A GIS SAMPLING ASSISTANT PROGRAM FOR FOREST INVENTORY POINT/PLOT SCHEMES

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ABSTRACT

Accurate forest inventory must include unbiased and precise measurement of a number of sampling points. The theoretical basis of sampling has been exhaustively studied and forest measurement techniques have a firm statistical basis. However, it is often the case that field difficulties result in abandonment of a rigorous application of all the assumptions of the statistical theory. In a field setting it is generally difficult to select truly random sample points. This paper outlines an ARC-GIS8.x tool that allows selection of completely random points in any chosen area, random points placed within grid squares to cover an area, or systematic grids of points from a random starting position. Tools are also available to perform stratified random sampling with number of points in the strata weighted by area of the strata. Outputs of the program are plot centers or fixed area plots. Plots are output as a separate shapefile (overlays) containing square or round polygons of selected sizes that are centered on the points. The attribute tables for the point and plot featurelayer has a point ID number, x-coordinate, y-coordinate of the center point, map units, projection, landclass code, and land class description. These attributes can then be utilized as waypoints in order to navigate to all sample points with a GPS device.

KEYWORDS. Inventory, randomization, GIS, UFORE.

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INTRODUCTION

The Urban Forest Effects (UFORE) computer model (Nowak and Crane, 2000) was developed at the Northeastern Research Station of the USDA Forest Service. It is intended to help managers and researchers quantify urban forest structure and function. The program uses standardized field data (Nowak et al., 2003a) from randomly located plots and locally collected environmental data to summarize urban land use and quantify several parameters related to pollution and energy conservation in urban environments. It is intended to produce real data about specific urban locations and thus has been used in a number of cities throughout the world (Nowak et al., 2003b, 2003c).

The standardized field data (Nowak et al., 2003a) was collected from plots located randomly using an ArcView 3.2 extension called 'UFORE Random Plot Selection Tool'. This ArcView extension allowed the user to enter a number of points to be randomly distributed inside a polygon boundary based on land cover. The points were computed proportional to the number of cells or area representing each land cover code inside the area of interest polygon and presented to the user in an editable form. The user could change the number of points assigned to any land class before creating the points. The program then created the assigned number of points randomly located in each land class. The point theme was then used to create a plot overlay.

The attribute data for each plot included plot id, stratum (land class), and location as X coordinates and Y coordinates. This information was entered into the UFORE program that ran in SAS and produced a number of useful outputs (Nowak, 2006). The program has been undergoing migration from its original operating environment (SAS) to Windows and ArcObjects programming for ArcGIS (Nowak, 2006).

This project was part of this larger program to migrate the UFORE model and its associated sampling program to Windows and to further automate and enhance it. More specifically we are developing a series of ArcObjects programs to locate points, make plot overlays, and output text files with the appropriate attribute data about the plots to automate input to the UFORE model in Windows. The GIS program discussed in this paper allows the user to map several point patterns in polygons that define a single specific area of interest or polygons that define strata within an area of interest. The program will allow land class information to be passed from raster coded data sets to the points and then output text files in the UFORE Plot List File Format (Crane, 2004) and UFORE Strata Area File Format (Crane, 2004).

The program allows the creation of sample point patterns that are random within the area of interest, distributed randomly proportional to area within strata in the area of interest, in a grid pattern with a one-cell randomly located starting point at the lower left, or randomly located within cells of a grid that divides the area of interest into a number of cells closely approximating the requested number of plots. The completely random and stratified random points exactly match the requested number, while the two grid patterns approximate the requested number as closely as possible. The patterns can be applied to polygons alone or to defined areas of interest in national land class data in a raster format.

METHODS

The sample point patterns program is being developed using Visual Basic for Applications (VBA) and Visual Basic 6 (VB6) in ArcGIS 8.3 with the intention of upgrading it for ArcGIS 9.x when it is complete. We used sample polygons to define the areas of interest and land class data in raster format from the National Land Cover Data Classification Scheme (Level II) for 1992 in the initial development and testing. Since the 2001 National Land Cover Data is not complete, it has not been tested at this time.

