E-iNET Workshop, University of Kent, December 2014

Depletion modelling for herpotological translocations

Rachel McCrea

NERC SCIENCE OF THE ENVIRONMENT

EPSRC Engineering and Physical Sciences Research Council

ncse National Centre for Statistical Ecology

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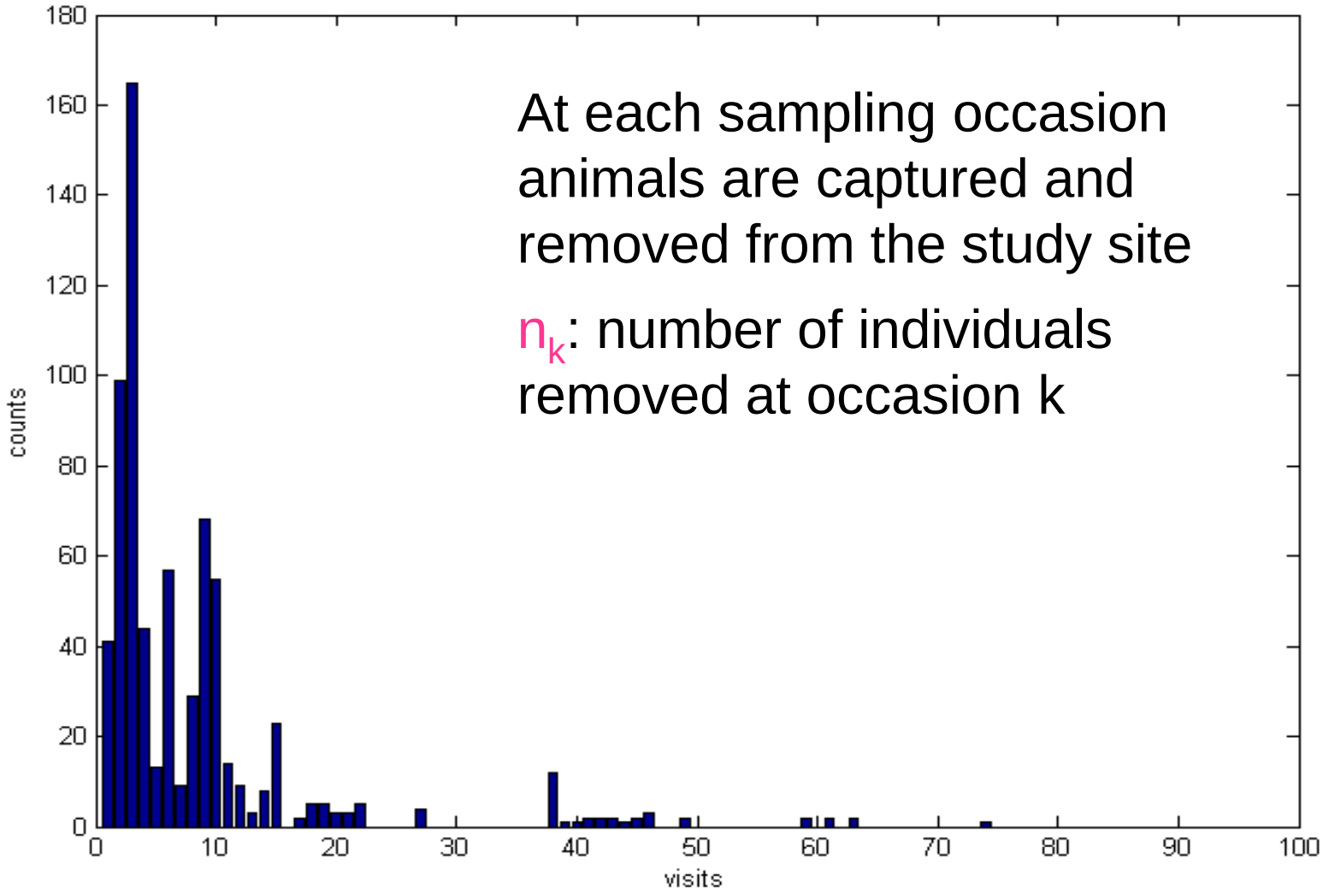
Eleni Matechou, Byron Morgan, Richard Griffiths, Brett Lewis and David Sewell

Overview

- Depletion data
- Existing models
- Incorporating weather covariates
- Incorporating “new arrivals”
- New developments
- Future directions

Depletion data



At each sampling occasion animals are captured and removed from the study site

n_k: number of individuals removed at occasion k

Depletion data

- Capture-recapture data – but with no recaptures!

- 1000
- 0100

- We want to know if there are any individuals who have not been captured by the end of the study….
- …individuals who have encounter history 0000

