Help Manual: Using *WildlifeDensity*

CONTENTS

Introduction

WildlifeDensity is a macOS computer program designed to estimate the density of a species population using visual detection distance sampling data collected by line transect or suitable related methods, such as particular aerial survey and fixed observing point techniques. Its use is particularly recommended for visual data collected from terrestrial vertebrate populations of normal detectability (e.g. most songbirds, larger mammals and reptiles) based on direct-line radial detection distances between the observer and detection points. This can include highly mobile species for which movement rate data are available; the effects of their mobility on estimates can now be allowed for. Hyper-cryptic animals that actively hide from an approaching observer remain difficult to estimate reliably from observational data.

WildlifeDensity 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 an appropriate set of fieldwork protocols, and data that documents the sampling situation itself. Data entry is outlined in the text below. Further details are in Parts One and Two of the *WildlifeDensity Techniques Manual and User's Guide,* available with most versions of 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 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 all data needed in the order set out below,* taking care to avoid any errors or omissions

Data Entry

To open the program, select (click on) the *WildlifeDensity* app in the dock, Applications folder or other location.

When the *WildlifeDensity* program is opened, a window appears headed 'Untitled', with a 'Data Set' panel at the top and a series of five tabs in a row 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. Select the **Data set** panel and type in an identification for the file, with an identification code for the run as a filename [e*.g.* Run24104] and a brief description of the data set. [*E.g.:* Run24104: Red-necked Wallaby, Black Range forest, July 2024]

Save the file in a readily locatable folder.

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

Census type. Select the button that indicates the type of survey data you will be entering under the Observations tab later (e.g. radial).

The ***Distances supplied as*** options will be greyed out (and unusable) 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 exclusively on sound (*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 narrow *range* of distances only (such as strips of vegetation bordering some 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 the centre of a road or pathway.

Transect length. Enter the total transect length travelled when collecting data [*e.g.:* 34524.5]. Select the distance unit button, expressed in m or km.

[To convert non-metric data: 1 ft = 0.3048 m; so 1242 ft = 1242 x 0.3048 = 378.6 m.] Also select 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. Check that you have selected 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 movement (i.e. horizontal displacement) rate of an individual of the relevant species, expressed in metres per minute [*e.g.:* 116 m/min]. 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 in the horizontal plane of an individual animal travelling from place to place, multiplied by the average proportion of the total survey time a typical population member spends moving. Movement rates vary with the species, time of day, weather conditions, its behaviour patterns and the characteristics of survey sites. Rates of different species often depend largely on the foraging methods the species uses.

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, try to use a movement rate based on your own field data 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, stationary or slow-moving birds watching for invertebrate prey or other foods	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)**

	Species and Foraging Method	Rate (m/min)
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.

***Eleva*tions. I**f a population is dispersed well above and/or below observer eye-level, that is likely to affect the number of detections made. You have a choice between two alternatives. If elevation angles were measured in the field and are supplied in the data (under the Observations tab), select the **Elevation angles supplied** button. ***WildlifeDensity* then** calculates its best estimate of the mean elevation difference between animals detected and observer eye-level (expressed as a root mean square value). It displays it (in m) on the next line.

If elevation angles were not measured during the survey, you can either enter the root mean square elevation difference in the panel at **Population elevation difference approximately** or enter your own estimate of the average difference in m **.** 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 survey area - the way the physical features of the landscape are arranged - is approximately even and level, so that the great majority of animals in the population being surveyed is unlikely to be hidden behind a hill or other physical feature, select **Topography approximately level.**

If the ground surface is undulating or hilly or so uneven that some of the more distant individuals could be out of sight as a result, the topography could affect estimates. If so, 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, hilltop or rocky outcrop *(*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 known to be 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, for example. Give the **proportion observable** a value between 0 and 1 [*e.g.* 0.85] based if possible on data collected at the survey site. 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 — it's usually much faster.

Copy-and-paste method. Begin with field data already collated on *Excel* or similar spreadsheets (see Chapter 7 of the full *Guide.)* **Distance, Group Size, Horizontal Lateral 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 <u>first</u> entered the survey details in the **Method** and **Sample Details** windows. The **Observations** window should then show an 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 <u>not</u> the column headings).

3. Open the **Observations** window and select Edit>Paste (⌘-V). Your data should then appear in the appropriate columns. The 2-4 columns should be in the order *Distance | Group Size | Horizontal Lateral angle | Angle of Elevation.* Don't be concerned if there are <u>whole</u> blank rows or columns in the table; they do not affect computation and can be left in. *But check there are no rows with single blanks in them; if so, delete all such rows before proceeding.* To do this, first select these rows while holing down the command key (⌘) and then the minus (-) button at the bottom of the page.