Each pattern was programmed in VBA for ArcGIS 8.3 to produce the desired point number and scheme in any selected polygon that defined an area of interest. The VBA version was stand-alone for producing a single sampling pattern during early testing in ArcMap. The VBA code was then migrated to VB6 and integrated into an overall interface design. The whole program was then compiled into a .dll file that allows the interface to be launched from a single graphic user interface (GUI) button on an ArcMap toolbar. When the program is launched it clears the document view and controls the order in which layers are added to maintain the views spatial reference. Spatial reference is then passed to new data sets created by the program from the view or from a layer.

The land cover data are used by the program in two different ways depending on the patterns chosen. The random points in a polygon, random points in raster cells, and the points in a grid pattern are intersected with the raster land cover data and the land cover code is passed to the attribute table for each point. Then the land cover code is interpreted in a 'case' set and the interpretation put in a text field. The 'stratified by land class' pattern is programmed to work much the same as its predecessor in ArcView. It automatically clips the land class raster dataset using the area of interest (AOI) polygon and then distributes the requested number of points among the land classes in clipped raster dataset. The classes in the land class raster are considered the strata and the points are distributed among them proportional to the number of cells in each. The 'stratified by land class' program presents the user with a summary of the intended point distribution and offers an opportunity to edit the number of points assigned to each class. This feature allows the user to remove points in open water or other urban areas that do not have any trees.

DISCUSSION

Choice of stratification method

When the program starts the active view is cleared, so that when the first layer is added it will set the view properties with respect to spatial reference. The start up form (Figure 1) is loaded with credits and presenting the user with four choices. The first is to use a land class raster to pass land class codes to the points in the pattern chosen. The second is to proceed without a land class raster and develop the sample point patterns using polygon features to define the AOI. There is a 'Procedure Help' button that outlines the procedure for using the program and also an 'Exit' button to leave the program.

