TESTS OF DISTANCE SAMPLING ON KNOWN POPULATIONS

At the hearing on 27 March 2024 for the inquiry '*Proposed Aerial Shooting of Brumbies in Kosciuszko National Park',* I was asked for examples of tests of Line Transect Distance Sampling against known populations. I described one test that I had been responsible for and agreed to supply further examples 'on notice'. Here are seven examples and a summary of what they all mean.

SUMMARY

Seven sets of tests of line transect distance sampling on known populations, comprising 33 known populations in total, produced reasonably accurate estimates of abundance with a slight tendency for underestimation. This was the case, whether the survey platform was a person on foot, a helicopter, or a video camera towed underwater. In one case the underestimation was severe; the case of wallaroos counted from a helicopter.

IN MORE DETAIL

1) The example I described on 27 March

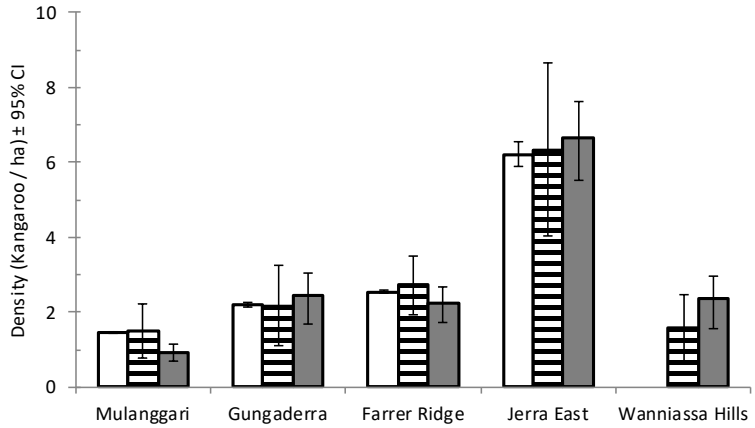
In 2014, my colleagues, Dr Mel Snape and Ms Claire Wimpenny, and I, with the help of casual employees and volunteers, used three fully independent methods to estimate abundance of Eastern Grey Kangaroos in five nature reserves in the ACT. The vegetation differed between reserves, and also the kangaroo population size. The three methods were:

(i) Walked Line Transect Distance Sampling;
(ii) Faecal Pellet Counts; and
(iii) Replicated Total Counts.

The result was that the three methods agreed. That is, in every nature reserve, the differences between methods were small and not statistically significant. And there was no consistency in which method gave the highest or lowest estimate (Figure 1). In these reserves, the total count result is considered to be the true density. That opinion is based on considerable experience with total counts between 2001 and 2016, including prior experience with the method in the same reserves used for the test, and strict rules around the conduct of the method.

In summary, Walked Line Transect Distance Sampling provided accurate estimates of abundance.

Figure 1: ACT kangaroo count methods compared: Outline = Total Count (Error bars are present in all cases but barely visible in some); Hatching = Pellet Count; Shading = Walked Line Transect Distance Sampling. (There was no total count at Wanniassa Hills.)



The remaining six examples are from the literature.

2) Southwell 1994 – counting 11 known kangaroo populations

Southwell (1994) conducted trials on 11 kangaroo populations of known size, using 15 alternative mathematical estimators on each, including all the estimators that are provided in the Distance computer program. Only two of the 15 estimators proved UNsatisfactory. Southwell found the remaining estimators were reasonably accurate but slightly negatively biased (i.e. prone to underestimate). He also found that the underestimation was both (i) worse in wild kangaroo populations than captive ones, and (ii) increased with increasing density (i.e. the more kangaroos per hectare, the greater the underestimation).

Regarding the findings about underestimation, note that the range of kangaroo densities encountered by Southwell was 0.14 to 2.25 ha^{-1} and that much greater densities (up to three times greater) have subsequently been measured repeatedly in Victoria and the ACT (e.g. Figure 1). Southwell's warning about negative bias is still relevant, however practitioners in both places have learned how to overcome bias in wild kangaroo populations, even when density is as high as 7 ha^{-1}. For example, see Figure 1.

In summary, Walked Line Transect Distance Sampling provided accurate estimates of abundance of 11 populations, with a tendency to underestimate slightly.