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

4. If you are entering detection distance data and the population concerned is actively mobile, you need to know that the *WildlifeDensity* program treats all detections that have a '0' value in the *Distance* column as overtakes. Check all such entries - particularly perpendicular distance data - against your field data to see whether an individual '0' entry really means 'zero distance from the transect line' or 'overtaking the observer from behind'. (A measured perpendicular distance of 0 m would normally be most unusual.) If it really means 'zero distance', alter the '0' value to '0.01' or a similar very small distance in m. Doing that stops the detection being identified as an overtake but has a negligible effect on the density estimates.

5. Save the program file, using the file code you chose earlier [*e.g.* Run24104]. The file name should appear at the top of the window with the extension *.WDdata*, and usually the *WildlifeDensity* icon as well.

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 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 or omissions. If you are entering detection distance data and the population concerned is actively mobile, you need to know that the *WildlifeDensity* program treats all detections with a '0' value in the *Distance* column as overtakes. Check all such entries - particularly perpendicular distance data - against your field data to see whether an individual '0' entry really means 'zero distance from the transect line' or 'overtaking the observer from behind'. (An measured perpendicular distance of 0 m would normally be most unusual.) If it really means 'zero distance', alter the '0' value to '0.01' or a similar very small distance in m. Doing that stops the detection being identified as an overtake but has a negligible effect on the density estimates.

5. Save the file, using the file code you chose earlier [*e.g.* Run24104]. 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*.* Previous versions of the *WildlifeDensity* program required the user to decide an appropriate class interval to use in computations. Doing so alters the number of detections in each class. From the current transitional version 2.4 onward, that is no longer the case; the program itself now decides an appropriate class interval width, thus standardising both the procedure and the program estimates it produces. This works well. However an inactive 'class interval for calculations' line still remains at the top of the Options in Version 2.4. Please disregard it; providing a value in the panel has no effect on calculations.

Number of sets of iterations*.* Enter the number of sets of bootstrapped data you wish to be computed by the program when estimating the population density and other parameters. User experience shows that 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 quadratic surface fitting (QSF) procedure within the program. This is an engineering-based mathematical method of directly fitting quadratic surfaces of various shapes to groups of points in a distribution. Although computation can then be very rapid, the method is less dependable and the output less. In addition, estimates may be slightly biased and standard errors low *(see* Chapter 8 in the full *Guide).* It is provided as an additional and sometimes useful resource.]

Other options. *WildlifeDensity* routinely provides initial values and step sizes for the various program parameters as a built-in default. We recommend allowing this. You can then leave this option unselected and go directly to **Very small samples.**

> [**Important:** 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 inappropriate. To disallow automatic selection, or to display progress in parameter estimation, first select the **Select initial values and options manually** button. Also select the 'Tabulate' button under the **Verbosity and debugging options** and follow the procedure described under the **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.**

Allowing the program to select its own initial parameter vales and step sizes automatically is usually your best option. Unless you have a particular reason for using the **manual selection alternative** (p.10), go directly to **Very small samples** ***on*** p.14*..*

Manual selection alternative *(if required):*

If you decide to use manual parameter selection for some reason, 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 survey conditions, 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 or ostrich), about 15m for a medium-sized animal (*e.g.* a kangaroo or deer), ±10m for a larger songbird 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 initial value from previous analyses, use that.

If uncertain, make your estimate higher rather than lower than your initial suggestion.

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 as realistic as possible. Because a hectare is a relatively small area (equivalent to square measuring 100m x 100m, or 2.47 acres), vertebrate population density estimates 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 per sq. m .] Fo this parameter, 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, without 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. If you 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 (<12), 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 detections is unlikely to be successful either. Try sampling the population repeatedly over an appropriate and relatively short period of time (say, one month) under fairly similar survey conditions each time, then combining the multiple data sets into a single (larger) pooled sample before submitting it to *WilidlifeDensity* for analysis.

Saving input files. Selecting **Save** or **Save as** in the *WildlifeDensity* File menu allows you to 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.

Selecting the **Estimate tab** opens the final window and lets you run the program.

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, the second of which (View Results) is currently non-functional. This window also allows space for a progress bar and a results summary.

