Assessment of male koala density in private native forest near Bulahdelah

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Introduction

The Forest Science team from NSW DPI were requested to process acoustic recordings and estimate male koala density from data collected using an array of sensors deployed in semi-cleared private native forest near Bulahdelah. Below we provide a description of the methods used and report on the results.

Methods

Acoustic sensors (Song meter SM4) were deployed in an array (approximately 5 x 5 with spacing ~400 m between sensors, though this did vary across the array) in spring 2023 to model male koala density. The spacing was selected to allow for correlated detections between adjacent sensors as required by Spatial Count models. A single acoustic sensor was deployed at each plot for ~11 nights in October - November, the breeding season for koalas and when males are most vocal. Sensors were programmed to record from sunset until sunrise, the peak calling period of koalas, with a sampling rate of 22,050 Hz, and resolution of 16 bits per sample.

Koala call analysis

Acoustic files (.wav) from each sensor location were scanned for male koala bellows in AviaNZ software using an algorithm developed by DPI to detect male koala bellows in .wav files (Version 4 (Koala_CNN_LG_010822; https://www.dpi.nsw.gov.au/forestry/science/forest-ecology/fauna-identification-service).

Spatial count model specifications

SC models use spatial correlation in temporally replicated counts across occasions K (nights in our case) to estimate the number and location of the activity (i.e., home range) centres instead of individual identification of animals. Specifically, N (abundance) is estimated as a subset of data augmentation variable M, an oversized population of which our population is a part (Royle and Dorazio, 2012). Abundance is estimated by summing inferred activity centres and density (D) is calculated by dividing N by the estimated study area, or state-space S, that encompasses potential activity centres for all individuals with a non-negligible probability of being detected by our detector traps over the study period.

In addition to estimating density, SC models, like all SCR models, also estimate the baseline encounter rate —$\lambda0$, the probability of encounter of an individual if their activity centre is at the detector location— and a spatial scale parameter — σ, a measure of the rate of decay of encounter as the distance between the activity centre and the detector location increases (Royle et al., 2014). The σ parameter is thus related to home range size and it is recommended that detectors are placed ~2 σ apart (Clark, 2019; Sun et al., 2014). We considered the detector locations, plus a 750 m buffer (to account for animal movements and transmission of bellows from outside the array) around the minimum rectangle envelope defined by the detector locations J, as the state-space S (~1172 ha) within which we estimated density. Our models did not consider potential habitat differences within S. We applied SC models using Poisson encounter models assuming bivariate normal movement in a Bayesian framework (Chandler and Royle, 2013). We ran SC models using JAGS (ver 4.2.0; Plummer, 2003), interfacing through R using the rjags package (Plummer, 2016). We specified a λ 0 prior with a uniform distribution between 0 and 100, a ψ prior with a beta distribution, shape and scale set to 1. We trialled three different σ priors: one weakly informative (calculated for a home range size ranging between 10-40 ha, and two strongly informed priors (site-specific home range of 10 ha and 20 ha. The weakly informative prior accounts for the fact that koala home range size is unknown in the study area. All σ priors assumed a gamma distribution with the shape and spread varying based on home range size. For each model, we set M = 500 after trialling smaller values. We ran one chains of the JAGS models for 50,000 iterations with a burn in of 10,000 (after an adaptive phase of 1,000) and did not thin the posterior distribution. Model convergence was assessed by calculating the Gelman-Rubin statistic using the R coda 200 package (Plummer et al., 2006), where values <1.1 indicated model convergence. Modelled male koala density was also visualised to explore the spatial variation in density.

Results

In all, 736 koala bellow detections were made across all sensors and nights of survey. However, the spatial distribution of detections was not uniform within the array (Fig. 1).

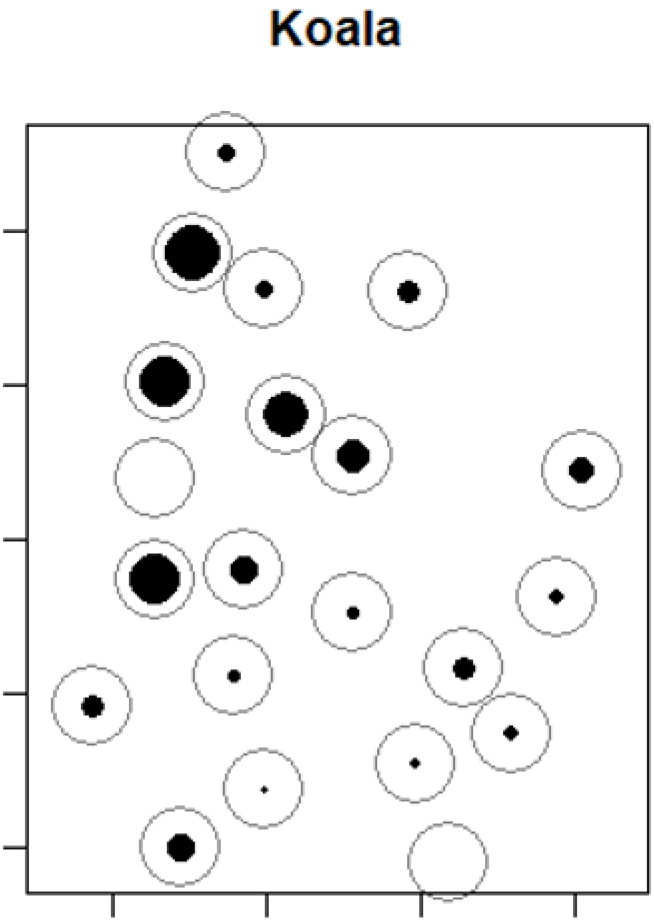

Fig. 1. Spatial visualisation of koala calls per site, with black filled circles scaled to the number of calls detected.

