Help Manual: Using *WildlifeDensity*

This Manual is an abbreviated version of parts of the *Techniques Manual and User's Guide.* For further information on any topic, please refer to the full *Guide*.

Introduction

WildlifeDensity is a MacOS computer program designed to estimate the density of a species population from visual detection distance sampling data collected by line transect or fixed observing point methods. It works by comparing the frequency distribution of a set of sample data with a mathematical model of the distribution based on attributes of the survey itself. The program modifies particular parameters (numerical characteristics) of the model progressively until the model's frequency distribution matches the distribution of the field data as closely as possible. The main survey attributes varied are the population density, the conspicuousness of population members to observers and the amount of vegetation cover between observer and population. Their final 'best fit' parameter values are reported in the program's output.

Requirements. To run, the program needs an adequate set of distance sampling data collected by field survey methods using relevant fieldwork protocols, and data that documents the sampling situation itself. Details are in Parts One and Two of the *WildlifeDensity Techniques Manual and User's Guide* that downloads with the program software.

How the program works. The program begins by dividing the data into distance classes and totalling the number of visual detection events in each. It then uses its internal models to calculate the expected number of such events in each class. Given initial values of the key parameters, It compares calculated and observed numbers in each class, then squares and totals the differences between them. The program next changes one of the parameter by a predetermined amount and calculates a new total difference value. It repeats the procedure with a second parameter, and so on. Difference values are then compared with the centre-point of a cluster of such values in a step-by-step mathematical procedure (the downhill simplex method) designed to reduce the overall difference between the observed and calculated values. This process continues until a minimum difference is reached, when computations stop. This completes the initial set of iterations. The first search for a minimum is complete and the 'best value' of each parameter is retained.

The program then randomly resamples the original data with replacement ('bootstrapping'), and repeats the entire process to produce a second set of best values, then a third set, then a fourth and so on up to a limit set by the user (see **Number of sets of iterations** below). The parameter values reported in the program output are the means and standard errors of the best values from the individual sets of iterations.

The process begins with data entry. *Enter your data in the order given below*.

Data Entry

When the *WildlifeDensity* program is opened, a window appears headed 'Untitled', with a 'Data Set' panel at the top, a series of five tabs below it with labels from 'Method' to 'Estimate', and a set of radio buttons and panels below that. It usually opens at the Method tab. Enter your data as described below.

Filename. Click in the **Data set** panel and type in an identification for the file, such as a brief description of the data set. [*E.g.:* Run18104: Red-necked Wallaby, Black Range forest, July 2018.]

Save the file, giving it a suitable identrfication [e.*g.* Run18104]

Method tab   [Click on the ‘Method‘ tab if its contents are not visible]

Census type. Select the button that indicates the type of survey data. The **Distances supplied as** options will be greyed out unless you select the perpendicular distances button; if you do, choose the button that indicates whether: 1) you are supplying radial distances and lateral angles for each observation or 2) you are supplying pre-calculated perpendicular distances.

Observation type. Select the appropriate button (usually the first). The **auditory data** option is rarely used — it is intended only for use with detection distances based on sound alone (*e.g.* frog populations) or for use with populations seen at very considerable distances where vegetation is absent (e.g. surfacing whales detected over the sea under misty conditions). The third option is for use with data within a *range* of distances only (such as strips of vegetation bordering many country roads). To enter these, select **visual data, distance range limited** and type in the distances to the inner and outer boundaries of the data range [e.g.: 0 250] The minimum radial or perpendicular distance is usually 0 unless for some reason detections very close to the observer or on the transect line are to be disregarded. For example, small minimum distances (*e.g.* <5 or <10m) may be sometimes be appropriate, as for a transect along a road or pathway.

Transect length. Enter the total transect length travelled when collecting data [*e.g.:* 34524.5]. Select the distance unit, in m or km. Also choose the button that indicates whether data came from **one side** or **both sides** of the transect line.

Detection distance unit. This will be greyed out unless the transect length is already in kilometres. If so, select the appropriate detection distance unit.

Select the **Sample Details** tab to open the next window.

Sample Details tab

Time spent. In the first panel, enter the total time spent collecting the data set being entered here, expressed in minutes [*e.g.:* 3496].

Population movement rate. Enter the average horizontal displacement rate of an individual of the relevant species, expressed in metres per minute [e.*g.:* 22]. Either obtain this from previous behavioural studies of your targeted species or estimate it from Table A below. If the population is relatively slow-moving compared to the observer’s rate of travel, the rate need only be approximate.

As set out in Chapter 5 of the full *Guide*, the ***population movement rate*** is the overall average travelling speed of an individual animal travelling from place to place, multiplied by the average proportion of survey time spent moving. Movement rates vary with the species. They seem to depend largely on its foraging methods and the characteristics of survey sites.

If you are happy to enter an approximation, Table A gives data on representative species as a guide. (Identify the appropriate category for your species and use the suggested rate for that category.) This is adequate for many line transect surveys, especially for species that have movement rates less than the observer's rate of travel. However, for line transect surveys of active species that have movement rates faster than the observer's, and for all fixed point censuses, use a movement rate based on actual field data. Enter a rate, in metres per min.

