ModelBuilder for ArcView Spatial Analyst 2

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Introduction

Geographic information system (GIS) technology has not only made it easy to process, analyze, and combine spatial data, but it has also made it easy to organize and integrate spatial processes into larger systems that model the real world. However, the more complex a spatial model becomes, the more difficult it is to keep track of the various data sets, processing procedures, parameters, and assumptions that you have used.

ModelBuilder™ software in the ArcView® Spatial Analyst extension is a new technology from ESRI that helps you create and manage spatial models that are automated and self-documenting. A spatial model in ModelBuilder is easy to build, run, save, modify, and share with others.

In this white paper, you will learn what a spatial model is and how ModelBuilder for ArcView Spatial Analyst simplifies the tasks of creating, maintaining, and sharing spatial models.

What Is ModelBuilder?

ModelBuilder is a tool in the ArcView Spatial Analyst extension that helps you create spatial models for geographic areas. A model is a set of spatial processes that converts input data into an output map using a specific function such as buffer or overlay. Large models can be built by connecting several processes together.

In ModelBuilder, a spatial model is represented as a diagram that looks like a flowchart. It has nodes that represent each component of a spatial process. Rectangles represent the input data, ovals represent functions that process the input data, and rounded rectangles represent the output data that is created when the model is run. The nodes are connected by arrows that show the sequence of processing in the model.

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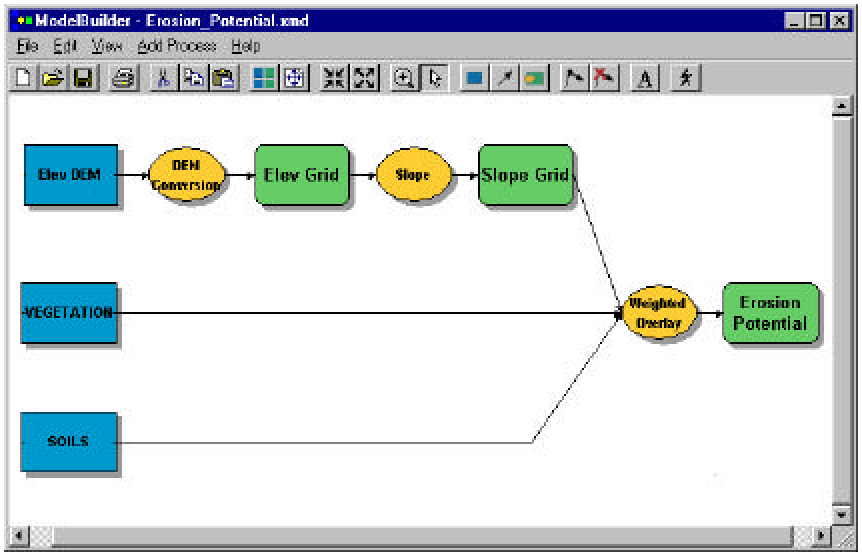

A spatial model is represented as a flowchart diagram in ModelBuilder.

The model is much more than a static diagram; it stores all the information necessary to run the processes and create the output data in ArcView GIS. You can also create documentation that is saved as part of the model. This enables you to reuse the model and share it with others. You can apply the same model to different geographic areas by changing the input data. You can easily modify the model to explore "what if" scenarios and obtain different solutions.

ModelBuilder has the tools you need to create, modify, and run a model. ModelBuilder uses ArcView GIS to process the input and create the output data.

Some features of ModelBuilder include

- A model window where you build and save your models.
- Wizards that automate the creation of new spatial processes or the editing of existing processes.
- Property sheets that let you quickly modify the properties of input data, processes, or output data.
- Drag-and-drop tools that let you build and connect processes manually.
- Layout tools that help you arrange your model neatly.
- The entire model (excluding the input data) is saved as a single XML file to enable you to easily share your model with others.

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What Is a Spatial Model?

In general terms, a model is a representation of reality. The purpose of a model is to help you understand, describe, or predict how things work in the real world. By representing only those factors that are important to your study, a model creates a simplified, manageable view of the real world.

Spatial models can do the following:

- Rate geographic areas according to a set of criteria.

