Appendix 1: Random Plots Workbook: Stratified Sample

These instructions will help users of all skill levels create a random sample of i-Tree Eco plot centers, plot areas, and the associated i-Tree Eco-required data files for their study area. ESRI ArcGIS software with the Spatial Analyst extension is used. The instructions are generic and applicable with modification to different versions of ArcGIS as well as other GIS software in terms of basic operations. The sample plots are stratified by land cover type (not by land-use data collected in the field). For purposes of example, 2001 USGS National Land Cover Database (NLCD) data are employed as these strata.These instructions are composed of four basic steps:

1 Prepare project area data

2 Prepare strata (land cover types)

3 Generate sample plots

4 Create Eco-ready output

When you are finished, you will have created the following:

- Area-of-interest (AOI) *polygon* map layer.
- Land cover map layer conforming to the AOI boundaries and composed of singular, multi-part land cover *polygons* with Eco-required fields added and populated.
- Random sample plot centers *point* map layer with Eco-required fields added and populated.
- Sample plot areas *polygon* map layer.
- Eco-ready Strata Area text file.
- Eco-ready Plot List text file.
- Eco-ready Projection prj file.

Tips

- The Spatial Analyst extension for ArcGIS is required.
- Field names and types are important.
- Obtain projection system and map unit information from the map data provider first.
- All map data must have valid projection information for proper alignment.

- Strata map data must be in a projection system that uses feet or meters – NOT degrees.

- Final Eco-required map units will be metric.

- AOI examples are polygons such as a city boundary, park areas, or management zones.

- ESRI shapefiles are easiest to use.

- "Pin" open ArcToolbox when starting – pushpin icon, upper right of ArcToolbox panel.

- Practice good file management: folders to hold copies of original data, folders to hold output, employ logical file naming, etc.

- ArcGIS should add the geoprocessed map layers to the view automatically. If not, use the File > Add Data > Add Data… menu to load them.

- Temporarily turn off any web browser pop-up blockers.

- Decide in advance the number of plots for each stratum.

Project Area Data Preparation

Overview

- Obtain a GIS map layer representing the area-of-interest (AOI) polygon(s) for your project area.
- Launch the ArcMap application of ArcGIS.
- Load the AOI map layer into the data view.
- Define the projection/coordinate system of the AOI if needed.

Detailed instructions

1 Obtain an area-of-interest (AOI) polygon from your GIS Department or an online resource. Several options can be found here: http://www.esri.com/data/free-data.

2 Launch ArcMap and save your project with an appropriate name at a new location via the **File** > **Save As** menu. Save periodically while working to avoid data loss.

3 Use the **File** > **Add Data** > **Add Data…** menu to browse to and load the AOI polygon map layer to the current view.

   a If your data are properly projected, ArcGIS should handle projection differences between the AOI and subsequent map layers on-the-fly.

b If your data lack projection information, an "Unknown Spatial Reference" message may appear. Click **OK** to move past it and use ArcToolbox to define the projection of the AOI map layer according to your data provider's specifications.

Navigate to **ArcToolbox** > **Data Management Tools** > **Projections and Transformations** > **Define Projection** and complete the Define Projection form:

For **Input Dataset**, choose the AOI map layer from the drop-down list.

For **Coordinate System**, click the **Properties** button to the right. In the **Spatial Reference Properties window** that appears, click **Select** and choose the coordinate system indicated by your data provider.

Results

An area-of-interest (AOI) polygon map layer: The AOI polygon map layer is now ready to be used to clip the strata layer.

Strata Preparation

Overview

- Obtain a land cover GIS map layer encompassing the entire AOI.
- Convert the land cover data to polygons, if needed.
- Clip the land cover polygon data to the AOI area.
- Select each land cover category and give it a plain text strata name in the attribute table.
- Dissolve the land cover polygons into a single, multi-part polygon for each land cover strata chosen for your i-Tree Eco project.
- Add Eco-required fields and calculate appropriate values for them.

Detailed instructions

Begin by obtaining land cover data from the Multi-Resolution Land Characteristics Consortium (http://www.mrlc.gov/):

1 Launch the MRLC Consortium Viewer; note the available user instructions.

2 Zoom and pan to your AOI, making sure you cover the entire AOI, plus a bit more.

3 Click on the **Download tab** at upper right, and make sure only Land Cover for a desired year is checked.

4 Use the **Download tool button** to delineate a square area on the map, and in the resulting pop-up window, click the **Download button** to save the layer. It may take a few moments before the web browser's file save window appears.

