Threatened Species Recovery Hub

National **Environmental Science** Programme

Estimating the density of foxes using spatially explicit mark-resight methods

In brief

Conservationists and managers increasingly want to use camera traps to estimate the population density of species that are elusive and difficult to observe, including invasive species such as feral cats and red foxes. Standard practice is to place cameras on tracks, however, for many species it is unclear whether this provides reliable estimates.

We compared density estimates for the red fox from three different camera trap survey designs (on-track grid, on-track transect, off-track grid), over a two-year period across a 14,000 ha area at Australian Wildlife Conservancy's Scotia Wildlife Sanctuary in western New South Wales.

An important factor in standard density estimating approaches is being able to resight known individuals, as the method relies on calculating the rate of detecting known individuals relative to all detections. As red foxes do not have distinctive markings that allow individuals to be identified, and in order to build models of fox spatial movement, we used GPS collars on a subset of red foxes in the area.

We found that camera surveys based either on- or off-track can provide reliable estimates of population density where a model of animal space use exists. We have developed a model of fox space use at Scotia, and this model could potentially be applied to similar landscapes, although new space use models would be needed for different habitats.

BELOW: Weighing a male fox after it was fitted with a GPS collar. Photo: Murray Schofield/AWC

We found that the spatial bias of on-track surveys was outweighed by the benefit of increasing the number of detections which improved the accuracy of the density estimate. In addition, on-track surveys required far less resources than off-track surveys.

This research provides guidance for spatially explicit mark-resight (SEMR) density estimate methods but will also contribute to the ultimate goal of developing methods which do not require marked individuals.

Background

Red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) are introduced predators that have driven the decline or extinction of one-third of Australia's native mammals. Reliable estimates of population density are important to developing appropriate management strategies for these species (e.g., population control versus eradication) and to evaluate the effectiveness of different interventions (e.g., trapping versus baiting versus shooting).

Conservationists and managers are increasingly using camera traps to estimate the population density of species that are elusive and difficult to observe, including foxes. A standard practice for these surveys is to place cameras on roads, trails and paths. This biases the data, but it does maximise detections and/or increases efficiency in the field. For many species it is unclear whether track-based camera surveys provide reliable estimates of population density.

This research assessed the effect that camera-trap placement has on density estimates and examined the trade-offs between unbiased designs and those that maximise detections and increase efficiency.

Fox caught on camera. Photo: Andrew Carter/AWC

australian wildlife conservancy

THE ANALYTICAL EDGE STATISTICAL CONSULTING

Using cameras to estimate fox densities

Standard camera trap-based density estimate methods rely on identifying known individuals and are known as spatially explicit capture recapture (SECR). For species like feral cats that have distinctive coat patterns it is often possible to identify individuals from camera-trap photographs. For species like red foxes that can't be uniquely identified by their coats, we needed another reliable means of identifying a proportion of the population. In our study, we fitted a subset of foxes with GPS collars, which enabled us to assign detections from photographs of marked foxes to individual animals with certainty. This method is known as spatially explicit mark–resight (SEMR).

Just two previous studies used camera traps to derive density estimates for foxes in Australia; moreover, comparisons with those studies are difficult as neither identified individuals uniquely, and both were based on substantially shorter survey periods (an important consideration as fox activity and density are influenced by seasonality). Our research is the first long-term study of the density of red foxes that combines camera traps and spatially explicit density estimation methods.

Research aims

We set out to evaluate the effect of camera-trap placement on density estimates of the red fox over a two-year period (2015–2017) at Scotia Wildlife Sanctuary. Scotia is a semi-arid 64,659 ha private conservation reserve in western New South Wales owned and managed by the Australian Wildlife Conservancy. Specifically, we wanted to compare the SEMR density estimates from three different spatial arrays of camera traps: on-track grid, on-track transect and off-track grid (see Figure 1).

What we did

Red foxes are the largest predator in semi-arid Scotia Wildlife Sanctuary, and were not subject to any population control during the period of the study or for the previous six years. To measure their density, over the two-year study period we deployed 107 camera traps across a 14,000 ha area in the three different types of spatial array. The breakdown, as shown in Figure 1, was on-track grid (a) 35 cameras; on-track transect (b) 28 cameras; and, for a short period when additional resources were available, off-track grid (c) 35 cameras. Map (d) is the combination of all three arrays plus nine supplementary cameras.

