Variable Circular Plots: Station Placement and the Independence Assumption

Master's Research Project

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June 11, 2014

Distance Sampling

- Population Density Estimation
- Used often in Ecological Sciences
- Began with roadside surveys in early 1900s
- Theory developed through mid-1900s

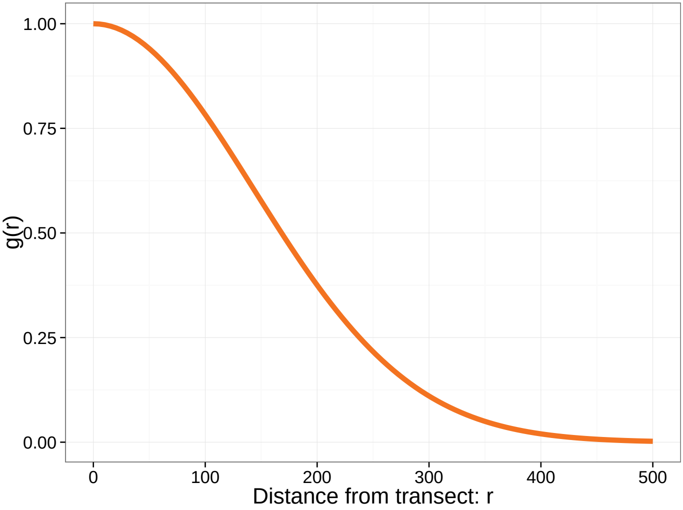
Distance Sampling: History

- Emlen—1971
- Ramsey, Scott—1979, 1980 Papers
- Burnham, Anderson, and Jeffrey L. Laake—1980 Monograph
- Buckland et. al. 1993, 2001—text
- Continued Development into 2000s
  - Combined with Mark-Recapture Methods
  - Extended for use with underwater acoustics for estimates of krill populations
  - Combined with camera traps to estimate populations

Line Vs. Point Transects

- Line transects are walked
  - Distances perpendicular to transect are recorded, as projected on ground
- Point transects: observer(s) stand at station, observe everything within 360°
  - Alternately: Variable Circular Plots (VCP)
  - Allow "cooling" period
  - Safer for observer
  - Straight line distance from Observer is recorded, as projected on ground
- Observations can be from visual sightings, auditory clues, or a combination

Detection Curve: $g(r)$



Density Estimation

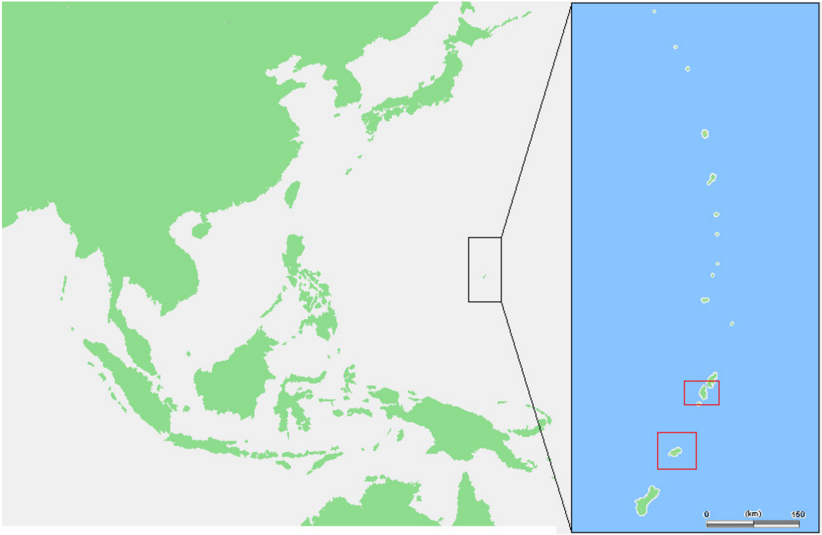
$$\hat{D} = \frac{n}{\text{Area} * P(\text{observing object}|\text{distance } r)}$$

