Using *WildlifeDensity*

This Help Manual is an abbreviated version of Part Three of the *Techniques Manual and User's Guide 2.* For further information on any topic, please refer to the full *Guide*. To find an item, view the bookmarks panel and click on its section heading or ernter the item in the find window above.

Introduction

How the program works. *WildlifeDensity* compares the frequency distribution of the data submitted with a mathematical model. It uses an iterative process to estimate the density of a population described in the data set, together with a set of shape parameters that best fit those data.

Before it runs, the program needs:

- certain *information* on the type of census involved;
- the *census data*, correctly formatted;
- a *class interval* for the detection distances; and
- *starting values* for model parameters. These are usually estimated by the program from the data, but can be supplied by the user instead.

Once a computer run begins, the program first calculates the numbers expected in each distance class, compares the calculated and observed numbers in each, then squares and totals the differences between them. The program next changes one of the parameter values by a predetermined amount and calculates a new overall 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 values in a step-by-step procedure (the 'downhill simplex method') that seeks to reduce the overall difference between the observed and calculated values. The process continues until a minimum difference value is reached, when computations stop. This completes the first set of iterations; the search for a minimum is complete. The 'best value' of each parameter is retained.

The program then resamples the original data at random 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 iteration sets below). The parameter values reported in the program output are the means and standard errors of the best values from the various sets of iterations.

The process begins with Data Entry.

Data Entry

When *WildlifeDensity* opens, 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 should be open at the Method tab. Enter data as described.

Filename. Click in the **Data set panel** and type in an identification name for the file. It might contain a brief description of the data set. [*E.g.:* Run12104: Red-necked Wallaby, Black Ra. forest, Jul12.]

Method window [Click the ‘Method‘ tab if it is not visible]

Census type. Select the button that indicates the type of census data being supplied.

The **Distances supplied as** options will be greyed out unless you select the perpendicular distances button; if so, choose the button that indicates whether: a) you are supplying radial distances and lateral angles for each observation or b) you are supplying pre-calculated perpendicular distances.

Observation type. Select the appropriate button (usually the first).

The two distance panels will be greyed out unless the data are from a selected range of distances. If they are, 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 the transect line are to be disregarded. For example, relatively 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 in collecting data [*e.g.:* 34524.5].

Select the distance unit, in **m** or **km**.

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 in kilometres. If so, select the appropriate detection distance unit.

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

Sample Details window

Time spent. In the first panel, enter the total time spent collecting the data, in minutes [*e.g.:* 3496]. This should be the total time involved in collecting the data set soon to be entered on the rest of this GUI.

Population movement rate. Enter the average horizontal displacement of an individual animal, expressed in metres per minute [e*.g.:* 22]. Obtain this either from previous behavioural studies or estimate it. If the population is relatively sedentary compared to the observer’s rate of travel, the value 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 the animal when travelling from place to place, multiplied by the average proportion of its time spent moving. Movement rates seem to depend largely on the foraging methods of the species and on characteristics of its foraging 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 may be adequate for line transect censuses, especially for species that have movement rates less than the observer’s rate of travel. However, for line transect censuses 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) in typical bird and mammal species, expressed in m/min. Their overall rates of movement 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 (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 - 100 **(75)**
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 that was scanned.

If the observer rotates more or less continually, an arc of 360° is scanned but, if scanning covers less than that, the arc scanned and expressed in degrees 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; otherwise leave it at 0.

Elevations. If the population is dispersed well above 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) either the approximate height difference between observer eyelevel and the median population height above ground, or, if you have it, the root mean square height difference between them in the panel at **Population**

elevation difference approximately. If height differences are small, an approximation will suffice [*e.g.* 5 m].

If you have some elevation angle data, but your data set is incomplete, you can calculate the **root mean square height difference** as $\sqrt{(h_1^2 + h_2^2 + h_3^2 \ldots) / n}$, where h is the height difference and n the number of measurements made.

Topography. If topography in the census area is approximately level, or the great majority of animals in the population are too close to the observer to be hidden behind a hill or rise, 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 from an observer, 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 should have a value between 0 and 1 [*e.g.* 0.85]; for most populations the proportion observable will be 1.

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

Observations window

This window is for the detection distance data. There are two ways you can enter data: 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 much quicker.