  Perhaps the most common type of spatial model evaluates site suitability. To choose the most suitable land for a park, you must decide how many factors you will consider and which are most important. You might decide that land cost is the most important factor, or proximity to residential neighborhoods, or aesthetic considerations such as the view.

- Make predictions about what occurs or will occur in geographic areas.

  To predict areas where soil erosion may be a problem, you need to know where loose soils occur in combination with steep slopes, the absence of vegetation, and high rainfall. Overlaying, or superimposing, layers (such as themes) of geographic data that occupy the same space to study the relationships between them lets you isolate areas of high erosion potential.

- Solve problems, find patterns, and enlarge your understanding of systems.

  To determine whether water contamination might be the cause of disease in a plant species, a model identifies a pattern of diseased plants occurring in proximity to water contamination.

How Is a Spatial Model Represented in ModelBuilder?

In ModelBuilder, a spatial model is composed of one or more processes. A process includes input data, a spatial function that operates on the input data, and output data. Processes can be connected so that the output of one process becomes the input to another process.

The model does not actually contain spatial data; it has placeholders, called nodes, which represent the data that is processed and created when the model is run. The actual data is managed and displayed in ArcView GIS. ModelBuilder gives processing instructions to ArcView GIS when you run the model.

The diagram below illustrates a model that has three processes. The rectangular nodes represent project (input) data. The oval nodes represent spatial functions that will process the data. The rounded rectangular nodes represent derived data (output data) created by the function. Connector lines connect the nodes and show the flow of processing through the model. Notice that the data derived from one process can become the input to another process.

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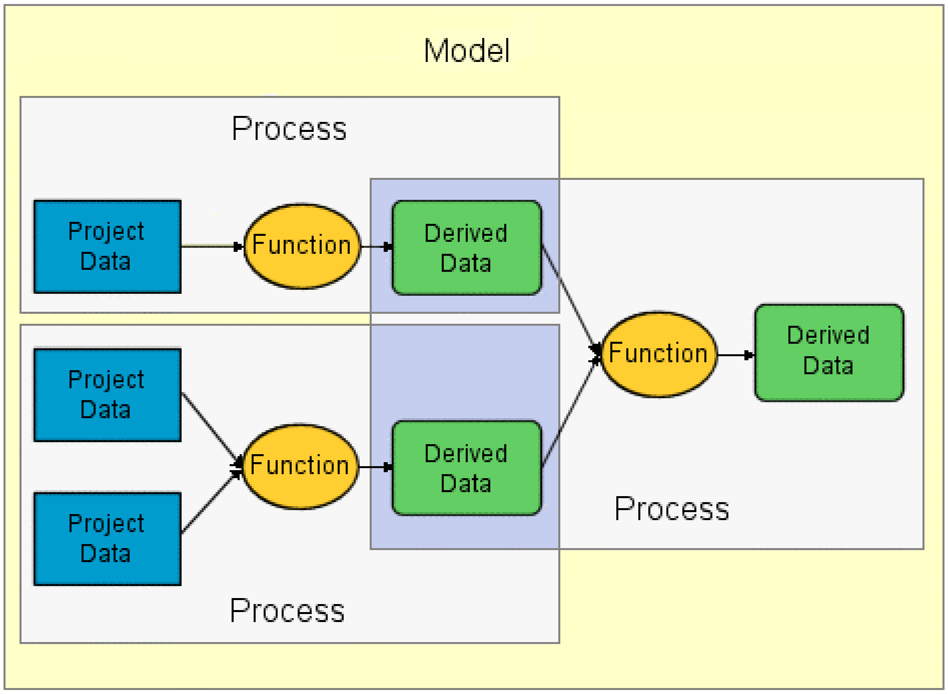
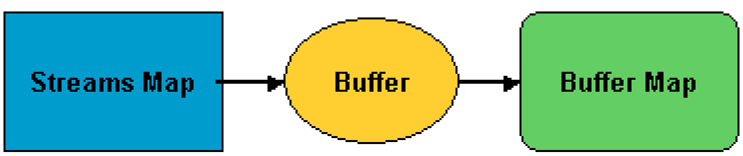


The model has three processes. The output data from two of the processes becomes the input data to the third process.