Table A. Approximate overall movement rates (travelling speed x time spent moving) of typical bird and mammal species, expressed in m/min. Overall movement rates have been grouped into seven categories based on their feeding methods and their use of foraging sites. A representative rate for each category is shown in bold type within the brackets (i.e. braces or parentheses).

	Species and Foraging Method	**Rate (m/min)**
1	* slow-moving grazing mammals that graze on the ground or browse in trees * larger, slow-moving birds that stand on the ground looking for invertebrate prey	under 5 **(2.5)**
2	* continually-moving grazing and browsing mammals (mainly the smaller herbivores) * larger seed-eating birds that mostly forage on the ground (*e.g.* pigeons) * small birds that glean insects from the ground, fallen timber and low vegetation, or drop on insect prey after long waits at a low vantage point	5 - 12 **(8.5)**
3	* largely seed-eating birds that forage both on the ground and in foliage (*e.g.* finches, parrots) * relatively slow-moving insectivorous birds that move about on the ground and/or in foliage, moving on to a new site occasionally (*e.g.* magpie-lark, pardalotes)	12 - 18 **(15)**
4	* active bird species that move about continually, often in small flocks, searching for food items in the foliage of trees and shrubs, or by flying from trees and shrubs to the ground and back * typical nectar-feeding birds of foliage that feed for a time in a tree, then move on to the next	18 - 25 **(22)**
5	* very active nectar-feeding and insectivorous birds that move about continually, and also fly in the air for short periods to hawk flying insects or glean prey from surfaces while in flight	25 - 50 **(38)**
6a	* birds that feed largely by hawking flying insects, but do so from vantage points amongst trees (*e.g.* typical flycatchers, fantails, wood-swallows)	50 - 120 **(85)**
6b	* birds that spend much of their time in flight over open ground, often in flocks (*e.g.* swallows, swifts)	100-200 **(150)**

Proportion of observing arc scanned (fixed point censuses only). Enter the proportion of a circle centred on the observer being scanned. If the observer rotates more or less continually, an arc of 360° is scanned. If scanning covers less than that, and the arc scanned is expressed in degrees, its portion must be converted to a proportion between 0 and 1. (*E.g.* a 180° scan gives a proportion of 180/360 = 0.5.) If your data are from fixed points, enter the relevant proportion; if from transects, leave its value at 0.

Elevations. If the population is dispersed well above and/or below observer eyelevel, and elevation angles are supplied in the data set, select **Elevation angles supplied.**

If you don't have angle data for the observations, enter (in m) the approximate height difference between observer eyelevel and the population's height above ground. If you have elevation angle data for your observations, enter them later under the **Observations** tab and select **Elevation angles supplied** now. You can also enter the root mean square height difference between them in the panel at **Population elevation difference approximately.** If the height differences are relatively small [*e.g.* 2 m or less], a rough approximation is enough. Finally, if you have some elevation angle data, but your data set is incomplete, you can calculate the ***root mean square height difference*** in metres and enter that here. It is $\sqrt{(h_1^2 + h_2^2 + h_3^2 \ldots) / n}$, where h is the height difference and n the number of measurements made.

Topography. If the topography of the land in the survey area is approximately level, or the great majority of animals in the population are relatively close to the observer and unlikely to be hidden behind a hill or other physical feature, select **Topography approximately level.**

If the ground surface is undulating or hilly and some distant individuals could be out of sight, select **Topography undulating, obscures some wildlife** and enter the approximate minimum distance from the observer (rounded to the nearest 10m) at which the target species starts to drop from view behind a ridge or hilltop (see Chapter 5 of the *Guide* for more information).

Proportion of the population observable. This is a special-case variable used only where part of the population is hidden and unobservable, as can happen if some individuals are sheltering in underground burrows (*e.g.* the European rabbit), in tree hollows, or a nest. The proportion observable must be given a value between 0 and 1 [*e.g.* 0.85]; for most populations the proportion observable will be 1.

Select the **Observations tab** to open the next window.

Observations tab

This window is for the detection distance data. There are two ways you can enter it: by copy-and-paste from data file spreadsheets, or by direct entry — one observation at a time. Try the copy-and-paste option — you'll find it's much faster.

Copy-and-paste method. Begin with field data already collated on *Excel* or similar spreadsheets, as described In Chapter 7 of the full *Guide.* **Distance, Group Size, Horizontal Angle,** and **Angle of Elevation** should be side-by-side in the data file worksheets, *in that order from left to right*. Whatever data you supply, make sure the two, three or four columns you paste in are in that sequence. Then proceed as follows.

1. **Important:** Don't enter data in this window unless you have first entered the survey details in the **Method** and **Sample Details** windows. The **Observations** window will then show the appropriate set of column headings in the correct order.

2. Open your survey data file, then the appropriate worksheet. Select and copy (Edit>Copy, or ⌘-C) the observational data columns (but not the column headings).

The 2-4 columns should be in the order *Detection distance* | *Number in group* | *Lateral detection angle* | *Angle of elevation.* Don't be concerned if there are whole blank rows or columns; they do not affect computation and can be left in. But check there are no single blanks; if so, delete* them.

