GIS for Designer:

Introduction to Sketching Environments in ArcGIS

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Abstract: ArcGIS is evolving from an application for cartographers to one that designers and planners can use. This paper will demonstrate various methods to use ArcGIS in design. Both 2D and 3D GIS will be briefly demonstrated and discussed.

Introduction

Over the years GIS has changed what the discipline of cartography is, more people are making maps and using them than ever before (Boulton, 2010). With the advent of applications such as Google Maps and Bing Maps, more and more data are being collected and eventually gets 'mapped out'. As GIS evolves as an application, more disciplines will have the opportunity to take advantage of its ability to make and manage maps.

For landscape designer and urban planner this opens a tremendous opportunity. Considering that a map is the start of most projects. The chance to work on a project dynamically on a GIS from beginning to end will provide the designer the ability to create, edit, and store the project directly in a database file or multiple databases.

It should be noted how the process of design is usually done sans GIS, this process will be referred to as the traditional method in this paper. The first step in the design process is to acquire information on the site; this is accomplished by acquiring as many maps of the site as possible or visiting the site itself depending on availability. Once all of the maps and data are acquired for the site, the process of transferring the data into the same scale on transparent paper is performed. This allows for the designer to examine the correlations between the maps, and then proper design can be made on the site. Although this process has been introduced by McHarg in his publication Design with Nature and used extensively throughout the industry, it is a very labor extensive one; a major down fall of the traditional method.

By using a GIS the design process can be streamlined; maps can be stored in a data base, along with a newly created maps showing changes, this data can be presented in various ways, either in 2D or 3D depending on the need of the user and the GIS application that is being used. This paper will explore the various options available for designers using ESRI's ArcGIS suite and the addition of various extensions associated with ArcGIS.

A two part design process shall be used in this examination of GIS for design. The first part will deal with the 2D aspect of the design, while the second part will consist of bringing the first part into a 3D environment. When these two parts are combined, the end product should match that of the traditional method, providing various plans and perspective rendering.

Part One

As mentioned early, the traditional design processes consist of collecting as many maps as possible for a location before the actual design process occurs. This procedure will still be done, but now in a GIS. Maps of location can be acquired digitally or scanned in and then transferred into a GIS by the process of digitizing. Once the data is stored in the GIS, the actual design process can proceed. This paper is not intended to judge different GIS approaches against each other, but more to convince designers that GIS is a viable option for use in the design process. The three approaches to GIS design consist of using Editor, ArcSketch, and Scenario 360's Sketch Tool. Given that all three of these approaches operate inside of ArcGIS, a following approach might build on the knowledge of the previous approach. These approaches will be showcase by stepping through the process of sketching in each approach, and then unique feature that is deemed useful will be highlighted. GIS data from Laketown Township, Minnesota will be used for the demonstration.

Editor

Editor has been the tool to use for creating and editing shape files in ArcGIS. An obstacle with using Editor to sketch is that it is necessary to use ArcCatalog to create new shape files. Along with this, the user needs to know how many point, line, or polygon shape files are needed for the sketch. The procedure of editing itself is fairly simple in Editor. To begin, the user starts an editing session. A specific task is then selected. The last step is to choose the shape file that the task will be performed on. Both of the above actions can be examine in *fig. 1.1 and 1.2.* For instance, if more trees were to be added to the tree layer the task *Create New Feature* will be selected and then the target will be cluster_trees because this is the point file that the tree data is stored in. Once new trees are added, the save edit/stop edit (with stop edit, ArcGIS will ask the user if they would like to save before stopping) task will update and add the newly trees.

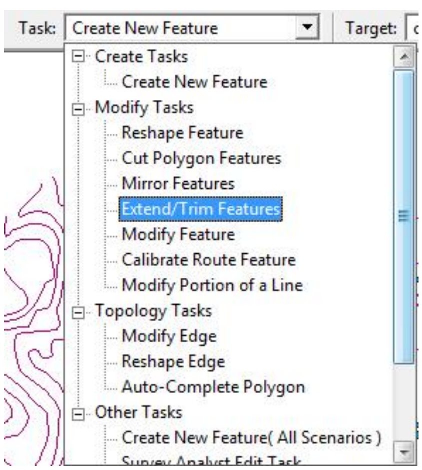


Fig. 1.1. Task

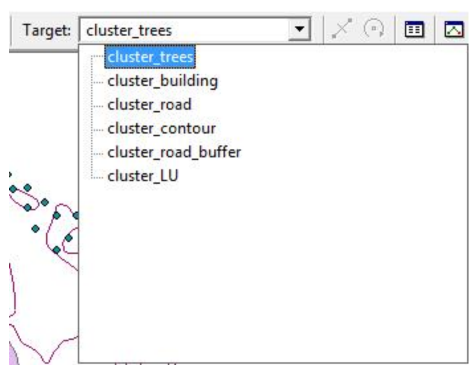


Fig. 1.2. Shape file

Visually, Editor can only create points, lines, and polygons initially. Once the feature is drawn, it can be visually alter with the symbol selector properties. In *fig. 1.3*, the cluster_tree's layer property window is shown. Since there are three types of trees (back yard, extra, and street), the best choice to distinguish between the three types of trees would be under *categories* and *unique values*. This breaks the three types of trees down into different color dots by default. The symbol selector can be used to change the appearance of the feature. Although there is an abundance amount of default symbols provided by ESRI, the user has the ability to change the symbol by going into the property of the feature.

Additional layers can also be added; outline and interior color, and size can be changed to create unique symbols.

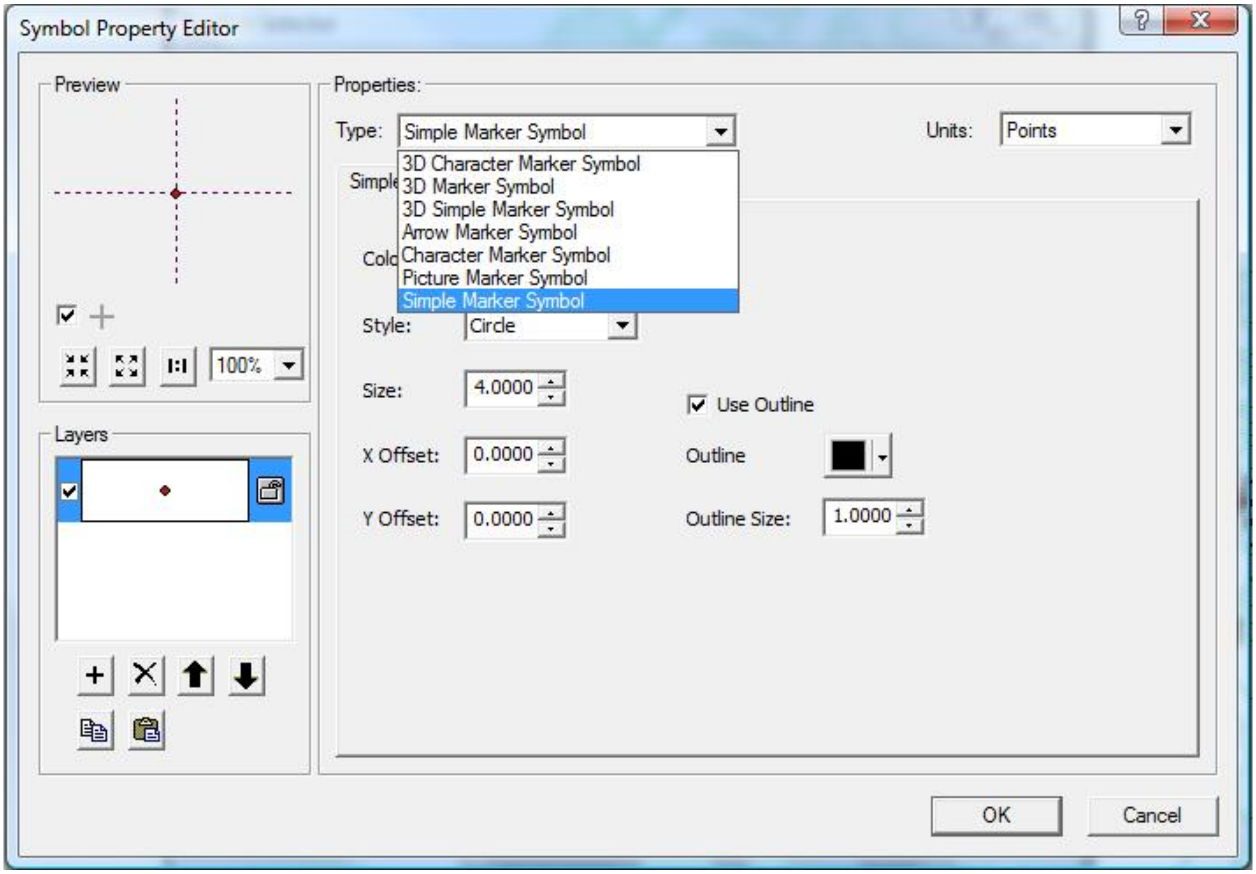


Fig. 1.3. Editing window for the modification of a symbol appearance.

