# Using *WildlifeDensity*

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

## 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 the population and a set of shape parameters that best fit the data.

For this to happen, you need to:

> set a class interval width for the distribution,
> decide the number of iterations to be used,
> notice the number of observations in the data set, and
> supply starter values for the density and shape parameters of the model.

The program first calculates the model, compares the calculated numbers with the observed numbers in each distance class, 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 another parameter, then another, and so on. Overall differences are then compared and new values computed to try and reduce the differences between 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, 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. The final parameter values are the means and standard errors of the best values from the various sets of iterations.

**A need for forethought.** Searches for minimum values in this way can fail if the initial values and steps supplied are poorly chosen. A useful analogy is to picture the user as a helicopter pilot flying over a rugged landscape looking for a village which s/he has been told lies in the deepest valley in the district. The initial values tell the pilot where to start looking, and the step sizes how far to look to either side. If the initial values are far from correct, the program begins its search in the wrong part of the [mathematical] landscape, finds the 'deepest valley' in that 'district' and puts down at the 'wrong village'. The resulting parameter values may then model the data very poorly. *It is therefore important that you choose initial estimates and step sizes wisely* to give a reasonable chance of finding the correct endpoint. Some suggestions are made below to help you do this, and to help you check your answers so that you will know whether or not your search has been successful.

Data entry begins the process.

## 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 that contains a brief description of the data set. [*E.g.:* Run08100: Red-necked Wallaby, Black Ra. forest, Jul08.]

### 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: • you are supplying radial distances and lateral angles for each observation or • are supplying pre-calculated perpendicular distances.

***Observation type.*** Select the appropriate button.

The two distance panels will be greyed out unless the data are from a selected range of distances. If so, 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 pathway.

***Transect length.*** Enter the total transect length travelled when collecting the data set.

Select the distance unit, in **m** or **km**. [*E.g.:* 34524.5]

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 panel, enter the time spent in minutes collecting the data for the data set concerned [*E.g.:* 3496].

***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 outlined 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 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 exceeding the observer's, and for all fixed point censuses, use a movement rate based on movement data. Enter a suitable rate, expressed in m/min.]

**Table A.** Approximate overall movement rates (travelling speed x time spent moving) in typical bird and mammal species, expressed in m/min, with approximations in bold type. 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 brackets.

| | Species and Foraging Method | Rate (m/ min) |
|---|---|---|
| 1 | * slow-moving grazing mammals that graze on the ground or browse in trees<br><br>* larger, slow-moving birds that stand on the ground looking for invertebrate prey | under 5<br>**(2.5)** |
| 2 | * continually-moving grazing and browsing mammals (mainly the smaller herbivores)<br><br>* larger seed-eating birds that mostly forage on the ground (*e.g.* pigeons)<br><br>* 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<br>**(8.5)** |
| 3 | * largely seed-eating birds that forage both on the ground and in foliage (*e.g.* finches, parrots)<br><br>* 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<br>**(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<br><br>* typical nectar-feeding birds of foliage that feed for a time in a tree, then move on to the next | 18 - 25<br>**(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<br>**(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<br>**(75)** |
| 6b | * birds that spend much of their time in flight over open ground, often in flocks (*e.g.* swallows, swifts) | 100-200<br>**(150)** |

***Proportion of observing arc scanned.*** Enter the proportion of a circle centred on the observer and scanned during a fixed point census.

[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 angles are not supplied, enter the approximate height difference between observer eyelevel and the median population height above ground, enter the root mean square difference, in m, in the panel at **Population elevation difference approximately**. If the difference is small, an approximation will suffice. [*e.g.* 5.4].

***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 metre) at which the target species starts to drop from view behind a ridge or hilltop *(see Chapter 5 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), 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.

***Vegetation height (if observer well above it).*** This is also a special-case variable, to be used only if the animal population is within and partially obscured by vegetation cover in situations and the observer is well above the vegetation (as in an aircraft over woodland, or in open grassland or low shrubland where the population is partly hidden within the ground cover), and where most of the observer's line of sight is clear of any obstructions. If so, express the approximate average vegetation height in metres [*e.g.* 0.6]; for most censuses let its value be 0.

