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Wildlife Research

Supplementary Material

Adaptive management of a remote threatened-species population on Aboriginal lands

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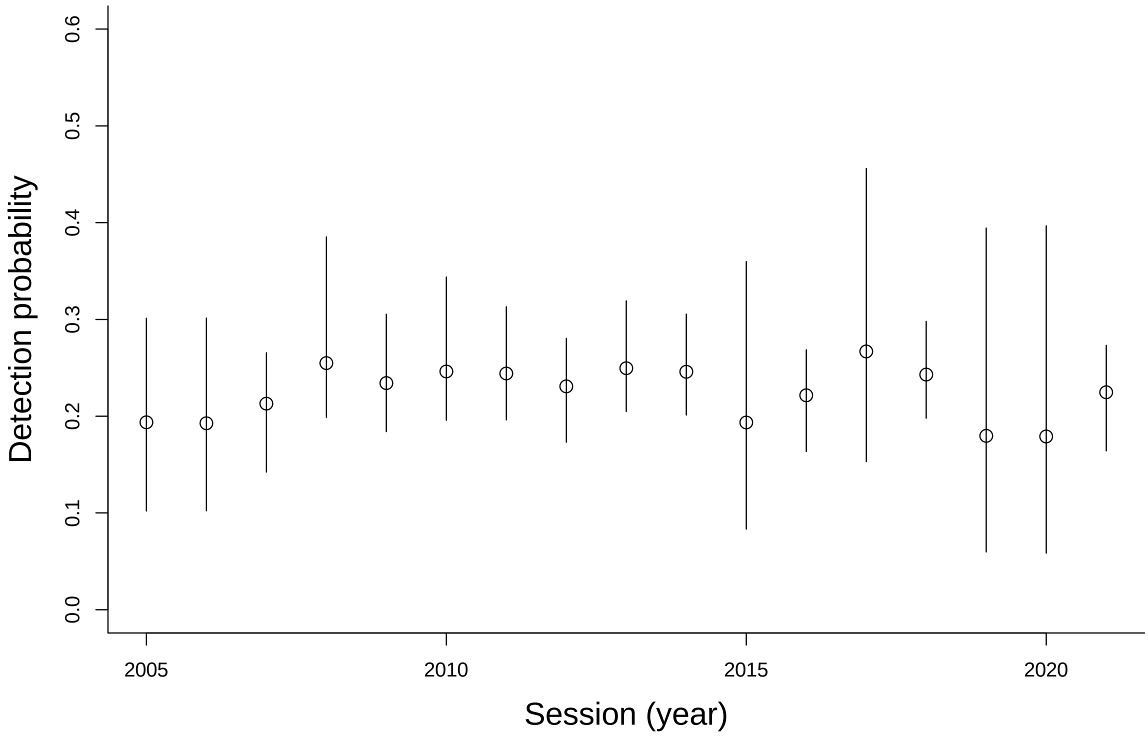
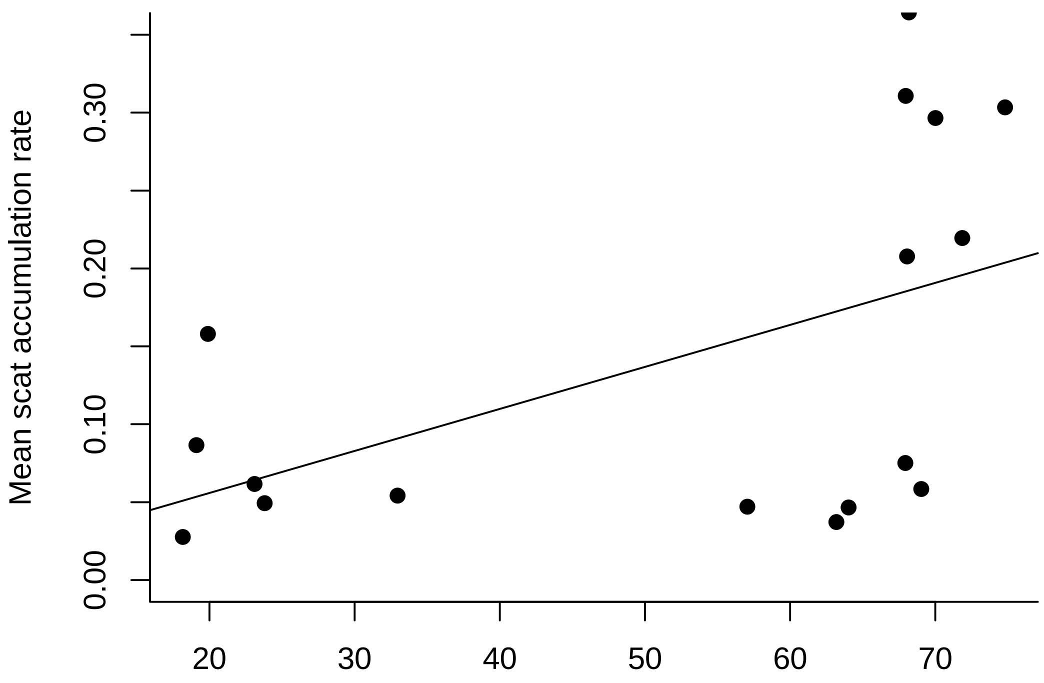
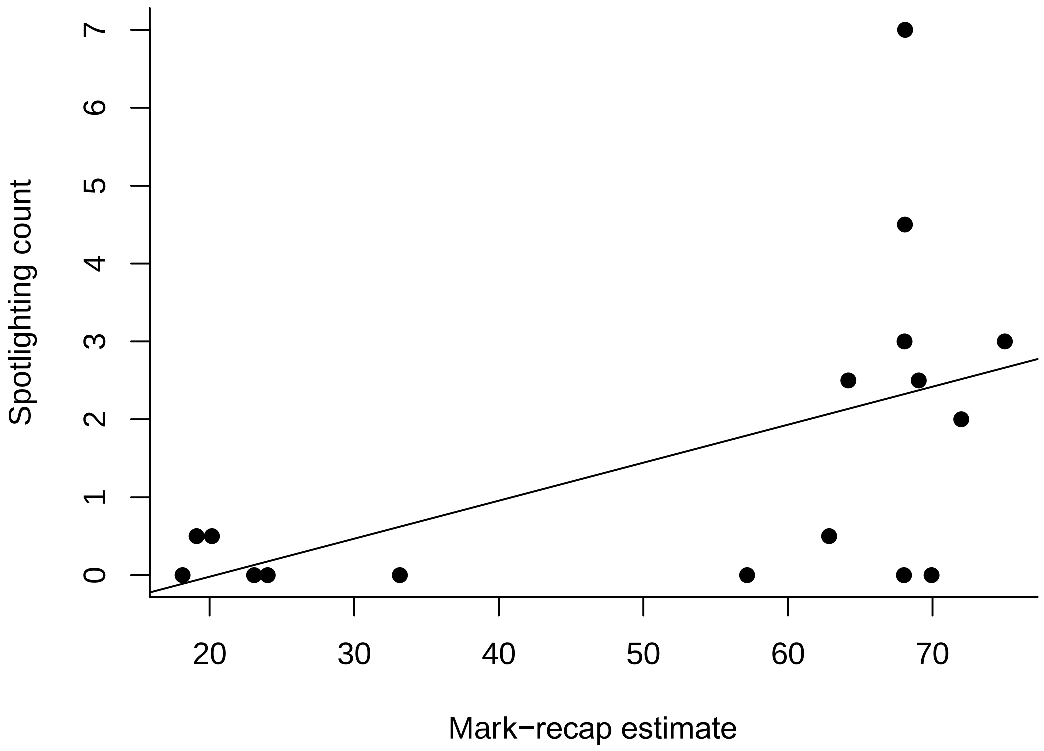