Attribute values can be added or changed in the attribute windows but for mass editing the attribute table should be used. It is also here that new attributes can be added to a feature. In *fig. 1.4* the selected trees can be viewed in the attribute window. The cluster_trees has four attribute fields associated with it: ObjectID, Shape, Id, and type. To add additional attribute field the user selects options and chooses the *add field* selection. It should be noted that fields cannot be added while an edit session is in progress. *Fig. 1.5* shows the add field window; a name, type, and additional properties is then required by the user. By default the short integer data type is chosen, this means that only a numeric value can be stored in this field and depending on the database management system it can only be a certain length.

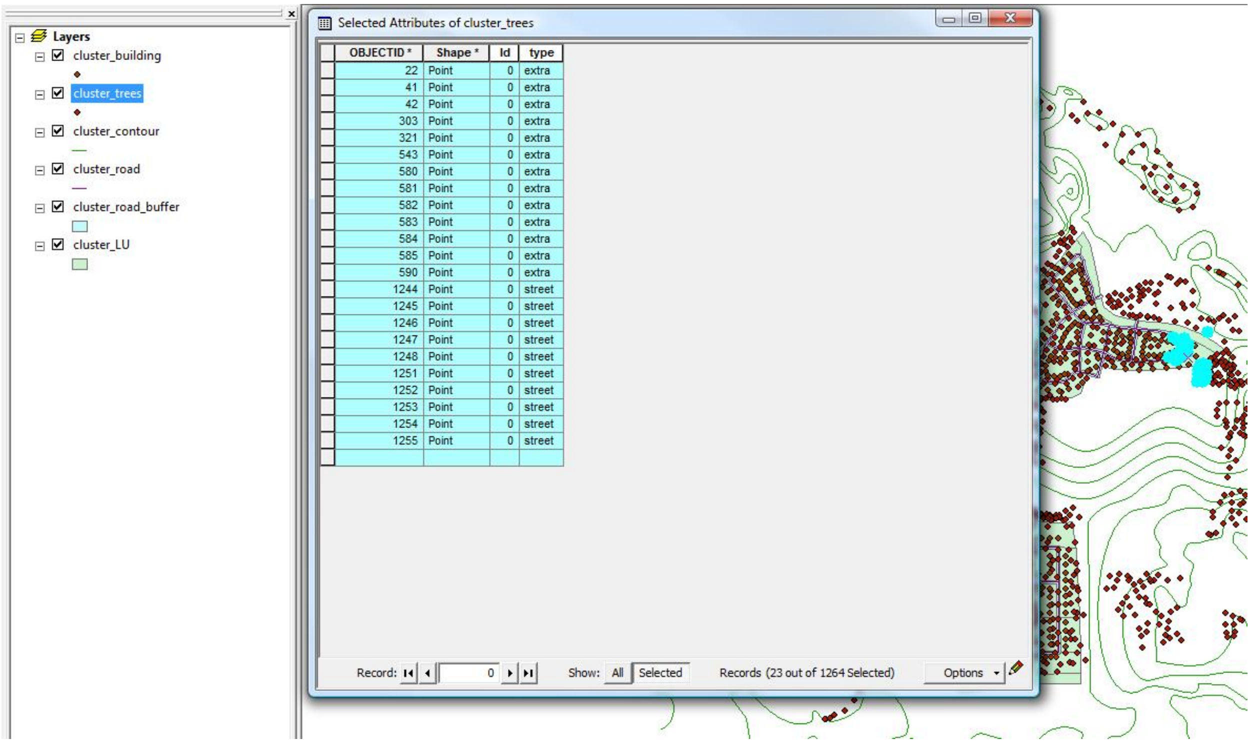


Fig. 1.4. Attribute window showing the selected feature in the map.

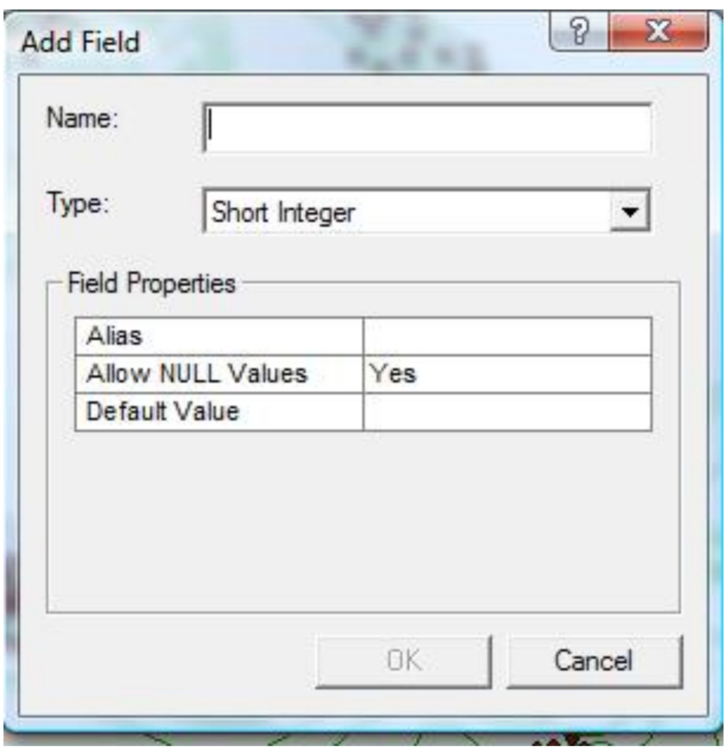


Fig. 1.5. Field creation window for attribute table.

There are two features that should be noted in Editor, which are the two read out windows provided while editing. The first readout is the attribute window in *fig. 1.6*. This window provides the user with information about the selected feature, within the attribute window there are two sections. The section on the left shows the feature that is selected, for this instance there is one a contour line selected. The section on the right shows the attributes associated with the feature. If an attribute is null or needed to be changed, the ability to alter the feature can also be done here.

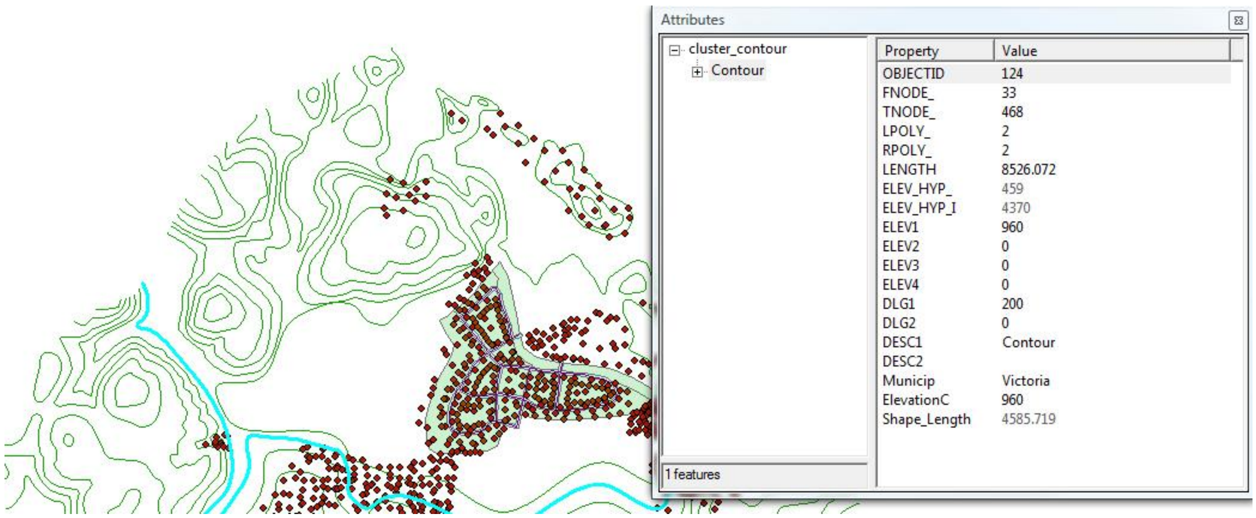


Fig. 1.6. Attributes window showing selected attribute on the map.

