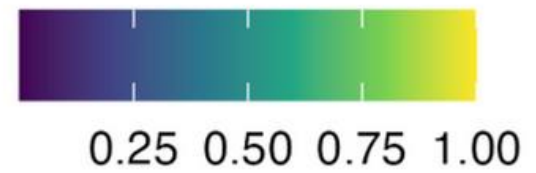


Collusion?



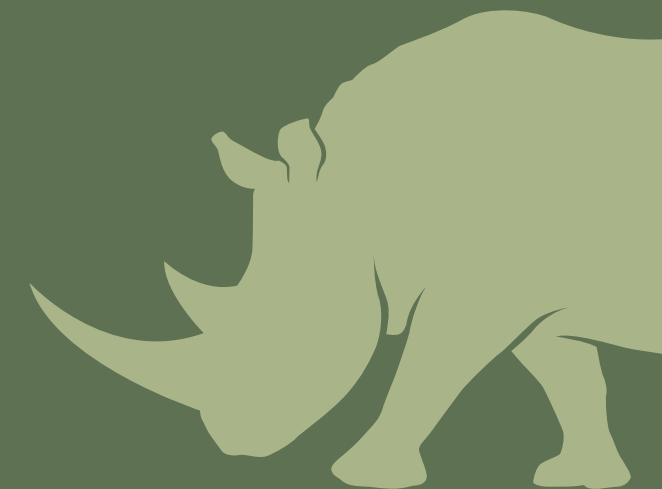
A. Poached rhino

Relative probability of poaching activity

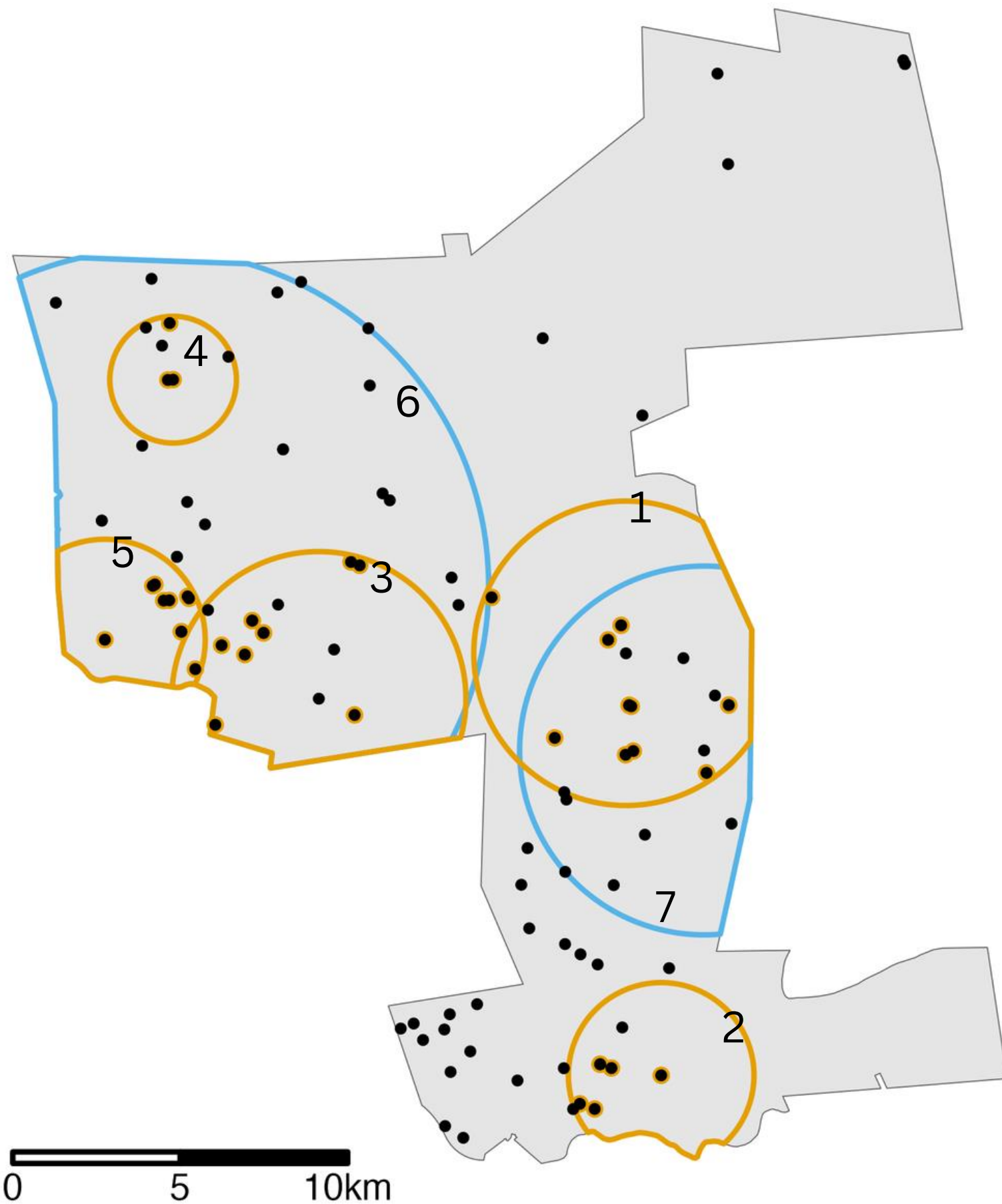


Poaching activity risk category

1 = lowest	2	3	4 = highest
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CLUSTERS OF POACHING SHIFT OVER TIME



