



Koala Distribution and Abundance

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Region
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Photo: C Geddes

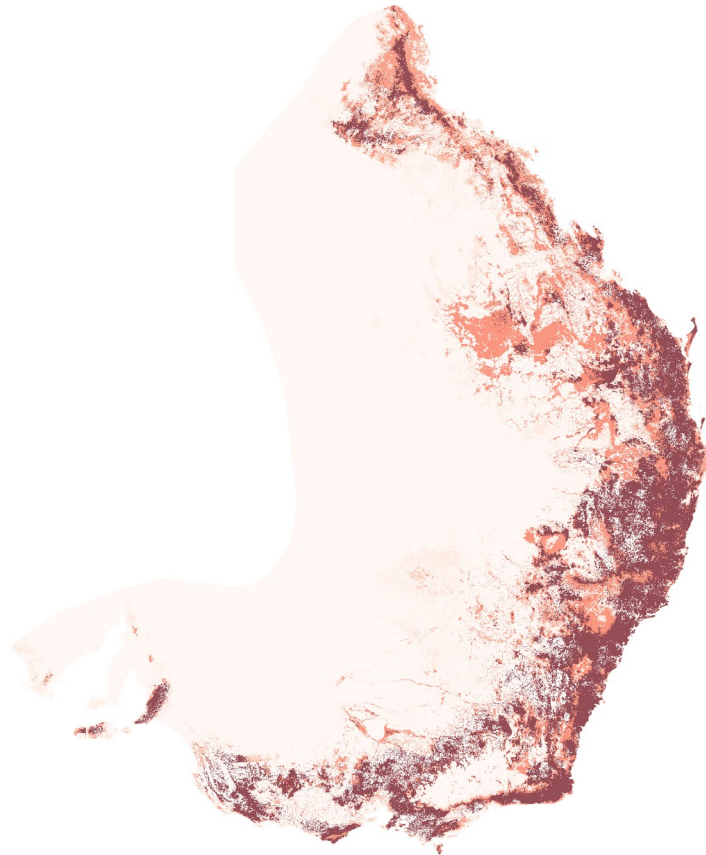


I would like to acknowledge the Traditional Owners of the land that we're meeting on today, and pay my respect to their Elders past, present and emerging.



Koalas

- Extremely well-known Australian Native
 - Cute
 - Emotive
- Distributed throughout forests in Eastern Australia
 - Not Tasmania
- Known to feed on ~100 species of gum trees



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- Here's a picture
 - (Naw, isn't it cute?)



Photo: C Geddes

Koala Distribution and Population(s)

- Some koala locations are ‘well known’, others ‘less known’.
- What about where koalas aren’t?
- Relative densities/abundances
- Varied Population Estimates
 - Expert-based and some data-based
- General trend in *estimates* is downward

Year	2001	2012	2012	2014	2018	2020	2020	2021	2021
Source	SA Gov ¹	SA Gov ¹	Expert ²	IUCN ³	AKF ⁴	VIC Gov ⁵	NSW Gov ⁶	AKF ⁴	Aus Gov ⁷
AUS			331 (144-605)	300 (100-500)	(45-82)			(32-58)	
sth pop ⁿ			216						
nth pop ⁿ			115						(37-183)
QLD			79 (33-153)		(10-19)			(6-12)	
NSW			36 (14-73)		(11-16)		20 (15-30)	(6-10)	
ACT									
VIC			183 (77-327)		(14-28)	460*		(12-23)	
SA	27 [†]	114 [‡]	33 (19-51)		(10-20) [§]			(8-13) [§]	

Table 1: Previous estimates of population size, or state abundance (units: 1,000 koalas). Interval estimates are in parentheses, and point estimates are without parentheses. *Combined estimates for koalas inside and outside eucalypt plantations. [†]Kangaroo Island population only. [‡]Adelaide Hills and Mount Lofty Ranges population only. [§]Excluding Kangaroo Island population. Sources: ¹National Parks South Australia (2016), ²Adams-Hosking et al. (2016), ³Woinarski and Burbidge (2020), ⁵The Australian Koala Foundation (2021), ⁶Heard and Ramsey (2020), ⁷Department of Planning and Environment (2022), ⁸Department of Agriculture, Water and the Environment (2022).