Depletion data

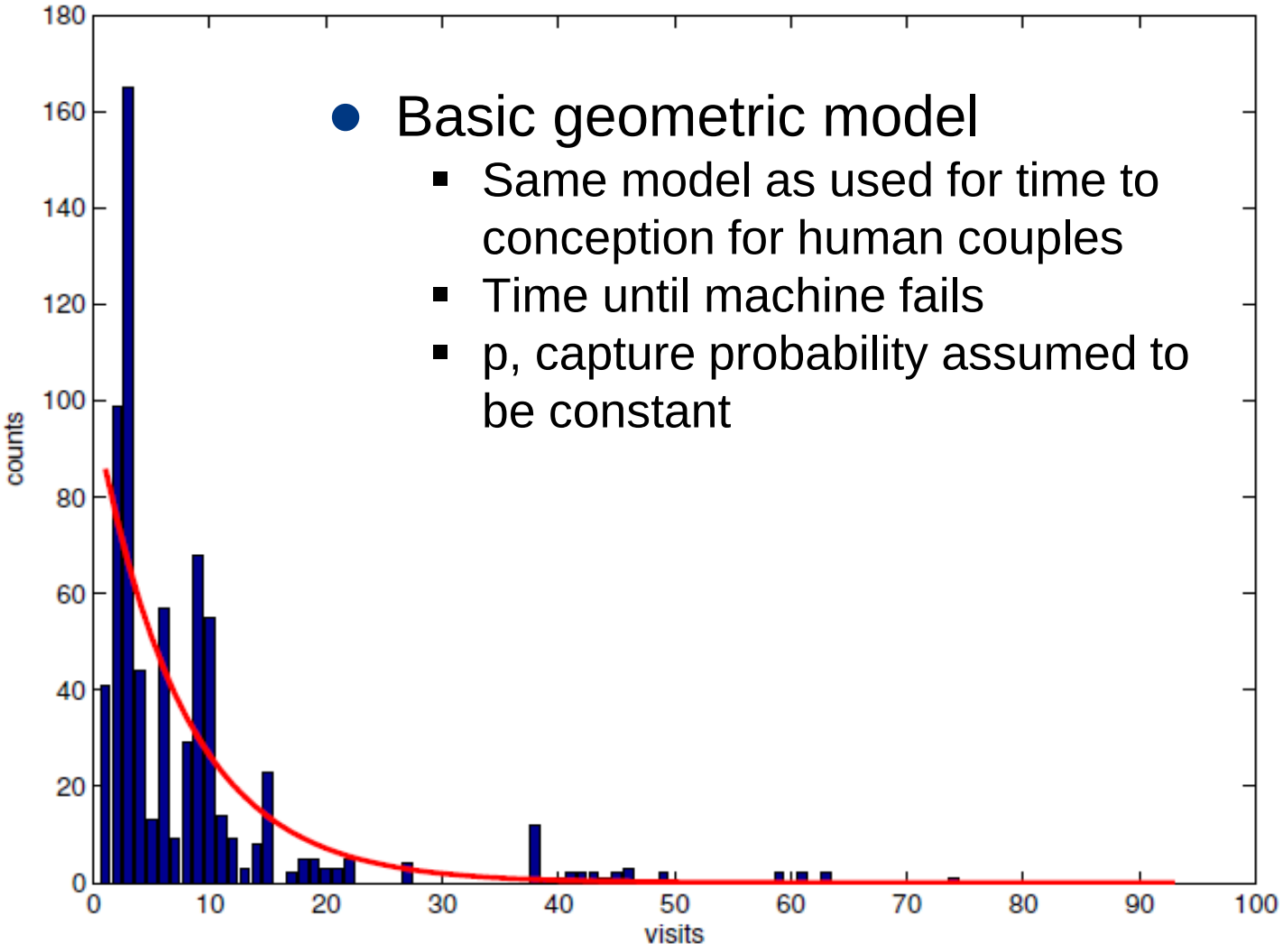
- Capture-recapture data – but with no recaptures!

- 1000 p
- 0100 (1-p)p

- We want to know if there are any individuals who have not been captured by the end of the study….
- …individuals who have encounter history 0000

(1-p)(1-p)(1-p)(1-p)

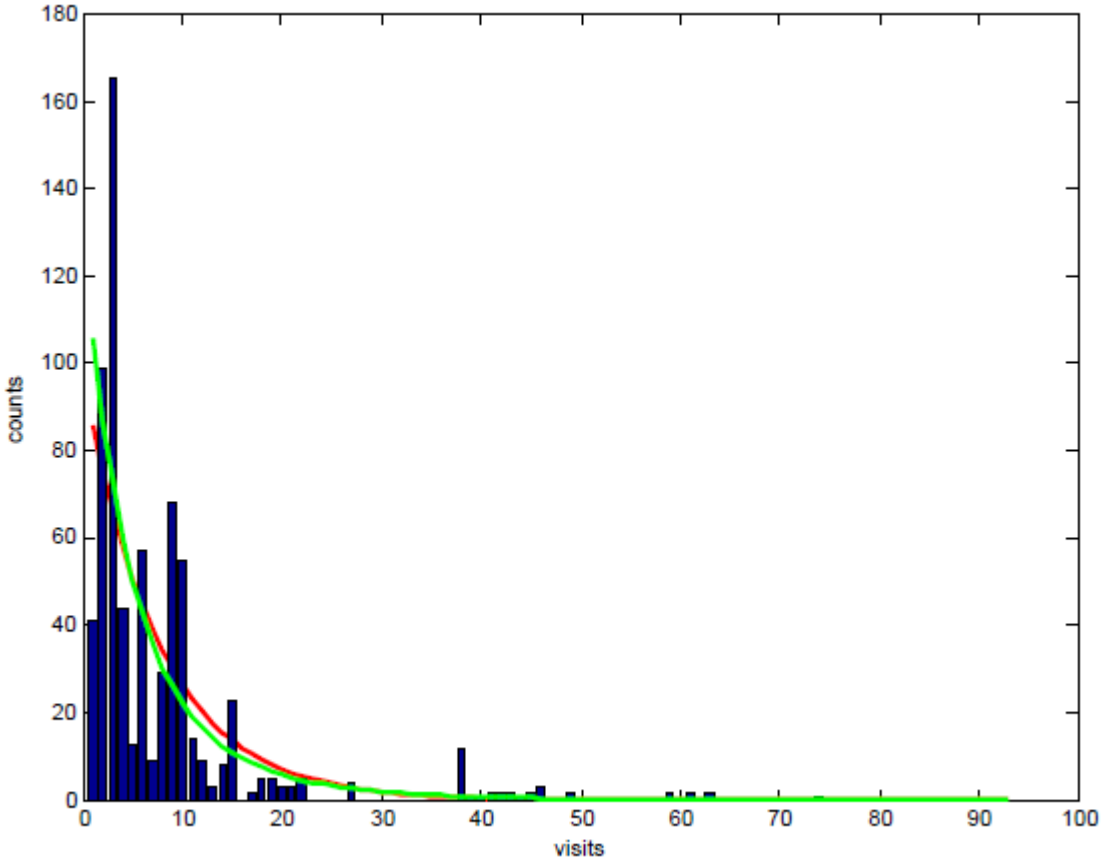
Depletion model



- Basic geometric model
  - Same model as used for time to conception for human couples
  - Time until machine fails
  - p, capture probability assumed to be constant

