

Aerial Survey population estimates:

contributions to variance



Outline

- Aerial surveys in western NSW are used to count kangaroos, goats, pigs and emus
 - Two people seated on the left independently record all groups which are detected on the LHS
 - One person seated on the right records all groups which are detected on the RHS
 - Mark-recapture methods are used to estimate the detection probabilities
 - Design-based and model-based methods are used to obtain population estimates
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Data

- Site, vegetation strata, transect number
 - For each detected group
 - Gps location
 - Perpendicular distance from transect, group size, habitat, observer pair
 - A detected/not detected status for each observer
 - Aircraft speed, height, direction, time of day
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Estimation of detection probability $g(\cdot)$

- Uses conditional likelihood to estimate logistic parameters (Ahlo, 1990; Huggins, 1989)
 - Significant factors are observer position, distance and group size
 - Habitat and observer pair not significant for this data
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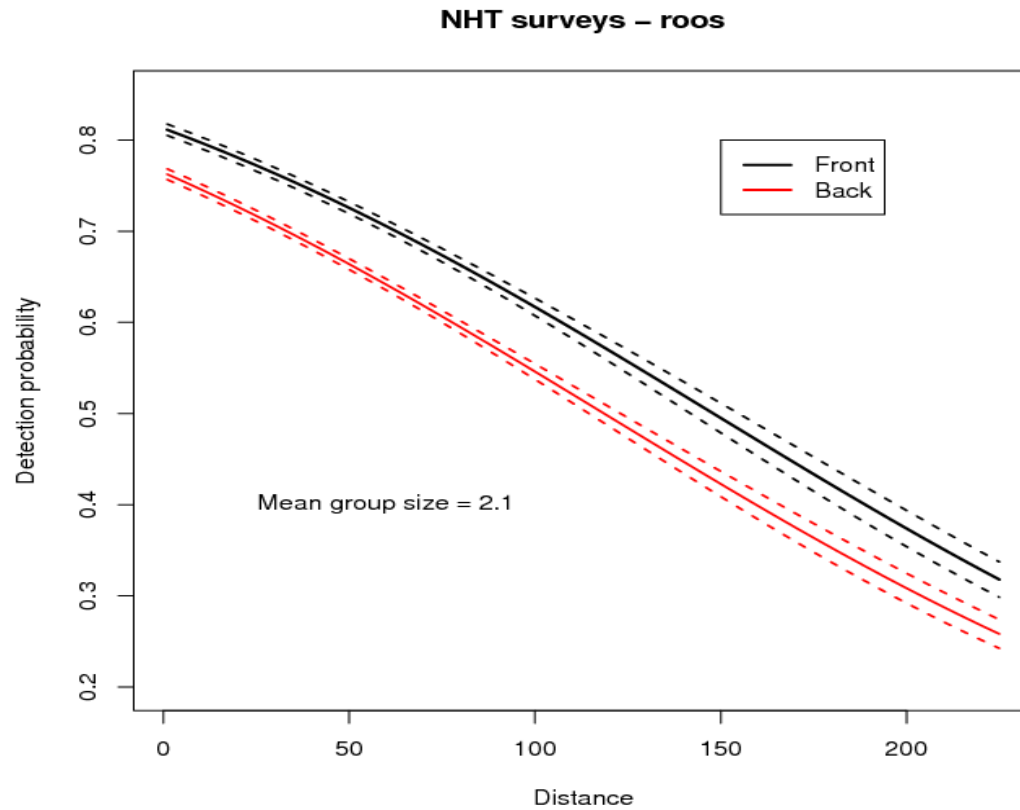
Detection model