Supp. Figure S1. Individual-level warru detection probability across the mark-recapture sessions. Error bars capture the 95% credible interval for the detection probability.

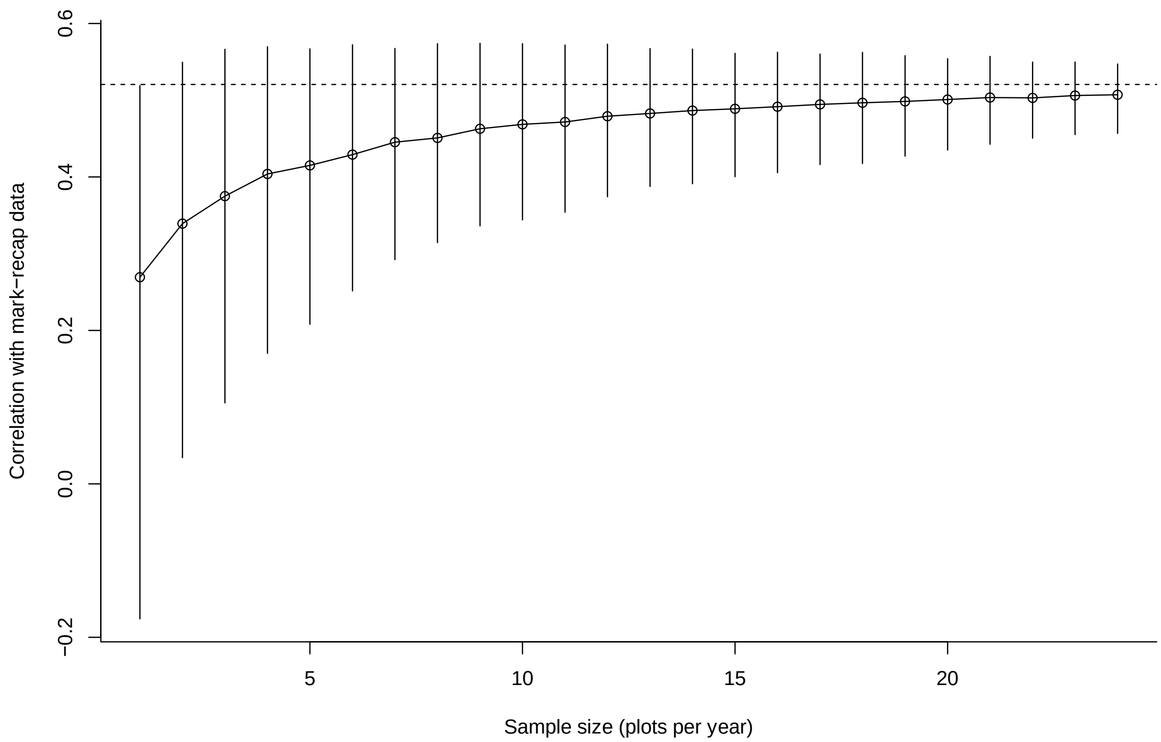
Scat index



Spotlight index



Supplementary Figure S2. Scatter plots showing the relationship between the two population indices and census population size (CMR estimate). Lines show the ordinary least squares regression line through the data.



Supplementary Figure S3. The correlation between the scat index and census population size as we vary the sample size (number of plots). Dashed line shows the observed correlation coefficient ($\hat{r} = 0.54$); error bars show the central 95% of resampled correlation values at each sample size.

Supplementary Table S1. Management strategies deployed at New Well over the study period 2000-2021 compared to BOM rainfall data from Ernabella.

	Rainfall mm	Ground bait	Aerial Bait	Shooting
2000	447	P		
2001	600	D		
2002	241	D		
2003	374	D		
2004	200	D	A	
2005	162	D	A	
2006	134	D	A	
2007	227	D	A	
2008	196	P	A	
2009	250	P	A	
2010	448	P	A	
2011	554	P	A	
2012	216	P	A	
2013	208	P	A	S
2014	165	P		S
2015	174		A	S
2016	545			S
2017	376			S
2018	224			S
2019	66			S
2020	181			S

2021	264			S

Supplementary File for Review **- Mark recapture analysis**

The mark-recap data is assigned to sessions (denoted s), and trap night within session (denoted t). An individual (denoted i within session) can only be observed once per trap night. Our observation model, describing whether or not an individual is observed, O_{ist} as,

$$O_{ist} \sim \text{Bernoulli}(p_{ist})$$

where p_{ist} is the probability of an individual being observed on trap night t of session s. We then define an upper value for the number of animals, N^* (Royle and Dorazio 2008), and we define a latent variable, Ω_{is} that describes whether each of these potential animals (indexed by i) is actually present in the population in that session,

$$\Omega_{is} \sim \text{Bernoulli}(\omega_s)$$

This allows a different number of individuals to be present in each session. The probability of observation of each potential individual is then,

$$p_{ist} = \Omega_{is} \times d_r$$

Where d_s is the individual-level detection probability in session s. In this way, potential individuals that are not present ($\Omega_{is} = 0$) set the observation probability p_{ist} to 0.

Our population size in each session is then the sum of our latent variables, $N_s = \sum_i \Omega_{is}$.