$$\hat{D} = \frac{n}{\text{Area} * g(r)}$$

Micronesian Forest Bird Survey: 1982

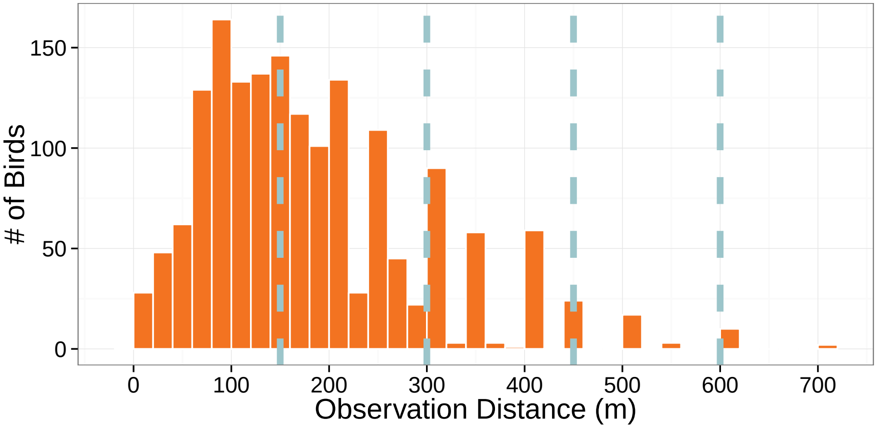
- Engbring, Ramsey & Wildman (1986)
- Used VCP to survey several bird species in the Micronesian islands
- Each of 5 Islands divided into regions
- Transect randomly placed within region (angle & starting position selected randomly)
- Stations placed every 150 m along transect
- Additional transects placed 2 km parallel

Micronesia



Mariana Islands, modified from work by M. Minderhoud, (public domain) via Wikimedia Commons

Collared Kingfisher Observation Data



Research Question

Do overlapping observation areas violate any underlying independence assumptions?

Will it make a difference in our final population density estimates if a bird is observed from more than one station?

VCP Indepencence

- Ramsey and Scott (1979), Buckland (1987), and Thompson (2012) discuss assumption that VCPs are randomly placed.
  - Implicit, but not explicit, possibility of overlap
- Reynolds, Scott, and Nussbaum (1980) state the possibility of observing the same bird from more than one station should be avoided.
- Buckland et al. (2001) states "Transects are normally spaced at a sufficient distance to avoid detecting an object from two neighboring transacts, although this is not usually critical unless sampling a line changes the animal distribution at neighboring, as yet un-sampled lines."

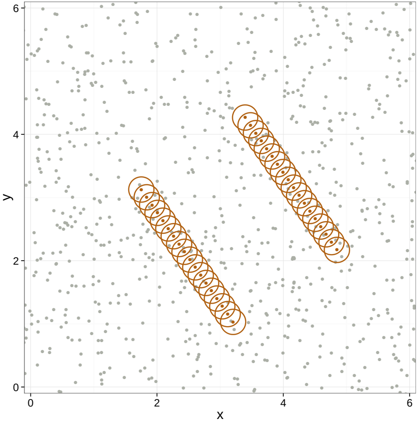
Simulation Set Up

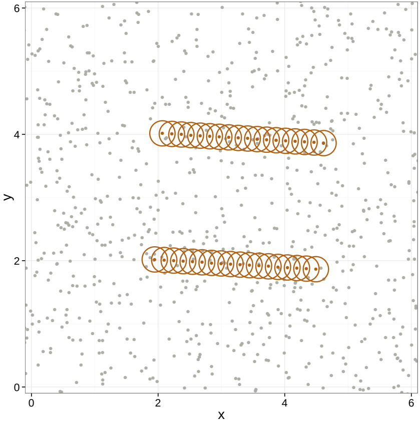
Modeled after Palie Region on Rota:

- 20 birds per km^2
- 9.41 km^2 Study Area
- Two transects, 16 & 17 stations each
- Truncation distance, w, taken to be 500 m