A spatial model can be simple or complex. The simplest possible model contains only a single process. In ModelBuilder, the buffer model is represented as a process that shows the flow of input data (the Streams Map) into the Buffer function (oval) and from the Buffer function to the output data (the Buffer Map).



Models become more complex as processes are added. For example, the model shown below has two parallel processes that share the same input data. The model generates two output themes, Aspect Map and Slope Map, from one input theme, Elevation Grid.

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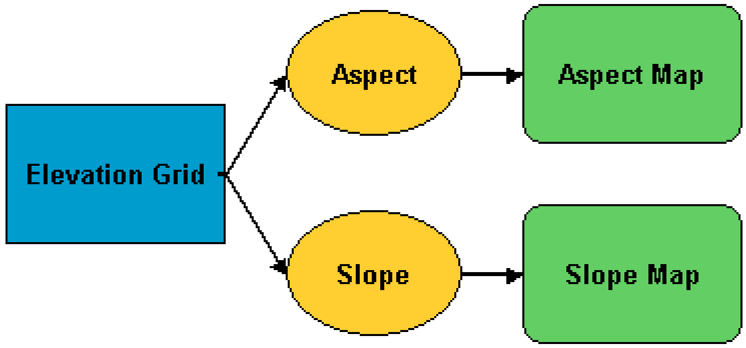
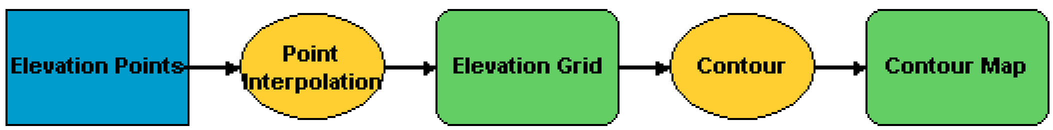
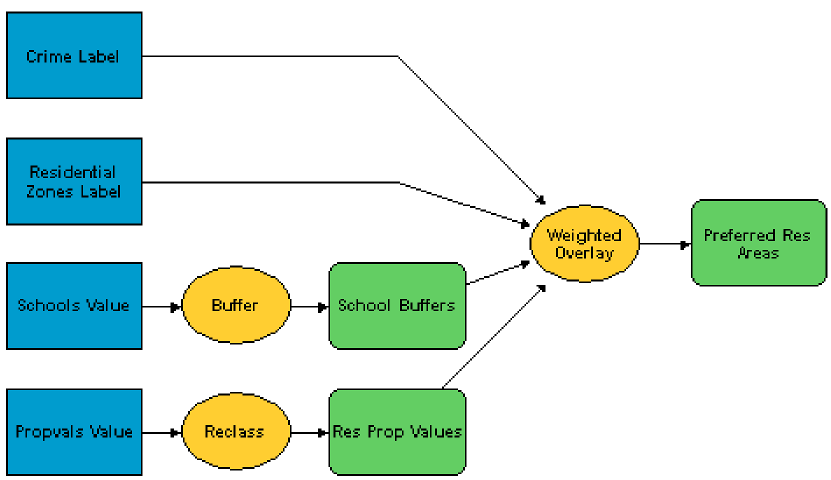


You can chain processes so that the output of one process becomes the input to subsequent processes. For example, one process might interpolate a continuous elevation surface from an input theme of measured elevation points. The derived data (Elevation Grid) could then become the input data to a second process that derived elevation contours.



You can use both parallel and chained processes to create more comprehensive models such as the housing suitability model below. First, buffer zones are created around schools (the Buffer process) to find residential areas close to schools. Next, property values are reclassified into affordable and unaffordable ranges (the Reclassification process). Finally, the school buffer and property value themes are combined with crime and zoning themes (the Weighted Overlay process) to create the housing suitability map.



Each derived data node represents a theme that is created in ArcView GIS and stored as a data set (usually in grid format) on disk. The model stores the graphical representation of the processes as well as information about the input data, the functions, the output data, and the relationships among processes. ModelBuilder also allows you to incorporate comments, assumptions, citations, and Web links directly into the model. Models can be reused, modified, and shared with others.