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

## Observations window

This window is for detection distance data. There are two ways you can enter data: by copy-and-paste from data file speadsheets, or manually—one number at a time. Try the copy-and-paste option—it's much quicker.

***Copy-and-Paste Method.*** Proceed as follows:

1. Collate your field data 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, if you follow the recommended procedure. Whatever data you supply, make sure the two, three or four columns supplied are in that sequence from left to right.

[Don't enter data in this window until you have entered the census details in the **Method** and **Sample Details** windows. The **Observations** window should 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). Don't be concerned if there are blank rows or columns; they do not affect computation and can be included.

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

4. Save the file, using the file number you chose earlier [*e.g.* Run08100]. The file name should appear at the top of the window with the extension *.WDdata*, and usually the *WildlifeDensity* icon as well.

Use the '+' and '-' buttons below the table to add in or delete whole rows in the table.

[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 if 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. Enter the census details in the **Method** and **Sample Details** windows. The **Observations** window should then show the appropriate set of column headings.

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

3. Repeat for the next row. And so on 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.* Run08100]. 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't copy, cut or paste an entire row. You can also amend the entry in an individual cell if you first select the cell by double-clicking, then retype its contents; you can also copy, cut and paste the contents of an individual cell provided that you first select it.]

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 limit is 1/80 times the maximum detection distance. If you try to set a smaller interval, the program automatically resets 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 affects the time needed to run the program: doubling the number roughly doubles computer running time. [*E.g.* 250]

***Number of observations.*** Curve-fitting usually works well if there is a large number of separate observations (*i.e.* groups, not individuals) in a data set. 80 or more observations are usually enough unless group sizes vary considerably. The procedure below assumes you have 80 or more. (You can find the total under the Estimate tab of the program window.) If you have fewer than that, you need to vary the procedure (see *Small Samples* below).

***Initial parameter values.*** 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 a 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, to just begin to overlook the occasional animal if it’s stationary, quiet and partly hidden. Typical values are about 30m for a relatively large animal (*e.g.* an emu), about 20m for a medium-sized animal (*e.g.* a kangaroo or a deer), ±15m for a larger passerine bird species, ±10m for an active, smaller passerine bird and ±5m for a cryptic species. Table B on p.7 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 given.
>
> 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.
>
> 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 on p.8. Again, if in doubt, err on the high side.
>
> 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].

**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 | 29 **(30)** | 3000 |
| eastern grey kangaroo | 30 - 70 kg | 16 - 23 **(20)** | 2400 |
| western grey kangaroo | 25 - 55 kg | 7 - 28 **(18)** | 1600 |
| koala | 7 - 14 kg | 6 - 12 **(8)** | 200 |
| common brushtail possum | 1.5 - 4 kg | 4.5 - 5.5 **(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 |

***Population density 'guesstimate'.*** This parameter affects the height of the 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 density will often be less than 1. [If you find it easier to estimate number per square kilometre, divide your estimate by 100 to convert it to no./ha. *E.g.* 5/100 = 0.05]

Choose a *step size* a little smaller than the initial estimate. [*E.g.* 0.03].

**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)** |

***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.

Either enter your own best estimate or, if you have a good sample size, allow the program to estimate its own maximum distance based on the distribution of detection distances in the data. To estimate its 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 15-80 observations in your data set (*see total under Estimate tab*), you should preset one shape parameter. Assign either conspicuousness or cover using the best initial estimate you have (*see Tables B & C*) and putting 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 need to preset *both* shape parameters. If you have fewer than 5 separate observations, this procedure is not recommended.

Presetting shape parameters makes the estimates of their value in the output unreliable. However error in one shape parameter is roughly compensated for by error in the other, with comparatively little effect on the model's curve shape; the density estimate, because it is a component of the height of the curve, remains relatively dependable.

***Verbosity and debugging options.*** Selecting any of these buttons provides you with additional (technical) output on the computation process.