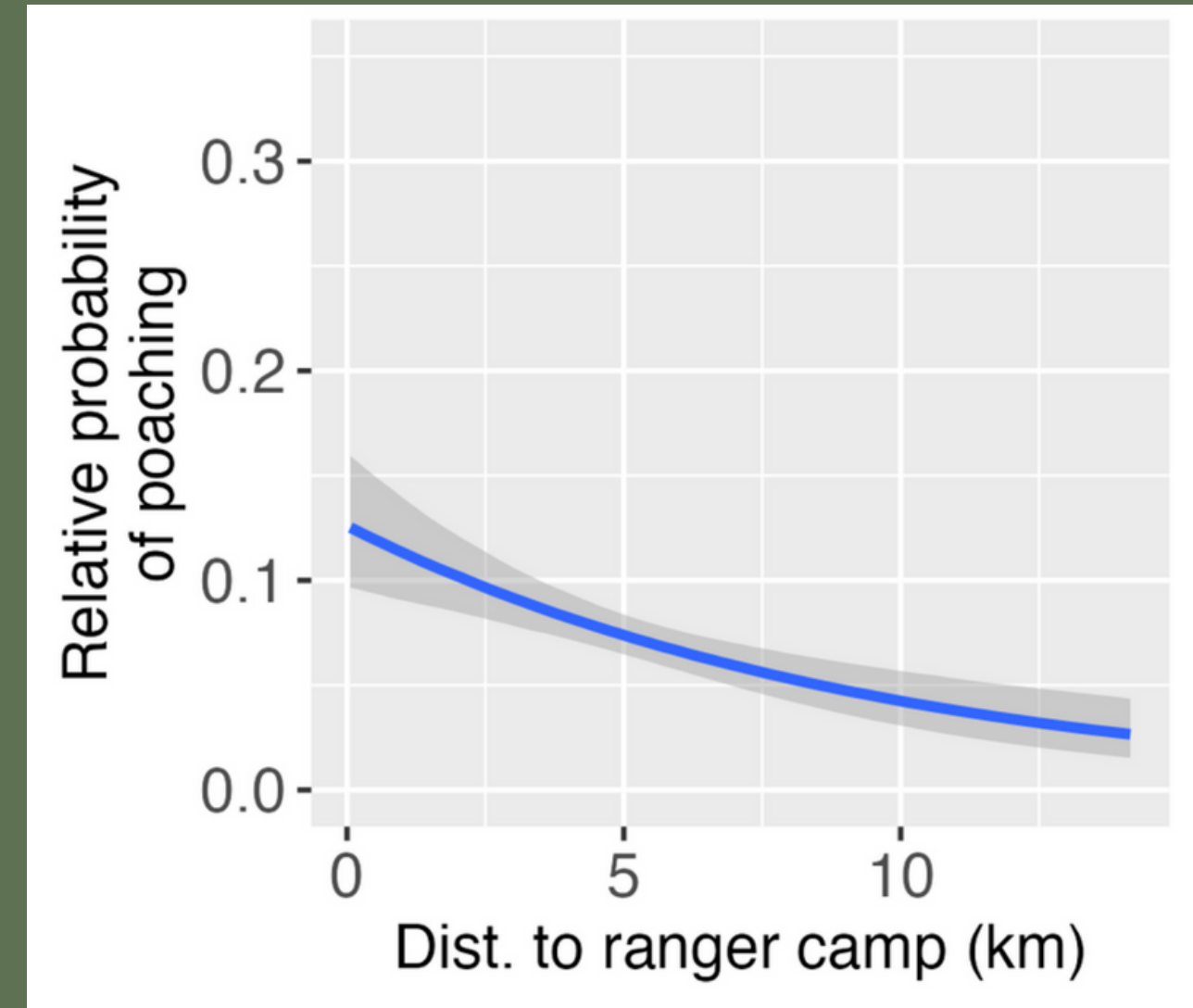
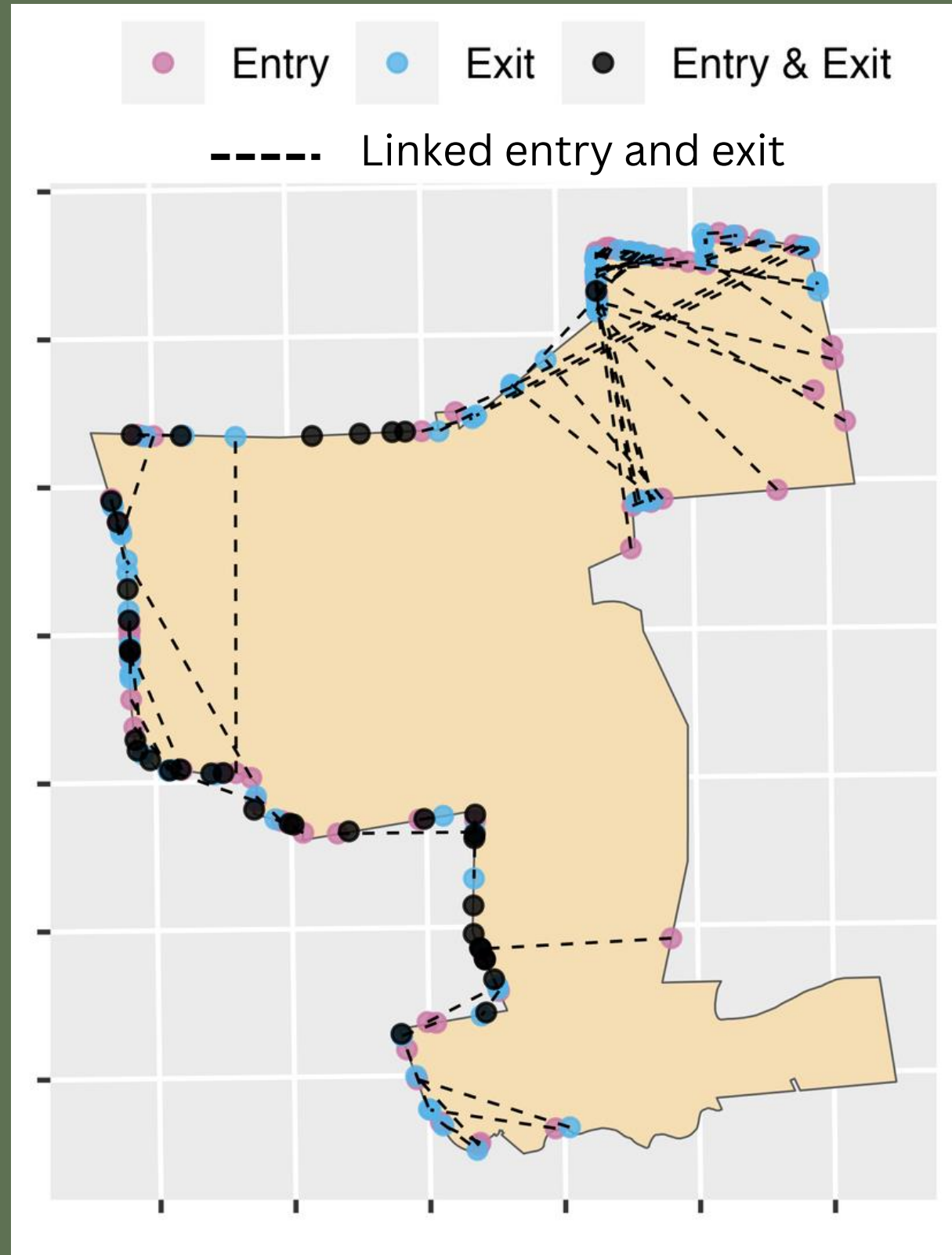
Space-time cluster	Radius (km)	Time period	No. days	Observed no. rhino poached in space-time cluster (vs. expected)	Observed no. rhino poached in spatial cluster (all time)	P-value
1	4.4	2019/08/10 - 2021/10/01	783	10 (2)	18	0.004
2	2.6	2021/05/22 - 2021/12/17	209	6 (1)	7	0.009
3	4.2	2011/02/12 - 2013/03/08	755	11 (3)	14	0.102
4	1.7	2012/12/29 - 2013/02/01	34	3 (0)	5	0.171
5	2.8	2013/05/04 - 2013/10/18	167	9 (2)	9	0.4
6	10.1	2019/07/20 - 2021/12/17	881	0 (9)	45	0.015
7	5.5	2011/02/12 - 2013/06/07	846	0 (6)	19	0.473

