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
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)
Traditional Capture-Recapture (CR) Models

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pbsg.npolar.no (Andrew Derocher)
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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:

\[ P(\Omega|S) = \prod_{i=1}^{n} P(\omega_i|s_i) \]
Observation process

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- Different types of detectors gather different types of data

David Borchers

SEEC - Statistics in Ecology, Environment and Conservation
Observation process

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(CC (Albert Herring))
Observation process

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Eric Rexstad
Observation process

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> Different types of detectors gather different types of data

John Measey
Observation process - encounter rate model

- For a camera trap survey of duration $T$:
  \[ c_{ij} \sim \text{Poisson}(\lambda(d_{ij})T) \]

- A suitable model (assuming $n$ caught individuals, $J$ traps, independence of captures):
  \[
P(\Omega|\mathbf{S}) = \prod_{i=1}^{n} P(\omega_i|s_i) = \prod_{i=1}^{n} \prod_{j=1}^{J} \text{Poisson}(c_{ij}; \lambda(d_{ij})T)\]
Observation process - binary model

- For a hair snare survey of duration $T$:
  \[ \delta_{ij} \sim \text{Bernoulli}(p(d_{ij}, T)) \]

- 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):
  \[ P(\Omega|\mathbf{S}) = \prod_{i=1}^{n} P(\omega_{i}|s_{i}) = \prod_{i=1}^{n} \prod_{j=1}^{J} \text{Bernoulli}(\delta_{ij}; p(d_{ij}, T)) \]
Observation process - multiple occasions

- So far no mention of occasions, SCR uses *spatial capture histories*. 

\[
P(\Omega | S) = n \prod_{i=1}^{K} \prod_{k=1}^{J} \prod_{j=1}^{I} \text{Poisson}(c_{ijk}; \lambda_k(d_{ij}, T))
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▶ EER model (assuming $n$ caught individuals, $K$ occasions, $J$ traps, independence of captures):

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

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

$$P(\Omega|S) = \prod_{i=1}^{n} \prod_{k=1}^{K} \prod_{j=1}^{J} \text{Bernoulli}(\delta_{ijk}; p_k(d_{ij}, T)))$$
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:

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

- The density for locations given $N$:

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

- Combining these:

$$f(s_1, \ldots, s_N) = e^{-\lambda} \prod_{i=1}^{N} D(s_i)$$
Thinned PP

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

\[ D(s) \]

\[ p(s) \]

\[ D(s) p(s) \]
Covariates

- Covariates on different levels:
  - Trap
  - Individual
  - Points in space (mask)

- GLM type transformations to ensure constraints:
  - $\sigma, \lambda \rightarrow \text{log link.}$
  - $g_0 \rightarrow \text{logit link.}$
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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We are going to use (part of) the leopard data from the SANParks and AFW Kruger National Park camera-trap photographic survey 2010-2012 to develop ideas.

\(^a\)South African National Parks Board (SANParks) and the African Wildlife Foundation (AWF);
(Some) SCR extensions

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


References