We account for the effect of varying trap effort on detection. To do this, we make detection a function of the number of traps deployed in a session, x_s and year,

$$\text{logit}(d_s) = \mu_d + \beta_d x_s + \epsilon_s,$$

where μ_d and β_d are parameters to be estimated (intercept and slope, respectively), and ϵ_s is a random effect of session (i.e. year), with variance $1/\tau_d$). This random effect accounts for changes across years that affect detection (for example variable food, cover, or behaviour).

To make inference on the effect of rainfall and management on population dynamics, and to assist with inference in years when mark-recapture was not undertaken, we link population size across years using the Ricker population map:

$$n_{s+1} = n_s e^{r_s(1-n_s/K)},$$

Where n is the expected population size in a given year, r_s defines the low density growth rate of the population in each year, and K defines the carrying capacity, which we assume constant across years. We define n_1 as a latent variable having a prior given by a Poisson distribution with a mean of 30; this prior came from a simple analysis of the year 1 mark-recapture data. In subsequent sessions, n_s is defined by the Ricker map. We then re-define $\omega_s = \frac{n_s}{N^*}$ to link population size into the mark-recapture model.

The time varying growth rate, r_s, is defined using a simple multiple regression model where:

$$r_s = \mu_r + \beta_p x_{p,s} + \beta_c x_{c,s} + \epsilon_{r,s},$$

where μ_r is the intercept, $x_{p,s}$ is the annual rainfall occurring in year s, $x_{c,s}$ is the control type in year s (shooting, or no shooting). The β terms are coefficients to be estimated and $\epsilon_{r,s}$ is an error associated with each year, drawn from a normal distribution with a mean of zero and variance $1/\tau_r$.

We fitted the model in a Bayesian framework, using JAGS (Plummer 2023). We used minimally informative priors (Supplementary Table S2), following the advice of Lunn *et al.* (2000) for minimally informative priors under a logit link. We ran three MCMC chains and checked for convergence by eye (using traceplots) and using the Gelman-Rubin statistic. Convergence was reliably obtained following a burn in of 30,000 iterations and with a further 40,000 iterations sampled every 20th iteration.

Supplementary Table S2. Parameters estimated in the models, and their prior distributions.

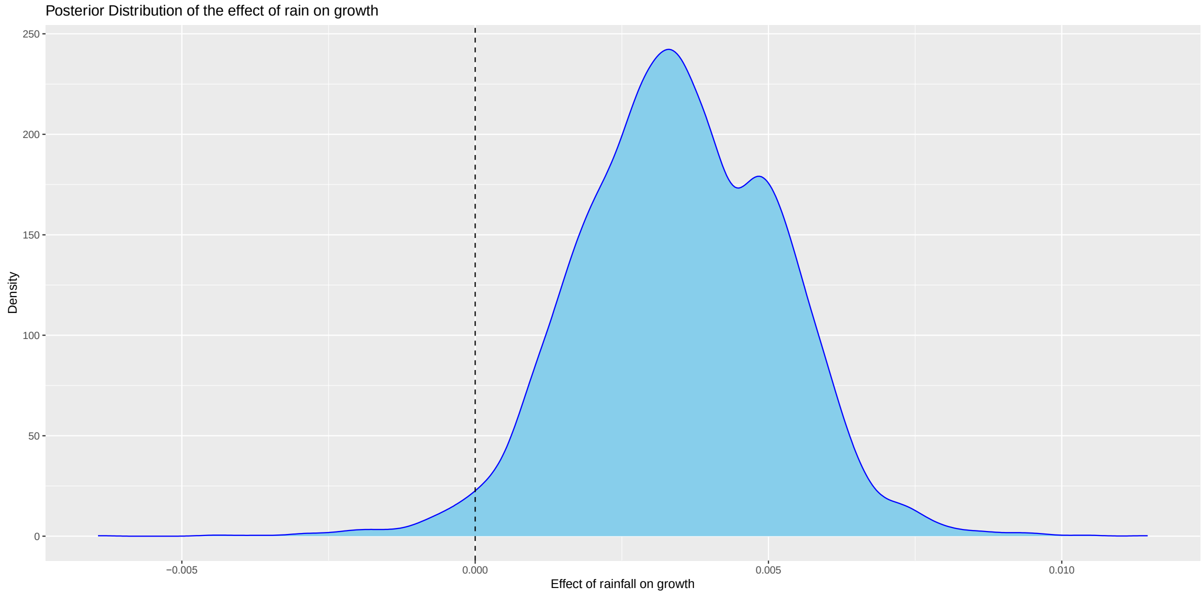
Parameter	Prior
μ_d, β_d	$\mathrm{N}(0, 2.71^2)$
μ_r, β_p, β_m	$\mathrm{N}(0, 10^6)$
τ_d, τ_r	Gamma$(0.001,0.001)$
N_1	Uniform(0, 100)
K	Uniform(0,200)

Supplementary Table S3. Details of trapping, and posterior parameter estimates of population size (lower, upper, and median of the posterior distribution) from the mark-recapture model.