Copy-and-Paste Method. Proceed as follows: Begin with field data 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 columns S-V of your data file worksheets, in that order. Whatever data you supply, make sure the two, three or four columns supplied are in that sequence from left to right.

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

2. Open your census data file, then the appropriate worksheet. Select and copy (Edit>Copy, or ⌘-C) the observational data columns (but <u>not</u> 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 blank rows or columns; they do not affect computation and can be left in.

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

4. Save the file, using the file number you chose earlier [*e.g.* Run12104]. 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 cannot copy, cut or paste an entire <u>row</u> within the table. 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.

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 census 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.* Run12104]. 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 cannot copy, cut or paste an entire <u>row</u> within the table. 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.

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

Options window

Class interval for calculations. Enter the class interval or 'bin' width used in program computations and output results files, in metres.

For radial and fixed point data, make the class interval relatively small, perhaps about a fiftieth of the distance range [*e.g*. 2.5 for a range of 125m, 25 for a range of 1250m]. For perpendicular distance data, bin widths can be larger, especially if cluster sizes vary greatly.

The minimum width is 1/80 times the maximum detection distance. If you try to set a smaller interval, the program will automatically reset it to the 1/80 value.

Number of iteration sets. Enter the number of sets of bootstrapped data to be computed by the program and used to estimate the population density and other parameters.

Suitable values are 250 for a good approximation to a 'best estimate', 750 for serious work based on a large data set, and 1500 for a 'best' answer. Increasing the number of sets adds to the time needed to run the program: doubling the number roughly doubles computer running time. [*E.g.* 250]

[You can also run the program without bootstrapping by setting the number of iterations at 1. This is rapid but estimates may by slightly biased and return standard errors that are too low *(see* Chapter 8 in the full *Guide).*]

Initial parameter values and options. *WildlifeDensity 2* provides built-in **automatic selection** of initial parameter values and step sizes. This is recommended. If you decide to use automatic selection, go directly to **Saving input files** on p.9**.**

To override automatic selection, or to display progress in parameter estimation, click on the **Select initial values and options manually** button and follow the procedure described under Manual selection below.

You must use manual selection if you set upper or lower limits to the range of detection distances used (or parameter estimates may be biased).

Manual selection (usually optional):

If you chose manual 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 known properties of the observing situation, 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.

There are four parameters in the model. The first two are *shape parameters,* determining the shape of the frequency distribution curve:

> ***Conspicuousness coefficient.*** The *initial estimate* is an approximation to the conspicuousness of the target species to an observer, 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 <u>begin</u> 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.* an emu), about 15m for a medium-sized animal (*e.g.* a kangaroo or deer), ±15m for a larger passerine bird species, ±10m for an active, smaller passerine bird, ±5m for a cryptic species and as little as 2m 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 <u>highe</u>r rather than lower than the 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.

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
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 just under half the initial estimate [*e.g.* a step size of 8 for an initial value of 18].

Lateral cover. Lateral cover is the average amount of vegetation (tree-trunks, branches, foliage) in a direct line between observer and an animal, stated as a proportion of the detection distance.

The *initial estimate* should be a dimensionless number (no unit) always appreciably less than 1 [*e.g.* 0.005]. Typical values are shown in Table C below. Again, if in doubt, err on the high side.

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 lateral vegetation cover.

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)**

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.

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

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), the population density will often be less than 1. [If you find it easier to estimate number per square kilometre, do that 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* a little smaller than the initial estimate. [*E.g.* 0.03].

Maximum recognition distance. This is a best estimate of the maximum distance at which you can recognize the animal with the unaided eye, in metres, <u>without</u> using binoculars.

Either enter your own best estimate or, if you have an adequate sample size (15 or more separate detections), allow the program to estimate its own maximum distance based on the distribution of detection distances in the data. To let the program estimate its own value from the data, 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]. Typical values are given in Table B on p.7.

Small samples. If you have 80 or fewer observations in your data set (*the total appears in the Estimate window*), you should preset one shape parameter. Fix either conspicuousness or cover using the best initial estimate you have (*see Tables B & C*) and put that step size at zero. If you don't do this, *WildlifeDensity* will preset conspicuousness for you using a value it calculates from the original data. If you have 5-15 observations, you may need to preset *both* shape parameters. If you have fewer than 5 separate observations, running *WildlifeDensity* is not recommended.