National Koala Monitoring Program (NKMP)

- DCCEE funded CSIRO to establish a national monitoring program
 - Big job
 - Lots of stake-holders, big area, cryptic critter
- General idea is to base management on observation:
 - Collate existing data from all sources
 - Collect new data in a principled manner
- Analyse for distribution and abundance



Collation of Existing Data

- Collaborate with many
 - Researchers
 - Institutions
 - Governments
 - Community groups
- Data have different SOPs, designs, measurements, etc
- Presence-only (PO) too
- 2020-2025 only

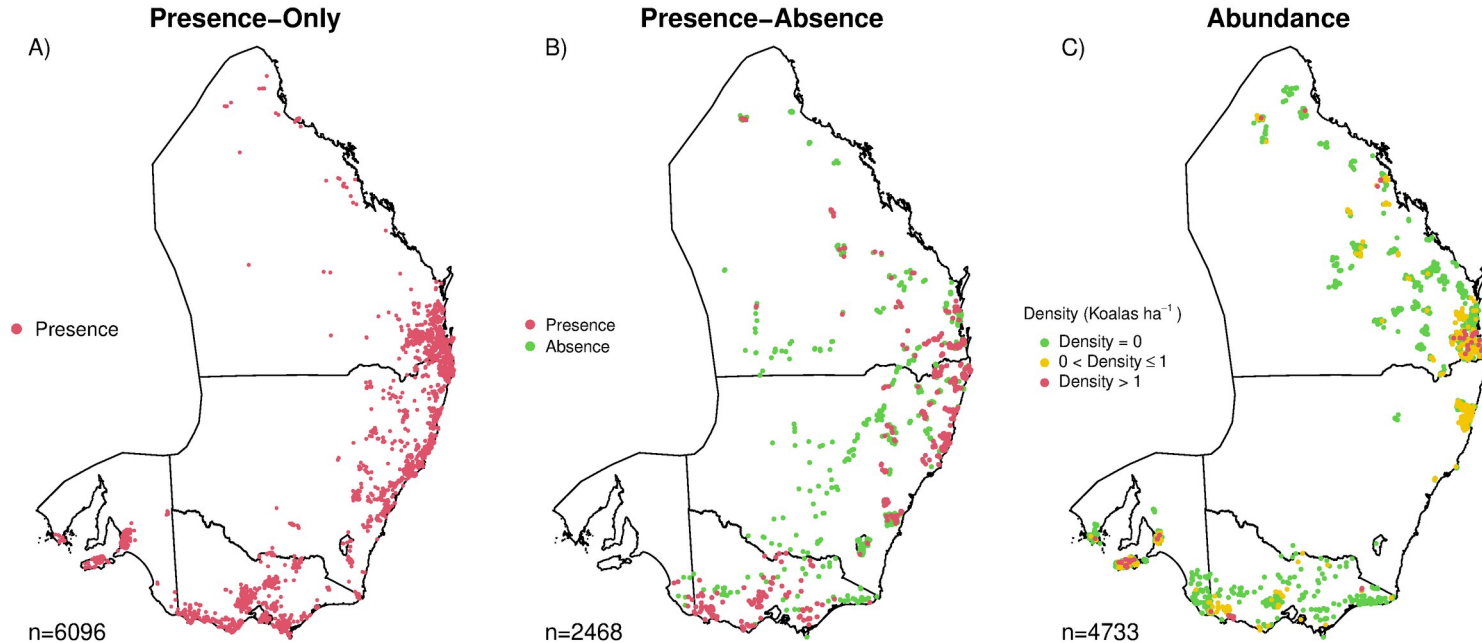


Presence-only Data

- Obtained from the ALA biodiversity data base (Belbin et al. 2015)
- Filtered according to Uribe-Rivera et al. (submitted)
- Thinned to avoid 'human interaction' in observation process
- Search effort estimated using marsupials
 - Same filtering and thinning