3. If you are entering perpendicular distance detection data and the population concerned is an actively mobile one, you need to know that the *WildlifeDensity* program treats a '0' value in the *Detection distance* column as an overtake. Double check all zero entries in the distance column against your field data to see whether an individual '0' entry means 'zero distance from the transect line' or 'overtaking the observer from behind'. If it means 'zero distance', then alter the '0' to '0.01' or a similar very small distance in m. Doing that stops it being identified as an overtake but has a negligible effect on the density estimates.

4. Open the **Observations** window and select Edit>Paste (⌘-V). Your data should then appear in the appropriate columns.

5. Save the program file, using the file number you chose earlier [*e.g.* Run18104]. The file name should appear at the top of the window with the extension *.WDdata*, and usually the *WildlifeDensity* icon as well.

   *You can use the '+' and '-' buttons below the table to add or delete whole rows.

You can amend the entry in any cell if you select the cell first by double-clicking it, then retyping its contents You can also copy, cut and paste the contents of an individual cell provided you first select it by double-clicking. You can use Select All (⌘-A) to get all the cells to respond together (*e.g.* if you wish to delete all the entries in the table).

Direct data entry method. You can also enter observational data into the Observations window directly, one detection at a time. This is relatively easy with a small data set, but tedious with a large one. Use the following procedure:

1. Check that you have entered the survey details in the **Method** and **Sample Details** windows. The **Observations** window should then show the appropriate number of columns and column headings.

2. Click on the '+' button at the bottom of the window, then double-click the first cell in which you are to enter data. Type in the relevant number. Repeat for the next cell, and so on.

3. Repeat for the next row. Continue until all data are entered.

4. Check the accuracy of entries, and correct any errors.

5. Save the file, using the file number you chose earlier [*e.g.* Run18104]. The file name should appear at the top of the window with the extension *.WDdata*, and usually the *WildlifeDensity* icon as well.

   You can use the '+' and '-' buttons to add in or delete whole rows.

[You can amend the entry in any cell if you select the cell first by double-clicking it, then retyping its contents You can also copy, cut and paste the contents of an individual cell provided you first select it by double-clicking. You can use Select All (⌘-A) to get all the cells to respond together.]

Click on the **Options** tab to open the next window.

Options tab

Class interval for calculations. Enter an appropriate class interval (or 'bin') width to be used in program computations and output results files, measured in metres and preferably to at least one decimal place (*e.g.* 7.3). Doing so alters the number of detections in each class. This changes the density estimate somewhat, especially if there are few detections and few classes (and can also reduce the impact of any 'heaping' errors in trhe data). You need to choose a width that works well with your data.

To decide a suitable bin width:

1. Identify the ***maximum*** and ***minimum*** detection distances in your sample. (With perpendicular distance data the minimum distance will be close to 0.)

2. Subtract the minimum from the maximum to give the ***range*** of distances.

3. Total the number of ***groups*** detected (*not* the total individuals).

4. With radial distance or fixed point data, calculate your bin width as

$$\textbf{\textit{r\_interval}} = 0.048 \times \textbf{\textit{r\_range}} - 0.01 \times \textbf{\textit{groups}} + 3.5$$

5. With perpendicular distance data where you have the radial distances available,

$$\textbf{\textit{y\_interval}} = 2 \times [\, 0.048 \times \textbf{\textit{r\_range}} - 0.01 \times \textbf{\textit{groups}} + 3.5 \,]$$

6. With perpendicular data when you only have pre-calculated perpendicular distances,

$$\textbf{\textit{y\_interval}} = 0.08 \times \textbf{\textit{y\_range}} + 3.4$$

You can also use other bases for your decision; the approach here is known to work well. Know that the minimum width allowed by the program is 1/80 times the maximum detection distance. If you try to set a smaller interval, the program will automatically reset it to 1/80 of the maximum detection distance.

Number of sets of iterations. Enter the number of sets of bootstrapped data to be computed by the program when estimating the population density and other parameters. Suitable values are 250 sets of iterations for a good approximation, 500 for a 'best estimate', 750 for serious work based on a large data set, and 1500 for a 'best' answer. Additional iterations usually improve the estimate but take a little longer to complete.

[You can also run the program without bootstrapping by setting the number of iterations at 1. This initiates a quadraric surface fitting procedure within the program. Although computation can then be very rapid, the method is less dependable, the output is less, density estimates may be slightly biased and standard errors low *(see* Chapter 8 in the full *Guide).*]

Initial parameter values and options. *WildlifeDensity 2* provides **automatic selection** of initial parameter values and step sizes as a built-in default. We recommend this.

[You should know that you *must* use manual selection if you decide to set upper or lower limits to the range of detection distances or parameter estimates may be biased. To disallow automatic selection, or to display progress in parameter estimation, select the **Select initial values and options manually** button, also select the 'Tabulate' button under the options and follow the procedure described under **Manual selection option** on p.10.]

Verbosity and debugging options. Selecting any of these buttons provides you with additional technical output on the computation process. The output is then included within the *.results* file. Warning: the output can from the upper two options can be considerable, potentially producing some very large output files. Details are in Chapter 10 of the full *Guide*.