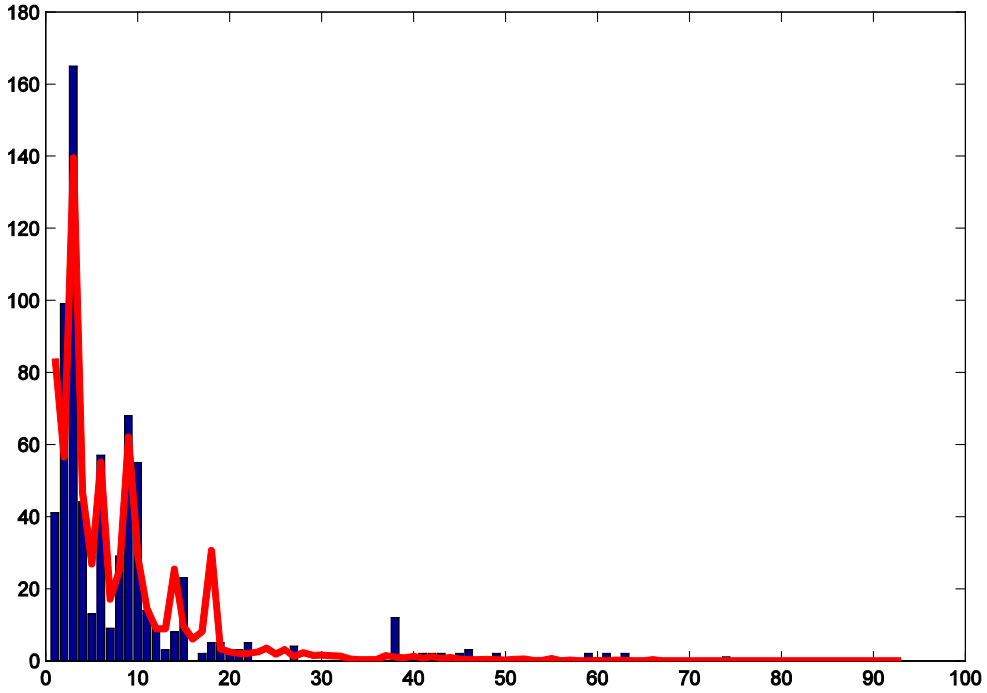
Heterogeneity

- Adding overdispersion – beta-geometric model

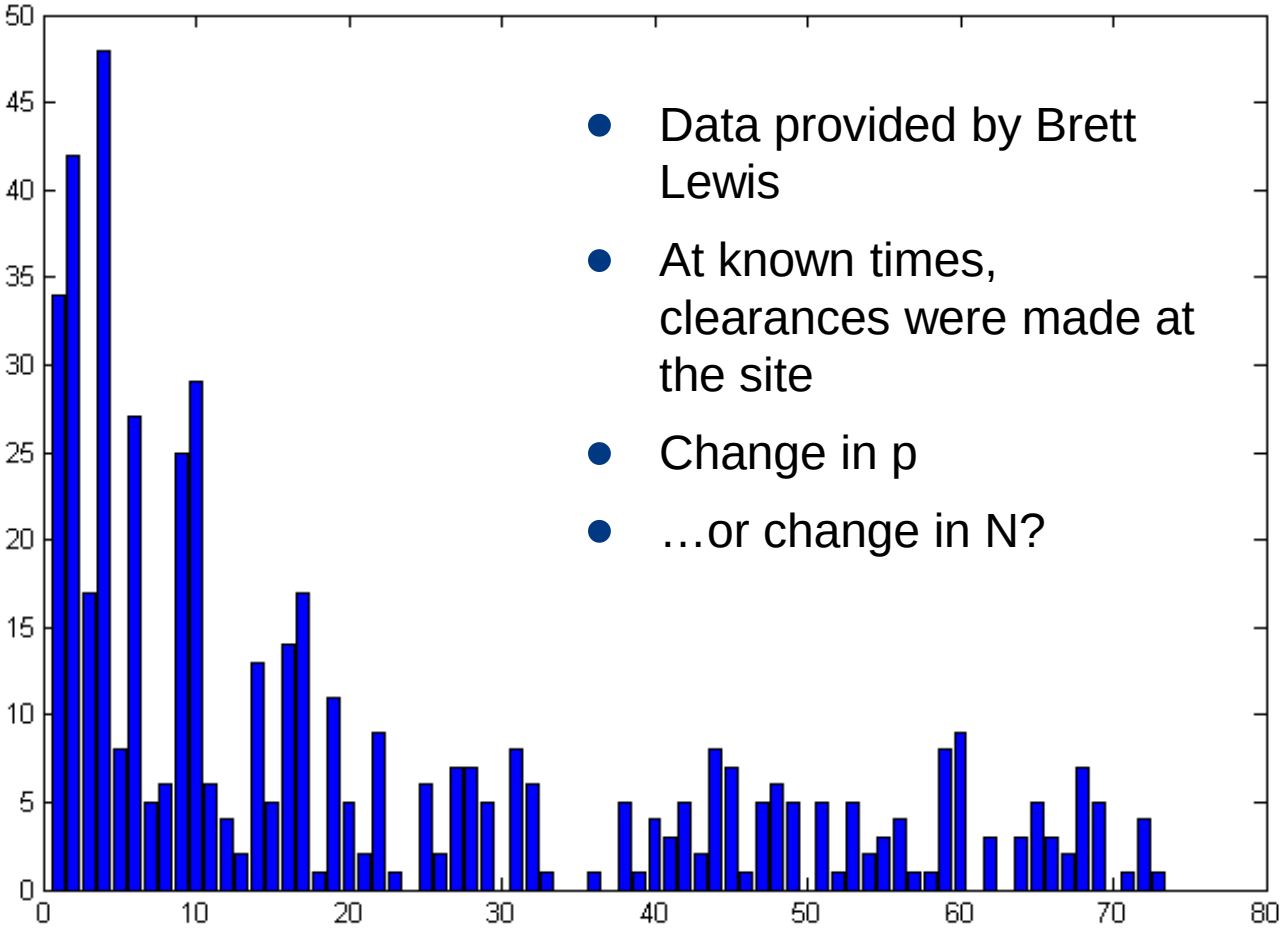


Weather covariates

- Temporal variation – weather covariates
- Minimum air temperature

