10. Survey design in DISTANCE

The survey design engine in DISTANCE lets you input information on your survey area, including strata, and then set up the parameters to define survey designs, calculate coverage probability of your survey area, and generate survey tracklines.

First you need to create a DISTANCE project to contain the geographic survey area data and survey designs.

1. Creating a DISTANCE project

Open DISTANCE. Select **File** > **New Project**. In the **Create Project** window that opens, select the directory to store your project, give it a name and click **Create**.

The **New Project Setup Wizard** now starts. Under **I want to:** choose *Design a new survey or simulation*. Click **Next**. In the next window, select *Exit wizards and return to Distance* and click **Finish**.

The **Data** tab of the **Project Browser** opens for your project, showing a **Data Layers** panel on the left, containing one data layer called *Study area*, and a **Contents of Global layer 'Study area'** panel on the right with information about your *Study area*.

2. Geographic coordinate system, projection and units

Before anything else, you need to make sure the geographic coordinate system, projection and units within DISTANCE are set correctly.

Select **Tools > Preferences** from the toolbar and select the **Geographic** tab in the **Distance Preferences** window. Set the *Geographic coordinate system* to be **WGS 1984**, the *Projection of shapefile data* and *Projection of map* to be **[None]**, and the *Shapefile units* and *Map units* to be **Degree**. Click **OK** to close the window.

Select **File > Project properties** from the toolbar and select the **Geographic** tab. Set the *Geographic coordinate system*, *Projection of shapefile data* and *Projection of map* all to be **[None]**, and the *Shapefile units* and *Map units* to be **Meter** (because these are the units for the example below). Click **OK**.

3. Importing geographic survey area data

Geographic data can be input to DISTANCE in several ways: typing in co-ordinates by hand; pasting in co-ordinates from a text file; or importing GIS shapefiles into the project file directory.

In this example, we will copy and paste survey area co-ordinates from a text file.

Open the file **StAndrewsBay.txt**, which contains the coordinates of St Andrews Bay in Scotland. The data are in units of meters. **Copy** all the rows (on your keyboard, *control-A*, then *control-C*).

Back in DISTANCE double-click on *Polygon* in the **Study area** column in the right hand panel, to open the **Shape Properties** window. Select **Paste from Clipboard** under *Whole shape* on the right hand side. The **X** and **Y** columns now contain your data from the text file; the **# of vertices** box in the top right corner should read 257. Click **OK**.

4. Showing your data on a map

Select the **Maps** tab in the **Project Browser** and click on the **New Map** button (4 from the left under the tabs). Alternatively, select **Maps > New Map** from the toolbar.

Double-click on the name "New Map" and rename as "St Andrews Bay".

Click on the **View Map** button (6 from the left), or select **Map > View Map** on the toolbar, to open a blank **Map** window, with title "Map 1: [St Andrews Bay]" at the top. Click the **Add Layer to Map** button (7 from the left), or select **Map > Add Layer** on the toolbar, and **OK** to confirm adding the layer Study area.

A window opens that should be showing the St Andrews Bay area.

However …

Sometimes the map is there but very small. If this is the case, make the map larger by clicking on the **Zoom In** icon on the tool bar (4 from the right) and using the cursor to draw a larger box around the map. Use the **Pan** button (the hand shape icon, 2 from the right) to move the map around. Make the map smaller by clicking on the **Zoom Out** button (3 from the right) and then clicking on the map. Clicking on the Full Extent button (5 from the right) will make the map go very small again.

If the map doesn't appear or doesn't look right check the settings for shapefile units or projections (point 2 above).

Close the map window (saving changes) to return to the **Project Browser**.

5. Adding a coverage layer

Before any surveys can be designed we need to add a second data layer. This layer is a grid of points for assessing coverage probability (the average probability that a survey transect line will cover each point). This can be used to visualise how evenly a survey design is covering the survey area.

Before creating a coverage layer, check the coordinate system is correct

Click on the **Data** tab under the **Project Browser**. Select **Data > Data layer properties** from the toolbar and select the **Geographic data** tab. The *Coordinate system* should be **No coordinate system**. If it isn't, click on the **Change coordinate system …** box and select **[None]** under *Geographic coordinate system*. Click OK to return.

On the **Data** tab click on the **Create New Data Layer** button (5 from the left), or select **Data > Create Data Layer** from the toolbar, to open the **Create New Layer** window.

Under *Layer Name*, give your coverage layer the name "Grid", and choose **Coverage** under *Layer type*.

To set the spacing of the grid points, click on the **Properties** box to open the **Grid Properties** window. As a rough guide when assessing coverage probability, a grid spacing approximately equal to total maximum strip width is often appropriate. For our example, choose **2** for *Distance between grid points* and **Kilometer** under *Units of distance*.

Click **OK** to close the **Grid Properties** and **Create New Layer** windows. DISTANCE tells you that the grid spacing you have chosen will lead to approximately 247 grid points being created. Click **OK** to confirm. You'll see that the Grid layer has been added under the Study area **Data layer** on the left and that there is a new column in the right hand panel containing your Grid points.

Now select the **Maps** tab and view your map of St Andrews Bay.

Select **Add Layer to Map** again, and click **OK** to confirm **Layer name** Grid. You should now see the coverage probability grid points on the map.