The second window is the Edit Sketch Properties. This window provides precision when creating a multi point feature (line or polygon). An X and Y coordinate are given to each point, for accurate precision a number value can be inputted into the box, as seen in the last row of column Y in *fig. 1.7.*

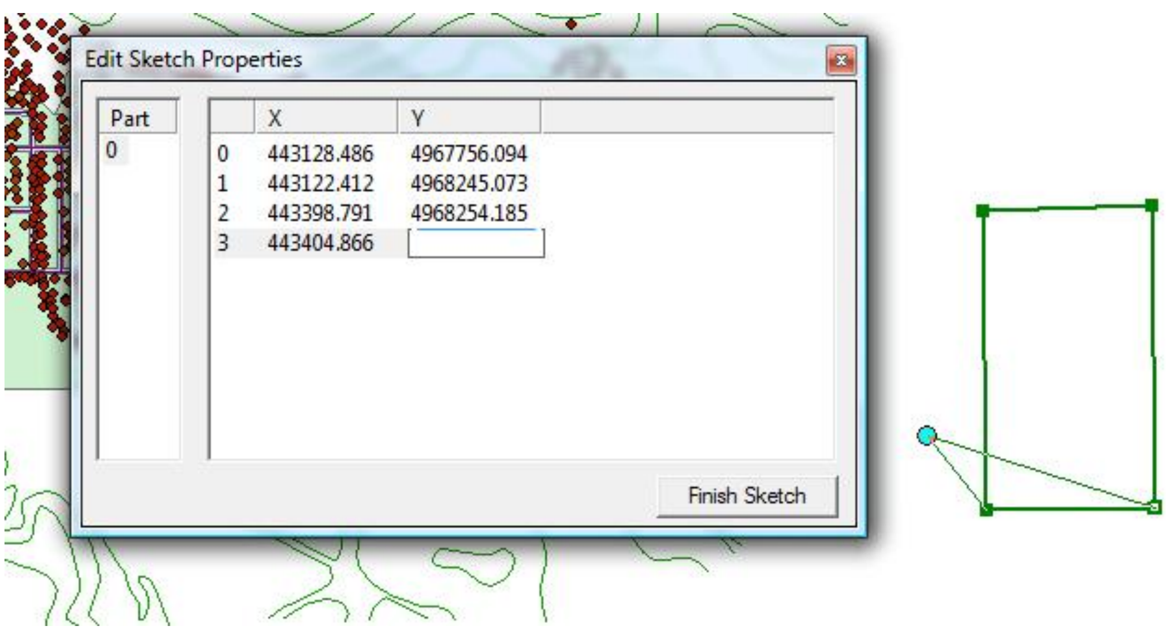


Fig. 1.7. Finishing a polygon by manually inputting the last Y condiment.

The last piece of Editor will be about its large array of tools. There are simple too many additional tools to discuss each individually; *fig. 1.8* is simply to show the vast amount of additional tools that are provided with Editor. For designer, the advanced Editing tools should be of major concern. These additional tools should allow for more control over feature, also there is the convenient square and circle drawing tool.

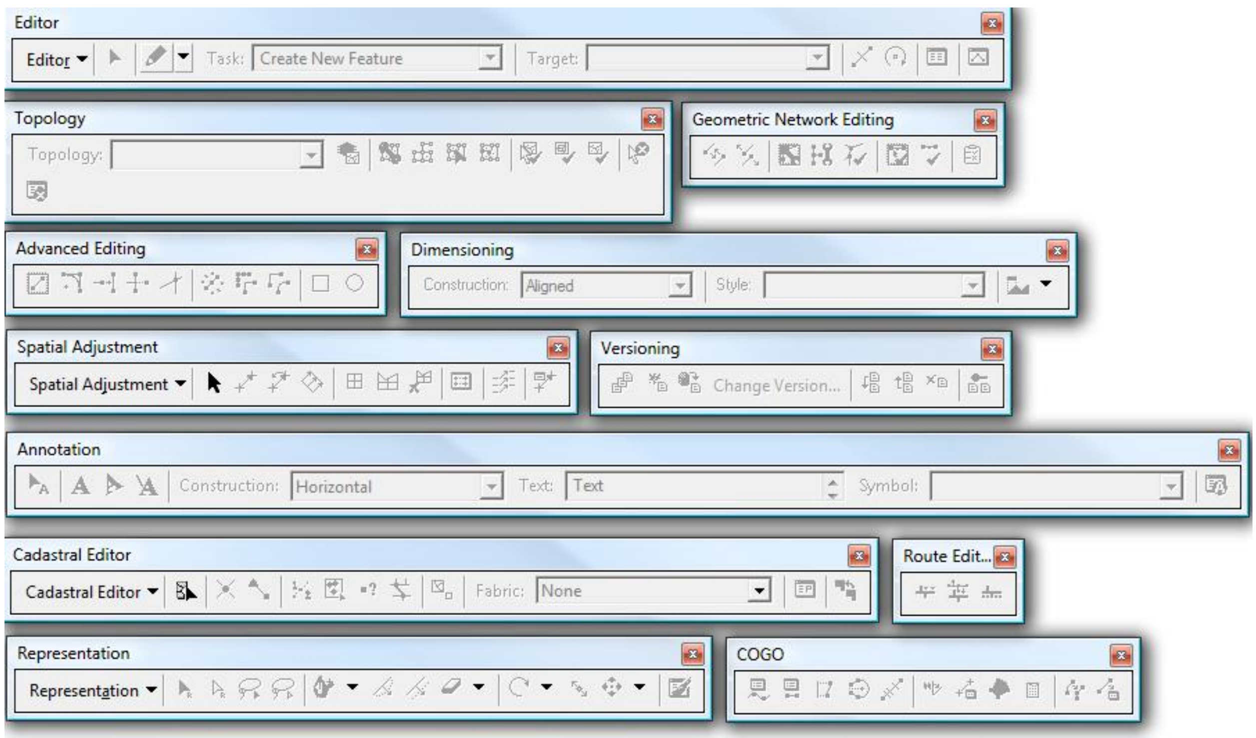


Fig. 1.8 Additional tools found in Editor

ArcSketch

ArcSketch is an ArcGIS extension released by ESRI that is aimed to be simpler for designers. In Arc Sketch, the user has the option to create a geo database in ArcCatalog or have ArcSketch automatically create one for them in a selected directory. Unlike Editor, there is no need to foresee and create the type of shape file (point, line, or polygon) required for the sketches, Arc Sketch will generate one of each(point, line, and polygon shape file) inside a coverage file once the geo database is selected or created for use in ArcSketch. ArcSketch does require a 'base layer' before a sketching session can begin. This base layer can either be a raster or vector layer.

The introduction of the symbol palette (fig. 2.1) changes the way feature are created in ArcMap. The symbol palette allows a user to select a symbol that has been created already and sketch with it. No longer is there a need to choose an action, and then select a layer. The symbol itself will simply know what layer it belongs to. Another feature that is promoted by ArcSketch is the ability to create and store symbol set for later use. A symbol set consists of custom symbol obtained or created by the user that can be shared with various users. The default symbol set is 'ESRI', the terms marker, line, and areas are used instead of the familiar point, line, and polygon. Users are allowed to create new symbol set through the *tool* drop down menu and then selecting the new symbol set feature. The default location for the style is my document/ArcSketch/Style directory, the file extension is .style. Once a symbol set is created new symbols can be created in it.