The output is 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.

**Save** the data file once again 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 *.dat* or *.txt* suffix (extension), a text file is produced. To open the *WildlifeDensity* program from a *.dat* (or *.txt*) file, either drag-and-drop it 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 can also be opened and examined using a text program such as *TextWrangler* or *TextEdit*. 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.

### Estimates window

The program runs from this window *(see below)*. It also shows the number of observations in the data set, and allows space for a progress bar and a results summary.

## Running the Program

There are three command buttons:

***Calculate button.*** Click this button to begin the estimation process; a progress bar shows how far calculations have progressed.

On completion, the window displays the **density estimate**, its **standard error** and paths to two output files: the **main results** (<*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**.

The other two buttons allow you to study the output:

***View results button.*** Click this to open the current <*filename*>*.results* file to display program inputs and output, in text format.

Before accepting the results shown there, check first that census details have been entered correctly, then see how well the model fits the data. You need either to plot the frequency distribution of the output or examine the contents of the *.graphData* file, to make sure that the program has reached an appropriate solution, with acceptable estimates of population density and the other parameters.

***Graph results button.*** Click the button to open program ***Plot*** (if installed) and produce a line graph to compare the original distance frequencies with those calculated using the model (as set out in file *<filename>.graphData*).

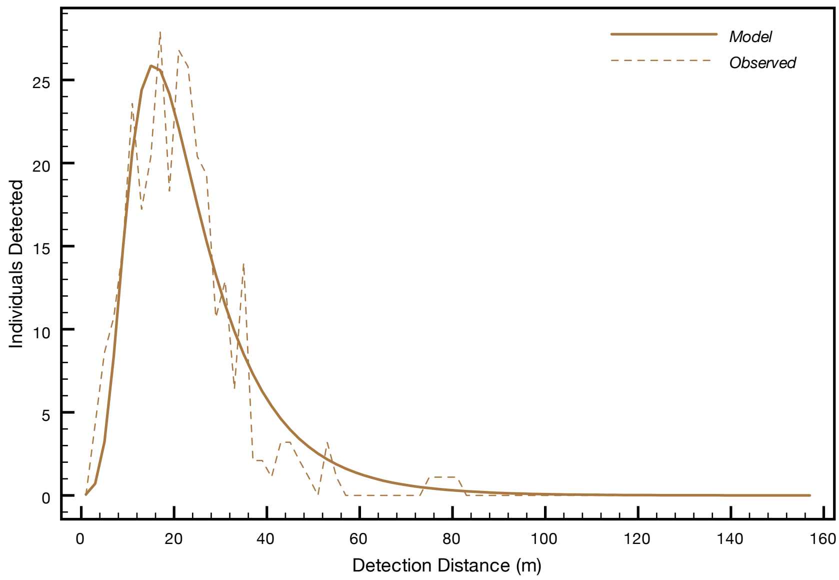
If *Plot* is installed, it should open, the model show as a continuous line and the original data as points joined by dashes. There are also formatting palettes that let you change its appearance if you wish. You can save the graph in the usual ways as well. The graph should help you identify any mismatching of the two distributions and show if you need to rerun the program.