Collation of Existing Data

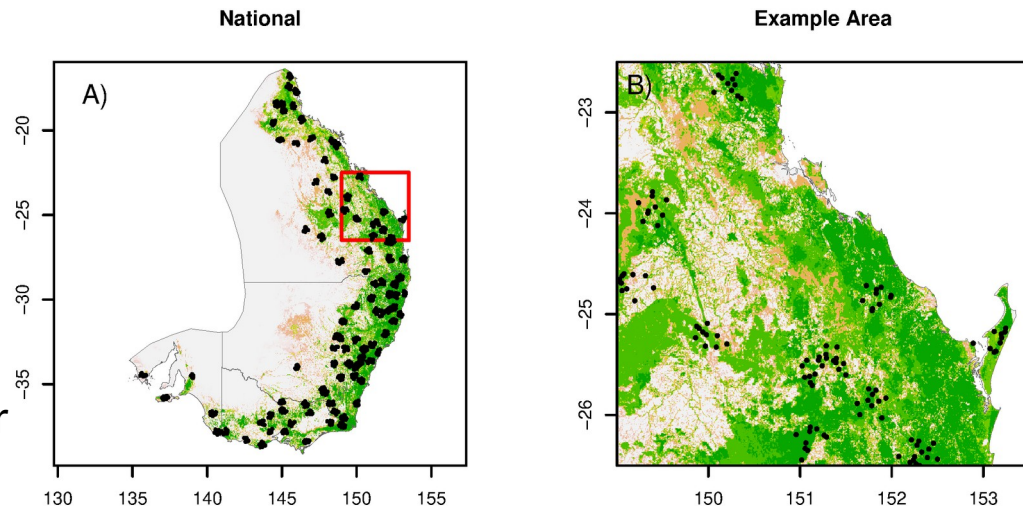


Note that these maps include survey points

Survey design of new collection

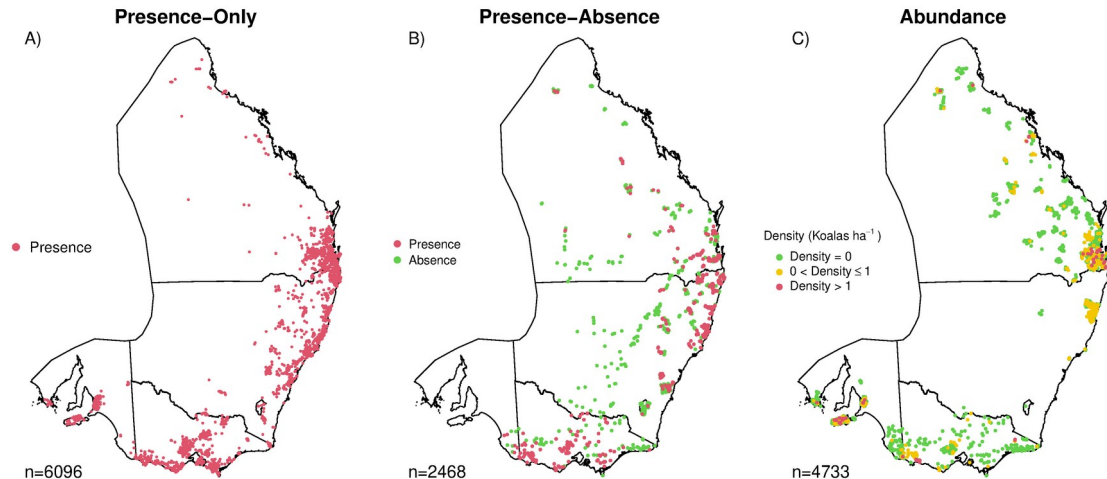
- Australia is a big place
- Leverage other survey efforts
 - (NSW) + Vic + SEQ
- NKMP to focus on remainder
 - With shared design parameters
- NSW + Vic used spatially balanced designs (Robertson et al. 2017, Foster 2021)
- NKMP used clustered spatially balanced designs (Foster et al. 2023)