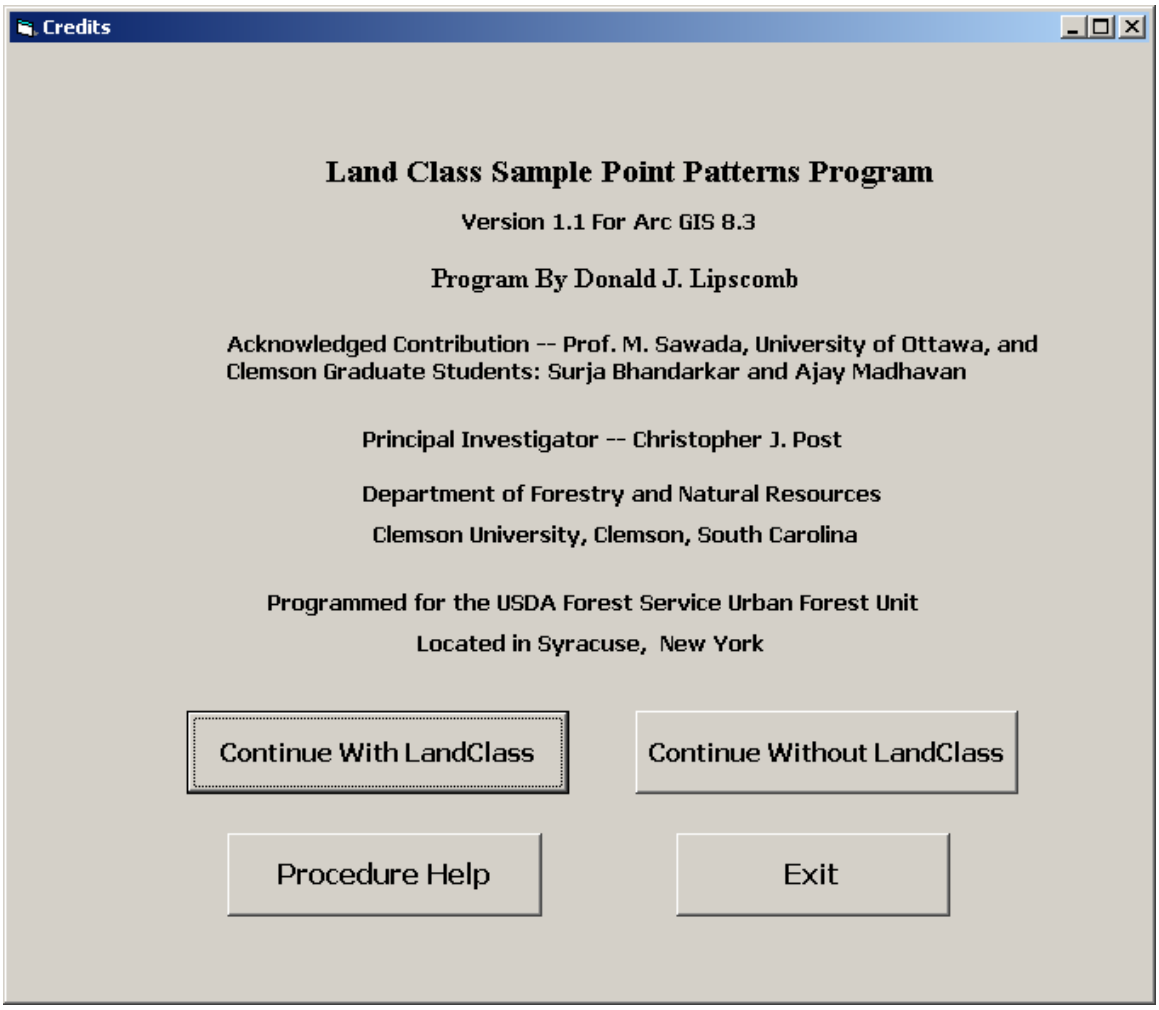

Figure 1. Start menu with credits and four options.

Raster land class option

If the user chooses to proceed with the land class, the next form (Figure 2) allows the user to browse and select the land class raster layer to be loaded. This layer sets the spatial properties of the viewer to those of the land class layer, and is used to transfer land use codes to the final points and text files. For this reason, the land class raster dataset should be in a projected coordinate system that has the map units to be used in the UFORE program. However, this is not required to run this sample point program. Next, the browse for the AOI layer button is activated and the user can select and load that layer. When the area of interest (AOI) layer is loaded ArcMap automatically overlays it in the same projection as the land use raster. The AOI does not have to be in the same projection as the land use raster dataset as long as it has a valid projection (.prj) file in the workspace with it. Next, the user chooses a workspace (folder) where results will be stored. If none is specified, results will be placed in the workspace with the AOI layer. Then the user may enter the number of points to be used for sampling the AOI. The view automatically zooms to the AOI but does not automatically select a polygon, even if there is only one. This allows the option to add a feature layer containing several polygons and

then pick one of them as the AOI. Since the program does not automatically select a polygon for the AOI, the user has to use the 'Select AOI Polygon' button and do that manually. At this point the 'Continue' button becomes active so the user can proceed to the next menu.