What ModelBuilder Does

ModelBuilder helps you build, manage, and automate spatial models. Without ModelBuilder, the management of models and of the data supporting them can be difficult. A sophisticated model contains a number of interrelated processes. At any time, you may add new processes, delete existing processes, or change the relationships among processes. In addition, you may replace old data sets with newer ones, change assumptions or model parameters, and consider alternative scenarios in which input factors are prioritized differently. ModelBuilder helps you manage the complexity of a model in the following ways:

- It makes processes and the relationships among processes explicit. ModelBuilder diagrams processes and the relationships among processes in a flowchart that is dynamically updated whenever a change is made.
- It lets you set the properties of the input data, the functions, and the output data, and it records this information in the model. This makes the model output reproducible.
- It stores documentation inside the model. You can document sources of input data and assumptions you made in the model.
- It stores and manages the model files and the output data on disk.
- It lets you edit the structure of the model by adding and deleting process or by changing the relationships among the processes.
- It lets you edit the properties of processes to experiment with alternative outcomes.

Using ModelBuilder you can create, visualize, document, run, modify, and share models.

Create a Model

You create a model by adding processes to the model window. Each process has a wizard—a sequence of dialog boxes that prompts you for the information needed to define the process and then adds the process to the model window. Alternatively, you can also add processes manually by using the diagramming tools on the ModelBuilder interface to create and connect nodes.

Visualize a Model

Organize model components and processes with ModelBuilder. Data, processes, and their connections are symbolized in the model window, allowing you to visualize the flow of processing in a model and see which factors are included in an analysis and which outputs are created from which inputs.

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Document a Model

ModelBuilder provides text boxes in which you can document the methods and assumptions you used in creating the model. The documentation informs your colleagues of how you built your model, what assumptions you used, and what results you obtained.

Run a Model

ModelBuilder runs the processes that make up a model. It creates the output data sets, saves them to disk, and loads them as themes in ArcView GIS.

Modify a Model

Every node in a process has property sheets that contain all the information about that node (names of data sets, parameters of spatial functions, and so on). By editing property sheets, you can modify the processes in your model and explore alternative outcomes. For example, you may decide to change a buffer zone from 500 meters to 1,000 meters. ModelBuilder preserves the integrity of the model and updates all the processes affected by the change automatically.

Share a Model

You can share models by sharing the model files created by ModelBuilder. Sharing a model lets you open your methodology to wider scrutiny and helps you refine and standardize modeling techniques. Models can be imported into other models, allowing you to incorporate model components that have been developed by experts in various disciplines.

Functions

A function in ModelBuilder is an operation that produces derived data from input data. The input data, function, and derived data together constitute a complete process. Processes are defined by the type of function they perform, that is, converting vector data to raster format, deriving slope from elevation, and so on.

Functions are organized by category and are accessible from a menu. The Data Conversion category includes Vector to Grid, DEM to Grid, and Point Interpolation functions; the Terrain category includes Contour, Slope, Aspect, and Hillshade functions; and the Overlay category includes Arithmetic Overlay and Weighted Overlay functions. The two remaining functions are Reclassification and Buffer.

Category	**Function**	**Description**
Conversion	Vector to Grid	Converts a point, line, or polygon theme to an integer grid
	DEM to Grid	Converts a digital elevation model file to a floating point grid
	Point to Grid	Converts a point theme to a floating point grid
Terrain	Contour	Converts a floating point elevation grid to a contour line grid
	Slope	Converts a floating point elevation grid to a slope grid
	Aspect	Converts a floating point elevation grid to an aspect grid

Category	Function	Description
	Hillshade	Converts a floating point elevation grid to a hillshade grid
Overlay	Arithmetic Overlay	Takes values assigned to two or more input themes and combines them arithmetically (+, -, *, /) to produce an output grid
	Weighted Overlay	Reclassifies the cell values on two or more input themes to a common scale, then multiplies the reclassified values by influence factors and adds the weighted values to produce an output grid
Classify	Reclassification	Groups the values in a grid theme into new classes and assigns them new values
Distance	Buffer	Reclassifies all cells within a specified distance from a feature into a single buffer zone

Overlay Function

The Overlay process provides ArcView Spatial Analyst users with a simple method of studying the relationship between superimposing layers (such as themes) of geographic data that occupy the same space. Two Overlay functions exist in ModelBuilder: Arithmetic Overlay and Weighted Overlay.