Randomised Cluster Design



Pragmatism

- Plans can't always eventuate
- Drop out due to (e.g.)
 - Access limitations
 - Safety
 - Etc.
- Best compromise sought
- Inclusion probabilities are not strictly respected
 - Removes the possibility of a simple design-based estimator



Goals of Analysis

- Distribution of Koalas throughout their range
- Break up into
 - North population (listed as endangered in 2022)
 - South population
- Abundance of each population



Photo: C Geddes

Challenges

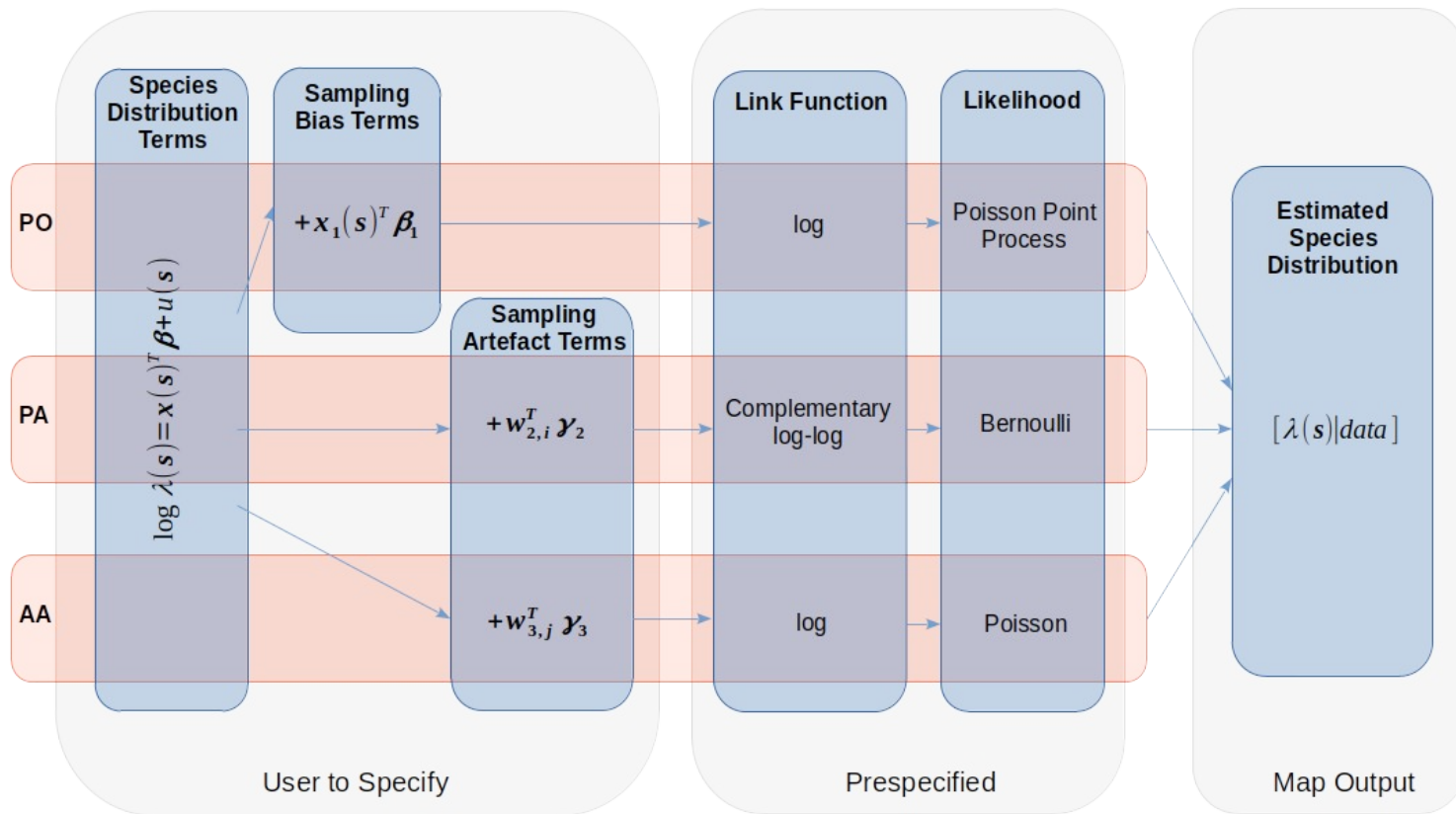
- Data is messy
 - Multiple data types
 - Multiple data sources
 - Sometimes patchy
 - Bias in presence-only data
- Large spatial scales
- Complex processes