Presetting shape parameters makes the estimates of their values in the output unreliable. However, because a curve-fitting process is being used, error in one shape parameter is roughly compensated for by error in the other, with comparatively little effect on the shape of the frequency distribution curve. Because population density is an important component of the area under the frequency distribution curve, its estimated value can remain relatively dependable even when a shape parameter is preset.

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 be very considerable, slow down the program and potentially produce some very large output files. Details are in Chapter 10 of the full *Guide*.

For most computer runs, leave these buttons unchecked.

You need to save the data file before running the program.

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) in an appropriate place on the computer. Saving also 'flags' the file with a *WildlifeDensity* icon. Clicking its icon or name in a list of folder contents then directly opens the program.

[If instead (or in addition) you decide to make a copy of the input file with a *.txt* or *.dat* suffix (extension), a text file is produced.]

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.

WDdata files, *.txt* and *.dat* files can also be opened and examined using a text program such as *TextWrangler* or *TextEdit*. Again, either drag-and-drop the files on to the program icon or open the text program first and use its **Open** command to locate and open the relevant file.

Click on the **Estimates** tab to open the final window.

Running the Program

Estimate window

The program is run from this window *(see below)*. It also 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.

What to expect. Selecting the *Calculate* button begins the estimation process, and a progress bar shows the progression of calculations. On completion, the 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 across the range of observing distances (*<filename>.graphData*). If a computer run is made more than once, this pair of files is retained each time and given the same name with a different *version number.*

A *comparison graph,* drawn from the numbers in the *<filename>.graphData* file, should also 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 in yellow the numbers calculated by the *WildlifeDensity* model.

Once the program has run, clicking the *View results button* 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.

Operating the program. Click on the *Calculate* button to start the search for a 'best-fit' model to the data you have submitted. The time this takes depends on the number of iterations selected, the number of observations entered, the variability of the group sizes and the speed of your computer. The appearance of the graph and a results summary in the input window marks the end of computation.

You can enlarge the graph by selecting either the third button from left at the top left of its window, or by selecting its bottom right-hand corner then dragging it to the right and downwards. Comparing the two distributions shows whether or not the run reached an appropriate solution.

Before you accept any of the results shown there, check first that the census details had been entered correctly, then consider how well the model fits the data. The graph is to help you identify any mismatching of the two distributions and show whether you need to rerun the program. If the model and the data shown in the graph correspond reasonably well, you can accept its estimates of population density and the other parameters.

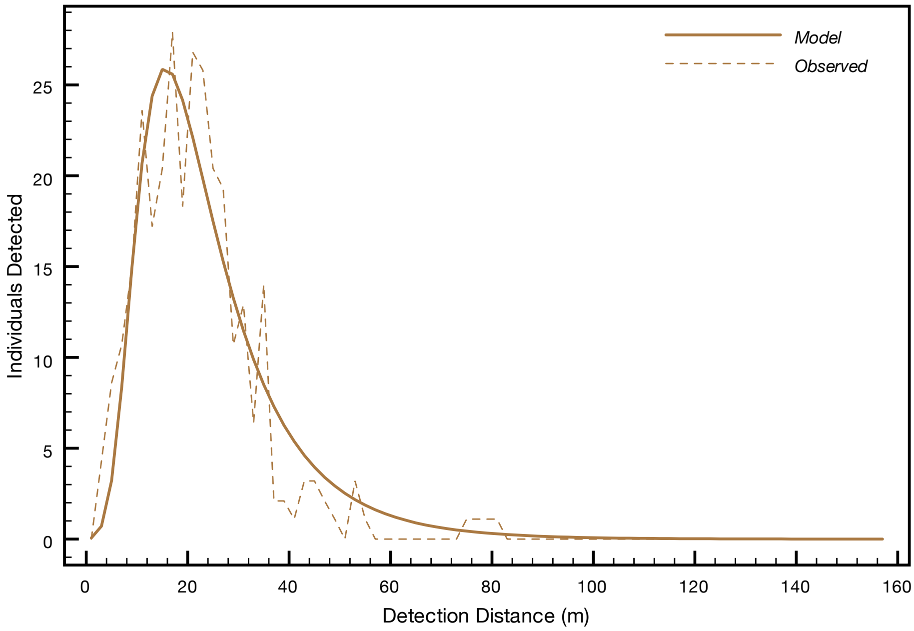
Now review the output.