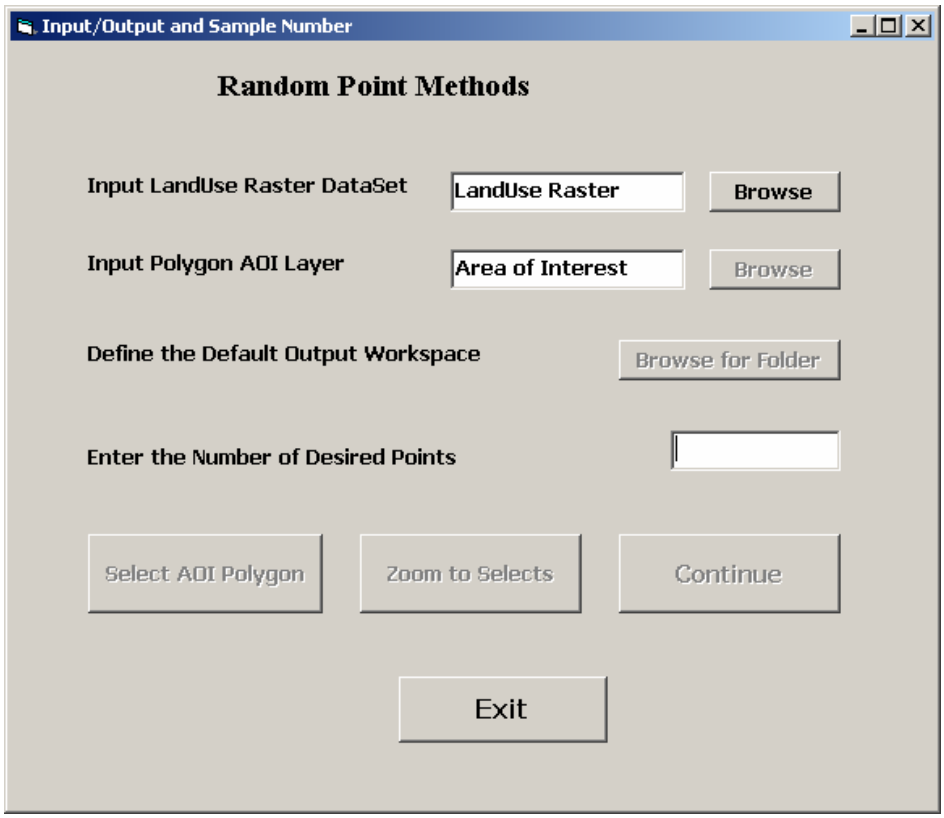

Figure 2. Form for input, output, and number of desired sample points.

Once the user has selected and loaded the land class raster data set, the AOI layer, selected a default output workspace, entered the desired number of sample points and select the AOI polygon, he is presented with a choice of four sample point patterns (Figure3). They are 'Random', 'Grid Pattern', 'Random Inside Grid Cells', and 'Stratified By LandClass'. The 'Random' button simply puts the number of points requested in the AOI polygon in a random pattern which is different each time it is requested. The 'Grid Pattern' constructs a grid of points inside the AOI polygon based on the number requested and using a random starting point in the lower left cell area of the grid which was calculated to fit the polygon. The 'Random Inside Grid Cells' button calculates a best fit grid for the AOI starting at the lower left corner of the polygon's envelope and then randomly locates each point in a cell inside the AOI. All of these patterns create a new shapefile and add it to the view. None of them have the land class information when created. The land class information is added by using the 'Get Pt LandClass' button and then picking the point layer and land class data set to be used. This action intersects the point layer with the raster data set and puts the land class code and interpretation in the point attribute table.

Figure 3. Form to allow the selection of sampling patterns.

The 'Stratified By LandClass' button works differently because it uses the land class values and their frequency from the raster data set's value attribute table to decide how many points to assign to each land class strata. Then a table with land class codes and number of points assigned appears giving the user an opportunity to change the number of points assigned to any of the land classes (Figure 4). When the user is satisfied with the number of points assigned to each land class, the 'Create Point Feature Layer' button on this form will create a new shape file with the points randomly located in the land class code area as specified and add the land class code to the attributes automatically. The coordinate position of each point in also added to the table in all cases because it is essential to the file reports to be used in the UFORE program. This is a specialized application of the random points that was requested by the urban forest unit, but may have application elsewhere.

Polygon option without land classes

If the user chooses the 'Continue Without LandClass' button in the startup form, the program prompts only for the AOI layer and spatial parameters of the view are set to agree with it. After loading the AOI, this branch of the program works the same way as the first, except there is no land class information to be added to the attribute tables. Each button performs its function based on the selected AOI boundary with no land class raster in the background.

