SEEC Stats Toolbox

Want to broaden your stats knowledge? Unsure of what you can do with your data? Still developing your proposal?

Join us for the monthly **SEEC Stats Toolbox** seminars where we introduce you to statistical methods that are useful for ecologists, environmental and conservation scientists.

Our next seminar:

Topic: **Movement Modelling**
Who: Dr Theoni Photopoulou
When: **Thursday 29 June 2017 (1-2pm)**
Where: To be confirmed

More details: www.seec.uct.ac.za

SEEC - Statistics in Ecology, Environment and Conservation

University of Cape Town · Universiteit van Kaapstad · iYunivesithi yaseKapa

Brief outline

From CR to SCR

- Capture-Recapture
- Spatial Capture-Recapture (SCR) Models

SCR Model Components

- Observation process
- State process

Demonstration with Kruger Park leopards

SCR Extensions

Traditional Capture-Recapture (CR) Models

⇒ Multiple sampling occasions

⇒ Animals captured, marked and released

⇒ Models for open vs closed populations.

Wikimedia Commons (Andreas Trepte)

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pbsg.npolar.no (Andrew Derocher)

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CC Derek Ramsey

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www.realscience.org.uk

Spatial Capture-Recapture (SCR) Models

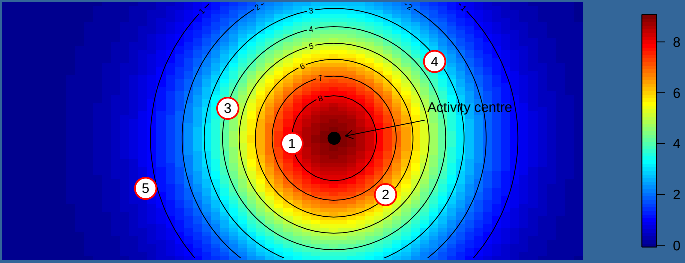
- Often an estimate of density is required.
- An estimate of the effective trapping area (ETA) is required to estimate density with CR.
- Several ad hoc methods used to estimate ETA but widely recognised as problematic.
- SCR models extend capture-recapture (CR) models to include spatial location information.
- SCR models solve the problem by directly estimating density.
- Can be implemented in a maximum likelihood or Bayesian framework.

Spatial Capture-Recapture (SCR) Models

- The standard approach for estimating and modelling animal density.
- Essentially a hierarchical CR model.
  - **Spatial point process model** that describes abundance and distribution of animals in space
  - **Observation model** that deals with the detection process

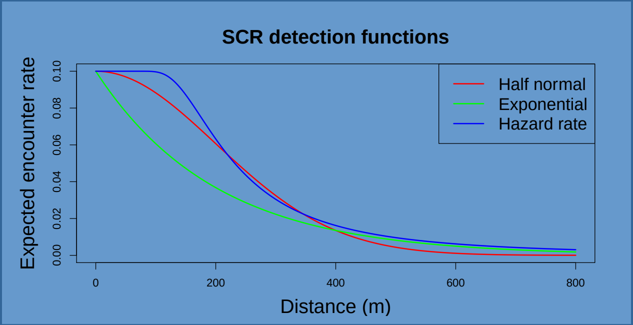
Observation process

- The expected frequency of encountering an individual depends on the individual's location in space.



Observation process

- The expected frequency of encountering an individual is a decreasing function of distance.



Observation process

- The observation component of the model can be written in a general form:

$$P(\boldsymbol{\Omega}|\mathbf{S}) = \prod_{i=1}^{n} P(\omega_{\mathbf{i}}|\mathbf{s_i})$$

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CC (Albert Herring)

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John Measey

Observation process - encounter rate model

- For a camera trap survey of duration T:

$$c_{ij} \sim \mathrm{Poisson}(\lambda(d_{ij})T)$$

- A suitable model (assuming n caught individuals, J traps, independence of captures):

$$P(\mathbf{\Omega}|\mathbf{S}) = \prod_{i=1}^{n} P(\boldsymbol{\omega}_\mathbf{i}|\mathbf{s}_\mathbf{i}) = \prod_{i=1}^{n}\prod_{j=1}^{J} \mathrm{Poisson}(c_{ij}; \lambda(d_{ij})T)$$

Observation process - binary model

- For a hair snare survey of duration T:

$$\delta_{ij} \sim \mathrm{Bernoulli}(p(d_{ij}, T))$$

- Can still use the EER model:

$$P(c_{ij} > 0) = 1 - P(c_{ij} = 0) = 1 - e^{-\lambda(d_{ij} T)}$$

- A suitable model (assuming n caught individuals, J traps, independence of captures):

$$P(\mathbf{\Omega}|\mathbf{S}) = \prod_{i=1}^{n} P(\boldsymbol{\omega}_\mathbf{i}|\mathbf{s}_\mathbf{i}) = \prod_{i=1}^{n}\prod_{j=1}^{J} \mathrm{Bernoulli}(\delta_{ij}; p(d_{ij}, T))$$