Transect Layouts

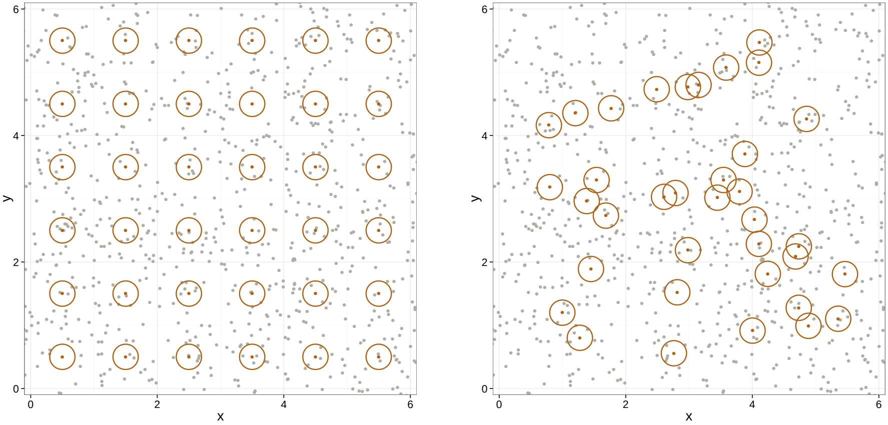
1 unit on graph = 1000 km



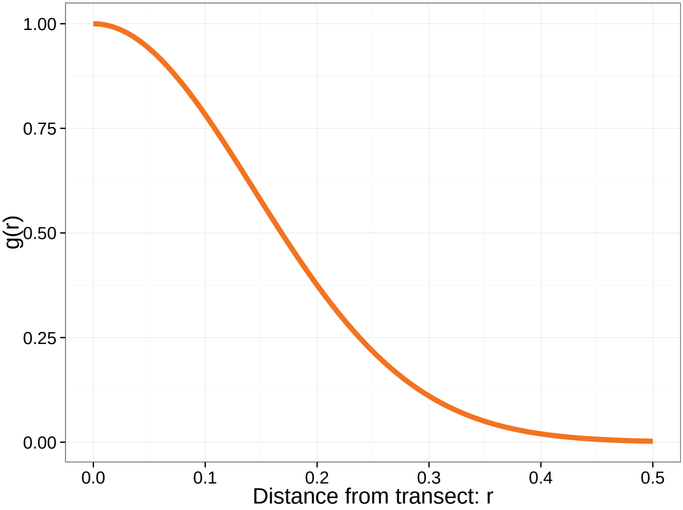


Structured and Random Layouts

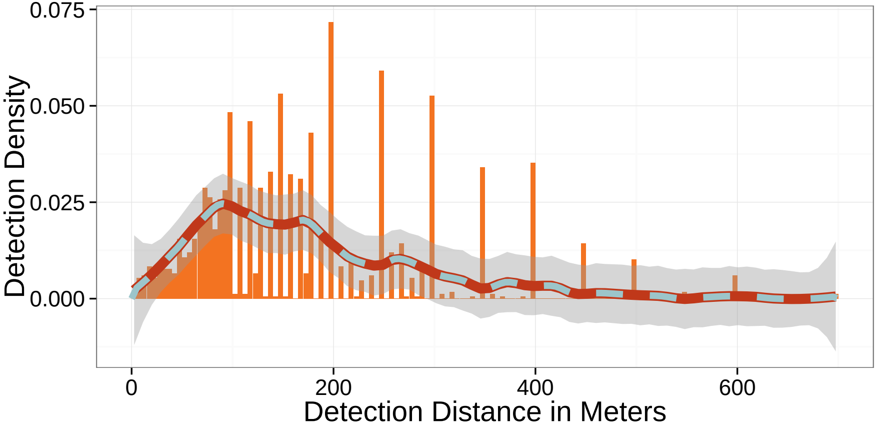
1 unit on graph = 1000 km



Detection Curve: Ideal



Detection Curve: Empirical

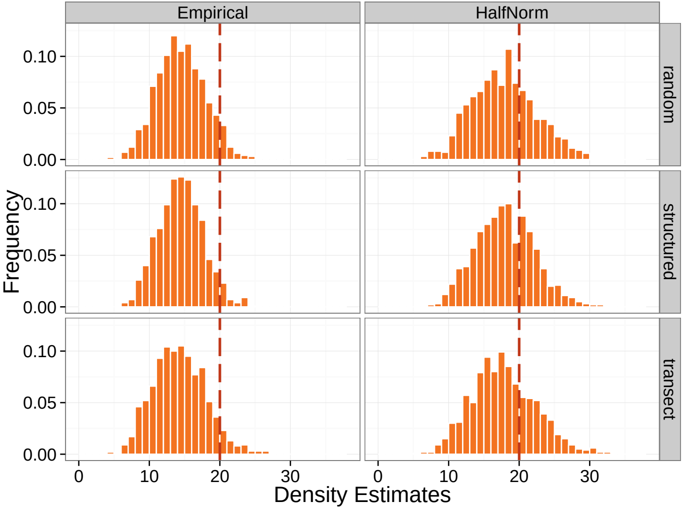


Movement

Three Movement Options:

- No Movement: Objects stayed at origin point
- Temporary Movement: Objects would shift away from observer, but shift back to origin after observer “left”
- Compounded Movement: Objects would shift away from observer, would remain at new point after observer moved. (Movement could compound if object was within movement radius for more than one VCP)

Empirical vs. Half-Normal



Empirical vs. Half-Normal

Centers and Spread

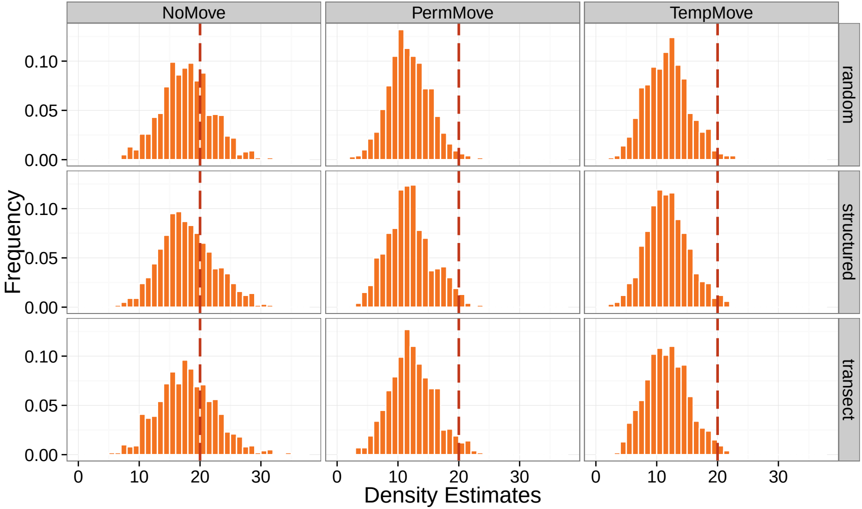
$g(x)$	Layout	Mean	Std Dev	25th	Median	75th
Empirical	Random	14.47	3.37	12.08	14.38	16.73
Empirical	Structured	14.49	3.15	12.27	14.47	16.59