5 Unzip the download file to your desired folder. The downloaded NLCD file is named numerically and consists of image (raster) data. The file is composed of pixels, and each pixel contains information such as a Land Cover code number. A metadata file describing the layer's Entity and Attribute information is included as well. Specific land cover category codes and names can be found within.

Use ArcToolbox to convert the land cover image data to polygons.

1 Load the Land Cover image into ArcMap. ArcGIS should reproject these data on-the-fly, so they should appear underneath your AOI.

2 Right-click the image map layer and Open Attribute Table to examine the Land Cover codes.

3 Navigate to **ArcToolbox** > **Conversion Tools** > **From Raster** > **Raster to Polygon**.

4 Fill out the **Raster to Polygon** form:

    a For **Input Raster**, choose your land cover map layer from the drop-down menu.

    b For **Field**, select the field containing the land cover values (refer to metadata documentation if necessary).

    c Under **Output Polygon Features**, use the **Browse** button to locate a suitable location and create a filename for the resulting polygon map layer.

    d The **Simplify** polygons box should be UNCHECKED.

    e Click **OK**.

Use ArcToolbox to clip the land cover polygon map layer by the AOI map layer.

1 Navigate to **ArcToolbox > Analysis Tools > Extract > Clip**.

2 Complete the **Clip** form:

    a Under **Input Features**, select the land cover polygon map layer from the drop-down list.

    b Under **Clip Features**, choose the AOI map layer from the drop-down list

    c Under **Output Feature Class**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.

    d Leave the **XY Tolerance field** and the **units** dropdown blank.

    e Click **OK**.

3 The land cover map layer should now conform to the inside of the project area boundaries.

Use ArcToolbox to add Eco-required fields to the clipped land cover polygon map layer.

1 Navigate to **ArcToolbox > Data Management Tools > Fields > Add Field**.

2 Complete the **Add Field** form:

    a Under **Input Table**, select the clipped land cover map layer from the drop-down list.

    b For **Field Name**, enter: `StratDslv`

    c For **Field Type**, select TEXT from the drop-down list.

    d Skip the following fields:

      Field Precision

      Field Scale

      Field Length

      Field Alias

      Field is Nullable

      Field is Required

      Field Domain

    e Click OK.

Use regular Selection Queries and ArcToolbox to create text values equivalent to the land cover categories for the clipped land cover polygon map layer.

1 Examine the metadata documentation file that downloaded with the NLCD Land Cover data. Each GRIDCODE value corresponds to one land cover category. Use the GRIDCODEs to decipher the land cover data.

2 In the main ArcMap menu bar, choose **Selection** > **Select by Attributes**.

3 Complete the **Select by Attributes** form:

   a For **Layer**, select your clipped land cover map layer.

   b For **Method**, select **Create a new selection** and format the queries in the **SELECT * FROM** box at the bottom

   c Make sure the box is empty. Delete old queries if necessary.

   d Double-click the "**GRIDCODE**" field name from the list above.

   e Click the **equals** button.

   f Click the **Get Unique Values** button.

   g Double-click the first land cover GRIDCODE value in the list.

   h A properly formatted query will look like this: **"GRIDCODE"=11**.

   i Click **Apply** – this keeps the selection form open.

4 With features in this first land cover category selected, use ArcToolbox to give the land cover category a text name. Navigate to **ArcToolbox > Data Management Tools > Fields > Calculate Field**.

5 Complete the **Calculate Field** window:

   a Under **Input Table**, select the clipped and dissolved land cover polygon map layer from the drop-down list.

   b For **Field Name**, select **StratDslv** from the drop-down list.

   c Under **Expression**, enter an appropriate name to describe the land cover type, for example: "Developed High Intensity" (including quotes)

   d Skip **Expression Type**.

   e Skip **Code Block**.

   f Click **OK**.

6 Right-click the clipped land cover polygon map layer in the map layers list, select **Open Attribute Table**, and verify that only those selected feature records were populated with the appropriate land cover category text.

7 Repeat steps 1–6 for each land cover category present in the land cover polygon map layer. Tip: you can formulate queries to select more than one land cover code to group them as a single strata if desired. e.g. **"GRIDCODE"=21 OR "GRIDCODE"=22**.