Program operation

1) Save the program file itself (with the filename extension *.WDdata)*. **[**If filename extensions are not showing on your macOS computer, a) first select the Finder icon at bottom left of the horizontal dock, b) under Finder, select Settings,, c) under Finder Settings, select Advanced, and finally, d) select *Show all filename extensions.*]

2) Select the ***Calculate*** button to start the search for a 'best-fit' model.

3) Wait for the progress bar that appears to reach its full length. [The time this takes depends on the number of iteration sets selected, the number of detections in the data set, their group sizes and the speed of your computer.]

4) The end of computations is marked by the appearance of a detection distance frequency distribution graph (Figure 1) with the density estimate temporarily below it. This consists of its estimated value, its *standard error* and the locations of two output files: the *main results* file (called *<filename>.results)* and a file with the final calculated and observed numbers in each distance class used in plotting the graph (*<filename>.graphData)*. These have the same filename as the original *<filename>.WDdata* file, and usually accompany it in the same folder on your computer. If a computer run is repeated, this pair of files is produced each time but differentiated with a different index number immediately after its filename.

Program output

Now examine the output.

Comparison graph. The detection distance frequency distribution graph that appeared at the end of computations was drawn from the numbers in the *<filename>.graphData* file. It plots the movement-corrected, observed numbers detected around each successive mid-point of the class intervals to show the detection distance frequency distribution as black dots joined by dashes. It also shows — as yellow dots connected by a yellow continuous line — the estimated numbers in each class calculated by the relevant *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 compare he two distributions.

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.

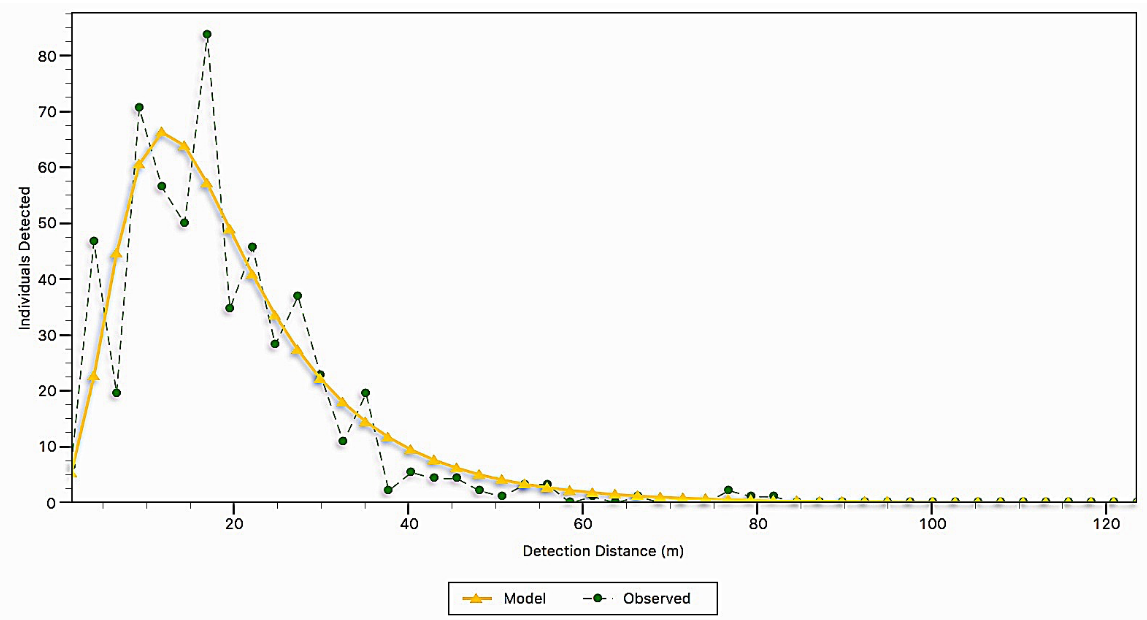

Figure 1. The fit of a modelled distance distribution (*yellow line*) to the numbers of a honeyeater population (*black* dots) observed in different radial distance classes from an observer walking a set of line transects. The yellow line follows a path that corresponds approximately to that of the data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

Because perhaps the commonest causes of apparently mismatched frequency distributions are mistakes and omissions in the data submitted to the program. Check this using the **Results summary** (see the next page**).**

Results summary. Once the program has run, 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.

Examining the Results

The output from program *WildlifeDensity* is in two files: a 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 7 of the main inputs to the program, and 16 of the main outputs, including 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 Eye-level: either the root mean square height difference between the population of interest and observer eye level 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 <filename>,WDdata 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. 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* is visible in a window called *(filename).graphData* from when it appears 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.

Troubleshooting

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