For most computer runs, leave these buttons unselected.

Unless you decide to use the manual selection option, go directly to **Very small samples** *on* p.13*..*

Manual selection *(usually optional):*

If you decide to use manual parameter selection, proceed as follows.

For each parameter used by the model, you need to enter an **initial estimate** to use in the first computation, and a **step size** to begin altering the parameter in later iterations. The initial values can be properties of the observing situation you already know, such as measured lateral vegetation cover, or estimates of those parameters. It is important that these are well chosen: if they are very inaccurate, the program may fail in its search for a minimum difference between observed and calculated frequencies.

Setting any step size at '0' fixes the parameter at its initial value for all calculations.

Four parameters are used in the *WildlifeDensity* program. The first two are *shape parameters,* determining the shape of the frequency distribution curve, *viz.*:

> ***Conspicuousness coefficient.*** The *initial estimate* is an approximation to the conspicuousness of the target species to an observer, expressed in metres.
>
> You can estimate its value by picturing how many metres from you an individual animal would have to be for you, under the census conditions, for you to just begin to overlook the occasional animal if it's stationary, quiet and partly hidden. Typical values are about 20m for a relatively large animal (*e.g.* cattle, an emu), about 15m for a medium-sized animal (*e.g.* a kangaroo or deer), ±10m for a larger passerine bird species, ±8m for an active, smaller songbird, ±5m for a cryptic species and as little as 3m for highly cryptic species (*e.g.* stationary quail amongst dense grass). Table B below gives typical values. If you already know a typical value from previous analyses, use that.
>
> If uncertain, make your estimate higher rather than lower than the suggestion made.

Table B. Estimates of the conspicuousness coefficient and maximum recognition distance (rounded) returned by *WildlifeDensity* for a variety of (Australian) mammal and bird species, and probably appropriate for other, similar populations. Notice the relationships between size, behaviour and conspicuousness. The bracketed value in the third column is a suggested initial value for data entry. (Ctd. on next page)

Species	Properties	Conspicuousness Coefficient	Maximum Recognition Distance (m)
emu	1.5 - 2 m; flightless	18 **(20)**	3000
eastern grey kangaroo	30 - 70 kg	14- 21 **(16)**	2400
western grey kangaroo	25 - 55 kg	11 - 20 **(15)**	1600
koala	7 - 14 kg	8 - 12 **(10)**	200
common brushtail possum	1.5 - 4 kg	4 - 6 **(5)**	150
white-browed wood-swallow	17 cm; aerial, noisy	42 - 44 **(40)**	160
green rosella	32-38 cm	14.4 **(15)**	150

Species	Properties	Conspicuousness Coefficient	Maximum Recognition Distance (m)
swift parrot	23-26 cm	16.4 **(15)**	190
yellow wattlebird	37-45 cm	13 **(15)**	170
red wattlebird	33-36 cm	12-13 **(15)**	200
noisy miner	24-27 cm	11 **(10)**	170
helmeted honeyeater	17-22 cm	5 - 16 **(10)**	160
spiny-cheeked honeyeater	22-26 cm	6 - 10 **(10)**	170
common starling	21 cm	9.3 **(10)**	210
yellow-plumed honeyeater	13 - 16 cm	4.8 - 5.2 **(5)**	110
weebill	8 - 9 cm	4 - 6.5 **(5)**	100
striated pardalote	9.5 - 11.5 cm	3.5 - 4.8 **(5)**	80
grassland quail	12-22 cm	1 - 5 **(3)**	30

A workable *step size* for the conspicuousness coefficient is about a third of the initial estimate [*e.g.* a step size of 6 to accompany an initial value of 18]. If you don't do this, *WildlifeDensity* will preset the parameter value for you using a number it calculates from the original data.

Lateral cover. Lateral cover is the average amount of vegetation (tree-trunks, branches, foliage) in a direct line between observer and an animal, potentially hiding the animal from view. For visual data from foggy conditions in the open, or for auditory data, this parameter is the current attenuation coefficient in air for the transmitted visual or auditory signal.]

Lateral cover is measured as a proportion of the line-of-sight obscured. Its value is a dimensionless number (no unit) always appreciably less than 1 [*e.g.* 0.005]. Typical values are shown in Table C (next page). Again, if in doubt, err on the high side.

Enter the same value for *step size* [*e.g.* 0.005].

Table C. Some values of lateral vegetation cover returned by *WildlifeDensity* for bird and mammal species in a variety of Australian vegetation. Species that forage within foliage have greater cover than those that forage elsewhere. Bracketed values in the last column are suggested initial values for computer runs.