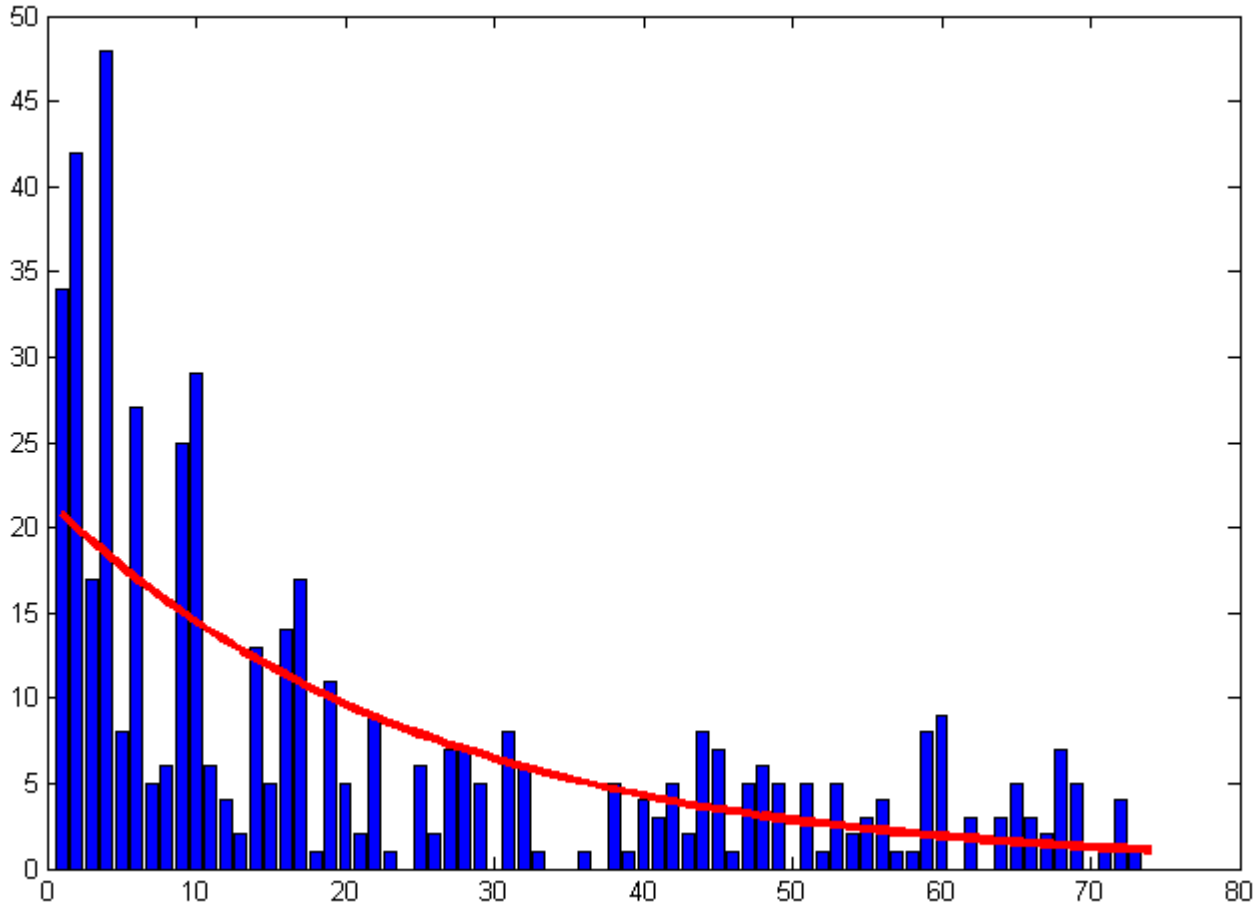


Timed clearances

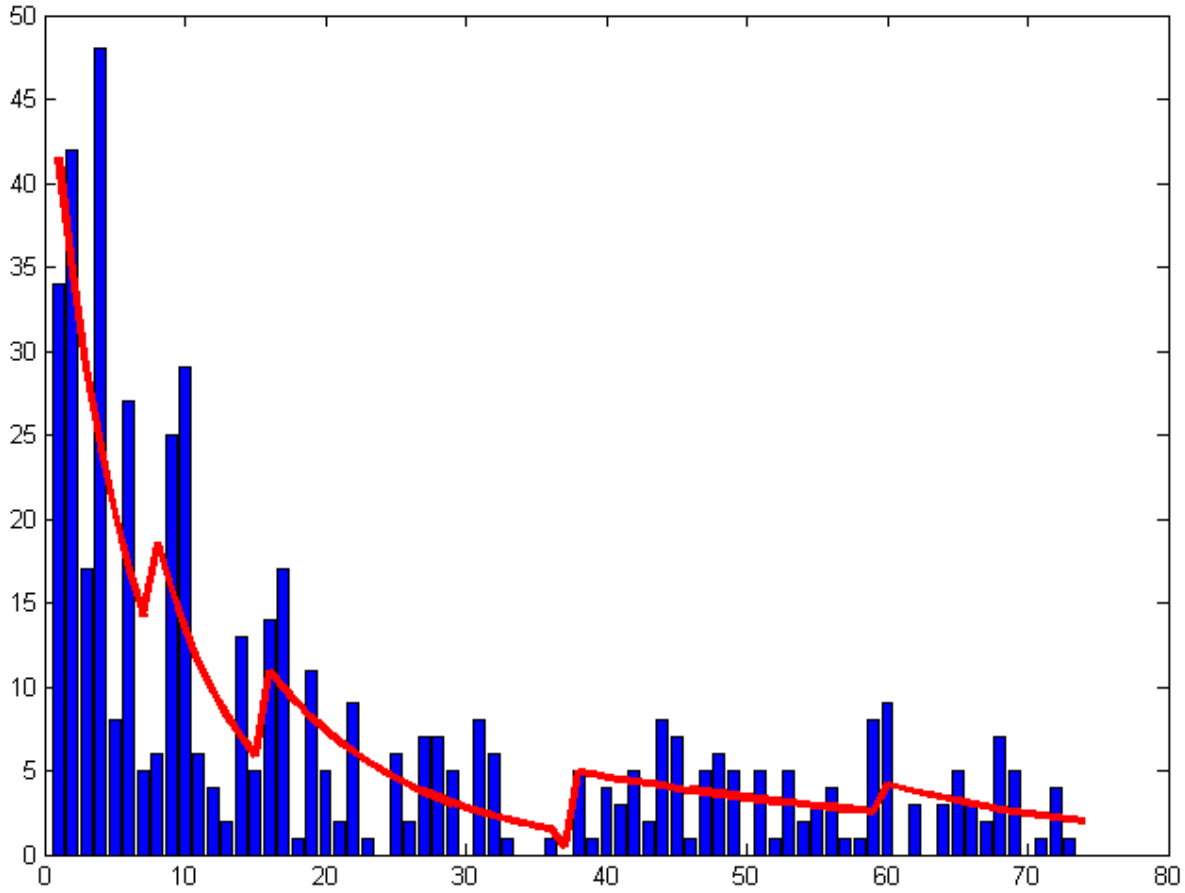


- Data provided by Brett Lewis
- At known times, clearances were made at the site
- Change in p
- …or change in N?

