Introduction to distance sampling

Workshop, 21-23 August 2019

Centre for Research into Ecological and Environmental Modelling

Exercise 1. Line transect detection functions by hand

In this practical, we plot a histogram of line transect data and estimate a detection function. The data were collected during a line transect survey of duck nests in Monte Vista National Wildlife Refuge, Colorado, USA: twenty lines of 128.75 km were specified and a distance out to 2.4m was searched and the perpendicular distances of detected nests were recorded and summarised (Table 1).

Table 1. Frequency of duck nests detected in perpendicular distance bands (metres).

Distance.band	Frequency
0.0-0.3	74
0.3-0.6	73
0.6-0.9	79
0.9-1.2	66
1.2-1.5	78
1.5-1.8	58
1.8-2.1	52
2.1-2.4	54

Objectives

The aim of this exercise is to plot a histogram of the perpendicular distances to the detected duck nests and estimate (by eye) a detection function and hence estimate density of duck nests, i.e. the number of nests per square metre or per square kilometre (be careful of units). Work through the following steps:

1. Plot a histogram of the data in Table 1 and fit a detection function by eye.
2. Estimate the areas under the rectangle and the fitted detection function curve and hence estimate the proportion of nests that are detected in the covered region, i.e. the region within 2.4m of the transect centre line.

$$Area_{rectangle} =$$

$$Area_{curve} =$$

$$\hat{P}_a = \frac{Area_{curve}}{Area_{rectangle}} =$$

3. Obtain an estimate of the number of nests in the covered region (Note $n = 534$):

$$\hat{N}_a = \frac{n}{\hat{P}_a} =$$

4. Estimate density (Note $L = 20 \times 128.75 = 2575$ km):

$$\hat{D} = \frac{\hat{N}_a}{a} = \frac{\hat{N}_a}{2wL} =$$

Stop here until instructed to go further.

5. Now use your histogram to estimate the effective half-width of search distance, μ.

$$\hat{\mu} =$$

6. Use your estimate of μ to estimate nest density, D.

$$\hat{D} = \frac{n}{2\hat{\mu}L} =$$

How does it compare to your estimate from part 4?

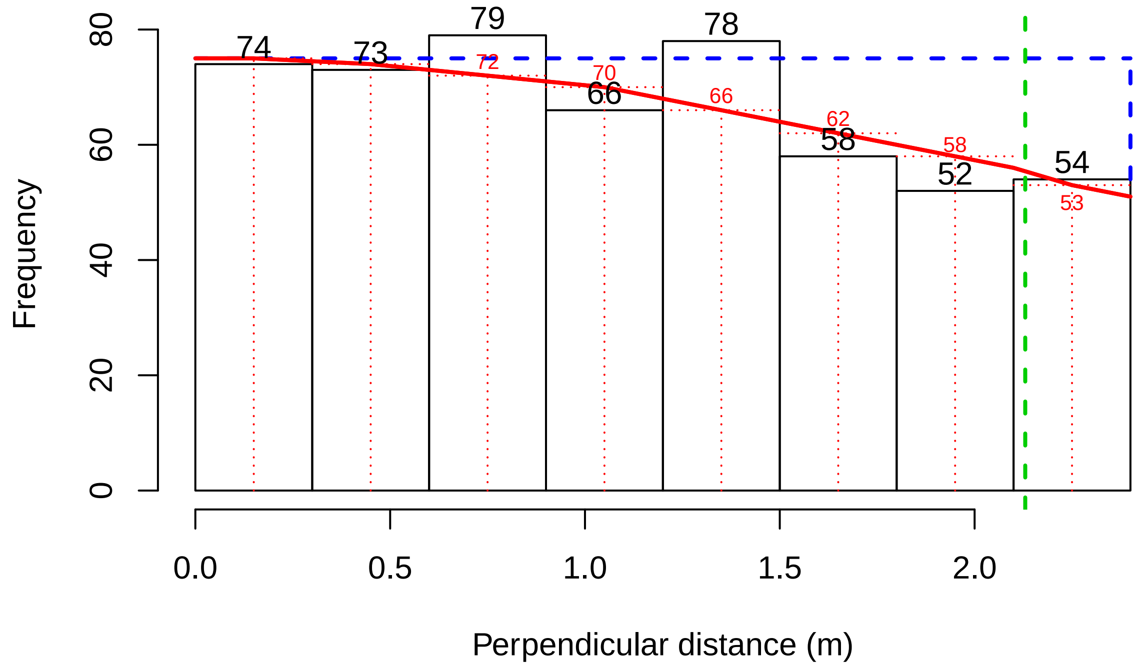
7. Rescale the y-axis to make your curve into the probability density function $f(x)$. Read off $f(0)$, and again estimate nest density D.