For transect i , group k and observer j

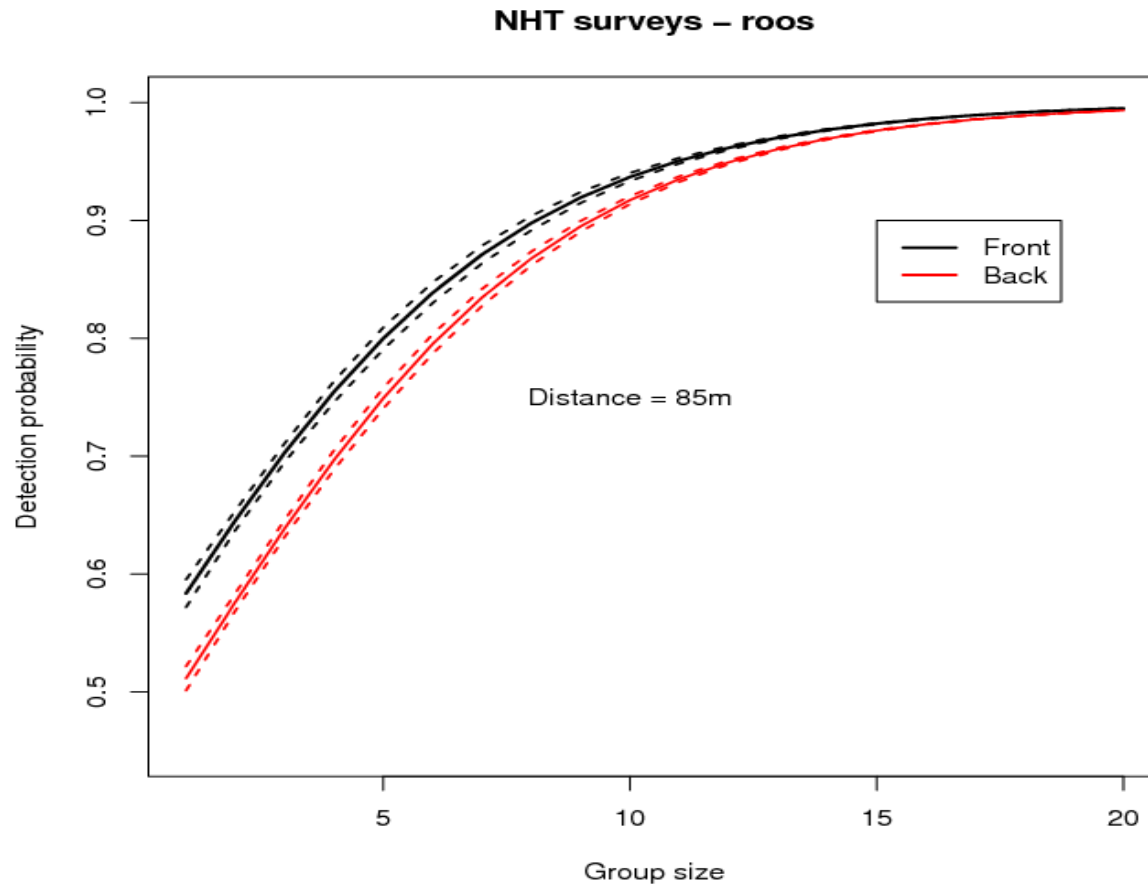
$$\eta_{ikj} = \alpha_{ik1}\theta_1 + \alpha_{ik2}\theta_2 + x_{ik}\theta_3 + N_{ik}\theta_4$$

Term	Parameter	Estimate
front observer	θ_1	0.931
rear observer	θ_2	0.626
distance	θ_3	-0.011
group size	θ_4	0.289

Detection probability vs distance



Detection probability vs group size



Design-based estimation

- Design-based method assumes that the population is fixed and the transect selection is random
 - Transects are selected systematically and with equal probability
 - Conditional likelihood is treated as function to be optimized within the design-based framework
 - Second stage sample (of groups) is based on the detection probabilities and employs a Horvitz-Thompson-type estimator
 - First stage sample (of transects) is based on the known selection probabilities
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Design-based theory

Notation

N_{ik}	the number of objects in group k of transect i
$g(\mathbf{x}_{ik}, \boldsymbol{\theta})$	the detection probability as a function of \mathbf{x}_{ik} and $\boldsymbol{\theta}$
π_i	the selection probability for transect i
q	the set of transects in the first stage sample
q_i	the set of observed groups in transect i

Design-based two-stage estimator

$$\hat{N}_d = \sum_{i \in q} \frac{1}{\pi_i} \sum_{k \in q_i} \frac{N_{ik}}{g(\mathbf{x}_{ik}, \hat{\boldsymbol{\theta}})}$$

Model-based estimation

- Model-based method assumes that the transects are fixed and the transect populations can be described by a model
 - Conditional likelihood is used to estimate the detection function
 - Transect populations are “corrected” from the observed counts and the detection function using a (second) binary model
 - Site abundance estimates are obtained from the transect model and the corrected counts
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Model-based theory

Notation

N_i	the population in transect i
\mathbf{z}_i	the transect level covariates
$\eta = \mu^{-1}, v$	the link and variance functions
$\alpha, \boldsymbol{\beta}$	the model parameters
$g(\mathbf{x}_{ik}, \boldsymbol{\theta})$	the detection probability as a function of \mathbf{x}_{ik} and $\boldsymbol{\theta}$
ϵ_i	the transect residuals
q	the set of transects in the first stage sample
q_i	the set of observed groups in transect i

Transect model

$$N_i = \mu(\boldsymbol{\beta}^T \mathbf{z}_i) + \epsilon_i$$

$$E_q N_i = \mu(\boldsymbol{\beta}^T \mathbf{z}_i)$$

$$\text{Var}_q(N_i) = v(\mu(\boldsymbol{\beta}^T \mathbf{z}_i), \alpha)$$

Model-based predictor

$$\hat{N}_m = \sum_{i \in q} \sum_{k \in q_i} \frac{N_{ik}}{g(\mathbf{x}_{ik}, \hat{\boldsymbol{\theta}})} + \sum_{j \notin q} \mu(\hat{\boldsymbol{\beta}}^T \mathbf{z}_j)$$