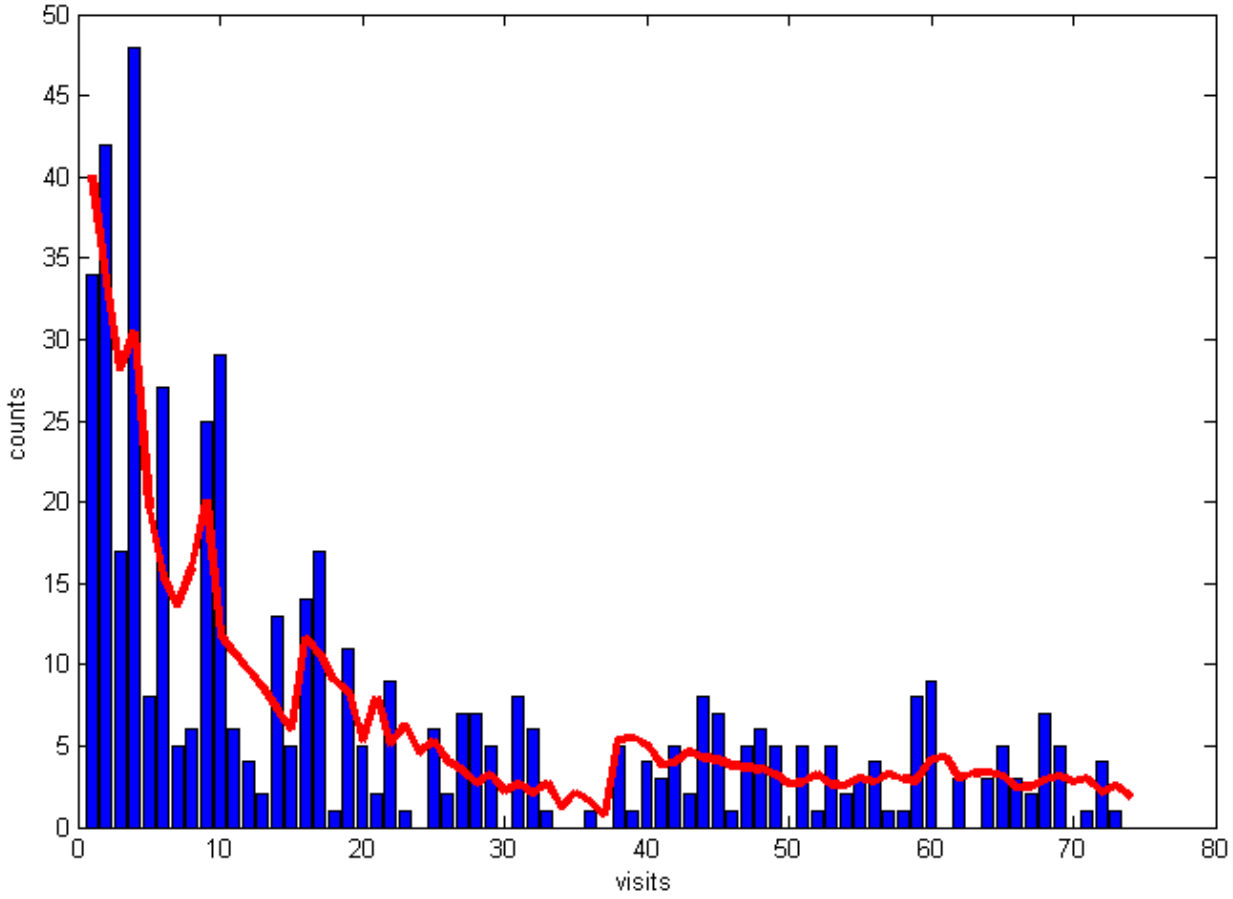
Fitting basic geometric model



Modelling known clearance times

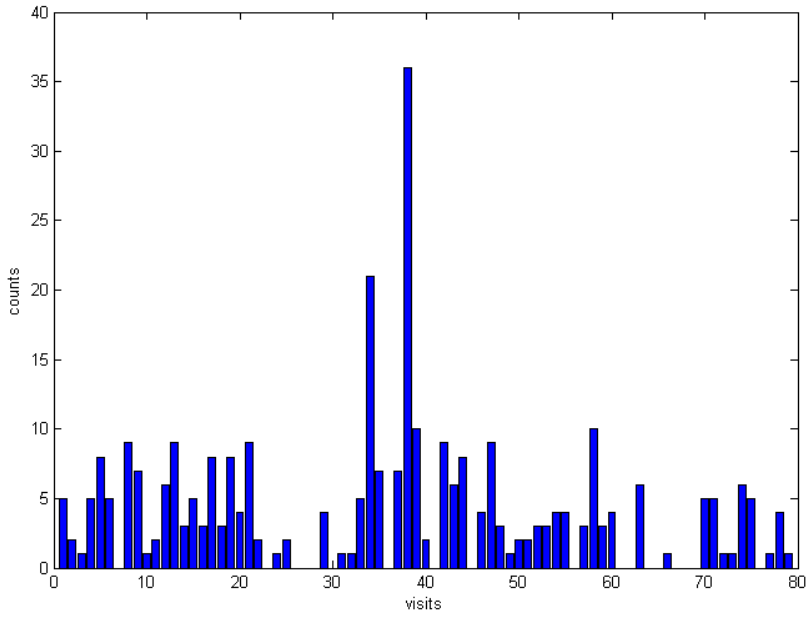


Modelling known clearance times & covariate



Times of population change

- What if times are unknown?



- Borrow an idea from capture-mark-recapture modelling, called **stopover models**

Returning to capture-mark-recapture models

- Studied population might not be closed, but still want to be able to estimate population size
- Jolly-Seber model
  - POPAN/Schwarz-Arnason formulation

0 0 1 0 0

- Entry time into the study population 

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0 0 1 0 0

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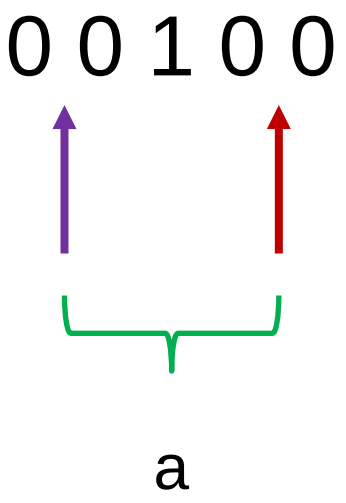
Jolly-Seber model

- If you assume the population is closed when it is not, the parameter estimates will be biased.

- Parameters for the Jolly-Seber model
  - N: **population size**
  - β_t: **proportion of individuals first available for capture at occasion t+1,** $\sum_{j=0}^{T-1} \beta_j$**=1**
  - p_t: probability an individual is **captured** at occasion t
  - ϕ_t: probability an individual present in the study area at occasion t **remains in the study area** until occasion t+1