Reviewing the Program Output

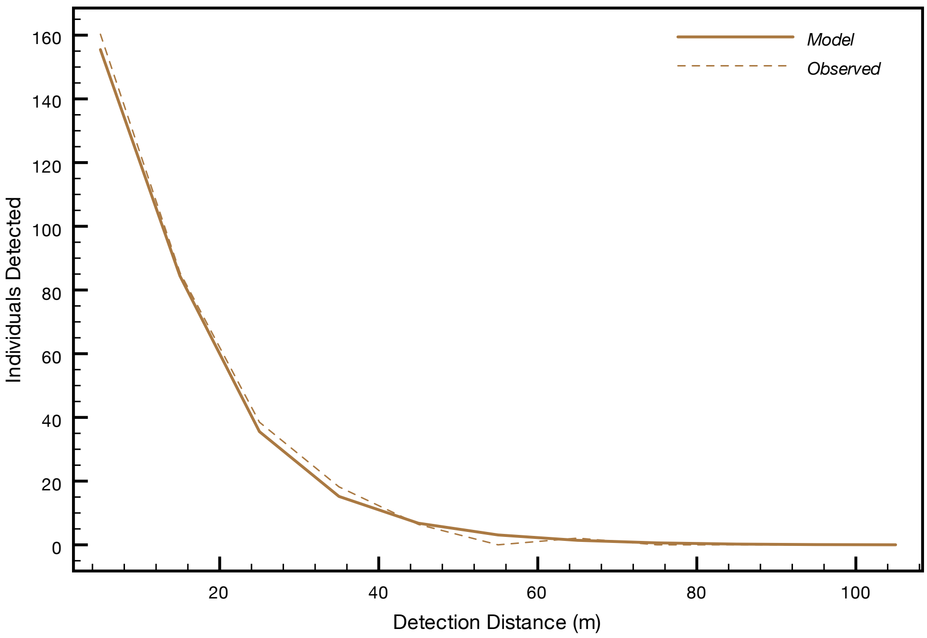
Before accepting the results of any computer run, you should compare the distribution of the WildlifeDensity model with the frequency distribution of the original data to make sure the program reached an appropriate end-point.

Examine the distribution. Compare the model (*continuous line)* with the data (dashes*)* on the graph. If the model follows the distribution of the data along its length, consider the search satisfactory. Some values will be higher and some lower, but one set should not be clearly above or below the other across a sizable range of distances. Nor should the calculated parameters be a set of zeroes. In either case the search for a minimum difference has failed for some reason. Figure 1 shows examples of the fit you expect between observed values and the modelled distribution.