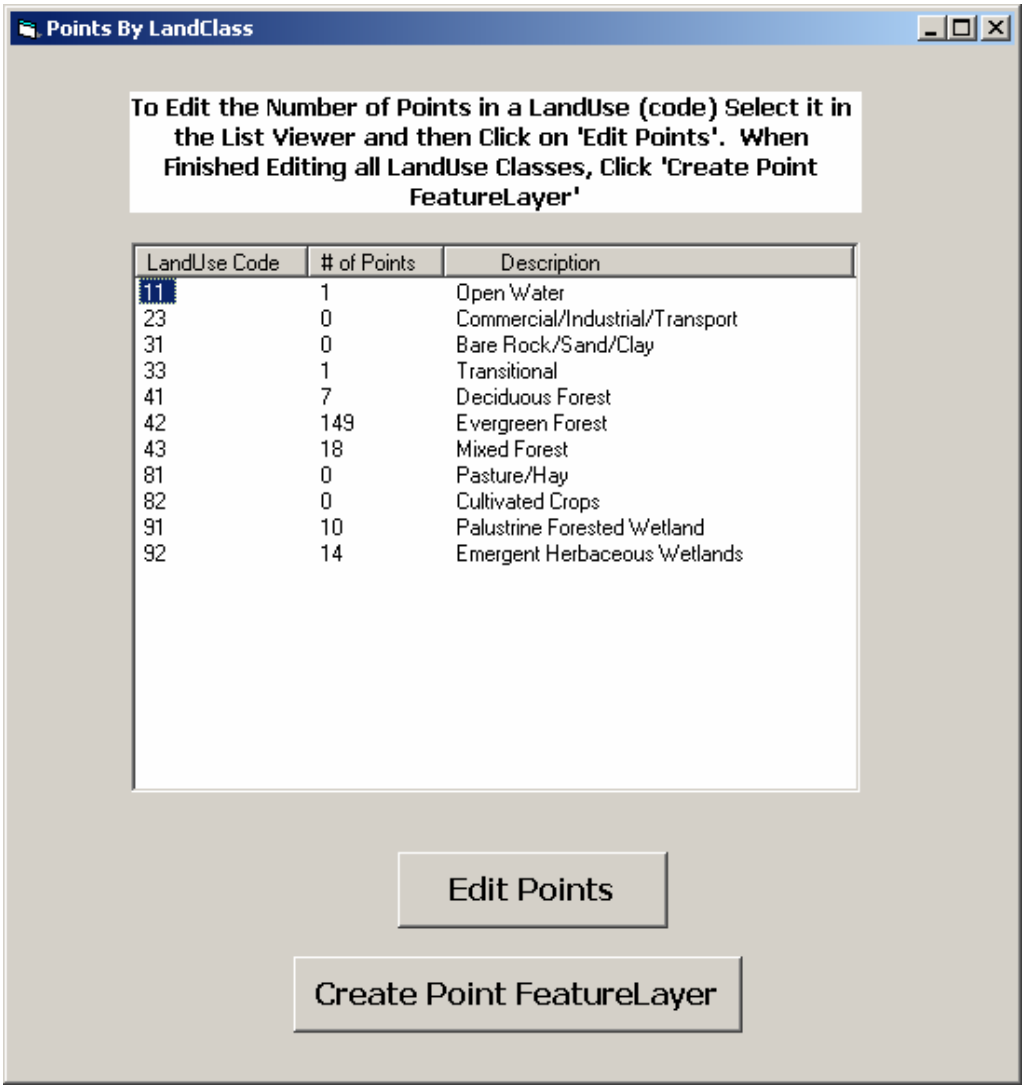

Figure 4. Form to list points assigned to each land class and allow the user to edit that number before actually creating the point feature layer.

However, in this option has the 'Stratified Random' button in place of the "Stratify by Landclass" button. In the vector mode it works differently from the one to stratify by land class. This module is designed to allow the user to select polygons that represent different strata like soils, watersheds, or vegetative types and then distribute the requested number of point in a random pattern between them proportional to the area in each. The user can select the polygons in the 'Input/Output and Sample Number' form (Figure 2) by using the 'Select AOI Polygon' button or the user can select by attribute after the 'Random Select' button has been activated (Figure 5). The selected polygons are then exported to a new shapefile with some added fields to assist in the point distribution process. The user then identifies the strata field and the points are created. The points are put in a new shapefile and that layer is added to the view.