$$\hat{D} = \frac{n\hat{f}(0)}{2L} =$$

How does it compare with your previous estimates?

Solution 1. Line transect detection functions by hand

1. Histogram of detected nests (black) overlaid with the estimated detection function (red) is shown below.



2. To estimate the area under the curve, I read off the heights of the mid points of my fitted curve (red) as follows: 75, 74, 72, 70, 66, 62, 58, 53. Therefore, my estimate of area under the curve is:

$$Area_{curve} = (75 + 74 + 72 + 70 + 66 + 62 + 58 + 53) \times 0.3 = 530 \times 0.3 = 159$$

There are lots of other ways to work out the area under a curve, e.g. counting the number of grid squares under the curve on your graph paper or using the trapezoidal rule.

$$Area_{rectangle} = height \times width = 75 \times 2.4 = 180$$

Hence, my estimate of the proportion of nests detected in the covered region is:

$$\hat{P}_a = \frac{159}{180} = 0.883$$

3. How many actual nests were there in the covered area? I saw 534 nests, and I estimate the proportion seen is 0.883, so my estimate of nests in the covered region is:

$$\hat{N}_a = \frac{n}{\hat{P}_a} = \frac{534}{0.883} = 604.7 \text{ nests in the covered area}$$

This estimate is for a covered area of $a = 2wL = 2 \times (\frac{2.4}{1000}) \times 2575 = 12.36$ km^2.

4. I therefore estimate nest density as:

$$\hat{D} = \frac{\hat{N}_a}{2wL} = \frac{604.7}{12.36} = 48.9 \text{ nests per km}^2$$

5. The green vertical dashed line shows my estimated effective strip half-width of 2.13 metres; I estimate that the area below my curve to the right of 2.13 is the same as the area above the curve to the left of 2.13.

6. Using this estimate of the effective strip half-width, the effective area covered is estimated as $2\mu L = 2 \times \frac{2.13}{1000} \times 2575 = 10.97$ km^2. Therefore,

$$\hat{D} = \frac{n}{2\hat{\mu}L} = \frac{534}{10.97} = 48.7 \text{ nests per km}^2$$

7. For my curve to represent the pdf $f(x)$, I need to rescale such that the area under the curve is 1.0. Since I estimated the area under my curve to be 159, I can rescale by dividing all the numbers on the y-axis by 159. The intercept, $f(0)$ is therefore $75/159 = 0.472$.

Substituting this into the formula gives a density estimate of:

$$\hat{D} = \frac{n\hat{f}(0)}{2L} = \frac{534 \times (0.472 \times 1000)}{2 \times 2575} = \frac{252048}{5750} = 48.9 \text{ nests per km}^2$$

(Note, I had to multiply $f(0)$ by 1,000 to convert from m^{-1} to km^{-1}.)

Another way to estimate $f(0)$ is $f(0) = 1/\mu$: using this method I'd get the same density estimate as in part 5.

Distance works by fitting a pdf $f(x)$ to the observed data and using the estimated $f(0)$ to estimate density.

QUESTIONS

1. What about esw and f(0) - not provided by ds.