Male koala density was estimated to be between 0.08 and 0.13 males per ha depending on which prior was used in the model (Table 1). Given limited information is available on the home range of male koalas in private native forest within semi-cleared landscapes, the estimate for the weakly informative prior model should be considered as a good approximation as this model encompasses a range of plausible home range sizes for male koalas.

Table 1. Density (no. of males per ha) estimates using three different priors.

model	Mean	CI_25	CI_75
KSI1 (10 ha prior)	0.076593	0.051198	0.09301
KSI2* (20 ha prior)	0.129655	0.072531	0.157861
KWI1 (10-40 prior)	0.129534	0.079357	0.160421

* indicates model convergence issues.

A density map revealed that male koala density varied within the extent of the array, with highest densities observed in the northwest and lowest densities in the south and southeast (Fig. 2).

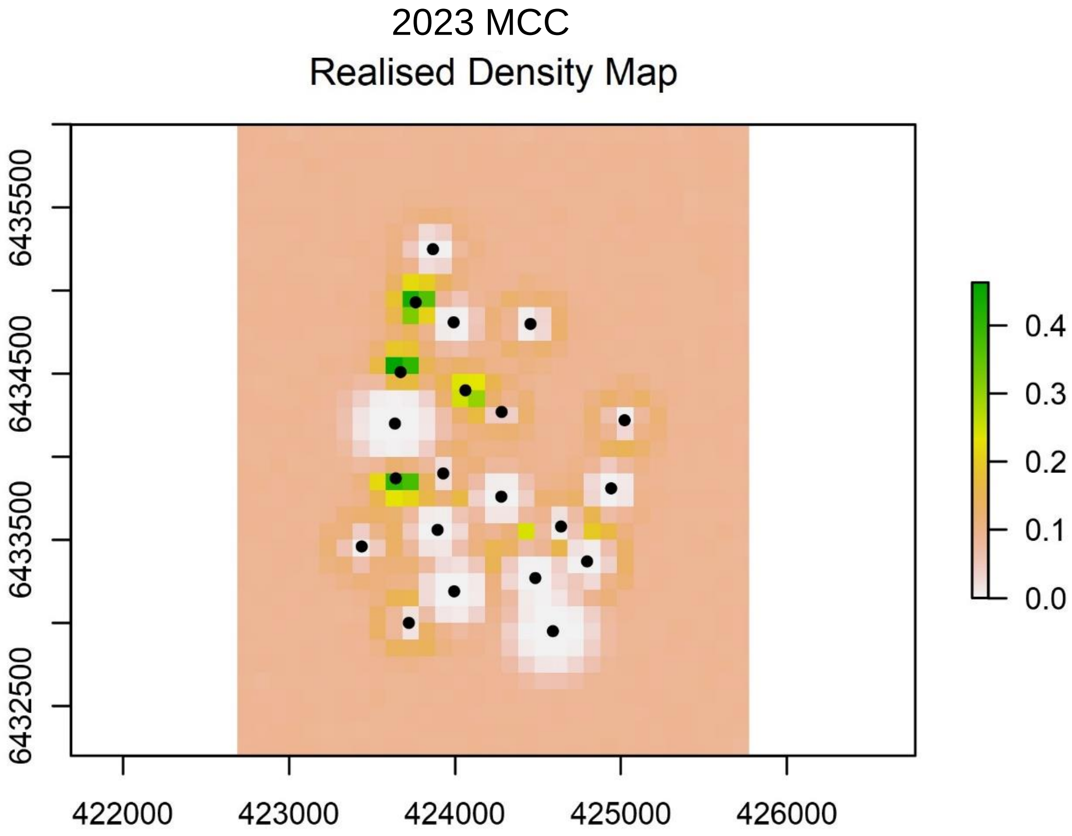

Fig. 2. Map of male koala density.

Discussion

- Estimated male koala density in the semi-cleared private native forest near Bulahdelah can be considered high and was comparable to estimates for a similar landscape (Bootawa) near Tinonee/Mondrook in 2021. More recent estimates for Bootawa are about 50 % lower than the estimates in this study when the weakly informed prior model is used.

- The density estimate for the Bulahdelah site is higher than that recorded pre-fire (2019) in the nearby Kiwarrak State Forest (0.07 males per ha) (Law et al. 2022). In comparison, koala density estimates based on acoustic arrays were considerably lower in other regions of NSW, for example Upper Nepean (0.03 males per ha), western Southern Highlands (0.01 males per ha), north coast wet sclerophyll forest (0.05 males per ha) and south coast forest (0.04 males per ha) (Law et al. 2021). An exception was a productive open woodland site at Gunnedah (0.32 males per ha) (Law et al. 2021).

- Density estimates are based on the total area covered by the array, not the area of forest present. While this is realistic considering koalas use fragmented landscapes, including paddock trees, it does mean true density estimates for forested portions are much higher than the overall mean for the array. This can be seen in the mapped estimated density, where certain local areas support considerably higher density. While estimated density in this map should not be interpreted at too fine a scale (e.g. individual pixels), some areas of contiguous pixels clearly had a high estimated density of male koalas (0.4 males per ha).