3) Glass *et al*. 2015 – counting a known population of tagged wild kangaroos

A population of wild Eastern Grey Kangaroos in which every individual was ear tagged, enabled Glass *et al*. (2005) to know precisely how many kangaroos were present on the research site at Wilsons Promontory on both occasions when Glass was conducting experiments in walked line transect distance sampling (i.e. 141 and 124 kangaroos). Glass used six transects which she surveyed repeatedly, up to 7 times in each survey period. In summary, the 95% confidence intervals of all estimation attempts always included the true density, i.e. the estimate was accurate. The method underestimated true density but the bias stabilised between –1% and –9% when the six transects were travelled four times. This also achieved maximum precision, i.e. Coefficient of Variation = 13% (i.e. neither accuracy nor precision improved with the extra effort of walking the transects more than four times).

In summary, Walked Line Transect Distance Sampling provided accurate estimates of abundance, though 1% to 9% underestimation was evident.

4) Clancy *et al*. 1997 – Helicopter line transect distance sampling of three kangaroo species across four sites

The densities of three species of kangaroos were estimated using Helicopter Line Transect Distance Sampling as well as Walked Line Transect Distance Sampling on four sites over four years (Clancy *et al*. 1997). Densities of Red Kangaroos and Eastern Grey Kangaroos were not significantly different between methods but the density of Wallaroos estimated by helicopter was consistently about half of the estimate obtained by walking. This was most likely because Wallaroos are much harder to see from aircraft than the other two species.

In summary, Helicopter Line Transect Distance Sampling provided accurate estimates of abundance of Red Kangaroos and Eastern Grey Kangaroos but severely underestimated the density of Wallaroos.

5) Hone 1988 – Helicopter line transect counting of dead feral pigs

Hone tested the Helicopter Line Transect method against a known population of 616 pig carcasses which had been shot in the previous two days (Hone 1988). Fifty one of the carcasses were detected from the helicopter, from which the correct density was estimated (2.8 km^{-2}). Of eight alternative mathematical estimation functions tested, the one that proved most acurate was The Fourier (aka Uniform) function. This is one of the estimators available in the Distance computer program.

In summary, Helicopter Line Transect Distance Sampling provided an accurate estimate of abundance.

6) Laake *et al*. 2008 – Helicopter Line Transect counting of feral horses in KNP

Laake, Dawson and Hone compared three different approaches for analysis of data collected by helicopter line transect in Kosciuszko National Park. These were:

(i) conventional Line Transect Distance Sampling (i.e. as used by Cairns 2023 and many other workers);
(ii) Mark Recapture analysis; and
(iii) a mathematical combination of both (i) and (ii) called Mark Recapture Distance Sampling (**MRDS**).

On their own, both (i) and (ii) were found to have underestimated true density. MRDS provided greater accuracy. MRDS is recommended in my submission for the future surveys in each retention area. It may require a larger helicopter.

The authors cautioned that even with MRDS, the estimate will be negatively biased if there is substantial and consistent movement of horses away from the line travelled by the helicopter. It will be positively biased if there is movement toward the helicopter. In practice movement toward the helicopter is not often observed (personal observations in 2001). Horses often move diagonally away from the helicopter.

In summary, Helicopter Line Transect Distance Sampling underestimated abundance. Mark Recapture Distance Sampling from a helicopter was more accurate and is recommended for future surveys.

7) Bergstedt and Anderson 1990 - Counting bricks by underwater video

Researchers wanting to estimate the number of trout carcasses on the bottom of lakes, first carried out a trial on a known 'population' of bricks dropped randomly into Lake Huron, USA. This research (Bergstedt and Anderson 1990) is published in a journal to which I do not have access, but fortunately the research is described in detail by both Thompson et al. (1998) and Buckland et al. (2001). The researchers towed an underwater video camera along transects, and found their Line Transect Distance Sampling estimates using five mathematically different estimators were close to, but slightly below, true density.

In summary, Underwater Line Transect Distance Sampling provided an accurate estimate of abundance, with slight underestimation.

Other cases

Distance Sampling has also been tested on other known populations. A well known example from 1978 is described by Buckland *et al*. (2001), in which students were asked to estimate the density of

short stakes driven into the ground in an area of sagebrush vegetation. Although the students failed to respect the standard 'rules' for Distance Sampling, the estimate was close to true density.

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Don Fletcher, Ecologist

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