Habitat Type	***Species***	***Lateral Vegetation Cover***
grassland, very open woodland, dry lake beds	ground-feeding species (e.g. kangaroos, emus)	0.000 **(0.000)**
shrublands, open woodlands	ground-foraging mammals and birds	.003 - .008 **(0.005)**
parks, woodlands	ground-foraging mammals, birds	.010 - .011 **(0.010)**
woodlands, tall shrublands (*e.g.* mallee)	arboreal mammals (*e.g.* possums) and larger tree-foraging birds	.013 - .018 **(0.015)**
tall shrublands, open forest	birds that forage or roost in more open foliage	.019 - .023 **(0.02)**
tall shrublands, open forest	birds that forage in denser foliage	.027 - .037 **(0.03)**
open forest	foliage-foraging birds	.040 - .070 **(0.05)**
open forest with shrub understorey	foliage-foraging birds	.080 - .100 **(0.10)**
forest with shrubs and dense foliage	foliage-foraging birds	.140 - .170 **(0.15)**
dense, long grass in grassland	cryptic, small ground vertebrates	.140 - .260 **(0.20)**

Population density 'guesstimate'. Population density affects the height of the detection distance frequency distribution curve, not its shape. Enter your *initial estimate* of density, stated as number of individuals per hectare (ha).

Base your estimate on previous knowledge if possible; it is important that the estimate is realistic. Because a hectare is a relatively small area (equivalent to 100m x 100m, or 2.47 acres), vertebrate population density will often be less than 1. [If you find it easier to estimate number per square kilometre, do that first then divide your estimate by 100 to convert it to no./ha. *E.g.* 5 per sq. km. becomes 5/100 = 0.05.]

Choose a *step size* identical to or slightly smaller than the initial estimate [e*.g.* 0.04].

Maximum recognition distance. This is a best estimate of the maximum distance at which you can recognise the animal with the unaided eye, in metres, <u>without</u> using binoculars. If your sample has at least 40 detections, allow the program to select its own estimate of maximum distance based on the distribution of detection distances in the data. To let the program do this, set the initial value at 0.

If you set an upper limit to the range of distances, or the data set is very small (<10), always supply your own estimated distance [*e.g.* 125]. Use the values given in Table B as a guide.

Very small samples. If you have fewer than 5 separate observations in your sample, estimating population density by any distance sampling method is not recommended. With *WildlifeDensity,* running the program with fewer than 12 deftections is unlikely to be successful.

Saving input files. Choosing **Save** or **Save as** in the File menu lets you save the data input file in *WildlifeDensity* format (with suffix .WDdata) within a folder on the computer. Saving it also 'flags' the file with a *WildlifeDensity* icon. Clicking its icon or name in a list of folder contents then directly opens the program. Files in *WildlifeDensity* format can also be opened by appropriate software as a text file. To open the *WildlifeDensity* program, either drag-and-drop your data file on to the *WildlifeDensity* icon in the dock or open *WildlifeDensity* first and choose the file using the Open command under the File menu.

Select the **Estimate tab** to open the final window.

Running the Program

Estimate tab

The program is run from this window. It shows the number of observations (detections) in the data set and two control buttons. It also allows space for a progress bar and a results summary.

Program operation. First, save the file before running the program. Click on the *Calculate* button to start the search for a 'best-fit' model to the data and wait for the progress bar to complete. The time this takes depends on the numbers of iterations selected and observations entered, the variability of the group sizes and the speed of your computer. The sudden appearance of a graph and a results summary in the Estimate window marks the end of computation.

Now examine the output.

> **Computer output.** On completion, the Estimate window should display the *density estimate*, its *standard error* and the paths to two output files: the *main results* file (*<filename>.results*) and the *observed and calculated numbers* in each class. If a computer run is repeated, this pair of files is produced each time and given the same name but with a different version number immediately after its filename.
>
> **Comparison graph.** *A comparison graph,* drawn from the numbers in the *<filename>.graphData* file, should appear in a separate window. It uses the class interval you chose to show the detection distance frequency distribution as dots joined by dashes. It also shows as a yellow continuous line the numbers calculated by the *WildlifeDensity* model. You can reopen this graph at any time by dragging and dropping the *.graphData* file on to the *WildlifeDensity* icon in the computer's dock. The graph is to help you identify any mismatching of the two distributions and show whether you need to rerun the program.

Reviewing the output. Compare the calculated distribution with that of the observed field data. If the yellow line follows the data along most of its length (Figure 1), consider the search satisfactory. The estimates and standard errors of density in the program's results should be reliable. Some observed values will be higher and some lower than the calculated values, but one set should not be clearly above or below the other across any sizeable range of distances. Nor should the calculated parameters be a set of zeroes. In either case the search for a minimum difference has failed. If that is the case, disregard the results and resubmit the input data file with soma appropriate changes (*see* **Troubleshhoting** on p.17 below).