Integrated Species Distribution model

- Emerging class of species distribution models (e.g. Flether et al. 2019)
- Based on log-Gaussian Cox Process
 - PO likelihood follows directly
 - PA & AA likelihood does too for finite sampling area
- Bayesian inference via RISDM (Foster et al. 2024)
 - Based on INLA (Rue et al. 2009)





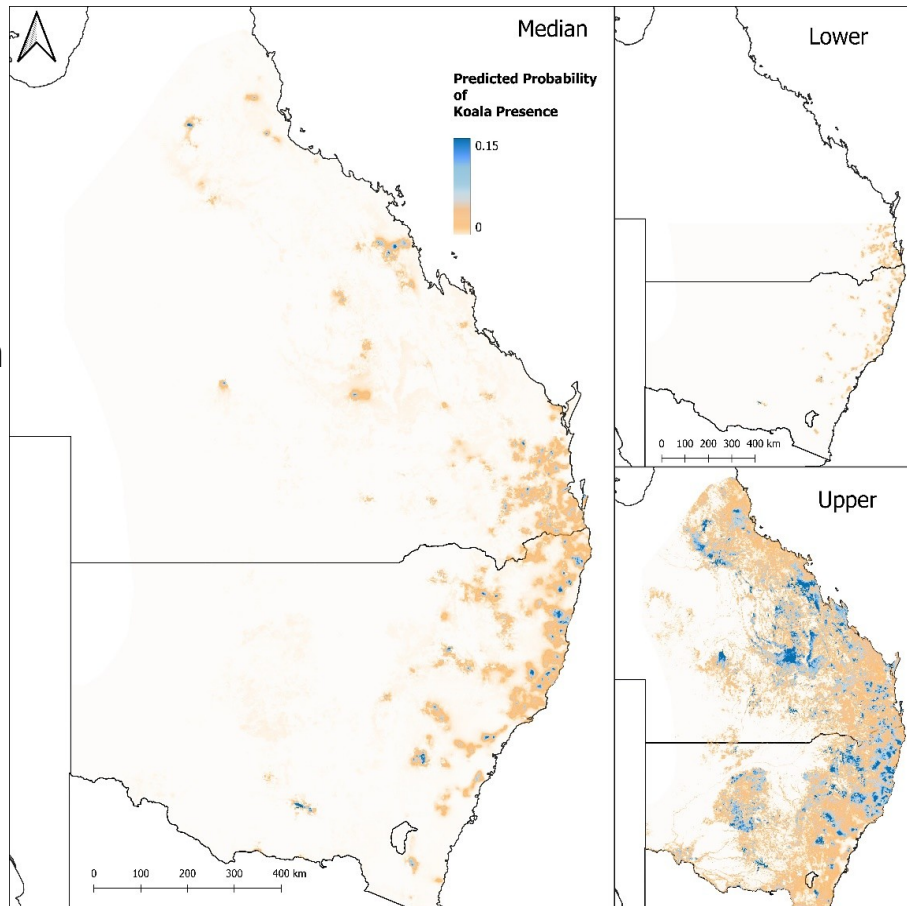


Some (brief) model details

- Covariates identified by expert process
 - Feed tree location, Temperature, Moisture, plantations.
 - All entered linear predictor as an orthogonal quadratic
 - PO offset taken to be the amount of habitat within a grid cell
 - PA / AA offset taken to be the area searched
- (Where appropriate) distance sampling used to pre-adjust transect data
- PO search bias modelled using marsupial density from ALA
- Priors for intercepts based on Adams-Hoskings et al. (2016)
- Visual inspection of (spatial) residuals