The Arithmetic Overlay process is used to add, subtract, multiply, or divide multiple factors on a geographic area. Each factor you wish to include in this overlay must be a grid theme. The result is a continuous grid theme. For example, you might use Arithmetic Overlay to add various costs together such as land costs, construction costs, and utility costs. You might also use it to subtract one area from another. You might subtract an area already inside a national park from a proposed conservation area.

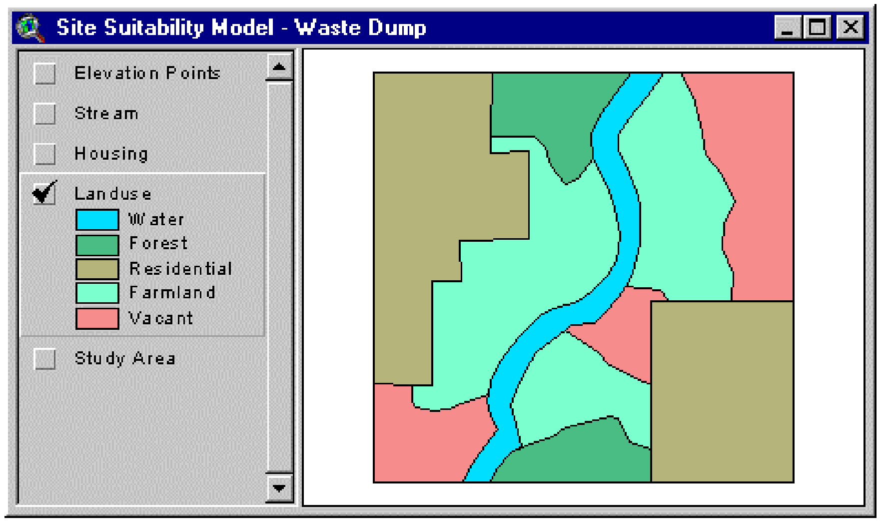
The Weighted Overlay process creates a discrete grid theme that combines multiple input themes. The output theme represents the weighted influence of multiple features in a geographic area. Each of the input themes is assigned a percent influence based on its importance. Values within the themes are reassigned to a common evaluation scale. This allows unlike measurements, such as temperature and rainfall, to be converted to common values that can be added. This process is often used in site suitability studies where several factors affect the suitability of a site.

A ModelBuilder Example

Creating a model begins with deciding which question you want to answer, which factors influence the answer, and what data is needed to measure these factors. Common spatial modeling questions concern the suitability of a particular site for a specific use—such as the best place to locate a business, a storage site, a pipeline, a park, or anything else.

This example locates suitable sites for a waste dump. The dump must be situated a minimum distance from residential areas and a stream. It must be on level ground so that rainfall doesn't carry waste out of the disposal area. Certain kinds of land (such as vacant land) are suitable, others (such as forested land) are less than ideal.

To create the model, you begin with a set of project data loaded as themes in an ArcView GIS view.



The view contains four themes that will be used in the model: a polygon theme of land use, a point theme of elevations, a line theme of a stream, and a polygon theme of housing.

There are a number of things you must do to find a suitable site.

- The data sets must be in a form suitable for spatial overlay analysis. In ModelBuilder, this means converting vector themes to grid themes.
- The elevation points must be transformed into an elevation surface from which slope may be derived.
- A buffer zone (or series of buffer zones) must be drawn around the stream so the dump is not located too near it.
- A similar buffer zone must be drawn around housing areas.
- Values within each theme must be rated with respect to their suitability. Which land uses are desirable, undesirable, and unacceptable? How steep a slope is too steep? How far from the stream or residential area is far enough?
- The themes must be weighted in importance relative to one another. For example, is slope gradient more important than land use? If so, how much more important?