In the vector mode portion of the program there is a button called 'Make Plots' which allows the user to make a plot overlay for any previously created point shape file. When

Figure 5. Form to create stratified random points in multiple polygons.

the 'Make Plots' button is activated the user is present with a new form (Figure 6) where first, the point layer (in the view) is to be identified in a pull-down list. Then the user must choose round or square plots. After choosing the plot shape, the user must select a plot size from a list of choices. At this time the plot size choices are fifth, tenth, twentieth, or hundredth-acre plots. The UFORE program uses some different sizes which will be added later.

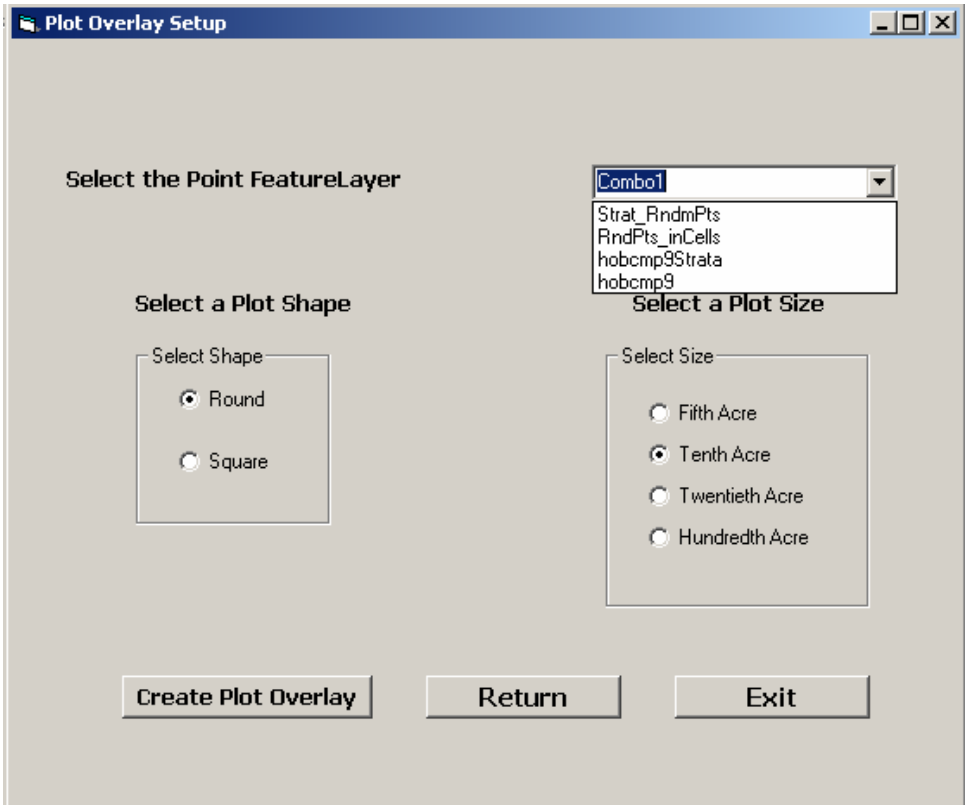

Figure 6. Form to create plot overlay for any point pattern.

CONCLUSIONS

The "Create Sample Points for a Study Area" program is written in Visual Basic 6 for use in ArcGIS 8.x to create sample point patterns with specified numbers of points. It allow a choice between point patterns with data passed from a land class raster to the point attribute tables or point patterns developed for polygons that define a study area. The program allows sample points to be developed in four different patterns that are normally used in forestry. Once the points are generated and saved in shapefiles, a plot overlay can be generated to map the areas to be sampled in location, shape, and size. Also several files with data formats that are compatible with the UFORE program can be generated.

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