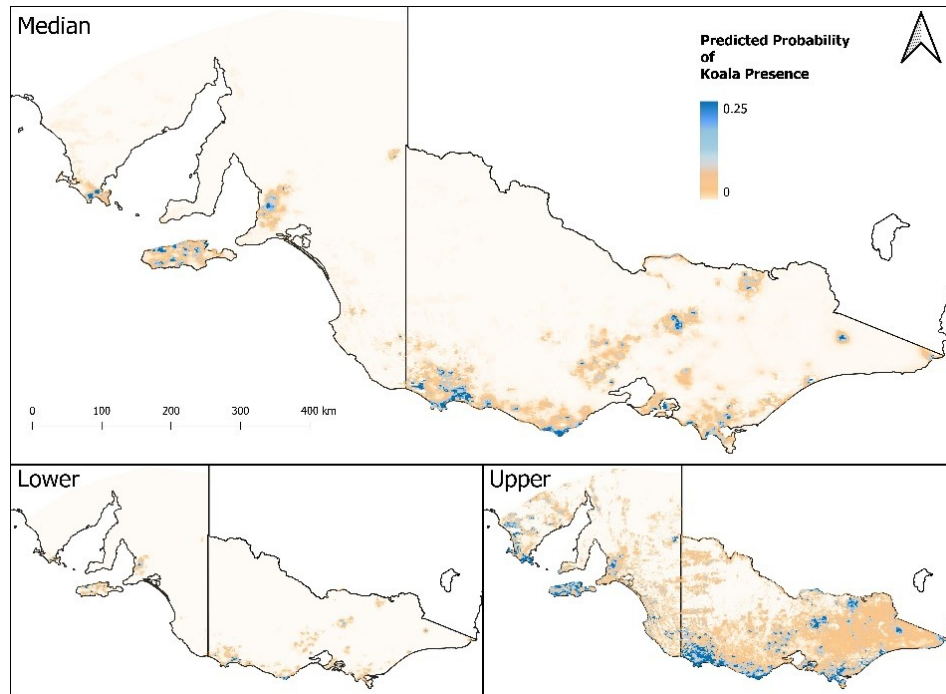
Predicted maps: North states

- Time window: 2020—2025
- Map: the probability of at least one koala being present in a hectare area.
 - Probabilities are truncated to 0.15 for visualisation.
 - White cells represent zero habitat area.
- Small areas with high probability
 - NSW: from coast to inland
 - QLD: the state's southeast



Predicted maps: South States

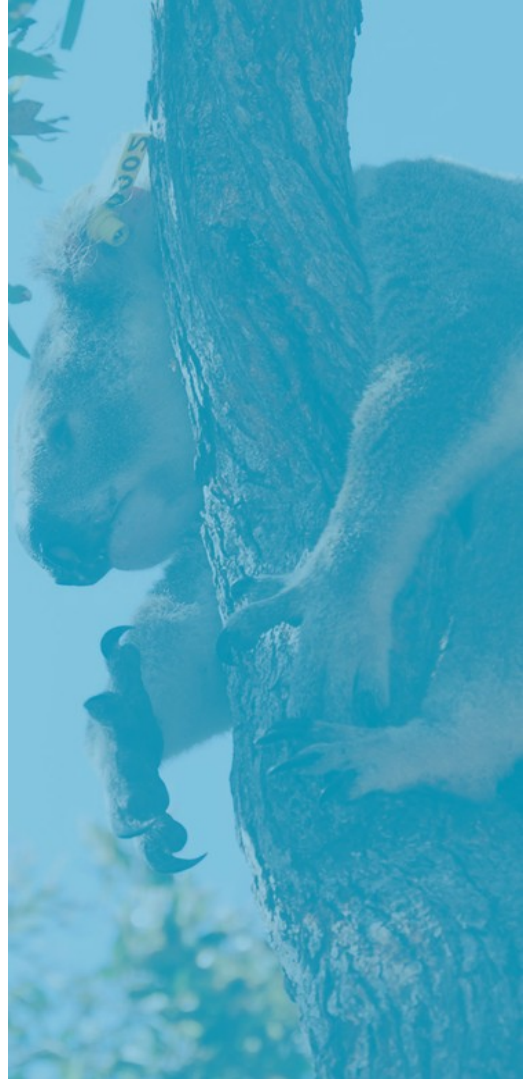
- Small areas with high probability
- Increased density in hardwood plantations