8 From the main Selection menu, choose Clear Selected Features to unselect all land cover features.

Use ArcToolbox to dissolve the land cover polygon(s).

1 Navigate to **ArcToolbox > Data Management Tools > Generalization > Dissolve**.

2 Fill out the **Dissolve** form:

   a Under **Input Features**, choose the clipped land cover polygon map layer from the drop-down list.

   b For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and create a file name for the resulting map layer.

   c Under **Dissolve_Field(s)**, check the **StratDslv** field (whose attribute values hold your names for the NLCD land cover values as described above).

   d Leave the **Statistics Field(s)** blank.

   e The box next to **Create Multipart Features** should be checked.

   f Skip the **Unsplit lines** checkbox.

   g Click **OK**.

3 Right-click the new dissolved Land Cover polygon layer, Open Attribute Table and verify that there are now single, multipart polygons for each land cover category.

Use ArcToolbox to add additional Eco-required fields to the dissolved land cover polygon map layer.

1 Navigate to **ArcToolbox > Data Management Tools > Fields > Add Field**.

2 Complete the **Add Field** form:

   a Under **Input Table**, select the dissolved land cover map layer from the drop-down list.

   b For **Field Name**, enter: `Strat_ID`

   c For **Field Type**, select **LONG** from the drop-down list.

   d Skip the following fields:

   Field Precision
   Field Scale

Field Length

Field Alias

Field is Nullable

Field is Required

Field Domain

e Click **OK**.

3 Repeat the steps above as follows for these additional fields:

a **Field Name**: `Strat_Area` with **Field Type:** Select **DOUBLE**.

b **Field Name:** `Strata` with **Field Type:** Select **TEXT**.

Use the attribute table Field Calculator to populate values for the Eco-specific fields added to the dissolved land cover polygon map layer:

1 Right-click the land cover map layer and select **Open Attribute Table**.

2 Right-click the **Strat_ID** field column heading and select **Field Calculator...**

a In the large text entry box below **Strat_ID =**, enter: `[FID]+1`

b Click **OK**.

3 Repeat for the **Strata** field.

a In the large text entry box below **Strata =**, enter: `StratDslv`

b Click **OK**.

4 Right-click the **Strat_Area** field column heading and select **Calculate Geometry…**

5 For **Property**: choose **Select Area**. If this is not available, your land cover polygon map layer is not in a projection system using feet or meters; the section above called Project Area Data Preparation.

6 For **Coordinate System** choose **Use coordinate system of the data source.**

7 For **Units**, select **Hectares [ha]**

8 Close the Attribute Table when finished.

Results

A converted, clipped, and dissolved polygon land cover map layer with Eco-required fields added and populated.

- It should align with and conform to the project area boundaries.

- It should have ONE record representing EACH land cover category present in its table.

- The processed land cover polygon map layer is now ready to be used for plot generation.

Sample Plot Generation

Overview

- Select each land cover category and run the Create Random Points tool from ArcToolbox for each land cover category.

- Merge the resulting random plots data together.

- Spatially join the land cover data to the random plots data.

- Add Eco-required Fields to the random plots data.

- Calculate field values for the random plots data.

- Buffer the random plots point data to form plot areas.

Detailed instructions

Use regular selection queries and ArcToolbox to select an individual land cover category and then generate the desired number of plots for it.

1 From the **Selection** menu, choose **Select by Attributes**.

2 Fill out the **Select by Attributes** form:

   a Under **Layer**, ensure that the dissolved land cover map layer is selected.

   b For **Method**, select **Create a new selection** and format the queries in the SELECT * FROM box at the bottom as follows:

   c Make sure the box is empty. Delete old queries if necessary.

   d Double-click the **Strata** field name from the list above.

   e Click the **equals** button.

   f Click the **Get Unique Values** button.

   g Double-click the first land cover Strata value in the list.

   h A properly formatted query will look like this: "Strata"='Developed, High Intensity'.

    i Click **Apply**.

3 Navigate to **ArcToolbox > Data Management Tools > Feature Class > Create Random Points**.

4 Complete the **Create Random Points** form:

    a For **Output Location**, browse to and single-click your working folder to select it and click **Add**.

    b For **Output Point Feature Class**, type in an appropriate name with a .SHP extension. (Sample plots will be created for individual land cover categories as separate map layer shapefiles. Choose a name for each file that reflects the category as they will eventually be merged together into one sample plots layer, e.g., plots_Developed_HighIntensity.shp)

    c For **Constraining Feature Class**, select your clipped and dissolved land cover map layer.

    d For **Number of Points** [value or field], enter the desired number of sample plots for this selected land cover.

    e Skip the remaining inputs.

    f Click **OK**.

    g Repeat steps 1–4 for each land cover category.