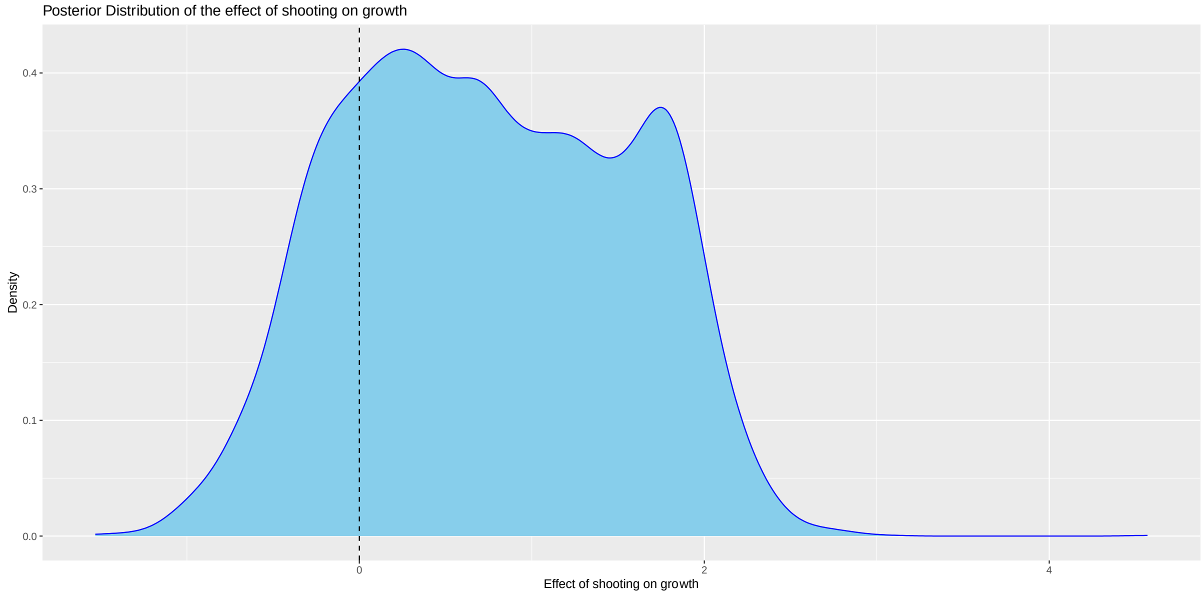
Year	Trap nights	Lower	Median	Upper
2005	44	14	20	35
2006	44	12	19	31
2007	120	19	23	29
2008	120	14	18	23
2009	120	20	24	30
2010	80	26	33	43
2011	100	46	57	72
2012	104	51	63	79
2013	104	54	64	78
2014	104	58	69	82
2015	0	51	68	87
2016	104	61	72	88
2017	0	49	68	89
2018	104	65	75	91
2019	0	42	68	89
2020	0	52	70	90
2021	104	56	68	85

Supplementary Table S4. Posterior parameter estimates for the parameters (lower, upper, and median of the posterior distribution) from the mark-recapture model.

Parameter	Lower	Median	Upper
μ_d	-2.659	-1.525	-0.470
β_d	-0.029	0.015	0.063
τ_d	4.052	46.467	7919.7
μ_r	-1.377	-0.530	0.261
β_p	-0.000195	0.00345	0.00658
β_c	-0.668	0.708	2.135
τ_r	1.643	133.264	11200.5
K	59.056	68.947	85.39



Supplementary Figure S4. Our estimated posterior distribution for the effect of rainfall on population growth in warru. 98% of the posterior distribution falls above 0.



Supplementary Figure S5. Our estimated posterior distribution for the effect of shooting on population growth in warru. 79% of the posterior distribution falls above 0.