## Reviewing the Output

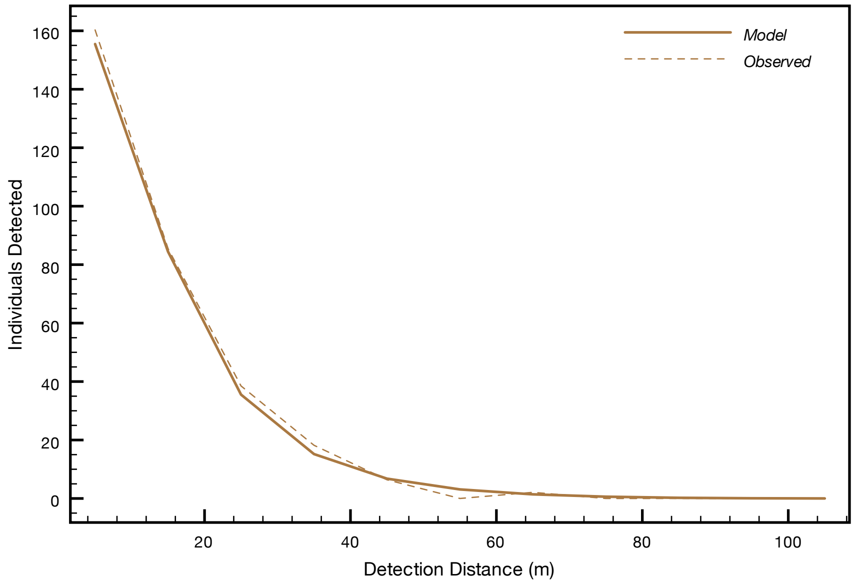
If the search for best values has been successful, the numbers calculated by the model should be broadly similar to the observed numbers. Some will be higher and some lower, but one set should not be clearly above or below the other across a sizable range of distances. Nor should the calculated parameters be a set of zeroes. In either case the search for a minimum difference has failed [been unable to locate the 'deepest valley' — *see p.1*] for some reason. If that is the case, disregard the results and resubmit the input data file with new, more appropriate initial parameter values (*see below*).

**Examine the distribution.** Compare the model with the data. If the model follows the distribution of the data along its length, consider the search satisfactory. Figure 1 shows examples of the fit you expect between observed values and the modelled distribution.

*(a) Radial distance data*



*(b) Perpendicular distance data*




*(c) Fixed observing point data*

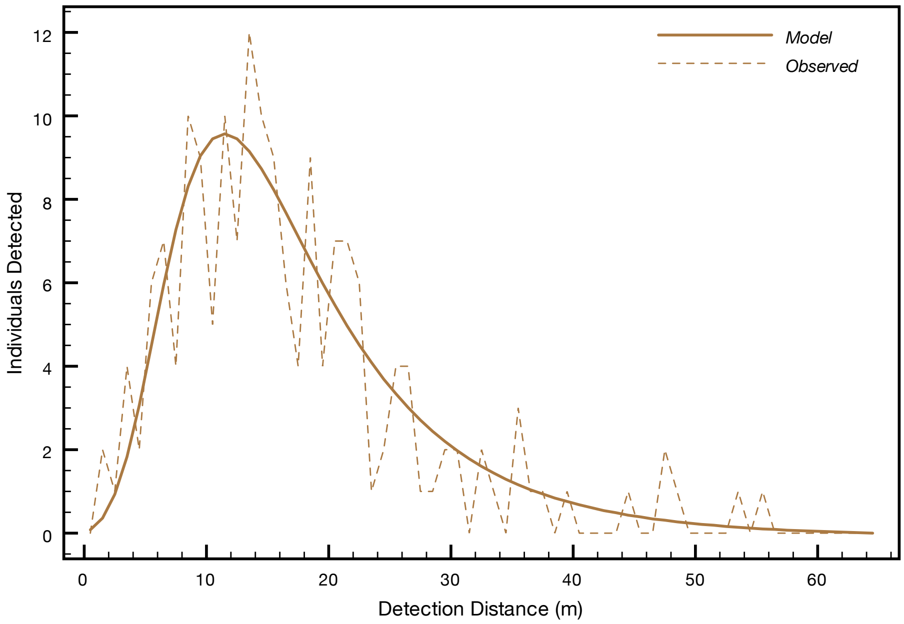



**Figure 1.** Acceptable fits of the *WildlifeDensity* model to different types of field data, all collected from the same population (a passerine bird in open forest with a shrub understorey), and plotted using program *Plot*. In each case the model follows the frequency distribution approximately,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

**If the fit is acceptable . . .** Close program *Plot* and go back to the results.

Open them either by clicking the **view results button** or opening *<filename>.results*.

If you think the fit is poor, look at Figure 2 on p.12, which shows the output of a run that failed to achieve an acceptable fit initially.