Empirical	Transect	14.26	3.66	11.65	14.14	16.80
Half-normal	Random	17.90	4.57	14.67	17.86	20.88
Half-normal	Structured	18.03	4.16	15.05	17.91	20.82
Half-normal	Transect	17.80	4.64	14.52	17.44	20.78

Empirical vs. Half-Normal

True Density Capture

	Empirical		Half Normal	
Layout	Mean $\hat{D}$	% Capture	Mean $\hat{D}$	% Capture
Random	14.47	73.6%	17.90	94.0%
Structured	14.49	77.5%	18.03	95.3%
Transect	14.27	69.6%	17.80	91.2%

Movement Results



Movement Results

Centers & Spread

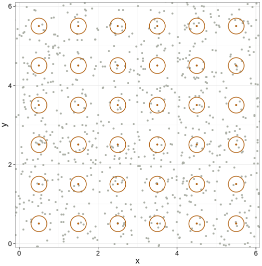
Movement	Layout	Mean	Std Dev	25th	Median	75th
None	Random	17.86	4.28	15.03	17.64	20.65
None	Structured	18.01	4.51	14.95	17.62	20.94
None	Transect	17.90	4.78	14.74	17.67	20.95
Compounded	Random	11.86	3.42	9.58	11.61	14.09
Compounded	Structured	11.90	3.65	9.37	11.67	14.08
Compounded	Transect	12.42	3.72	9.93	12.17	14.79
Temporary	Random	11.76	3.57	9.22	11.75	14.02
Temporary	Structured	11.74	3.48	9.37	11.56	13.85
Temporary	Transect	11.75	3.57	9.24	11.72	14.20