What drives spatial patterns?

- Spatial random effect mostly
 - Idiosyncratic habitat preferences?
 - Missing covariates?
 - Spatial Resolution?
- History of reintroductions/translocations
- Influence of plantations
- Habitat but low predicted presence:
History of drought, hunting, fire history?
Data deficient?



Abundance Estimation

- Add up predicted abundance in each cell
- Uncertainty (intervals) obtained from repeating over posterior samples
- Sometimes posterior samples are wild and they are therefore Winsorised prior to summary

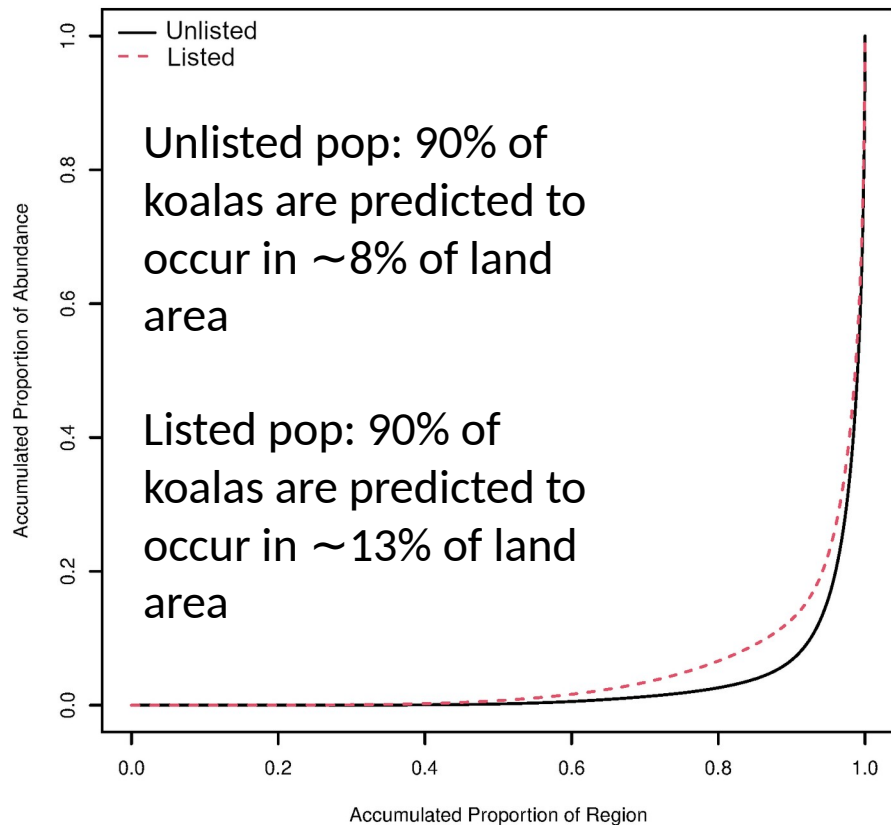


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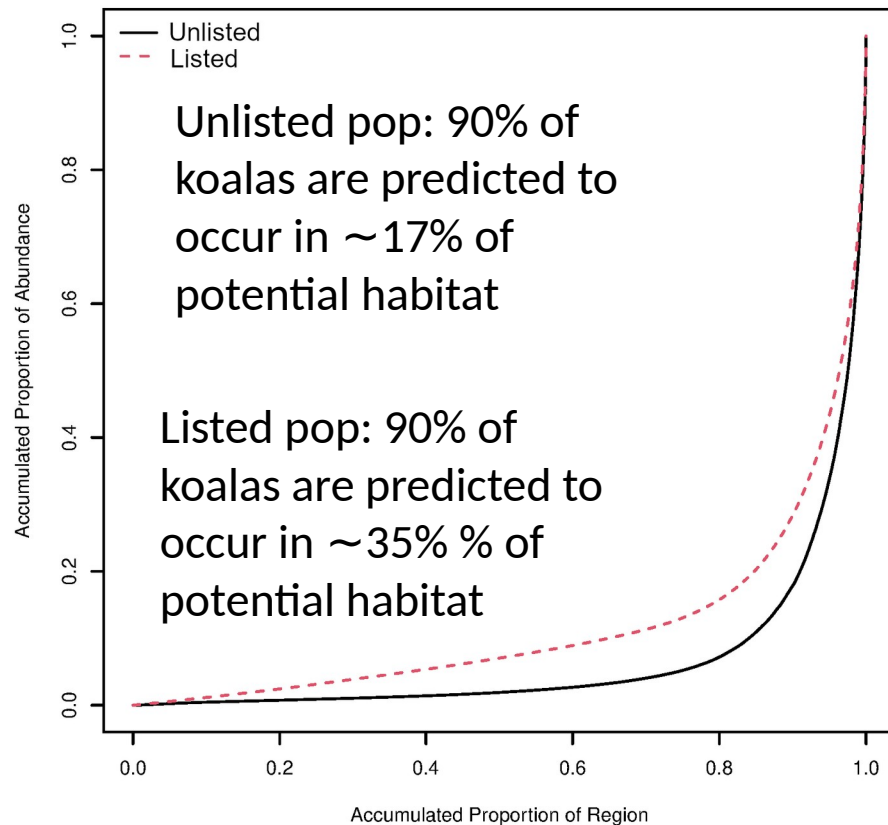
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Estimate (date)	Method	National population range	Listed population range (QLD, NSW, ACT)	Unlisted population range
NKMP 3 rd annual estimate (2025) ⁴	Data-driven NKMP model	729,000 – 918,000	398,000 – 569,000 ¹	303,000 – 381,000

Population Land Area Coverage



Population Habitat Coverage



References

- Uribe-Rivera, D et al. (submitted) Tackling spatial sampling bias in biodiversity records “blindly”: A simple solution to improve species distribution models and conservation decisions
- Belbin, L et al. (2021). The Atlas of Living Australia:15 History, current state and future directions. Biodiversity Data Journal 9, e65023.
- Robertson, B et al. (2017) A modification of balanced acceptance sampling Statistics & Probability Letters, 129, 107 - 112
- Foster, S (2021) MBHdesign: An R-package for efficient spatial survey designs Methods in Ecology and Evolution, 12, 415-420
- Foster, S et al. (2023) Spatially Clustered Survey Designs Journal of Agricultural, Biological and Environmental Statistics, 29, 130 - 146
- Fletcher Jr, R et al. (2019) A practical guide for combining data to model species distributions Ecology, 100, e02710
- Foster, S et al. (2024) RISDM: species distribution modelling from multiple data sources in R Ecography, 2024, e06964
- Rue, H et al. (2009) Approximate Bayesian inference for latent Gaussian models by using integrated nested Laplace approximations Journal of the Royal Statistical Society: Series B (Statistical Methodology), Blackwell Publishing Ltd, 71, 319-392
- Adams-Hosking, C et al. (2016) Use of expert knowledge to elicit population trends for the koala (*Phascolarctos cinereus*) Diversity and Distributions, 22, 249-262



Thank You

For more details and updates
visit www.nkmp.org.au

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