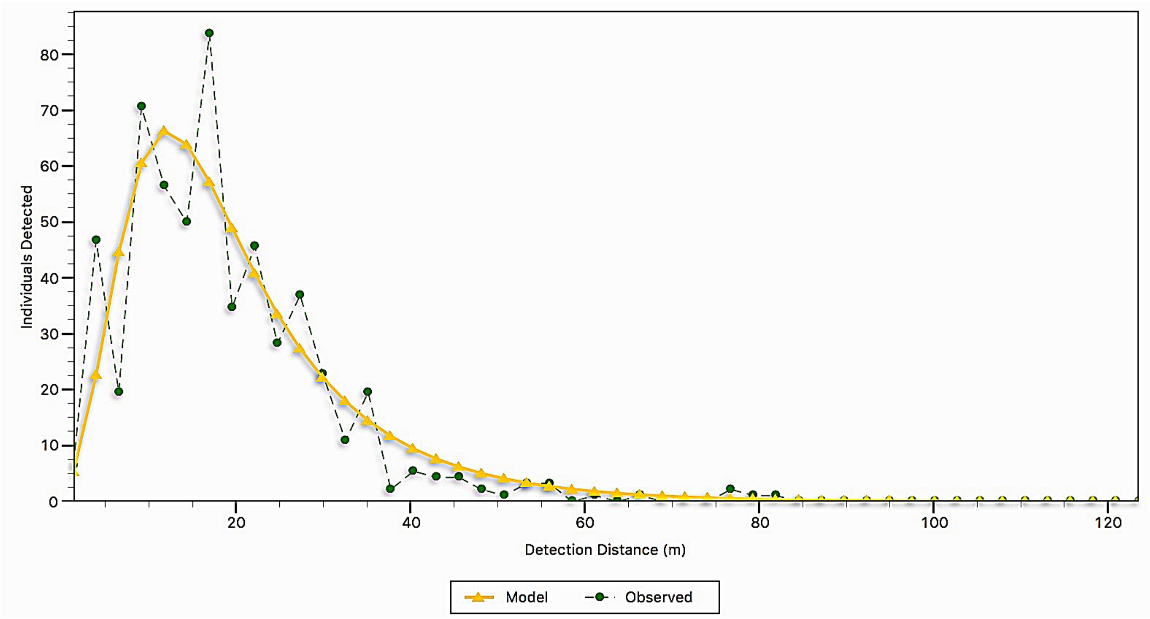

Figure 1. The fit of a modelled distance distribution (*yellow line*) to the numbers of a honeyeater population (*black* dots) observed at different radial distances from an observer walking a set of line transects. The line follows a path that corresponds approximately to that of the data points. (Based on 544 observations).

Results summary. Once the program has run, selecting the *View results* button will open the current *<filename>.results* file to display the program inputs and outputs in text format. It will open in whichever text application you select. The *.results* file can also be opened at any time by double-clicking its file name.

Interpreting the Results

The output from program *WildlifeDensity* is in two files: the main results file, called *<filename>.results*, and a file that compares the original and modelled frequency distributions, called *<filename>.graphData*. Both output files should be in the same folder as the data input file, and both are printable.

The *.results* file. The main results file sets out some of the main inputs to the program, together with the population density estimate, its standard error, and a variety of other outputs, as follows:

INPUT:

Data type: the type of data processing selected.

Transect sides: whether observations were made on one or both sides of the transect line.

Class interval width: usually the class interval width submitted, unless this would subdivide the data into more than 80 classes, when it is set automatically at 1/80 of the maximum recognition distance.

Total transect length: in metres.

Total time spent: in minutes.

Overall population movement rate: the overall population movement rate entered, in metres/min.

Topography: the overall topographical attributes entered.

OUTPUT:

Number of Groups in Distance Range: the total number of animal groups (separate observations) within the selected data range.

Number of Individuals Detected Ahead: the total number of individual animals detected ahead of observers in the selected data range.

Number Overtaking: the total number of individuals overtaking observers from behind.

Height Difference from Eyelevel: either the root mean square height difference between the population of interest and observer eyelevel calculated from elevation angles submitted, or an approximation supplied by the user. Considerable height differences tend to reduce detectability.

Movement Correction Factor (J): a correction factor, calculated from population and observer rates of travel, to allow for the effects of relative movement on the numbers detected during line transects.

Adjusted Transect Length (LJ): the product of overall transect length and the movement correction factor.

Topographical Cover Value: an index to indicate the amount of topographical heterogeneity in the census area (higher values indicating a hillier terrain).

Maximum Detection Distance: the maximum detection distance, in metres, either estimated from the detection distances in the data set or supplied by the user.

Number of Parameter Estimations: the number of (bootstrapped) iteration sets carried successfully to completion by the program. If that number is less than the number you set in the Options window, this indicates that some analyses of bootstrapped data sets did not carry successfully to completion. (Failure to complete some analyses may indicate highly variable data, or very small samples, or inappropriate initial and step values for the parameters.)

Estimated Density (D): the estimated population density and its standard error, expressed either in numbers per hectare or numbers per square kilometre, as indicated. (Standard errors of the parameters are the standard deviations of the estimated 'best values' produced by the multiple iterations of the program, not the standard errors of their means.)

Conspicuousness Coefficient (a): the estimated conspicuousness coefficient for the population of interest under the conditions of the census (habitat, weather, observers) and its standard error, expressed in metres.

Lateral Cover Proportion (c) or ***Attenuation Coefficient (b)*****:** the estimated proportion of cover (vegetation, atmospheric dust or haze) in a line of sight between the observer and animals or, in some circumstances, the estimated attenuation coefficient for light or sound passing from an animal to the observer.

95% confidence limits for density estimates: Estimates of the lower and upper confidence limits of the density estimate, calculated by assuming a lognormal distribution of the estimates.

