

## MN252: Occupancy modeling with camera traps

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In the Mahamavo dry forest, most diurnal and nocturnal lemur species are easily seen by teams walking sample routes by day and at night. However, two nocturnal species, the fork-marked lemur *Phaner pallescens* and fat-tailed dwarf lemur *Cheirogaleus medius*, are seldom seen by the field teams. Additionally, the forest is within the range of aye-aye *Daubentonia madagascariensis*, so it could occur in Mahamavo, although it has not yet been detected. Every year, there are a small number of sightings of carnivores including the Fossa *Cryptoprocta ferox*, Falanouc *Eupleres goudotti*, and Ring-tailed mongoose *Galidia elegans*, but not enough observations to infer their distributions or population sizes. The dry forests are also home to relatively large numbers of bush pigs *Potamochoerus larvatus*, feeding signs and droppings are often found, but the pigs are shy and very rarely encountered. We also have anecdotal evidence that there are feral domestic cats *Felis catus* in the forest, however since their density is unknown it is hard to evaluate if their presence is a significant threat. For cryptic species such as these, a network of camera traps is the best way to gain reliable data on distributions, densities and trends through time, without needing to trap animals.

### Field work

In the summer 2012 field season we will deploy a network of Bushnell trail cameras in the Mariarano and Matsedroy dry forests in the Mahamavo region to begin to seriously study these animals. Since camera traps are expensive this limits the total number that can be deployed. To ameliorate this situation we will probably operate the traps in one set of sample units for three weeks, then move them all to a second set of sample units for a further three weeks in order to double the number of sample units from which we collect detection histories for the study species.



Bushnell cameras use a PIR to detect movement and have an IR flash which allows them to take photos at night and in the day.



Ben Evans installs and tests a camera trap in 2010

Collectively, the students who choose this project will help design the spatial and temporal sampling strategy for a long-term monitoring programme with the cameras. When in the field, your main research tasks will be select 'best' sites at the very local scale to install them on the ground or in trees, visit the cameras to change SD cards and look at the photos, enter records in our database and then undertake analysis of the detection histories of each species recorded by the cameras at each site using occupancy models. Note that the camera trap locations will be recorded using GPS receivers so there is scope to join these locations with spatial covariates from GIS data such as elevation, forest patch area, distances to sources of disturbance such as village etc. It would also be possible to measure microhabitat properties in the field at the locations

where the traps are deployed. The dates of every detection and non-detection are also known, so it would also be possible to incorporate occasion-specific covariates into the modeling process. Probably the most important of these is lunar phase as this is known to affect activity patterns of nocturnal mammals, but there may be others eg weather.

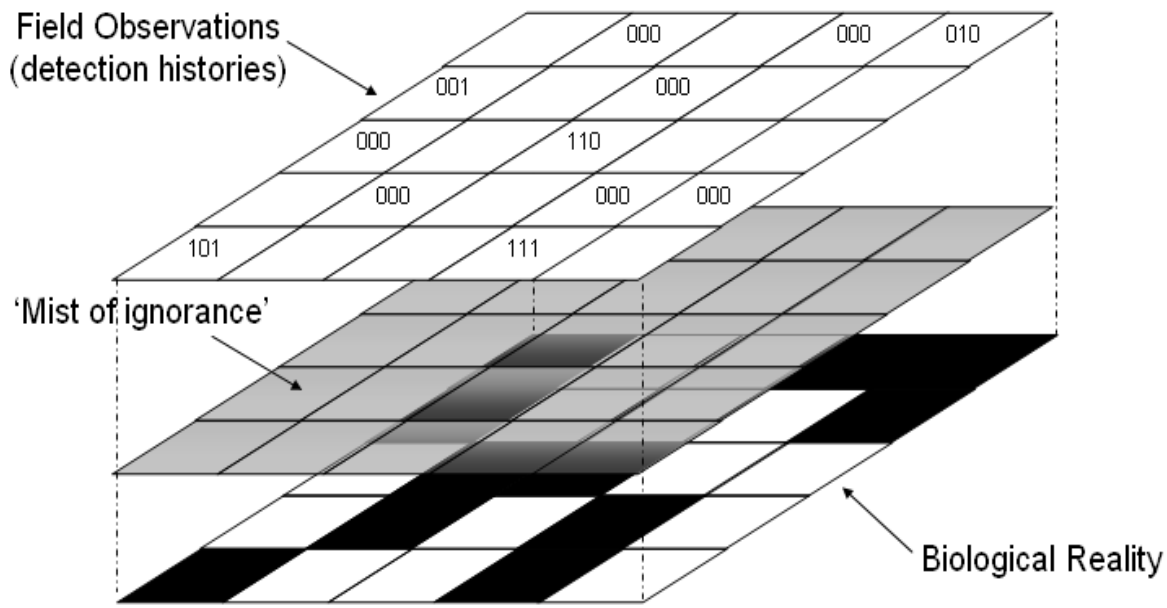
The results will look something like this:

Year	Species	Camera location	Detection history (over about 20 consecutive days)
2012	A	1	00000010010000000000
2012	A	2	00000000000000000000
2012	A	3	000000000000000001000
2012	A	n	00000000000000000000
2012	B	1	00000000000000000000
2012	B	2	00000001000000000000
2012	B	3	00000000000000000000
2012	B	n	00000000000000000000
2012	C	1	00110001110000010100
2012	C	2	01000000000010000000
2012	C	3	00000000000000000000
2012	C	n	00000000000000000000
2012	N	1	00000000000000000000
2012	N	2	00001110010000111011
2012	N	3	00000000000000000000
2012	N	n	00111010010011000010

### Occupancy modelling

This powerful approach allows occupancy of sampling units (camera locations) over the course of the season to be estimated taking account of the detectability of each species.

In the diagram below, the bottom layer represents biological reality. The landscape has been discretised into square units which are either habitat or not habitat for a given species in a particular year (black = habitat, white = not habitat). Unfortunately because the species of interest are cryptic: we can't just walk around and assume that we will be able to spot them in the forest. As a result there is a 'mist of ignorance', the central grey layer. The only way we can find out about these species is to use a sampling method. We can't put a regular grid of camera traps everywhere in the whole landscape, so instead we choose to sample just a small number of possible sites, say the 12 in the diagram. In order to draw strong inference these sites need to be chosen such that they are randomised, representative and independent of each other and also taking into account factors such as the habitat stratum (forest floor/canopy) used by the target species and their home range sizes. We deploy camera traps and record a history of detections (1) and non-detections (0) over several days (for simplicity just 3 days in this example). If a species has been detected at on a least one occasion during a field season we can consider a camera trap location to be occupied by that species. However if we record a detection history of all zeros then this could be a realisation of two different processes: the species is absent and so we didn't detect it. Alternatively, the species was present but we failed to detect it. There are examples of both of these processes in the diagram.



Estimate:

$\psi$  = probability a unit is occupied.

$p_j$  = probability species is detected at sample unit in survey  $j$  (given presence).

$$\text{logit}(\psi_i) = a + bx_i$$

$$\text{logit}(p_{ij}) = c + dx_i$$

McKenzie *et al.* (2007)

At the core of occupancy modeling is the assumption of closure ie. a landscape unit remains habitat or non-habitat over a moderate period of time. We will assume closure over the OpWall 2012 summer season. Given the closure assumption, it is then possible to evaluate the conditional probability of failing to detect a species in a sampling unit over a period of field observations given that the sample unit is actually occupied and simultaneously estimate the detectability of the species and its true occupancy of the set of sample units. You will do the modeling using free software PRESENCE. However, to use this program effectively, in particular to correctly specify design matrixes for different models, it is important to have a sound understanding of the statistical basis of occupancy modeling. We may also use other software such as OpenBUGS for MCMC and simulations in designing the camera trap sampling scheme.

The main results to be expected are estimates with confidence intervals of occupancy of each species, perhaps with respect to environmental and occasion specific covariates. This will permit an evaluation of whether the main utility of camera traps is merely extending species lists and gathering geo-referenced occurrence records or whether they have the potential to contribute to a powerful long-term monitoring programme. Of course, you will also get lots of interesting photos of weird forest creatures going about their nocturnal business. It might also be possible to use the parameters of appropriate occupancy models to make maps of distributions of some of the species corrected for detectability.

## Extensions

The data should permit a range of possible further questions to be pursued should you wish. Here are a few ideas.

- Compare the diurnal and common nocturnal lemur occupancies estimated from sample routes with the estimates from the camera traps.
- Estimate density of some animal detected with the camera traps using Brownian motion logic (Rowcliffe 2008)
- Multiple devices approach. Camera traps are expensive and could never be very widely deployed for large-scale participatory monitoring programme in Madagascar. However sand-traps for detecting carnivore footprints are cheap. You might want to establish a double sampling design in which we put sand-traps in front of some cameras to calibrate this method to aggregate camera trap detections.

## References

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