(a) Radial distance line transect data



(b) Perpendicular distance data



(c) Fixed observing point data

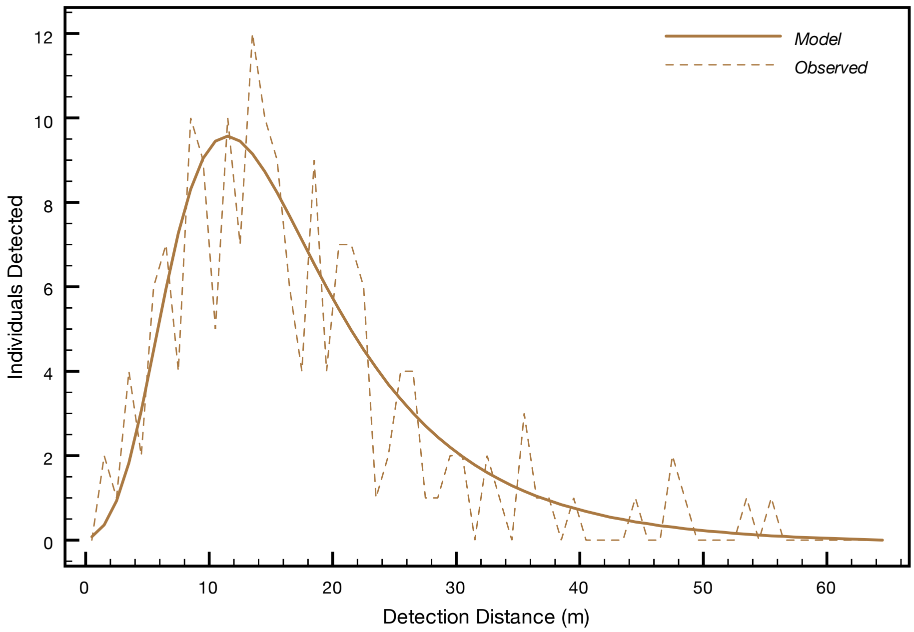


Figure 1. Acceptable fits of the *WildlifeDensity* model to different types of field data, all collected from the same population (a passerine bird in open forest with a shrub understorey). In each case the model follows the frequency distribution approximately, with the model in a roughly 'average' position, The areas under both the model and the observed distribution are similar.

If the fit is acceptable . . .

Open the window under the Estimates tab. Select the **view results** button and examine the detailed output (also visible if you open the *<filename>.results* file).

For a description of the results output, see *Interpreting the Results* on p.15.

If the fit is poor . . .

If you think the fit is poor, look at Figure 2 on the next page. It shows output from a run that gave a poor fit at first. A mismatch like this between the observed frequency distribution and the model indicates an unsuccessful search for the minimum overall difference.

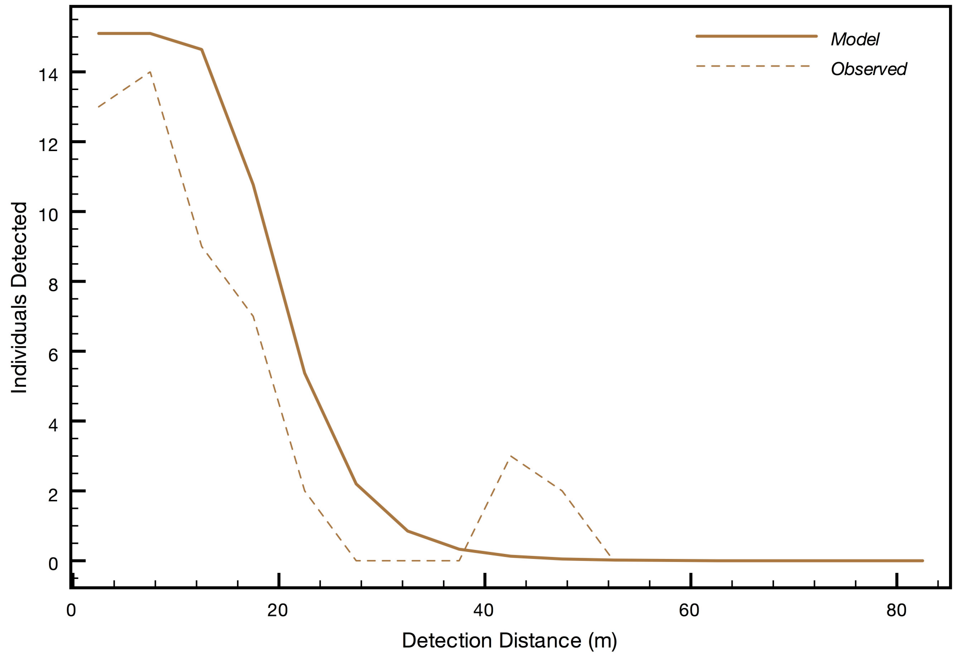


Figure 2. An unacceptable fit of the *WildlifeDensity* model to an observed distribution of field data. This came from running a small sample of data (49 observations) from the same population as the large data set used for Fig.1b. To overcome the poor fit, the conspicuousness coefficient was preset at a value from Table C, the step size was set at zero, and the program rerun. The result is in Figure 3.