We conducted 24 camera-trapping nights each month, for two consecutive years during the study. Density estimates were generated separately for each type of camera array, and month, across this period. We attached the cameras to galvanised steel posts driven into the ground. When triggered, they recorded five consecutive high-quality images, which were stamped with information about the camera location, date and time. We did not use baits or lures at the cameras.

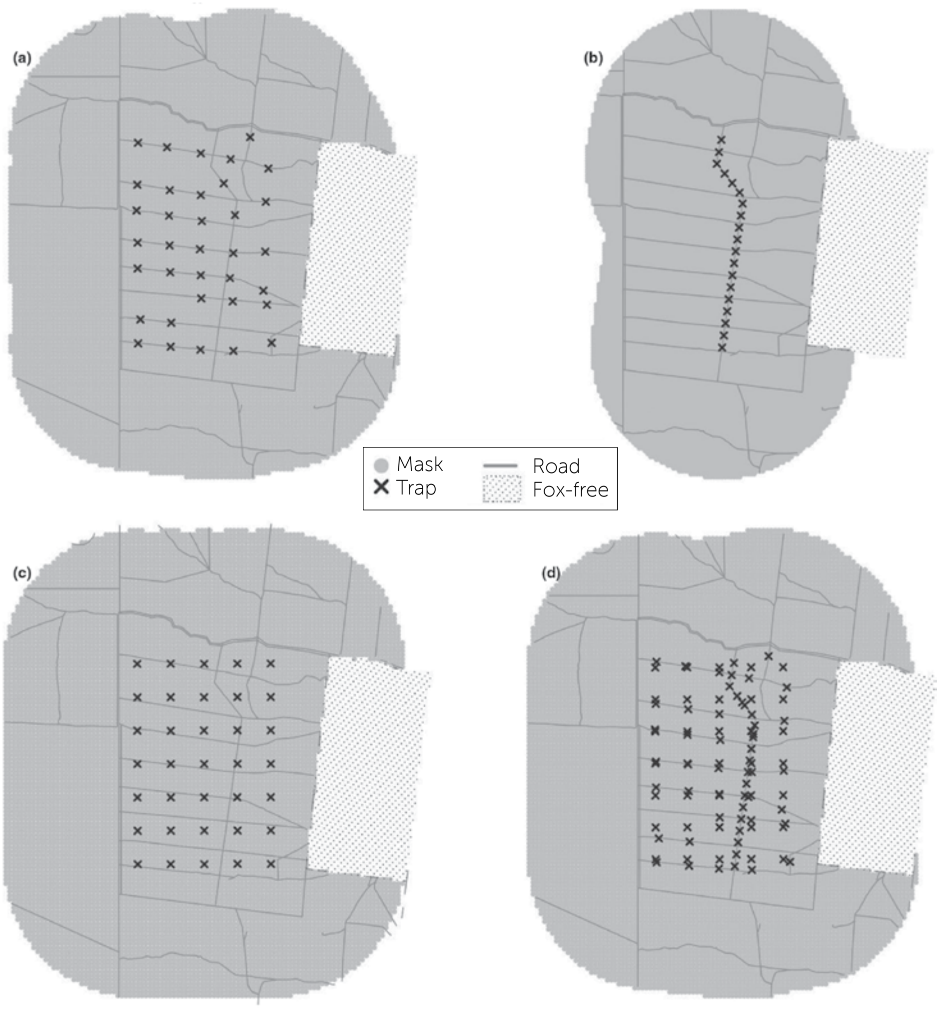

Figure 1. The three camera-trap arrays used at Scotia Sanctuary, 2015–2017: a) on-track grid; b) on-track transect; and c) off-track grid. Map d) represents all cameras combined, which was used for additional analyses. (Carter, et al. 2019, Ecology and Evolution)

RIGHT: AWC Wildlife Ecologist Dr Andrew Carter collecting morphological measurements on a fox prior to its release. Photo: Murray Schofield/AWC

With the uniform colour and lack of patterning of their coat, red foxes can't be identified reliably from photographs unless they are marked artificially. So, to identify individuals on camera-trap images, we fitted 28 foxes with GPS collars over a three-year period: seven foxes October 2015 – March 2016, 10 foxes July – December 2016 and 11 foxes June – September 2017. The collars operated for approximately four months before detaching automatically, and recorded the foxes' locations at 20-minute intervals between 5pm and 9am and at 96-minute intervals during the daytime remainder. We identified individual foxes in camera-trap images by comparing the time stamp of the image with all available GPS data.

