Novel removal models for amphibian and reptile populations

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Objective

Removal models (Zippin,1956) can be used to estimate the number of animals that need to be removed by successively sampling the area for protected animal species and relocating captured individuals to other sites. Once animals are no longer captured, the monitoring stops.

The aim of the research is to develop unbiased estimates of abundance of amphibian and reptile populations within a closed area by,

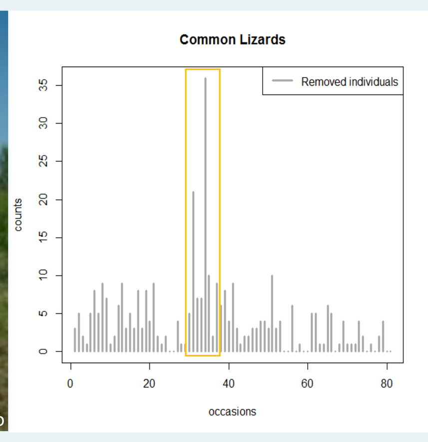
- Accounting for variation in climate in capture probabilities (p).
- Allowing for individuals to become temporarily unavailable for detection by incorporating with multi-event framework (Pradel, 2009).

Data

- Great crested newts, *Triturus cristatus*: 1624 individuals removed over 93 sampling occasions from March 2010 to June 2010. Two night visits and the rest are during the daytime.
- Common lizards, *Zootoca vivipara*: 334 individuals captured over 80 occasions from September 2010 to October 2010. Eight immatures and the rest are juveniles.
- Slow worms, *Anguis fragilis* : 80 individuals are detected and translocated over 80 occasions.

Why do we need a new method?

- Data exhibit unexpected peaks. Why?



- The traditional removal method (Zippin,1956) assumes all the animals are present and available for capture throughout the study, and produces a geometric decline of predicted counts of individuals by assuming constant detection probability over time.
- However, this is not the case for amphibian and reptile populations, as they may be sensitive to climate changes and become undetectable when they hide underground.

Method

Variation in climate

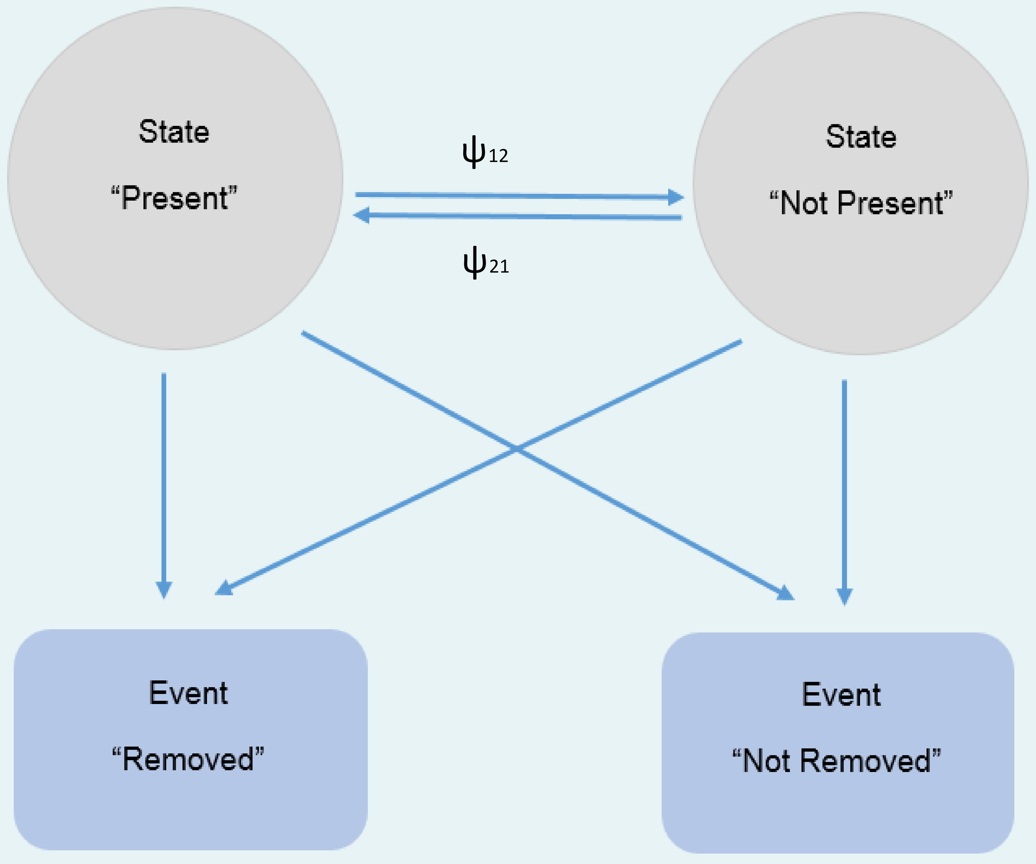
- The probability of detecting an individual usually depends on weather conditions, especially for amphibian and reptile animals. For instance, they are unlikely to be captured on a day of heavy rain.
- Time varying capture probability (p_t) can be modelled as a function of environmental factors in a logistic form,

$$\text{Logist}(p_t) = \log\left(\frac{p_t}{1-p_t}\right) = \alpha+\beta Z$$

where α and β are coefficients to be estimated, Z is a weather covariate, e.g. maximum temperature.