Abundance estimates

Site	Model-based		Design-based	
	estimate*	s.e.	estimate*	s.e.
Coona Coona	8.4	1.6	8.5	1.9
Mutawinji South	20.5	2.2	20.5	3.7
Nocoleche West	9.8	1.3	9.8	0.8
Nuntherungie Cotaurundie	1.9	1.0	1.9	1.2

* per km²

Contributions to variance

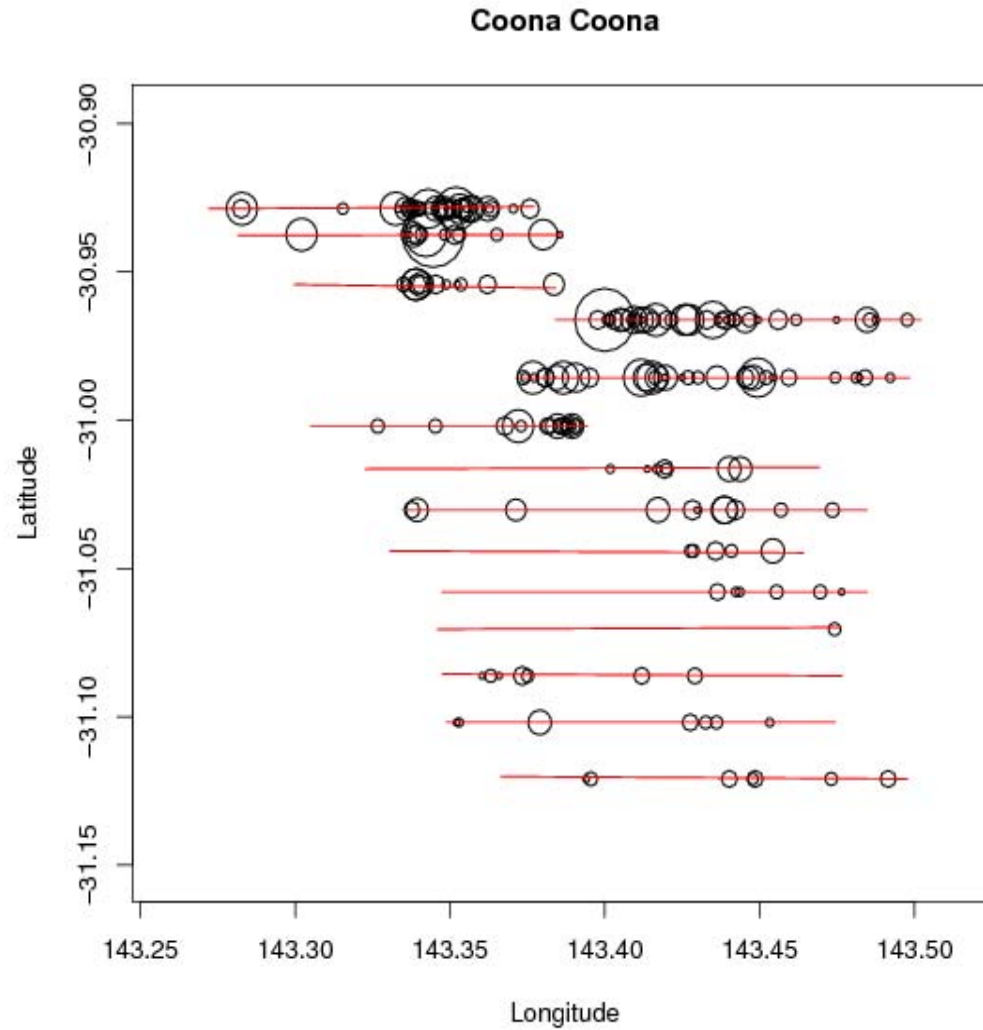
Source	Variance contribution	Key attributes
Transects	92.0%	cv = 98%
Incomplete detection	6.6%	g = 0.7
Estimation of detection function	1.3%	n = 1600

Other studies

Source	Variance contribution	Key attributes
Transects	73%	cv = 18%
Incomplete detection	21%	g = 0.64
Estimation of detection function	6%	n = 148

Steinhorst & Samuel (1989)

Abundance estimates



Design-based issues

- Number of transects $M = X/w$
 - Truncation of transect widths
 - Shape of region
 - coverage
 - transect length
 - Deviations in design - selection probabilities
 - Detection model
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Mark-recapture issues

- observers not independent
 - evidence of correlation beyond 175m
 - comprehensive treatment of correlation requires specially designed studies
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