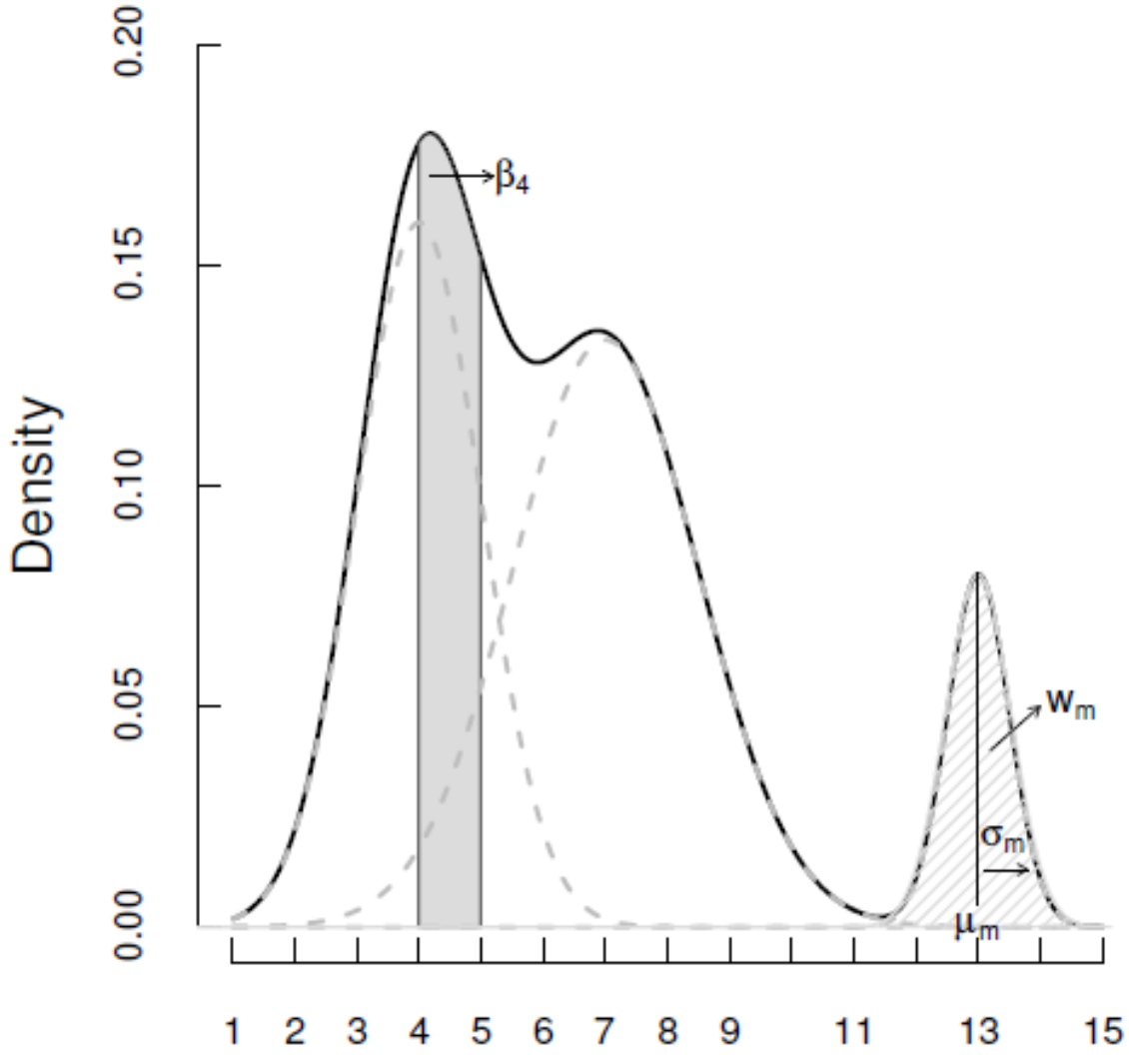
Stopover model

- Generalised version of the Jolly-Seber model
- Parameters are defined to be age-dependent
  - **age** corresponds to the time spent in the study area