Multi-event structure

- Individuals can transit independently between a finite set of states through a finite number of sampling occasions.
- The successive states occupied for an animal are not observed directly, rather an event at each sampling occasion is recorded.



Parameter Redundancy

- A model is parameter redundant if you can reparameterise in terms of a smaller set of parameters.
- Diagnose the models by forming a derivative matrix **D** = $\frac{d\kappa}{d\theta}$ where κ denotes an exhaustive summary for a model that provides a unique representation of the model and θ denotes the parameters.
- Rank **D** = no. of parameters, the model is full rank.
- Rank **D** < no. of parameters, the model is parameter redundant (or non-identifiable); see Cole *et al.*, (2010).

Results

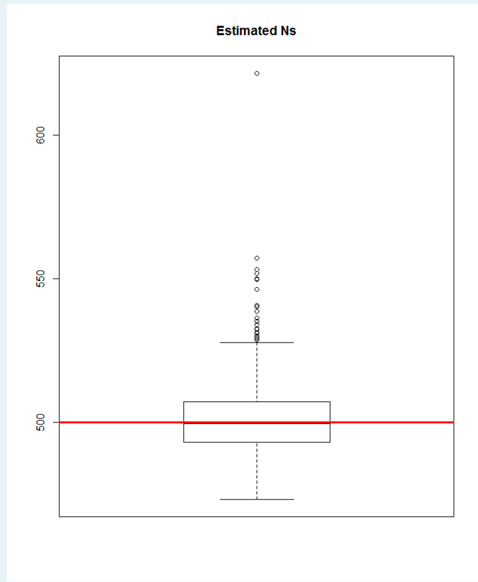
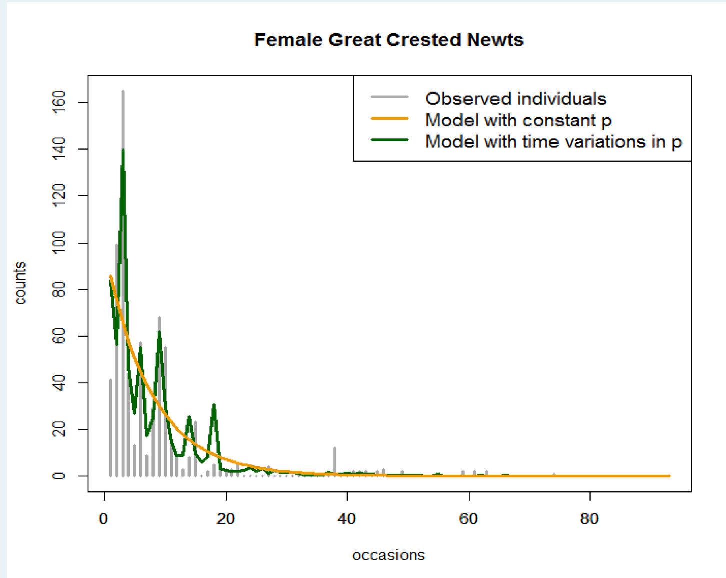


Figure: Simulation results, estimates of N

Figure: Observed and expected values from fitting models to female great crested newt data



Results of deficiency of diagnosed multi-event models.

Model	Constraint	No. pars	Rank of D	Deficiency	Estimable pars
$\pi\ p\ \psi_{12}\ \psi_{21}$	-	4	3	1	πp, $p\psi_{21}$, $(p(\psi_{12}-1)-\psi_{12}-\psi_{21})$
$\pi\ p_t\ \psi_{12}\ \psi_{21}$	$\text{Logist}(p_t) = \alpha+\beta Z$	5	5	0	*
$\pi\ p\ \psi_{21}$	$\psi_{12} = 1 - \psi_{21}$	3	2	1	πp, $p\psi_{21}$
$p\ \psi_{21}$	$\psi_{12} = 1 - \psi_{21}$, $\pi = \frac{\psi_{21}}{\psi_{21}+\psi_{21}}$	2	1	1	$p\psi_{21}$
$\pi\ p_t\ \psi_{21}(t)$	$\text{Logist}(p_t) = \alpha+\beta Z$, $\text{Logist}(\psi_{21}(t)) = \gamma+\delta Y$, $\psi_{12}(t) = 1 - \psi_{21}(t)$	5	5	0	*

* Indicates all parameters in the model are individually estimable.

Remarks

- Significantly improved estimation of total number of animals by incorporating environmental covariates.
- Unbiased estimate of total number of animals can be obtained across all models, however, some parameters cannot be estimated individually in the models with deficiency >1, as shown in the table above.

Future work

- Exploration of more covariates in both capture probability and state mobility.
- Investigation of the poor performance of near-redundant models where the smallest eigenvalue of the hessian matrix will be close to zero (Catchpole, *et al.*, 2001).
- Relax the assumption of closure and allow for new arrivals of individuals as well as temporary emigration, see Matechou, *et al.* (2015).

References

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