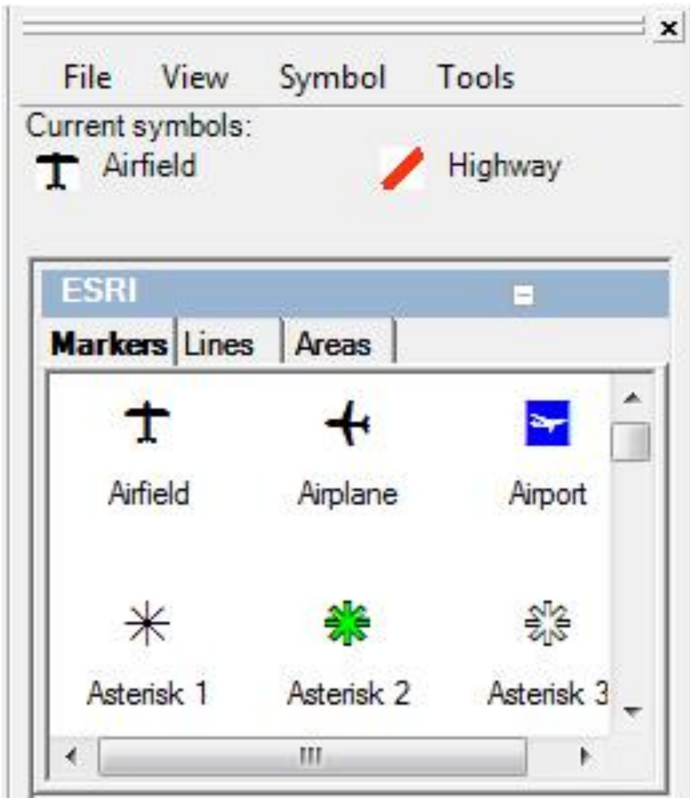


Fig. 2.1. Symbol palette included in ArcSketch.

A symbol has two major types of properties associated with it, definition and appearance. The definition is the name and data associated with the symbol, while the appearance is how the symbol appears to be when drawn. Part of the definition of a symbol is the multi tier system employed by Arc Sketch to contain the symbols when drawn. By default, the highest tier is the geo database, the middle tier is a coverage titled *composite sketch*, the bottom tier consist of the marker, line, and areas. Additional coverage can be added to the geo database file for the management of the symbols. In *fig. 2.2*, a simple a,b,c, and d naming scheme was produced to show the relationship to the coverage file and how the symbol will be stored and viewed in ArcCatalog. It is also here that a user can add additional attribute to a feature. By default there will be a few attribute associated with any feature, these attribute help ArcMap distinguish between different features on the map.

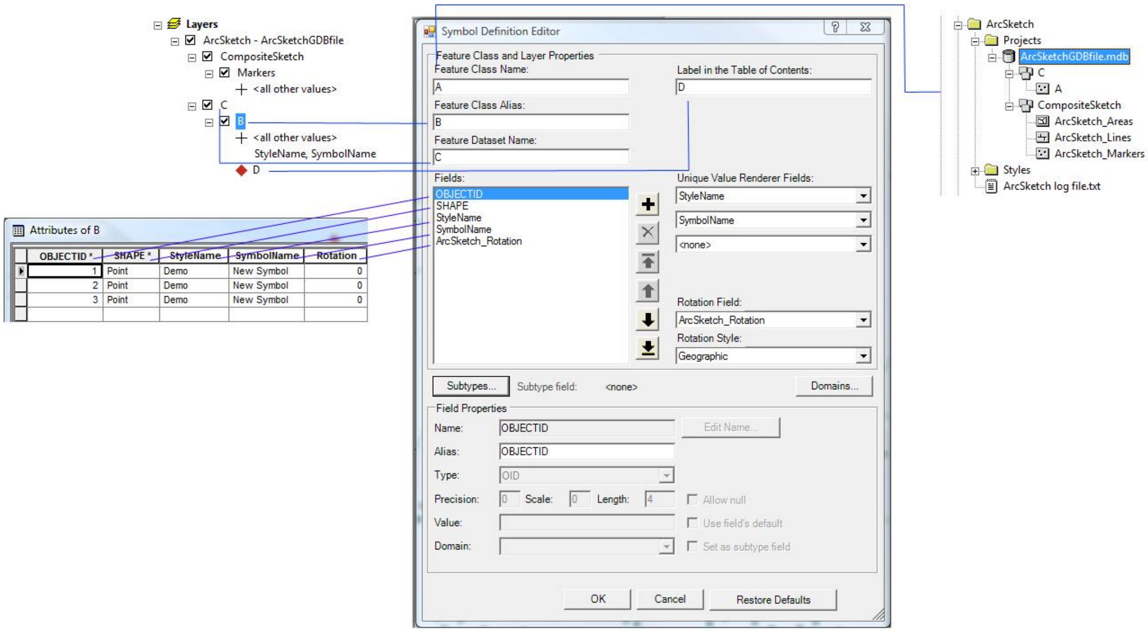


Fig. 2.2. Relationship between definition and feature in ArcSketch.

Although it is possible to edit the definition of a stock feature such as airfield in the ESRI library, it is not possible to edit the appearance of it. Only custom feature's appearance can be edited. Editing a feature in ArcSketch is identical to editing a feature in Editor. For this example a tree symbol is created in the symbol property editor. This is simply two layers, the first layer is a solid black circle while the second layer is a bigger circle that has no color and a black outline. The right of the *fig. 2.3* shows what the symbol looks like in ArcMap, on the left side it shows the symbol in the table of content and symbol palette.

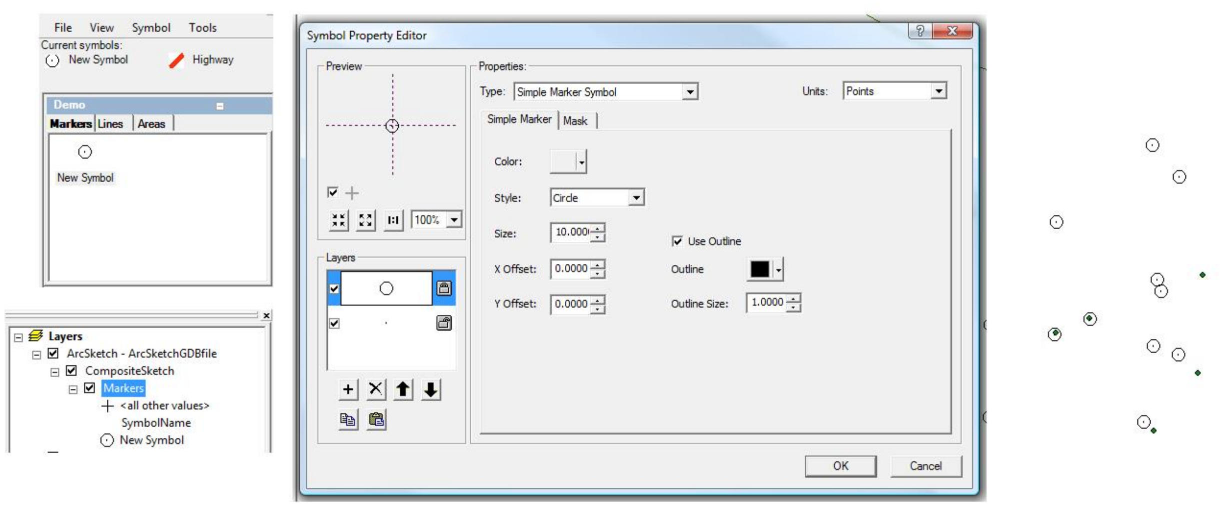


Fig. 2.3. A tree symbol created in the symbol editor and used in the map.

ArcSketch offers some similar drawing tools found in Editor but there are also new tools introduced in ArcSketch. The two new line tools are *curved polyline tool* and *stream polygon tool*. The curved polyline tool allows the user to bend a straight line in any direction that is desired. The *stream polygon tool* operates like a drawing utensil; the user pushes down on the mouse and draws continuous lines. The benefit found in the curved polyline tool is that the curves were extremely smooth, while the stream polygon tool allows for greater control of the curve or bend. On the polygon side, two similar tool were introduced; the *curved polygon tool* and *stream polygon tool*. *Fig. 2.4* shows the four new tools in action. In the curved poly line tool a balanced curved was attempted, it was found difficult to get the bend to be equally divided. The stream polygon tool allows for a better balance curve, but it was found to be difficult to draw a smooth curve. These principles can be applied to their polygon counterpart.