  - arrival times and departure times are not independent



Combining unknown arrivals with removals

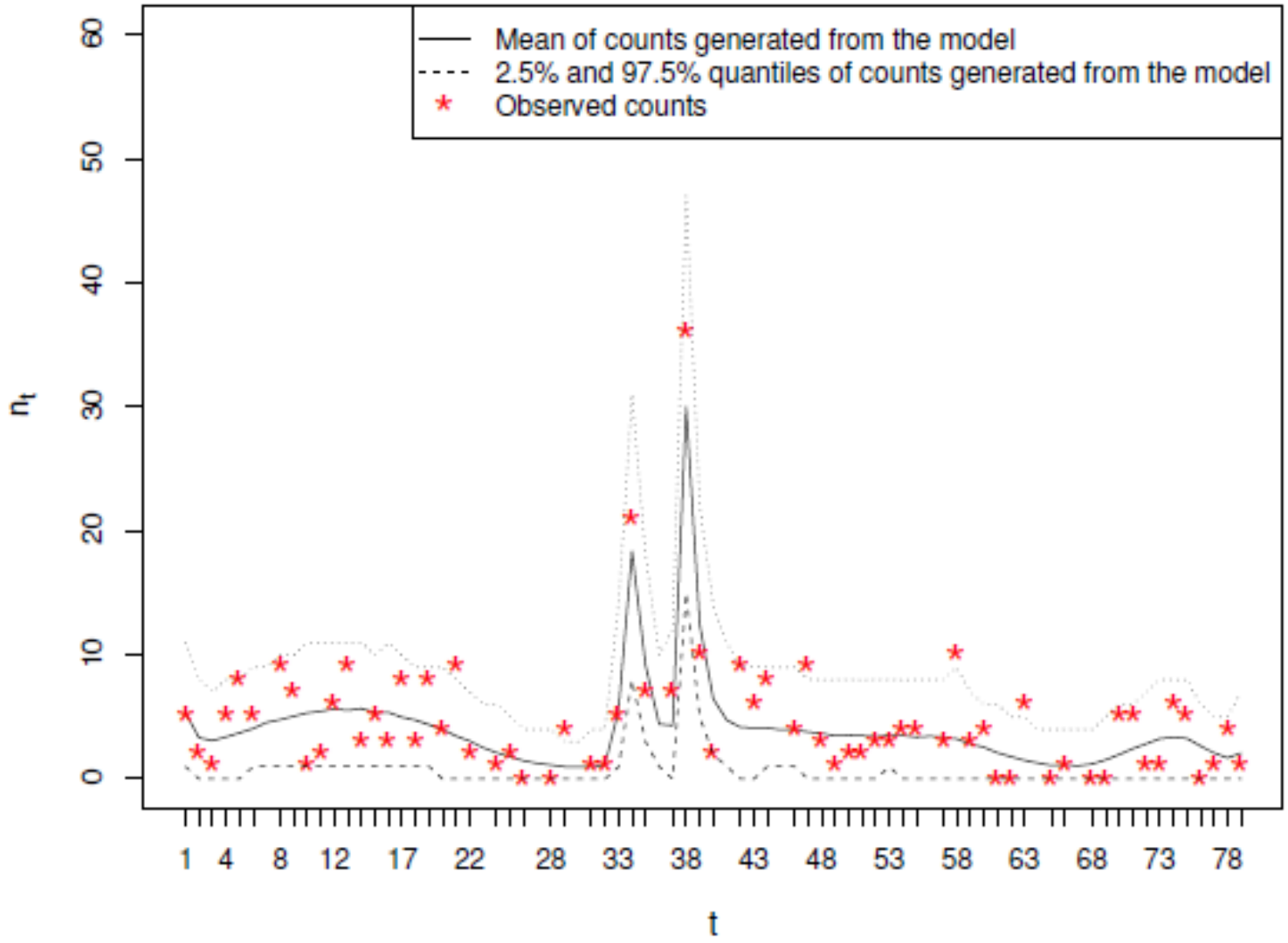
- N: population size
- M: number of arrival groups
- Model arrivals using mixture of normal distributions