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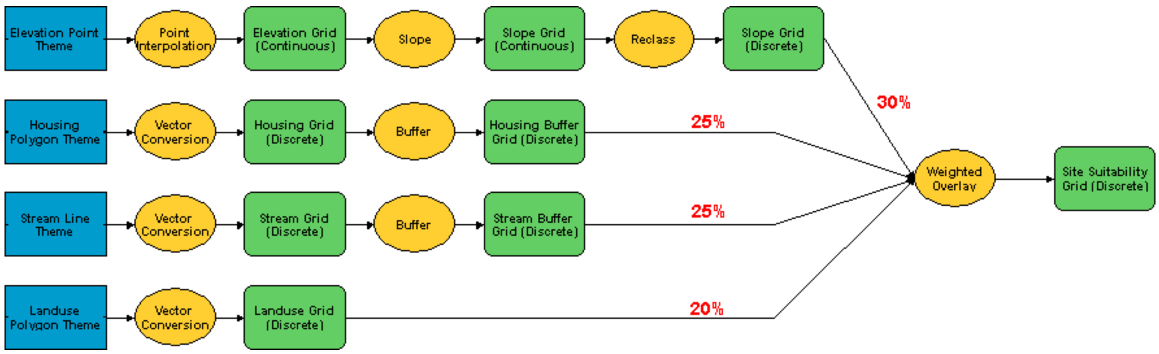
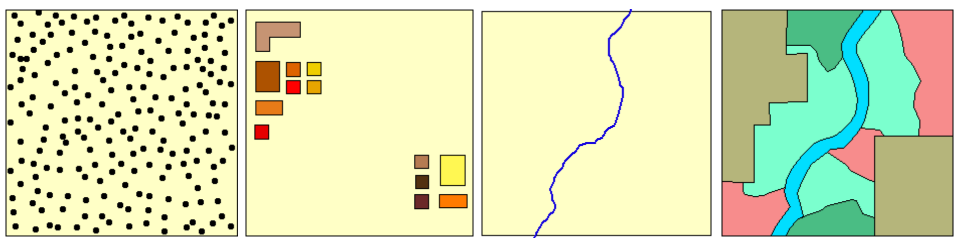


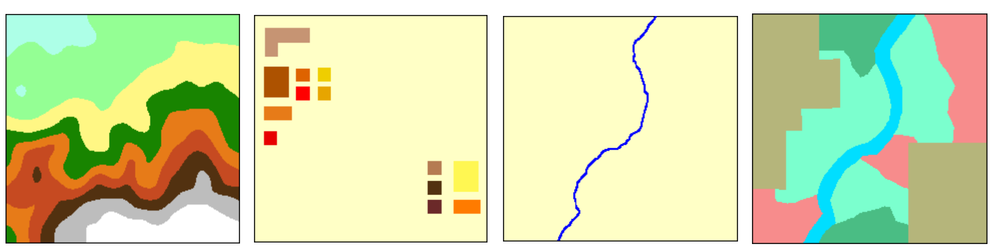
The first set of model processes converts the input vector themes (represented by project data nodes) to grid themes for analysis in the ArcView Spatial Analyst environment. The elevation point data is interpolated to create a continuous elevation surface.

The project data themes are the inputs to the first set of processes.



Elevation Points *Housing* *Stream* *Land Use*

The derived data themes have been converted from vector to raster format. The elevation points are interpolated into a continuous elevation surface. ArcView Spatial Analyst requires that data be in raster format for overlay analysis.



Elevation Grid *Housing Grid* *Stream Grid* *Land Use Grid*

In the second set of processes, a slope grid is derived from the elevation grid, and buffers are drawn around the housing and stream grid themes. The derived data from the first set of processes becomes the input to the second set of processes. No further processing needs to be done on the land use grid.

In the slope grid derived from the elevation grid, darker areas are steep slopes (less suitable) and light areas are flat (more suitable). In the housing and stream buffer grids, darker colors are farther from the buffered features and represent more suitable locations.