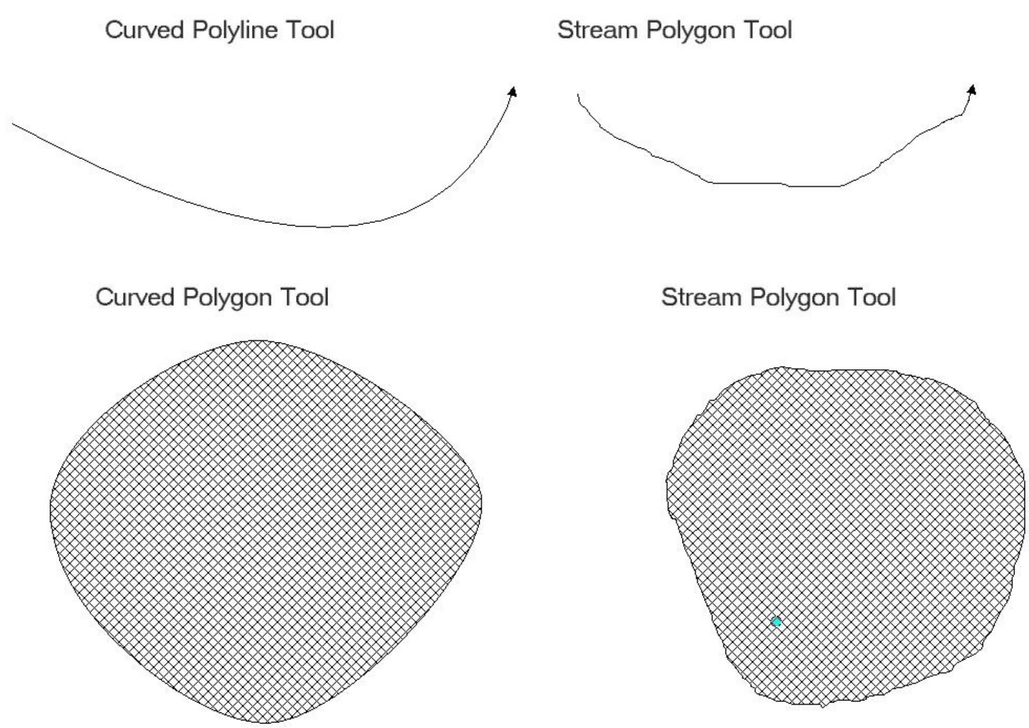


Fig. 2.4. New tools introduced in ArcSketch.

Scenario 360 Sketch Tools

Scenario 360 is part of the Community Viz, an ArcMap extension that is produced by Placeways. Although Scenario 360 is used for many analytical purposes, only the Sketch Tools will be closely examined. Similar to ArcSketch, a sketching session can be started within ArcMap. Scenario 360 provides a wizard that creates a geo database for the user. Once the geo database is created, shape files can be created or added to the geo database for sketching as seen in *fig. 3.1.*

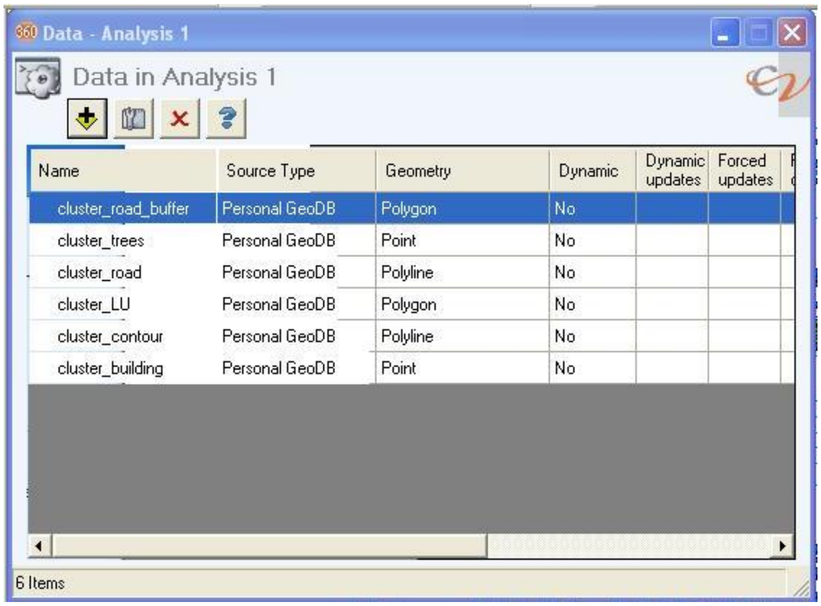


Fig. 3.1. Adding data into a Scenario 360 session.

Because Sketch Tools uses a special format associated with Scenario 360, an imported shape file needs to be made "dynamic" before editing can occur through the sketch tools. A new shape file can be made dynamic from the beginning. Once a shape file is dynamic, the box in the check box in the table of content will glow orange, as demonstrated in *fig. 3.2.*

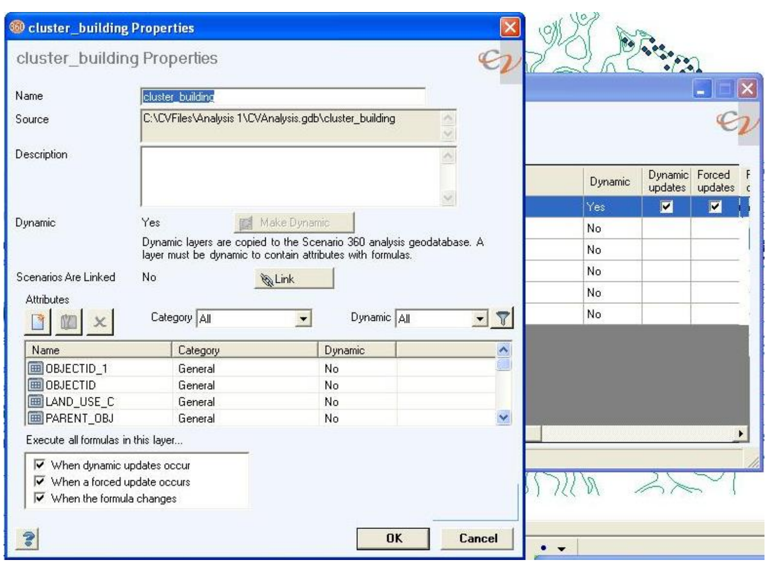


Fig. 3.2. Converting a .shp into a Scenario 360 dynamic .shp file.

Similar to ArcSketch Sketch Tools allows for styles to be created and shared. These files are Scenario 360 Style files or .s3s. Inside of the style manager, new style can be created. In *fig. 3.3*, three styles are created for the cluster_building shape file. Each style starts out with null value for the attributes; the user is required to input each value in individually for each style. In the case of cluster building, all that is of concern is the Land_Use_C, which holds the type of building it is.

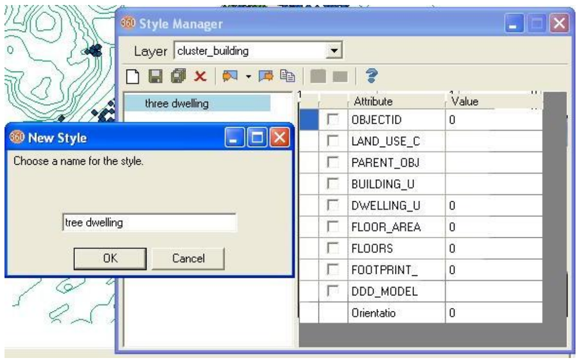


Fig. 3.3. Creating a new style in the Style Manager with Scenario 360.

The act of sketching in Sketch Tools operates in two phases. The first phase uses the Editor, which creates the feature. In fig. 3.4 newly created building points are shown with null values in them, except for the attribute land_use_c, which has been filled in. This leads to the second phase of the Sketch Tools, once features are created in Editor the paint brush tool can be used to 'paint' over it. This is simple done by choosing the paint brush tool, choosing the style which should be used (three, six, or ten dwelling units) and clicking on the feature that was created.