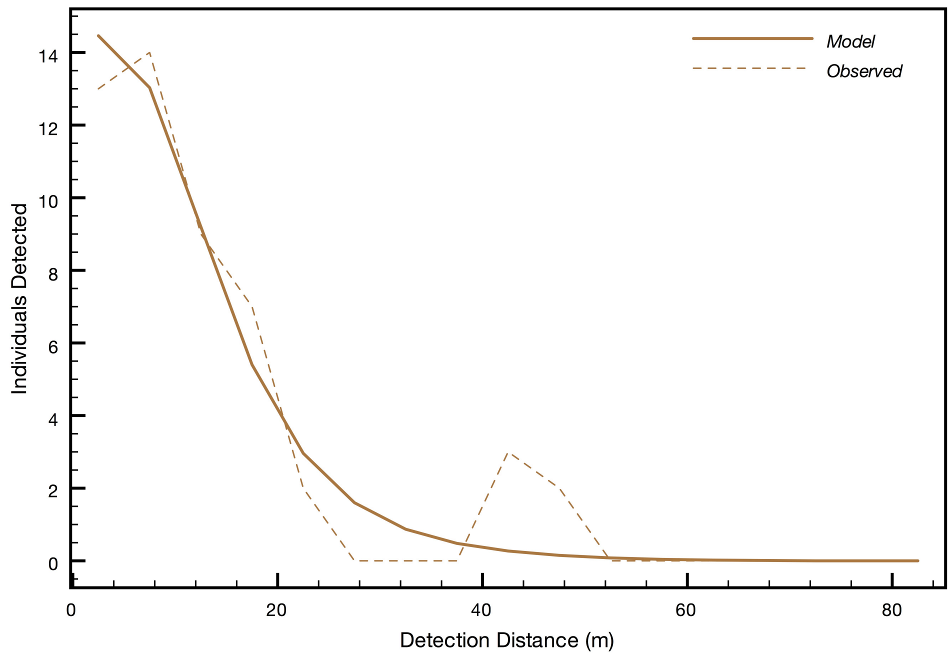


Figure 3. The result of a program rerun after setting the conspicuousness coefficient at a typical value (see Table C) and the conspicuousness step size at 0. The fit between the model and the distribution of observed distances is now acceptable.

The data set may too small, or the true parameter values are really much higher or lower than the starting values you entered, or the cluster sizes varied greatly, or the range of data entered was unduly restricted. Random resampling of the data then produced some atypical frequency distributions that made curve-fitting difficult. (If the number of parameter estimations shown in the *.results* file is less than the number you set, that is the likely reason.)

Some suggestions to improve the search:

1. **A0 first step.** Under the Options tab, first choose the 'Select initial values and options manually' button, then 'Tabulate final estimated function value . . '. Choosing the latter overrides the program's automatic operations.

2. **Preset one of the shape parameters** (conspicuousness or lateral cover). Presetting either makes a successful search more likely. Unless you know the cover proportion (e.g. 0 for open habitats), preset the conspicuousness coefficient and allow the program to find a matching value for cover. Enter the initial estimate based on Table C or a fractionally higher value if you prefer. Set its step size at 0. (Erring on the 'high' side is preferable to being too low. This happens automatically if the sample size is less than 80 and the initial step size is set higher than 0.)

   Provide both initial and step size values for cover (Table D). Rerun the program and examine the graph. If the match is now OK, select **Show results** below the Estimate tab.. If the fit is still unsatisfactory, preset the lateral cover at the best value you can (Table D) and put back a step size for the conspicuousness coefficient. Rerun the program and graph the results. If the fit is now satisfactory, select **Show results**. Otherwise go to Step 3.

3. **If you have a small data set**, preset the maximum recognition distance (Table C) and rerun the program. If it now runs OK, go to **Show results.** Otherwise go to Step 4.

4. **If presetting doesn't work**, change the class interval width under the Options tab, then rerun the program. Examine the graph. If the match is now OK, go to the results. Otherwise read on.

If the fit remains unsatisfactory, you could preset ***both*** the conspicuousness coefficient and lateral cover and rerun the program. However, unless both values are very well chosen, presetting both is likely to bias the density estimate. Presetting both parameters is not recommended *unless you already know the likely parameter value*s from previous effective data runs.

[There is another type of data set that can produce problems in modelling: one where the population is located either high above or well below observer eye-level. The shape of the frequency distribution is then not particularly distinctive—particularly the case with perpendicular distance data—making many different solutions to the modelling process possible. In such cases it pays to have a very large data set.]

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!

Interpreting 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 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.

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.

Cover Proportion (c) or ***Attenuation Coefficient (b)*****:** with most data, the estimated proportion of cover in the line of sight between observer and animals or, in some circumstances, an estimated attenuation coefficient for light or sound passing from animals to 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 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).

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 , class-by-class, the 'best-fit' model calculated with the original data submitted in the data input. 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. 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.

If you need to save a copy of the graph, use program *Grab* (built into 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

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