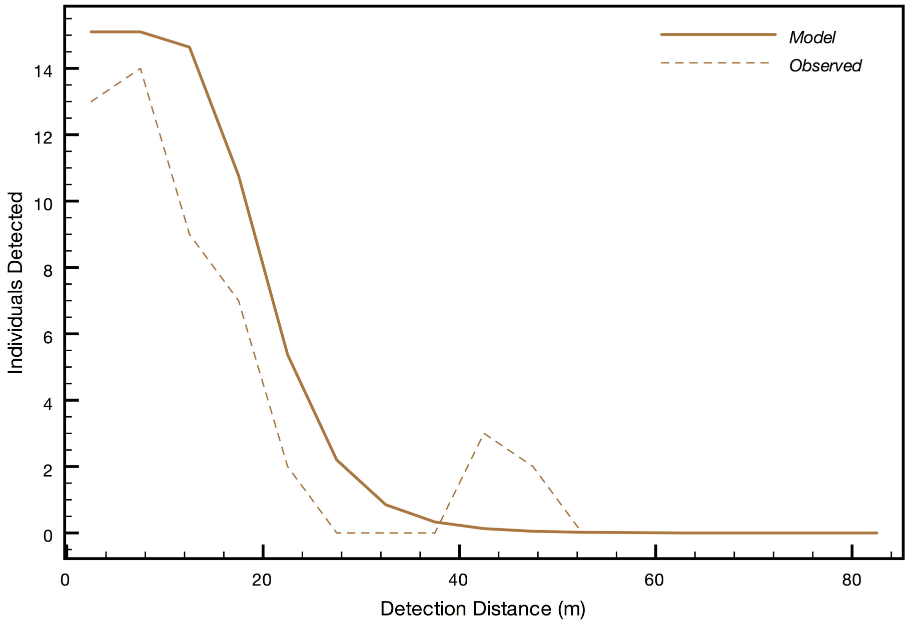



**Figure 2**. An unacceptable fit of the *WildlifeDensity* model to an observed distribution of field data. This came from running a small sample of data (49 observations) from the same population as the large data set used for Fig.1b. To overcome the poor fit, the conspicuousness coefficient was preset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

**If the fit is poor . . .** A mismatch between the observed frequency distribution and the model (*Figure* 2*)* indicates an unsuccessful search for the minimum overall difference.

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 as well, so that random resampling of the data produced some atypical frequency distributions that made curve-fitting difficult. (This is the likely reason if the number of parameter estimations shown in the *.results* file is less than the number you set.)

The number of observations and the amount of variability in group sizes are the main factors that determine how many parameters you can estimate from a set of data. Other factors, such as a large differences between observer and population planes, or restrictions on the range of distance data analyzed, may also have an effect. If the number of observations is relatively small, or cluster sizes are highly variable, or there are other possible contributing factors, consider presetting one or both of the shape parameters (conspicuousness coefficient, lateral cover) or the density guesstimate. Presetting either the conspicuousness coefficient or the cover proportion can make a successful search more likely.

Preset parameters with care. Very inappropriate values can produce some bias in the density estimate. The estimates returned for the shape parameters are likely to be unreliable (see full *Guide)*, though this may not matter if a reliable density estimate is your only objective. Unless you know the cover proportion (*e.g.* 0 for open habitats), try presetting the conspicuousness coefficient and allow the program to find a matching value for cover. Because cover proportion has the greater effect, doing this is less likely to bias the density estimate.

Proceed as follows:

1. If you have previously let the program find its own **maximum recognition distance** by setting it at '0' in the **Options** window, enter a suitable value instead (*see Table B*).

2. Re-examine the initial parameter values and the **class interval** you entered to make sure they were suitable (*Tables B* and *C*). If you think they were not, alter them, rerun the program and plot the output. If the fit is now acceptable, select the **View results** button and examine the output.

3. If you are happy with the values submitted, and especially if the data set is small, reduce the number of parameters you are trying to estimate. If you know the **cover proportion** (*e.g.* 0), enter that as the *initial estimate* and set the *step size* at 0. Provide an initial value and a step size for conspicuousness.