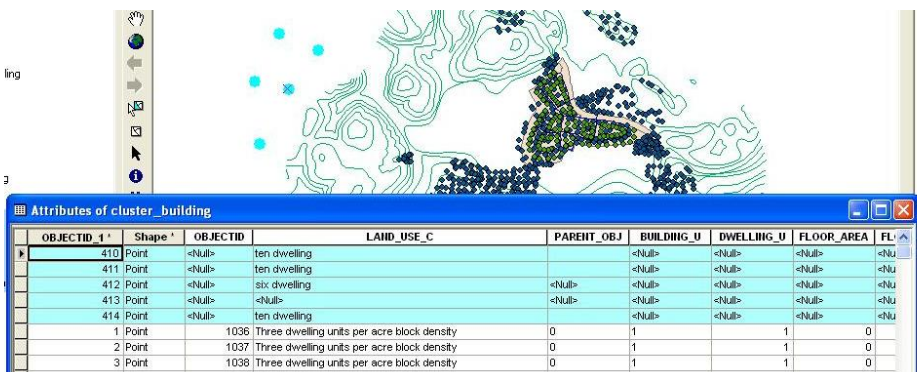


Fig. 3.4. Attribute table showing the new building created in the sketch tool.

On the visual side, a layer needs to be symbolizes before different icon can be given to each style. In most cases unique value under categories in the symbology tab should suffice, this depends on the type of feature that is being created. Once categorized, the "add layers symbols for selected styles" in the style manager should become available. On the table of content, the symbols can be edited with the traditional symbol selector property. Similar to Editor, Sketch 360 provides the Sketch Monitor to show the selected features and their attributes, *fig. 3.5* shows five points that was created, the highlighted three dwelling feature has its attribute in the bottom right panel. Unlike Editor, attributes cannot be added or change in the monitor itself.

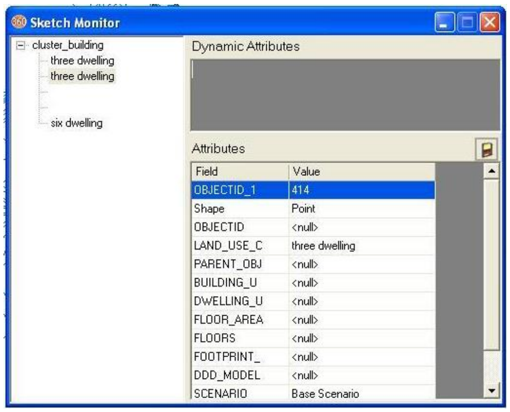


Fig. 3.5. Attribute window for Scenario 360's SketchTool.

Part II

Maps and plans might be able to show a location well, but lack the ability to show how a space might actually look like (Haberling, et. al.). The use of 3D models has been a great tool for designers to show off how an environment might appear to be. Part II will examine two applications that can transform 2D GIS data into 3D, although there are more applications for 3D transformations these two have been chosen. The first application that will be looked at is ArcScene, which is part of ESRI's ArcGIS family. This allows for great compatibility between ArcMap and ArcScene. The second application is Scenario 3D, the 3D renderer that is packaged with Scenario 360. These two applications will be reviewed similar to Part I. Before the discussion of these applications begins, a short discussion of what 3D in the context of these applications will be presented.

In essence there are 2D, 2.5D, and 3D when dealing with data in GIS. The two types of data that are familiar to the majority of people are 2D and 3D, the concept of 2.5D is an important one to understand when transitioning from 2D to 3D. In *fig. 4.1* below a box is displayed in 2D, 2.5D, and 3D. The dots in the images represent vertices in the diagram. The 2D example only allows two dimensions to be displayed at a time, thus it is only possible to display one plane of an object, in this example only the top is visible from the box. 2.5D takes the appearance of 3D, but it is not "true" 3D. Extruded data is one of the most common uses of 2.5D data. When a square is extruded in certain GIS applications it might take on a cube appearance, visually this is '3D' but the data itself may not be. The extruded object, in this case the cube only has one Z value. This Z value determines the height source for the original four vertices in the 2D data. In the 3D diagram there are vertices for every points in the box, each vertices' Z value is independent of each other. The majority of the data that is used in ArcScene and Scenario 3D will be regarded as 2.5D. That is, the majority of 3D objects will only have one Z value associated with it.

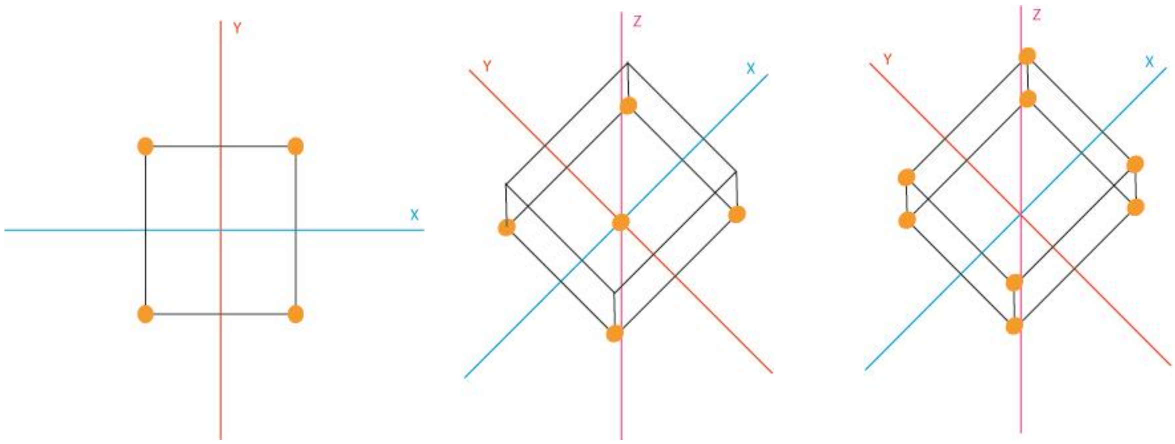


Fig. 4.1 2D 2.5D 3D

ArcScene

Layers in a 3D GIS should be regarded similarly as in a 2D GIS. Depending on how many layers a designer wants to incorporate into a scene. A benefit of ArcScene is that it has a very similar feel to ArcMap, thus if one knows ArcMap they should be able to start in ArcScene easily. *Fig. 5.1* shows Laketown Township with simple points, line, and polygon. The starkest difference between ArcMap and ArcScene for a new user might be that layers are now shown at an angle.