5 From the Selection menu, choose Clear Selected Features to unselect all land cover features.

Use ArcToolBox to merge the individual land cover category random plots map layers together:

1 Navigate to **ArcToolbox > Data Management Tools > General > Merge.**

2 Complete the **Merge** form:

    a FIRST, you must enter **Output Dataset** with a file extension of SHP. Click the **Browse** button to navigate to a suitable location and enter a file name for the resulting map layer, e.g., SamplePlots_Merge.shp

    b Then, from the drop-down list under **Input Datasets**, select each land cover plot layer, one at a time.

    c Skip the **Field Map** option.

    d Click **OK**.

Perform a spatial join between the merged sample plots point map layer and the dissolved land cover polygon map layer. This step assigns land cover types to the sample plot points.

1　Right-click the merged sample plots layer and select **Joins** and **Relates > Join...**

2　Complete the **Join Data** form.

　　a　Under **What do you want to join to this layer?** select **Join data from another layer based on spatial location**.

　　b　Under **Choose the layer to join to this layer…** select the dissolved land cover polygon layer.

　　c　Under **Each point will be given all the attributes of the polygon that:** click the button next to **it falls inside**.

　　d　Under **The result of the join will be saved into a new layer**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer. These will be the final i-Tree Eco plot centers.

　　e　Click **OK**.

Use ArcToolbox to add Eco fields to the spatially joined sample plots point map layer.

1　Navigate to **ArcToolbox > Data Management Tools > Fields > Add Field**.

2　Complete the **Add Field** form.

　　a　For **Input Table,** select the spatially joined sample plots point map layer from the drop-down list.

　　b　For **Field Name**, enter:　**ID**

　　c　For **Field Type**, select **LONG** from the drop-down list.

　　d　Skip the following fields:

　　　Field Precision
　　　Field Scale
　　　Field Length
　　　Field Alias
　　　Field is Nullable
　　　Field is Required
　　　Field Domain

e　Click **OK**.

3　Repeat the steps above as follows for these additional fields:

　　　a　Field Name: LCCode with **Field Type**: Select **SHORT**.

　　　b　Field Name: X_Coord with **Field Type**: Select **DOUBLE**.

　　　c　Field Name: Y_Coord with **Field Type**: Select **DOUBLE**.

Use the attribute table Field Calculator to populate values for the Eco-specific fields added to the spatially joined sample plots point map layer in the steps above.

1　Right-click the spatially joined sample plots point map layer and select **Open Attribute Table**.

2　Right-click the **ID field** column heading and select **Field Calculator...**

　　　a　In the large text entry box below **ID =**, enter: [FID]+1

　　　b　Click OK.

3　Repeat for the **LCCode** field.

　　　a　In the large text entry box below **LCCode =**, enter: [Strat_ID]

4　Right-click the **X_Coord** field column heading and select **Calculate Geometry…**

　　　a　For **Property**: select **X Coordinate of Point**

　　　b　For **Coordinate System** choose **Use coordinate system of the data source**

　　　c　For **Units**, select **Meters [m]**

　　　d　Click **OK.**

5　Right-click the **Y_Coord** field column heading and select **Calculate Geometry…**

　　　a　For **Property**: select **Y Coordinate of Point**

　　　b　For **Coordinate System** choose **Use coordinate system of the data source**

　　　c　For **Units**, select **Meters [m]**

　　　d　Click **OK**

6 To verify the attributes have been correctly modified in the sample plots point map layer, right-click the spatially joined sample plots point map layer in the map layers list, and choose **Open Attribute Table**.

    a Scan through the fields and their values to verify they are correct.

(Optional) Use ArcToolbox to buffer the spatially joined sample plots point map layer. This step creates the plot of your desired survey size around the plot centers and can be used to make field data collection plot maps.

1 Navigate to **ArcToolbox > Analysis Tools > Proximity > Buffer.**

2 Complete the **Buffer** form:

    a Under **Input Features**, select the spatially joined sample plots point map layer from the drop-down list.

    b For **Output Feature Class**, use the **Browse** button to navigate to a suitable location and choose a file name for the resulting map layer.

    c For **Distance**, in the **Linear Unit** box, enter the distance value from the list below, based on your desired plot size. (The distance is the radius of the plot.)