For SEMR analyses, it is assumed that no GPS collars are lost, which was the case in our study. It also assumes that animal home ranges are circular; and we chose a 4000m buffer around the camera-trap locations, based on GPS location data that indicated that foxes rarely moved further than this distance. Collared individuals were also assumed as part of the SEMR analysis to be a random sample of the larger population.

Key findings

Across the 24-month study, we found foxes to be widespread throughout the study area. We detected them at all locations in the on-track grid and on-track transect arrays (plus the nine supplementary cameras), while during the three sessions (months) that the off-track grid was active, we detected foxes at 63% (22/35) of those camera-trap locations.

Camera placement

While we found that fox detection rates were much higher at cameras placed on tracks compared with off-track cameras, in the majority of survey sessions, the placement of cameras had relatively little effect on density estimates. However, for each camera array, the *precision* of those density estimates varied considerably across the survey sessions. In general, arrays that had more detections increased the accuracy of the density estimate, but only when there were adequate sightings and resightings of known individuals, upon which the method relies on.

During July–September (winter/spring) 2017, when the three different survey designs were operating at the same time, the median estimated density across the three sessions was 0.06 foxes per km^2 for on-track grid cameras, 0.07 foxes per km^2 for off-track grid cameras, 0.11 foxes per km^2 for on-track transect cameras, and 0.08 foxes per km^2 when data from all cameras were combined.

Generally, our findings suggest that wherever populations are in low densities, an appropriate survey design will be one that makes it most likely that uniquely identifiable individuals will be detected and resighted. The reduced uncertainty that this design would deliver will outweigh the biases associated with any particular survey design. In other words, if foxes and feral cats are more likely to be detected on cameras placed on roads or tracks, then it is acceptable to place cameras there, as the higher number of detections will improve the confidence we have in the estimates of population density at those points.

Survey efficiency

To develop a means to estimate density that is practicable, and to evaluate camera-trap survey design, it is necessary to give key consideration to the amount of effort involved in deploying and maintaining cameras.

The time spent in the field each month to keep cameras operational (i.e., maintain batteries and memory cards) varied greatly for the different camera arrays. The effort to maintain the off-track grid array was 2.7 times greater than for the on-track grid, and more than 10 times greater than for the on-track transect array. This was because the off-track grid required approximately 30 km of off-track walking each time we visited the 35-camera array.

Fox detections

In total, we recorded 2773 detections across 24 survey months and 37,137 trap nights. Despite this great survey effort, on average 26% of collared foxes were not detected in any given month, even though GPS data indicated they were within the study area. In total, less than 20% of total detections were of collared foxes. Two collared foxes were never detected on camera even though they were present for 44 and 77 days respectively.

These results suggest that short-term camera-trap surveys may fail to detect a considerable proportion of the fox population. This will likely have important implications for the ability to produce reliable density estimates.

One of the many photographs of collared foxes captured by camera traps in the study conducted at AWC's Scotia Wildlife Sanctuary. Photo: Andrew Carter/AWC

Recommendations

Our findings demonstrate the tension between deploying unbiased survey designs and the practicalities of reducing uncertainty around density estimates. That is, the need to ensure that camera placement enables frequent resightings of uniquely identifiable individuals outweighs concerns about the magnitude of unknown biases associated with placing cameras on roads, tracks or trails.

The variation in precision that is associated with different survey designs may increase if individuals or groups within a population show different preferences for microhabitat (as has been shown in previous studies of large wild cats). This serves to further highlight the importance of taking into account the spatial behaviour and/or preferences of the subject species before starting camera-trap surveys, to ensure that the placement of cameras maximises exposure to the population as a whole.

These findings should help inform effective and reliable design of feral predator surveys at other sites. This research will also contribute to the development of density estimate methods for foxes that do not rely on marked individuals.

Work cited:

Carter, A., Potts, J.M. & Roshier, D.A. (2019). Toward reliable population density estimates of partially marked populations using spatially explicit mark–resight methods. *Ecology and Evolution*, vol. 9, no. 4, pp. 2131–2141.

Fitting a female fox with a GPS collar. Photo: Murray Schofield/AWC

Further Information

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