Example - Cluster 1

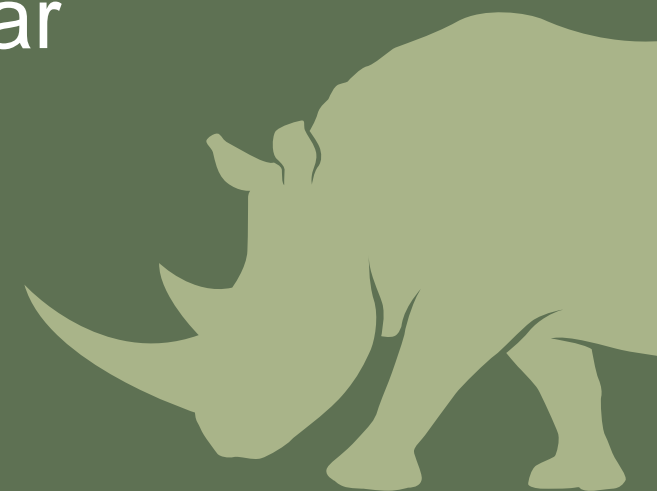
- 10 rhinos poached within a radius of 4.4km (58km²) from 10 Aug 2019 to 1 Oct 2021
- Only 7 rhinos poached across the rest of the reserve (520 km²) during same period.



RESULTS



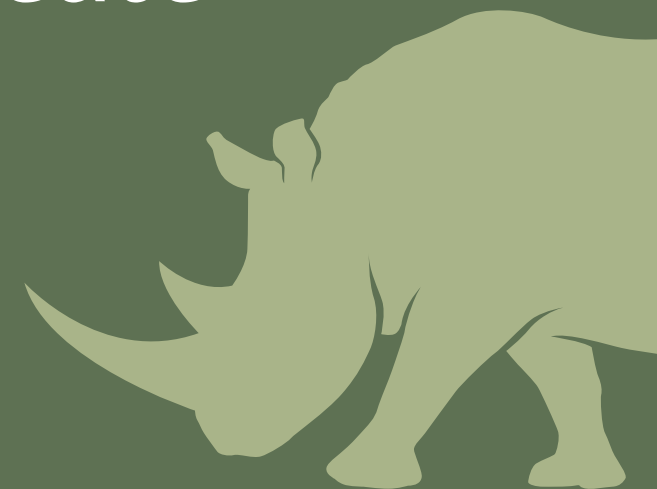
Entries also more likely near ranger camps



CONCLUSIONS

Our results lend empirical support to the following hypotheses:

1. Poachers seek to minimise the probability of detection (lodge and road deterrence effects, quick entry to exit)
2. Poachers maximise the probability of encountering suitable targets (distance to water effect)
3. Poachers take advantage of windows of low risk and high opportunity
4. Poachers may collude with law enforcement officers to create opportunities for crime



THANK YOU

1. Rangers and security managers at Sabi Sand Nature Reserve (SSNR)
2. Iain Olivier: CEO at SSNR
3. Julie Olivier: Head of Conservation at SSNR