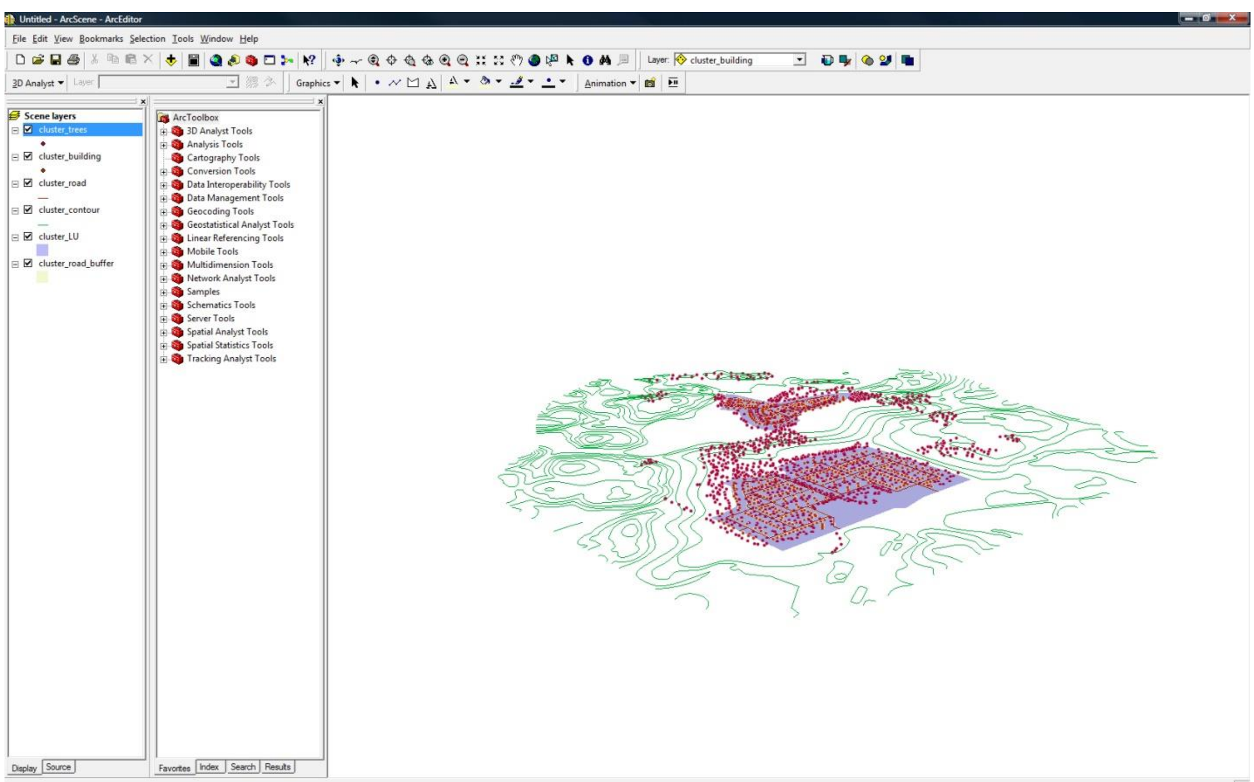


Fig. 5.1. ArcScene showing shape files in a 3D environment.

The 3D Analyst Extension found in ArcGIS allows for terrain to be created from contours or DEM (digital elevation model). In the case of Laketown Township a contour was obtained, which also has a height attribute associated to it. The create/modify tin tool under the 3D analyst extension is used to create a TIN (triangulated irregular network) of the area. If a DEM were used instead of contour, a separate process would not be necessary. ArcScene can obtain a 3D surface directly from it.

The TIN will provide base height for the trees, building, road, and land use. *Fig. 5.2* shows the TIN floating on top of the other layers that currently does not have a height value. *Fig. 5.3* shows a zoom in view of the space, here an aerial photograph has been draped over the TIN. The cluster_building layer has been categorized into three types of units three, six, and ten dwelling. The use of 3D models has been employed to show how the area would look like once buildings are built. ArcScene supports OpenFlight 15.8 (.flt), SketchUp 5.0 (.skp), 3ds max (.3ds), and VRML 2.0 models (.wrl); (ESRI, 2010). The placement of trees or other objects in the landscape is done with the same process.

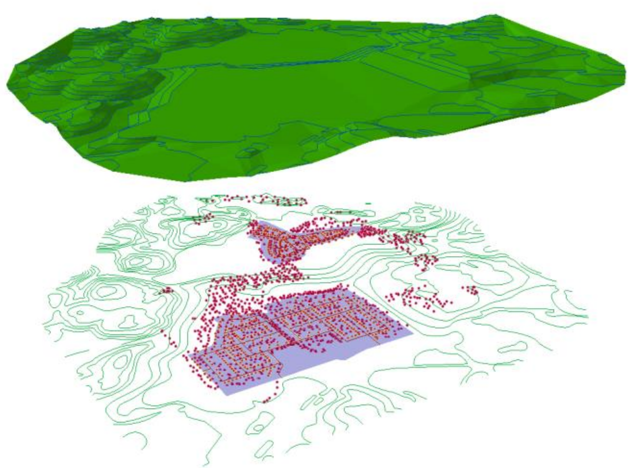


Fig. 5.2. TIN with height value floating on top of 2D GIS data.

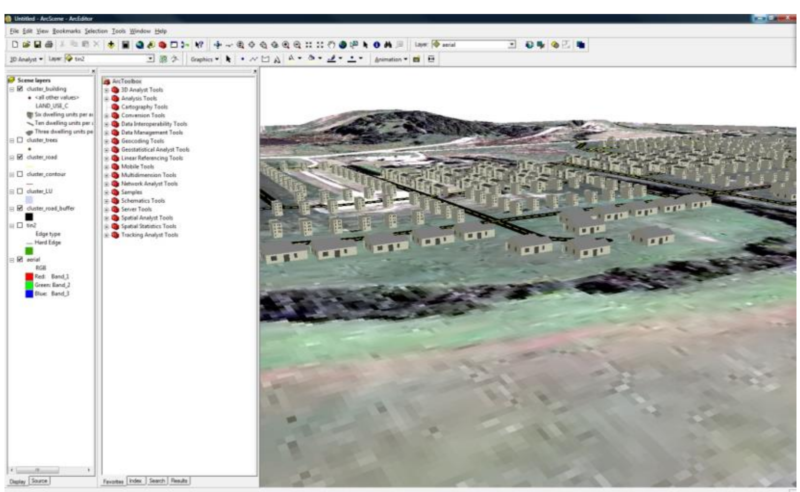
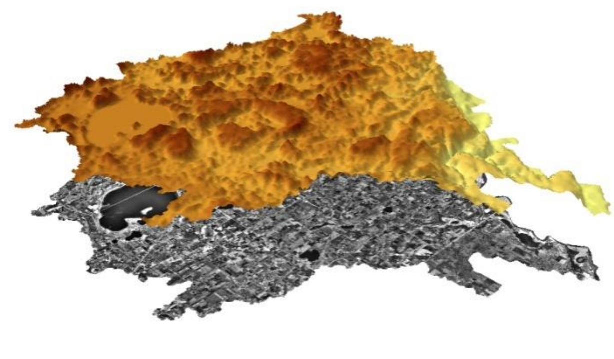


Fig. 5.3. ArcScene with housing marker replaced by 3D building.

In ArcMap layers are laid on top of each other, if the top layer is opaque, the layer will completely cover the bottom layer. In ArcScene layers 'compete' for space. That is, if a layer borrows or shares the height value of another layer, the layers will be laid in each other as seen in *fig. 5.4* below (a color ramp of Yellow to Dark Red has been applied to the DEM for visibility purposes).   This allows for only sections from each layer to be rendered. A solution around this problem is setting an offset for one of the layers, a positive offset should be applied if you want the layer to be more visible, and a negative offset should be applied if you want less of the layer to be visible. An offset of one has been used in *fig. 5.4-C*. There is also drawing priority in ArcScene, a scale of 1-10 (1 being the highest and 10 being the lowest), *fig. 5.4-D* demonstrate a value of two being set to the DEM. A combination of both offsets and drawing priority might be required for desired results.



A

B

C

D

Fig. 5.4: Rendering option for space.

Scenario 3D

Part of the Scenario 360 package is Scenario 3D, the in house 3D viewing application produced by Placeways. Like many features in Scenario 360, there is an excellent wizard that guides a user to transform 2D GIS into 3D. *Fig. 6.1* shows the 3D Scene setting window. There are three tabs associated with the setting windows. The first tab is the general tab where the user chooses a directory for their .scene file. It is also here that a back ground image can be chosen for the 3D environment.

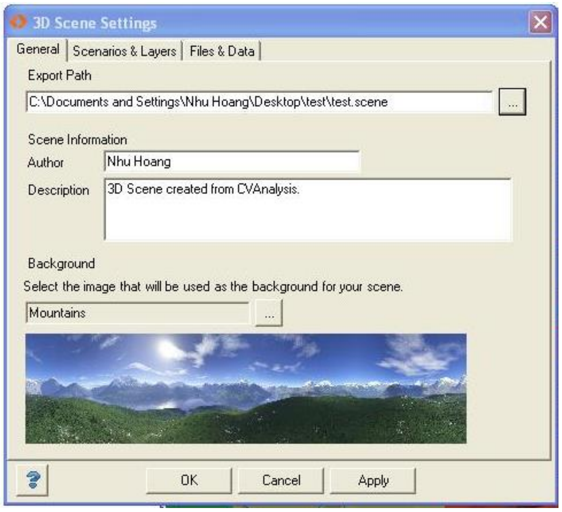


Fig. 6.1. General setting tab for Scenario 3D.