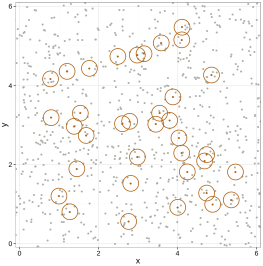
Movement Results

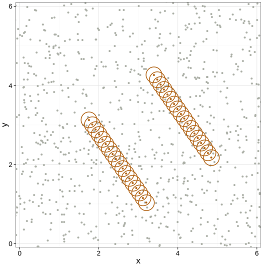
True Density Capture

	No Movement		Compounded		Temporary	
Layout	Mean $\hat{D}$	%	Mean $\hat{D}$	%	Mean $\hat{D}$	%
Random	17.86	94.2%	11.86	59.6%	11.76	59.3%
Structured	18.01	94.3%	11.90	59.9%	11.74	59.5%
Transect	17.90	90.8%	12.42	65.0%	11.75	58.0%

Movement And Layouts







1 unit = 1000 km, circles represent 200 m out from station

Conclusion

If all else is held equal, VCP layout does not seem to play a large role in the bias of population density estimates using the kernel method described by Quang (1993).

Violations of the expected detection probability curve, or by movement of the objects away from the observer play a greater role in biasing the resulting estimate.

Future Work

- Explore the possible interaction effect from Compounded Movement and the Transect Layout
- Modify simulation functions to return more information to assist diagnostics
  - Count of Observed Objects
  - Observation Distances
- Modify using the Empirical data as a detectability function, to account for difference between line and point transects.
- Add the option to bias-correct the estimates, to see how well Quang's kernel method adjusts for these variations.

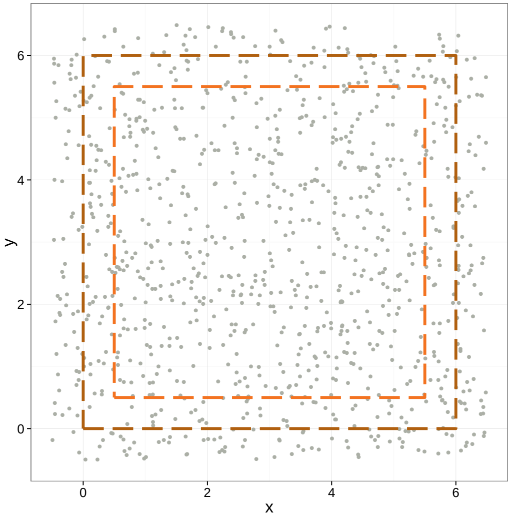
Final Words

"All models are wrong, but some are useful." –George E. P. Box

Questions?

"Collared Kingfisher (Todiramphus chloris)" by JJ Harrison, (CC-BY-SA 3.0) via Wikimedia Commons

Object placement Simulation



Half-Normal Scaling

The half-normal parameter θ is related to the standard deviation of a standard normal distribution by the relationship:

$$\theta = \frac{\sqrt{\pi/2}}{\sigma}$$

If we estimate σ by $w/3.5$ (with w being the maximum distance at which we might observe an object, and 3.5 being the standard deviation point where $P(X > 3.5) < 0.001$) then θ is:

$$\sigma = \frac{w}{3.5} = 0.1429$$

$$\theta = \frac{\sqrt{\pi/2}}{0.1429} = 8.7732$$

Half-Normal Scaling

For a half-normal with parameter $\theta = 8.7732$, $f(0) = 5.5852$ so to scale the value to 1:

$$\delta_{HN} = \frac{1}{5.5852} = 0.1790$$

Half-normal density functions were executed in R with the `fdrtool` package.