    Feet:

    For 1/5 acre plots: enter: **52.66**

    For 1/10 acre plots: enter: **37.24**

    For 1/20 acre plots: enter: **26.33**

    For 1/100 acre plots: enter: **11.78**

    Meters:

    For 1/5 hectare plots: enter: **25.23**

    For 1/10 hectare plots: enter: **17.84**

    For 1/20 hectare plots: enter: **12.62**

    For 1/100 hectare plots: enter: **5.64**

    d Select Feet or Meters as appropriate from the units dropdown

    e Skip the following entries:

    Side Type

    End Type

    Dissolve Type

    Dissolve Field(s)

    f Click **OK.**

3 The buffered sample points layer is added to the map view automatically; zoom in to examine individual plot areas. Note: choose an equal-area appropriate projection system in the layers data view properties if your plot areas appear not to be circular.

Results

Sample plots point map layer

- User-defined number of plots randomly spread throughout each stratum (land cover category)
- Plot points assigned with land cover categories
- Eco-required fields added and populated

(Optional) Sample plot areas polygon map layer

Create Eco-ready Output

Overview

- Export select fields from the Plot attribute table to a text file.
- Export select fields from the Strata polygons attribute table to a text file.
- Copy and rename the AOI projection file.

Detailed instructions

1 From the **Selection** menu, choose **Clear Selected Features** if available to unselect all features.

2 Right-click the spatially joined sample plot centers point map layer in the map layers list and select **Open Attribute Table**.

    a Right-click the **FID** field and select **Turn Field Off.**

    b Repeat for all but the **ID, LCCode, X_Coord**, and **Y_Coord** fields (added in Sample Plot Generation above).

    c Under the upper left **Table Options** drop-down button, select **Export**.

    d Browse to a folder where you wish to save the output file.

    e For **Save the file as** type select **Text File**.

f Name the export appropriately, such as "myEcoPlots_mmyyyy.txt".

g Click **No** when asked to add the new table to the current map.

3 Open the text file in a simple editor such as Windows Notepad (avoid using word processing software due to formatting issues).

a Use the **Search and Replace** function to replace each comma with a space.

b Save the file

c Delete the first line containing the field names: "ID","LCCode","X_ Coord","Y_Coord"

d Copy and paste these two lines at the top of the file:

$ U4PLLS! 1.3 20040728 1549
1

e A properly formatted file will look like this:

$U4PLLS! 1.3 20040728 1549
1
1 1 1199094.600650 2095374.121430
2 1 1202999.760510 2094522.116280
3 1 1207382.288000 2096877.180300
4 1 1198150.473980 2101783.086320
...

4 Right-click the dissolved land cover polygon layer in the map layers list and select **Open Attribute Table**.

a Right-click the **FID** field and select **Turn Field Off**.

b Repeat for all but the **Strat_ID, Strat_Area,** and **Strata** fields (added in Strata Preparation above).

c Under the **Table Options** drop-down button, select **Export**.

d Browse to a folder where you wish to save the output file and save as a Text File.

e Name the export appropriately, such as "myEcoStrata_mmyyyy.txt".

f Click **No** when asked to add the new table to the current map.

5 Open the text file in a simple editor (avoid using word processing software).

    a Use the **Search and Replace** function to replace each comma with a space.

    b Save the file.

    c Delete the first line containing the field names: "Strat_ID","Strat_Area","Strata"

    d Copy and paste these two lines at the top of the file:

        $U4STAR! 1.3 20040728 1549
        1

    e A properly formatted file will look like this:

        $U4STAR! 1.3 20040728 1549
        1
        1 15138.785733 "Developed"
        2 3187.141038 "Open"
        3 217.131072 "Other"
        ...

6 Make a copy of the PRJ file associated with your dissolved land cover polygons layer.

    a In Windows Explorer, browse to your working folder and copy/paste the PRJ file associated with this shapefile.

    b Right-click the copied file, and Rename it appropriately, such as "myEcoProjection_mmddyyyy.prj"

Results

Three Eco-ready files:

- Plot List
- Strata Area
- Projection (automatically created in the Define Projection/Reprojection steps above as part of the AOI Shapefile)