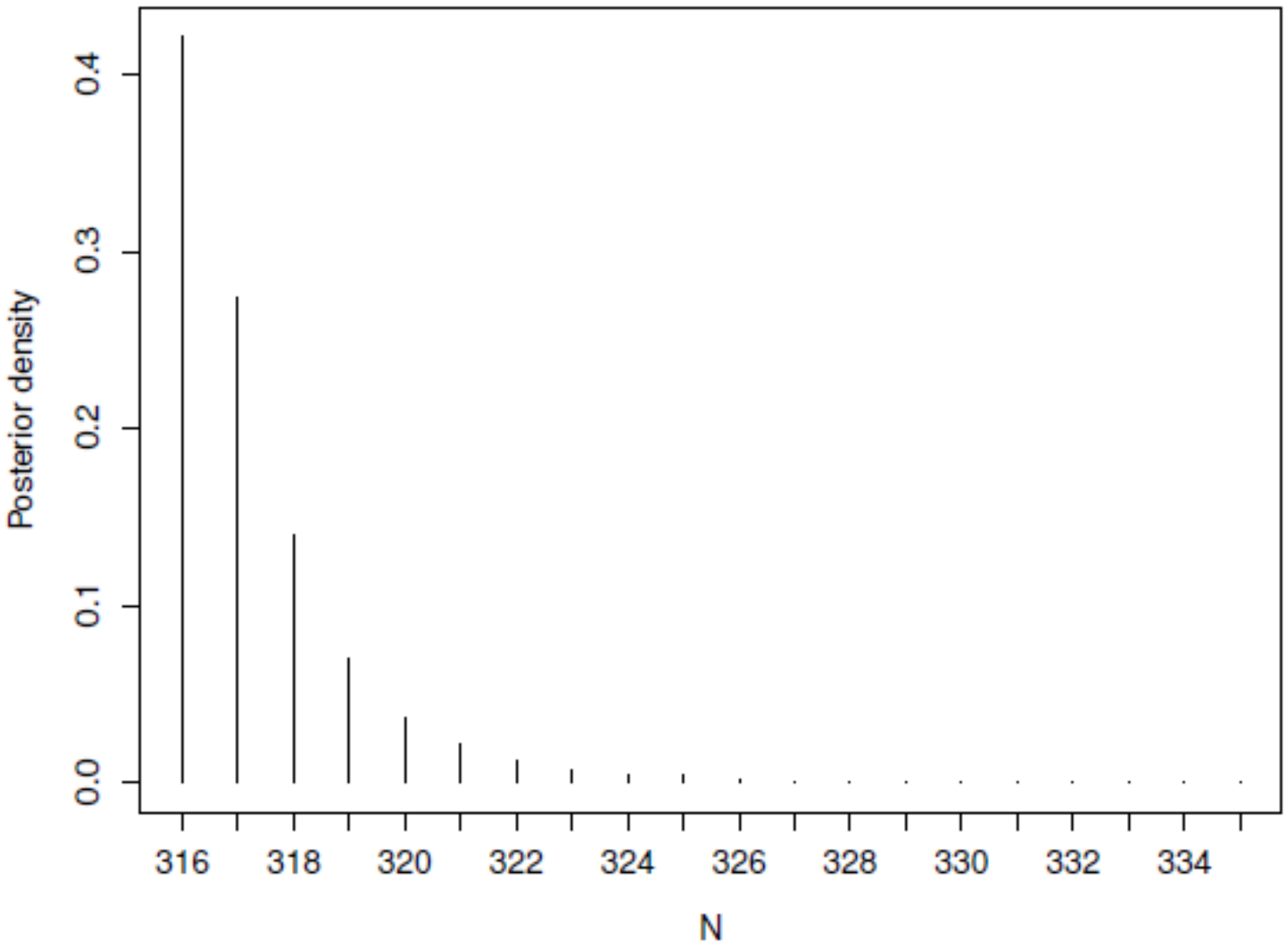

Density
0.00
0.05
0.10
0.15
0.20
β_4
w_m
σ_m
μ_m
1 2 3 4 5 6 7 8 9 11 13 15
Sampling occasions

BES 2014

Technical aspects

- Use Bayesian modelling approach
- Reversible jump Markov chain Monte Carlo (RJMCMC)
  - Model selection
- Tuning of the RJMCMC is complex


Mean of counts generated from the model
2.5% and 97.5% quantiles of counts generated from the model
Observed counts
n_t
0
10
20
30
40
50
60
1
4
8
12
17
22
28
33
38
43
48
53
58
63
68
73
78
t


Posterior density
0.0
0.1
0.2
0.3
0.4
316
318
320
322
324
326
328
330
332
334
N

Conclusions

- It is easy to fit a simple geometric model to depletion data but it is not always sensible
- Use extra information within the modelling
- Advanced approaches to account for unknowns

Future directions

- Statistics PhD student
- Development motivated by real case studies
- How sensible are current guidelines for site clearance?
- Release of R package to allow non-statisticians to fit new complex models

Useful References

- Seber (1982) *The estimation of animal abundance and related parameters.* Griffin. 2nd Edition.
- Dorazio, Jelks and Jordan (2005) Improving removal-based estimates of abundance by sampling a population of spatially distinct subpopulations. *Biometrics.* **61**, 1093-1101.
- Matechou, E., McCrea, R.S., Morgan, B.J.T., Sewell, D. and Griffiths, R.A. (2014) Removal models accounting for unknown arrival times of individuals. In prep.