4. If you don't know the cover proportion, preset the **conspicuousness coefficient**: enter the *initial estimate*, either a known value, an estimate based on Table B, or a slightly higher value, and set its *step size* at 0. (Erring on the 'high' side is preferable.) Provide both initial and step size values for cover.

5. Rerun the program and again plot the output. Select the **View results** button if the fit is now acceptable (see *Figure 3*).

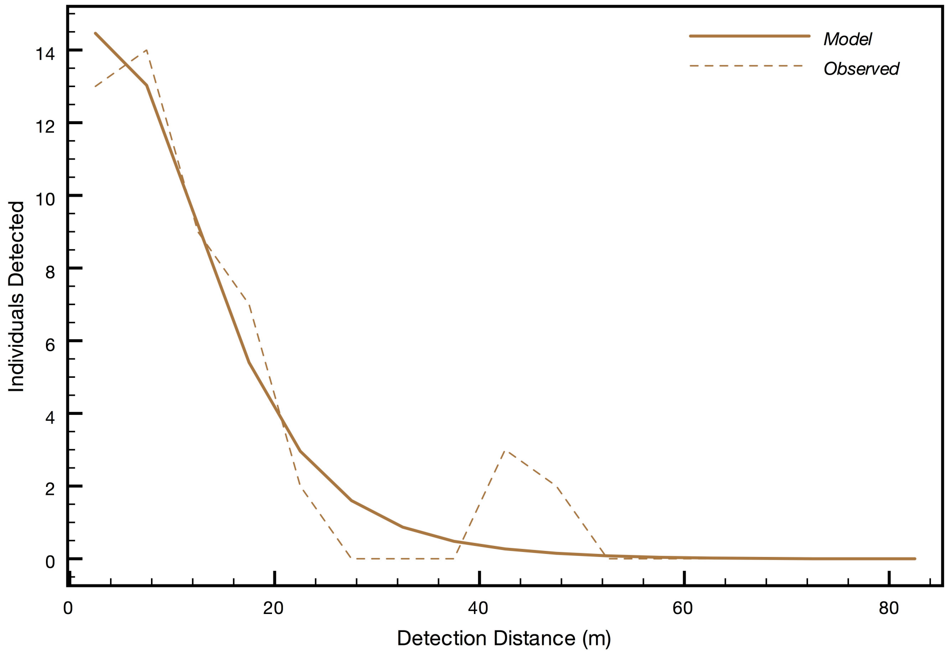



**Figure 3**. The result of a program rerun after setting the conspicuousness coefficient at a typical value (*see Table C*) and the conspicuousness step size at 0. The fit between the model and the distribution of observed distances is now acceptable.

6. If the fit is still unsatisfactory, you could preset both the conspicuousness coefficient and lateral cover and rerun the program. However, unless both are very well chosen, presetting both is likely to bias the density estimate. That step is usually inappropriate unless you already know the likely parameter values from previous data runs, or are try to achieve an estimate from an extremely small 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 collect it!

## Interpreting the Results

The output from program *WildlifeDensity* is in two files: the main results file, called <*filename*>*.results*, and the 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 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 variation 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) iterations used by the program. If the number is less than that set by the observer in the Options window, it is the number of iterations carried successfully to completion. (Failure to complete 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 later in this 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 sum of the squared differences between observed and expected frequencies at its search minimum 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*, pp.90-93).

**The *.graphData* file.** The second output file, <*filename*>*.graphData*, sets out and compares the 'best-fit' model calculated, class-by-class, with the original data submitted in the data input file. These are the data plotted when the **Graph results** button is clicked.

## Printing and Exporting Results

Both of the output files (*.results* and *.copyGraph*) are text files that can be read by text-based programs and printed as such. Follow the usual **Print** commands.

The graph produced by program *Plot* can be saved and printed in the usual ways. The palettes and other commands provided by *Plot* also enable you to vary the graph format in selected ways. The image can be exported in PNG, JPG, EPS or PDF formats too.

## Troubleshooting

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