Detectability Coefficient (S): an overall general detectability coefficient for the population under the prevailing census conditions, together with its standard error, capable of being used not only to express overall detectability but also to enable density estimation without using distance data (see the full *Guide*).

Est. Detectability at g(y=0): an estimate of the probability of detecting all individuals along the transect line itself under the prevailing census conditions (=1.00 if all are detected; less than 1 if some individuals are undetected).

Final Difference at Minimum: the minimum function value, *i.e.* the sum of the squared differences between observed and expected frequencies at its search minimum end-point. Its value varies not only with the goodness of fit but also with the numbers of observations and the number of classes into which the distributions were divided. Very high values (e.g. >10,000) may indicate that the program has selected an inappropriate minimum point.

The output from fixed point data runs is similar. You can use the density estimates to calculate overall population estimates (see the full *Guide*, Chapter 9).

The *.graphData* file. The second output file, *<filename>.graphData*, sets out and compares the 'best-fit' model, as calculated, with the original data submitted in the data input file. These are the data plotted in the output graph.

Both output files should be in the same folder as the associated data input file.

Printing and Exporting Results

Text file output. The two text output files (*.results* and *.graphData*) are added automatically to the folder with the .WDdata file when the computer run ends. The .results file contains the main results of the run, while the .graphData file compares the calculated frequencies with the observed data for each class distance interval.

Both types of file can be read by any text-based program and printed as such: just open the file and follow the usual Print commands.

Graphical output. The graph produced by *WildlifeDensity* 2 is visible in a window called *(filename).graphData* until you close it, when the graph is lost. To redraw it:

1. Locate the *.graphData* file in the folder with the *.WDdata* file. Instead of simply opening it, hold down the Control key while you click on the *.graphData* file. A popup panel should open.

2. In that panel, go to 'Open With' and click on the name of the most recent *WildlifeDensity* program. The graph should open once again.

3. Alternatively, close the *.WDdata* file, then reopen it. The last graph you drew should appear once again, behind the program window.

If you need to save a copy of the graph, use program *Grab* (built into the *Utilities* fclder in Macintosh computers) before you close it. Proceed as follows:

1. Open *Applications/Utilities/Grab.*

2. Using the mouse cursor, drag the bottom right-hand corner of the graph window downwards and to the right until the graph has a shape you prefer.

3. Select the *Grab* icon now visible in the dock.

4. In the menu bar, select *Capture/Window.* A window called ‘Window Grab’ should open.

5. In that window select *Choose Window*, then click on the graph itself. A copy of the graph (in *.tiff* format) will open on the computer screen.

6. Save this graph, giving it a suitable name and location. This graphical image can be stored, printed and converted to a PNG, JPG, EPS or PDF format if desired.

Troubleshooting

Field surveys of birds, mammals and other land vertebrates often result in low numbers of detections, even with extensive fieldwork. Is it possible to get useful density estimates from WildlifeDensity when this happens? The approach described below applies to program versions from WildlifeDensity_2.2 onwards. The procedure depends on the number of population observations in your sample. Large samples, properly collected and entered, should not give many problems. However, processing difficulties are encountered occasionally, especially with smaller samples (say, those under 260).

Larger samples (260 or more detections)

If the third verbosity and debugging option below the Options tab remains unselected (unchecked) and field data have been collected and entered correctly and completely, the program should proceed to completion automatically. This is the normal or default situation. Examine the graph to assess how well the yellow line fits the data points. If the line follows along the path of the data points approximately (as in Fig.1), consider the computer run satisfactory.

Smaller samples (fewer than 260 detections)

With lower numbers, unless the third verbosity and debugging option under the Options tab is selected, the program will usually proceed to completion automatically, though with a difference. It will use the distribution of detection distances in the sample to estimate and then pre-set the amount of lateral cover between observers and the target population before it estimates population conspicuousness and density. Doing this should not affect the density estimate, but makes the estimates of the shape parameters approximate only.

[Pre-setting a shape parameter (*e.g.* conspicuousness, cover) makes estimates of *that and other shape parameters* by the program unreliable. Because a curve-fitting process is being used, error in one shape parameter is roughly compensated for by error in the other, witrelatively little effect on the shape of the frequency distribution curve. Population density affects the height of the curve rather than its shape, so its estimated value can remain relatively dependable even when a shape parameter is preset.]

Once the run has finished, examine the graph to assess how well the yellow line fits the data points. If the line follows along the path of the data points approximately, consider the computer run satisfactory. The density estimate and its standard error should once again be dependable, but estimates of other parameters will be approximations only and should be regarded as such.

If the fit is poor . . . . In a minority of cases, particularly at the lower end of the sample size range (under about 40 detections with radial data and under 80 with perpendicular data)), the fit of the modelled line to the data may be disappointing (see Figure 2).