Note: In larger study areas, choosing a grid spacing of the strip width may cause a very large number of grid points to be created (many thousands). In such cases, it is more appropriate to choose a wider grid spacing.

Close the map window (saving changes) to return to the **Project Browser**.

6. Creating a survey design

As an example, we can create a design for a systematic survey with parallel lines with line spacing of 5 km.

On the **Designs** tab of the **Project Browser**, select **Designs > New Design** (or click on the first button (yellow triangle) to the right of **Design:** below the tabs)

In the left hand panel, double-click on the name "New Design" and rename your design as "5 km spacing" or something similar.

Click on the **Show details for selected design** button (triangle with magnifying glass), or select **Designs > Design Details** from the toolbar, to open a window to define the details of your design.

You are in the **Inputs** tab. There are also **Log** and **Results** tabs (on the right hand side).

Under **Type of design**, choose Line for *Sampler:*, and Systematic Random Sampling for *Class:*

Click on the **Properties…** button to open the **Design Properties** window.

Ignore the **General properties** tab for this example.

Under the **Effort Allocation** tab, leave *Edge sampling* as Minus.

Under *Allocation by stratum*, choose Kilometer.

In the table at the bottom, enter **5** under **Spacing**. DISTANCE estimates that, on average, 8 Samplers (lines) will be created and that the average on-effort length will be 226.2 km.

Angle defines the angle of the design axis across which the transect lines will be designed. If this is 0, the axis runs north-south, which means that the lines will run west-east.

Under the **Sampler** tab, select *Line sampler width units* of kilometer and *Width* of **0.5**. This is the strip half width so the total area sampled is defined here as a strip 1km wide.

Under the **Coverage Probability** tab, select **Estimate by simulation**, with 100 **repetitions** (simulations).

Click **OK** to save your survey design.

Close the design window to return to the **Project Browser**.

7. Generation of a survey

Having defined the properties of your survey design you can now create a survey. This survey will be a single random realisation of your design; i.e., it will have a random starting point and 5km spacing between parallel lines running east-west.

Click the **Run selected design** button (4 from the right) or select **Design > Run design** to open a **Run Design** window. Select the second option, **Create new Survey …** and click **OK**.

A new Survey is created, the **Survey Details** window opens, and you are taken to the **Results** tab.

This tab has three pages, scrolled from the top.

The first **Design engine output** page, summarises your input information and results for this survey, including the number of lines generated, the amount of "realised on effort trackline length" (transect length) and "total line length" (on effort + distance moving between the end of one line and the beginning of the next). The "total cyclic trackline length" includes distance from the end of the survey back to the starting point. The "proportion of stratum surveyed" on the bottom line is the "realised sampler area coverage" as a proportion of the total "stratum area" on the two lines above.

The second **Survey map** page shows the placement of the samplers (transect lines). If the map is very small at the top of the window, follow instructions under point 4 above to make it bigger.

The third **Sampler location list** page gives the start and end points of each line. These could be copied and pasted into a text file to be uploaded to a GPS system.

Close the survey details window to return to the **Project Browser**.

Summary results for your survey are shown under the **Surveys** tab.

Under the **Data** tab, your survey lines have been added to the project as a new data layer, which has an associated shapefile (which may be a more convenient format for exporting to other systems such as GPS). Click on the name of your survey to see the data on the length of the transect lines in the right-hand panel.

Under the **Maps** tab, add a new data layer to your map containing your survey.

8. Design statistics

Because surveys are randomly generated from the design, properties such as total line length and proportion of time on effort are random properties with a mean and a distribution. We should be interested in the average proportion of total trackline that is on-effort, because the higher this is the more efficient is the design. We may also be interested in the minimum and maximum total trackline length that could be generated from the design.

Bring back the **Design Details** window using the **Design** tab, **Show details for selected design** button (triangle with magnifying glass), or select **Designs > Design Details** from the toolbar.

Click on **Run…** again but this time choose the option to **Calculate coverage probability statistics …**, and click **OK**.

100 repetitions were selected in the Design Properties, so DISTANCE does 100 simulations. The progress bar at the top tells you what percentage has been achieved. When this reaches 100%, the Design details **Results** tab goes green to give access to the results.

There are two pages of results.

The **Design engine output** page contains results in text format.

The **Coverage probability map** shows a colour-coded image of how coverage probability varies over the survey area. There may be a suggestion of lower coverage along the edges of the survey area. To the north and south, this could be because of the angle of the survey area boundary relative to the design axis. To the east and west, this could be because we chose “minus” edge sampling in our design. Choosing “plus” edge sampling under **Effort Allocation** in the **Design Properties** should alleviate this but would require longer tracklines.

But, overall, you should see an even coverage probability as we might expect. This will not necessarily be so for designs with zigzag sampling or with convoluted survey areas.

If the coverage probability map shows “stripes” of high and low coverage, you could re-run the design using more simulations and/or using a grid with a narrower spacing of points. To do this, you need either to go back to your Design and modify the properties under the Inputs tab or to create a new design.

If you go back to the Data tab, and click on the Grid layer in the left-hand panel, you’ll see that columns of coverage probability data (as proportions and percentages) have been added under Grid in the right-hand panel

9. Further investigations

Variations in survey designs to explore include:

- Parallel lines with different between-transect line spacings or with a different design axis;
- Zigzag lines with equal spacing or equal angles.