Observation process - multiple occasions

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$$P(\mathbf{\Omega}|\mathbf{S}) = \prod_{i=1}^{n} \prod_{k=1}^{K} \prod_{j=1}^{J} \mathrm{Poisson}(c_{ijk}; \lambda_k(d_{ij})T)$$

- Binary model (assuming n caught individuals, K occasions, J traps, independence of captures):

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Spatial Models

- The goal is to draw inferences about the **density**, **abundance** and **spatial distribution** of the activity centres of a population BUT:
  - don't observe the locations of any of them
  - and don't even know how many there are

Spatial Models

- The goal is to draw inferences about the **density**, **abundance** and **spatial distribution** of the activity centres of a population BUT:
    - don't observe the locations of any of them
    - and don't even know how many there are
- A spatial point process (SPP) model can be used. It is a statistical model that describes how the number and locations of points in space arise.

Spatial Models

- We assume that the points in a survey area A are generated by a Poisson process with intensity (density) $D(s)$ at $s \in A$.
- The number of points in a region:

$$N \sim P(\lambda) \text{ where } \lambda = \int_A D(\mathbf{s})\, ds$$

- The density for locations given N:

$$f(\mathbf{s_1}, \ldots, \mathbf{s_N} | N) = \prod_{i=1}^{N} f(\mathbf{s}_i) = \frac{\prod_{i=1}^{N} D(\mathbf{s}_i)}{\lambda}$$

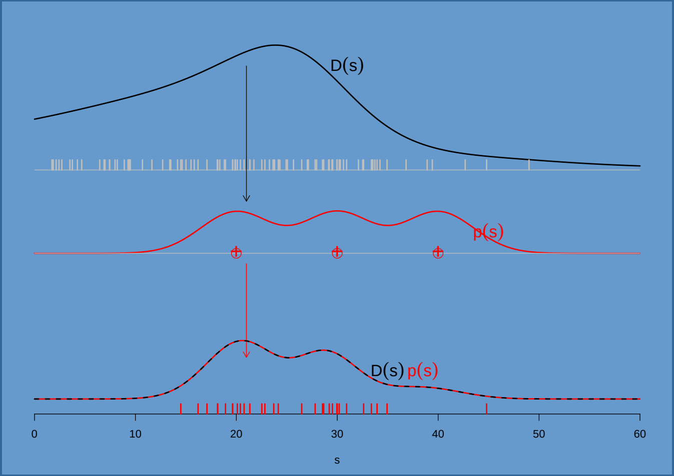
- Combining these:

$$f(\mathbf{s_1}, \ldots, \mathbf{s_N}) = e^{-\lambda} \prod_{i=1}^{N} D(\mathbf{s}_i)$$

Thinned PP

- When points from a point process are detected probabilistically
  $\rightarrow$ the detected points comprise a "thinned" point process.
- For a Poisson point process: the thinned point process is also a Poisson point process.
- If $X \sim P(\lambda(\mathbf{s}))$ then $X_{Thinned} \sim P(\lambda(\mathbf{s})p(\mathbf{s}))$.

Thinned PP



Covariates

- Covariates on different levels:
  - Trap
  - Individual
  - Points in space (mask)
- GLM type transformations to ensure constraints:
  - $\sigma, \lambda \rightarrow$ log link.
  - $g_0 \rightarrow$ logit link.

Summary of components needed for SCR

- Spatial locations of traps.
- Spatial capture histories (for one or more occasions).
- Region to be specified from where individuals could conceivably be detected.
- Model for encounter rate / detection probability (as a function of distance)
- Model for density (as a function of location **s** in space).
- Software for estimation.

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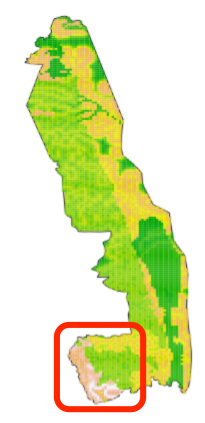
Example data

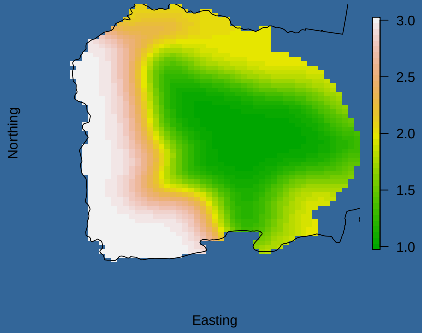


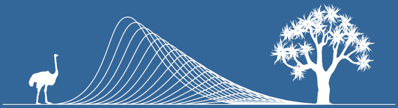
Kruger Park leopards

We are going to use (part of) the leopard data from the SANParks and AFW Kruger National Park camera-trap photographic survey 2010-2012 [a] to develop ideas.

[a] South African National Parks Board (SANParks) and the African Wildlife Foundation (AWF);
Maputla, N.W. 2014. Drivers of leopard population dynamics in the Kruger National Park, South Africa. PhD Thesis, University of Pretoria, Pretoria, RSA.

Habitat suitability





(Some) SCR extensions

- Ecological distance
- Continuous-time SCR
- Acoustic SCR
- Open Population SCR

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