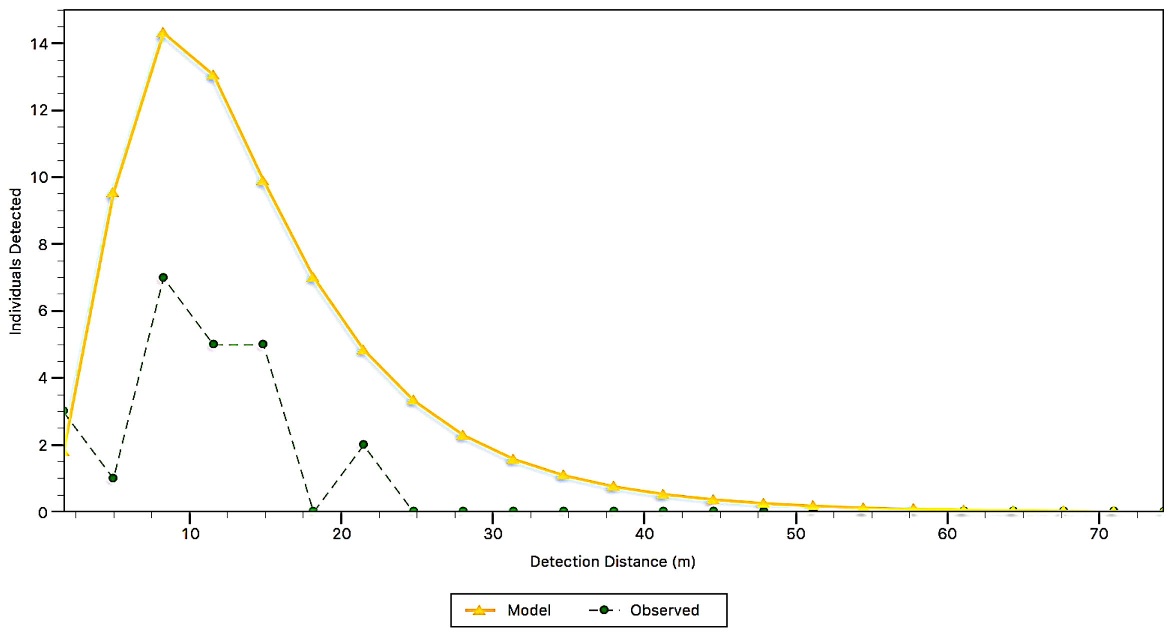

Figure 2. A poor fit of a modelled small sample distribution of a honeyeater population (*yellow line*) to the numbers observed (*black dots*) by an observer walking along a transect through the population's habitat. The modelled numbers (*yellow*) and data points do not match. (Based on 23 observations)

This indicates that the search for a 'best fit' solution ended before the modelled distribution fitted the data. If that happens, proceed as follows.

Strategy 1 *— preset conspicuousness instead of cover*

1. Open the *WildlifeDensity* app.
2. Select the Options tab.
3. Select the '**Select initial values and options manually**' button.
4. For **Conspicuousness coefficient,** enter an initial estimate (e.g. 9) and enter a zero (0) for step size.
5. For **Lateral cover,** enter a suitable value for both the initial estimate and the step size (e.g. 0.05, and 0.05).
6. For **Population density**, enter a suitable value for both the initial estimate and the step size (e.g. 3 and 3).
7. For **Maximum recognition distance**, enter a zero (0)
8. Under **Verbosity and debugging options**, select the bottom line, viz. 'Tabulate final estimated function values for each distance class'.
9. Save what you have entered (i.e. 'Save' under the File menu).
10. Under the Estimate tab, select the **Calculate** button.
11. When the computer run finishes, deselect the 'Tabulate final estimated values . . ' button at the bottom of the Options tab.

All being well, the program should now have reached a best fit solution. If it still hasn't, try the strategies suggested below.

Strategy 2 *— preset both cover and conspicuousness*

1. Select the Options tab.
2. Select the '**Select initial values and options manually**' button.
3. For **Conspicuousness coefficient,** retain the initial estimate (e.g. 9) and enter a zero (0) for step size.
4. For **Lateral cover,** retain the initial estimate (e.g. 0.05) and enter a zero (0) for step size.
5. For **Population density,** retain a suitable value for both the initial estimate and the step size (e.g. 3 and 3).
6. For **Maximum recognition distance**, either enter a zero (0), when it will estimate that distance from the data entered, or enter a maximum recogition distance calculated by entering and running a pooled data set for that species from the survey site, then reading the distance from the resultung *.results* file. (The second option should give you a better estimate of the maximum distance.)
7. Under V**erbosity and debugging options**, select the bottom line, viz. 'Tabulate final estimated function values for each distance class'.

8. Save what you have entered (i.e. 'Save' under the File menu).
9. Under the Estimate tab, select the **Calculate** button.
10. When the computer run finishes, deselect the 'Tabulate final estimated values . . ' button at the bottom of the Options tab.

The program should now have reached a final solution. Note though that pre-selecting both shape parameters tends to under-estimate the standard error. Using a larger dataset is — as ever — the preferred option.

Don't consider your task complete until you have a model that clearly fits your data; when it does, the density estimate it produces should be as reliable as your data set allows. If you really need more data, be prepared to go out and collect it!

If you encounter other problems running *WildlifeDensity*, refer to Chapter 10 in the full *Guide*.