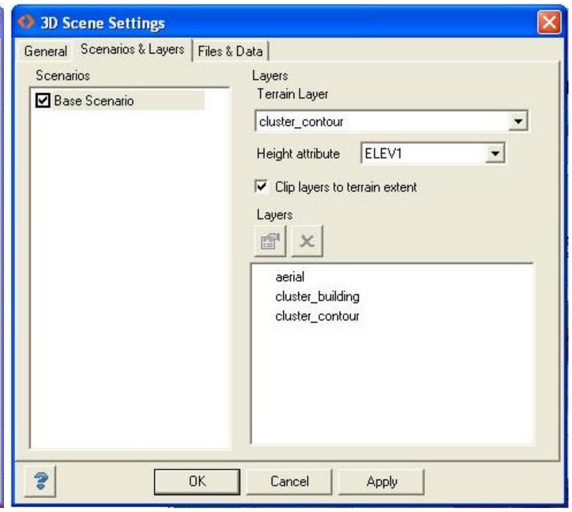


Fig. 6.2. Adding or delete layers for Scenario 3D.

The second tab is the Scenario and layers. In this instance only three layers have been imported into the scene. Layer one is the contour layer, this provides the Z value for the scene. *Fig. 6.2* shows that the height is derived from "Elev1" from the cluster_contour layer. Layer two is an aerial photograph that is draped over the contour to give the scene more accurate representation of the area. *Fig. 6.3* shows what the property of a raster image looks like in the 3D layer setting. Layer three is a point file titled cluster_building, this layer contains the location of where a building should be and the type it is. As with a raster file, a vector file can be modified for the scene. In this case a house should be used, Scenario 3D provides some building that can be used for this example, but users can also import their own into the scene. The supported formats are .skp (sketch up) and .DAE (COLLADA), (Placeways, 2010).

The third tab, the file & data tab allows for more setting such as copying the data and models directly into the .scene file or simply just linking it to the directory. Once the settings have been set, the user exports the scene. The scene can be automatically launched into the 3D viewer or saved and opened manually by the user. *Fig. 6.4* shows how the three layers looks like in the 3D viewer. It is also in the viewer where user can record movies and adjust atmospheric settings.

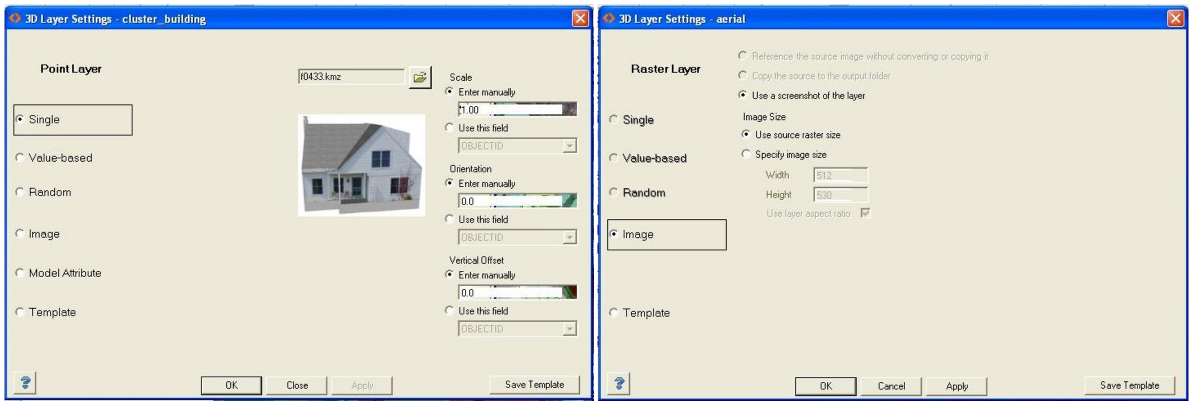


Fig. 6.3. Specific layer property, depending on vector or raster layer; the settings will be different.

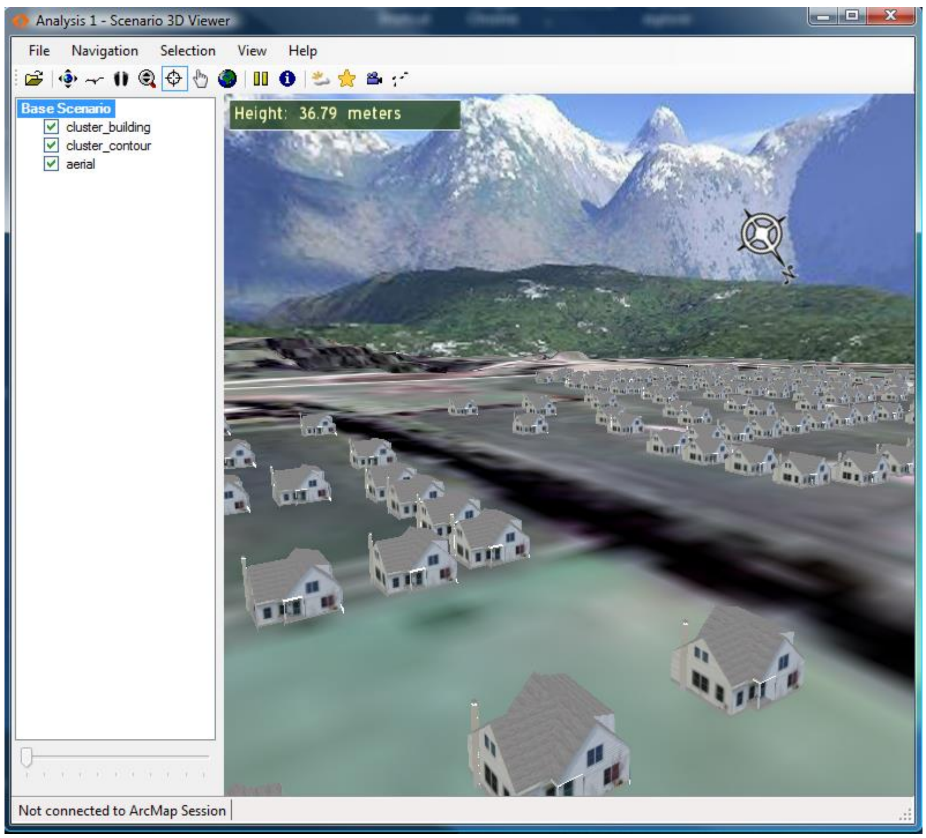


Fig. 6.4. Scenario 3D window showing location of building with 3D models.

Conclusion

Above has shown how GIS could be used by designers. Although no method has been scrutinized thoroughly, each one has been display to show how it functions for designer. Since all of the methods in phase one operates inside of ArcGIS, a lot of similarities were found between them. For instance the symbol selector is still used in each method to modify the appearance of the symbol. The attribute table still plays a major part in modifying the definition of the symbol. The major benefit found in the later two methods (ArcSketch and Scenario 3D) is ease of use. The process of sketching without the hassle of creating shape files in ArcCatalog allows for greater limitation in the design, no longer will a designer be confined to how many shape files were created beforehand. The ability for the user to store custom 'palettes' for use later on or sharing with other users will boost productivity.

This paper has mainly discussed design in ArcGIS with little conversation about the processing power of a GIS. The ability of a GIS to process geographic data is what separates ArcGIS from a graphic editing program. If all that was needed from a designer was the ability to sketch an image then an application such as Adobe Photoshop would suffice. The idea that geographic data could be stored, managed, and used for design in one system should appeal to any designer working on a large scale system. It is understood that GeoDesign is still in the early stage of development at this point, but with progress from the GIS community and utilization from designers, this could be significant.

As to which application was found best to use for design using GIS, this question relies heavily on what is required from the site. As mentioned earlier, GIS offers great analytic tools. In addition, more tools are found in Scenario 360 for planning. The wizards for Scenario 360 might give an experience designer the opportunity to take advantage of GIS better. Since Scenario 360 is a separate extension to ArcGIS, so there is the cost of purchasing the software. As for ArcSketch, it is currently a free extension from ESRI as of ArcGIS 9.3. Considering that ArcSketch and Scenario 360 sketch tool are very similar, if a designer is well trained in ArcGIS and does not need the added tools found in Scenario 360, then Arc Sketch should be the application to use. In regard of the Editor, there are some function found in it that is not found in either ArcSketch or Scenario 3D. Because of this reason, a designer should not disregard the editor in a sketching session.

Appendeix:

Software Version

ArcGIS 9.3.1

-Editor

-ArcSketch 2.0

ArcScene 9.3.1

Scenario 360 4.1

Scenario 3D 1.1.0.0

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