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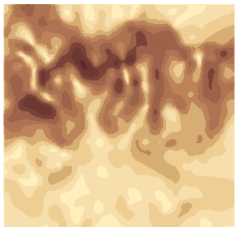


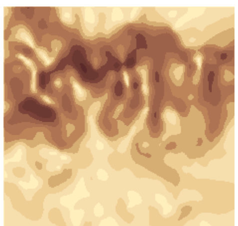
Slope Grid

Housing Buffer Grid

Stream Buffer Grid

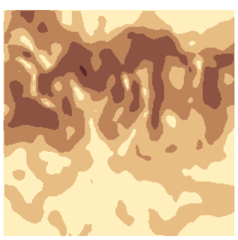
In the third phase of the model, the values in the slope grid are reclassified.

The derived data from the second set of processes becomes the input to the third set. No further processing needs to be done on the two buffer grids.



Continuous Slope Grid

Reclassification replaces the values in the input grid with a new set of values in the output grid. In this case, ranges of values in the input grid are assigned to single values in the output grid; the effect is to reduce the total number of values in the output grid and thus to simplify the data.



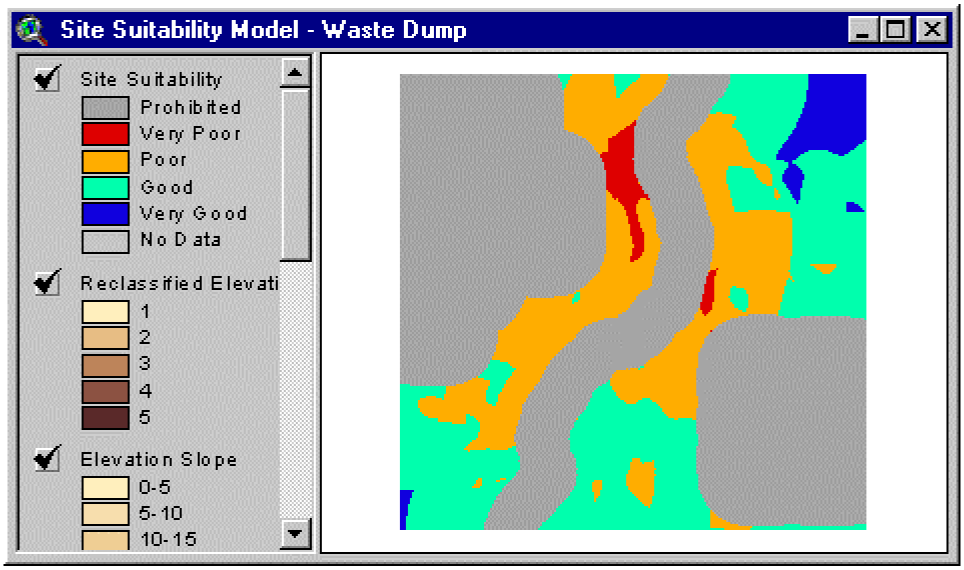
Discrete Slope Grid

In the final phase of the model, the land use grid, the housing buffer grid, the stream buffer grid, and the reclassified slope grid become the inputs to the final suitability grid. The Weighted Overlay function rates the values in each input grid on a numeric preference scale and then weights the influence of the grids relative to one another. ModelBuilder calculates both the preference scales and the relative influences of the input factors to produce a map that represents the suitability of each location.

By changing preference ratings and influences, you can vary the outcome of the model and explore alternative scenarios.

The derived data themes from earlier processes become the input to the final output model:

- Land use grid: 20 percent influence
- Housing buffer grid: 25 percent influence
- Stream buffer grid: 25 percent influence
- Discrete slope grid: 30 percent influence



The suitability model rates areas as very good if they are vacant, have flat or gentle slopes, and are far from housing areas and the stream. The final map identifies the northeast corner of the study area as the best location for the dump.

System Requirements

ArcView Spatial Analyst 2 with ModelBuilder is available for Microsoft Windows 95/98/NT/2000 and requires ArcView GIS 3.2.

Conclusion

ModelBuilder provides both beginning and advanced users with a set of easy-to-use tools for building various types of spatial models within ArcView Spatial Analyst. ModelBuilder is a comprehensive geographic decision support tool that makes complicated problem solving simple for everyone. ModelBuilder will help you easily manage your project analysis requirements, from simple geographic analysis to complex spatial modeling.

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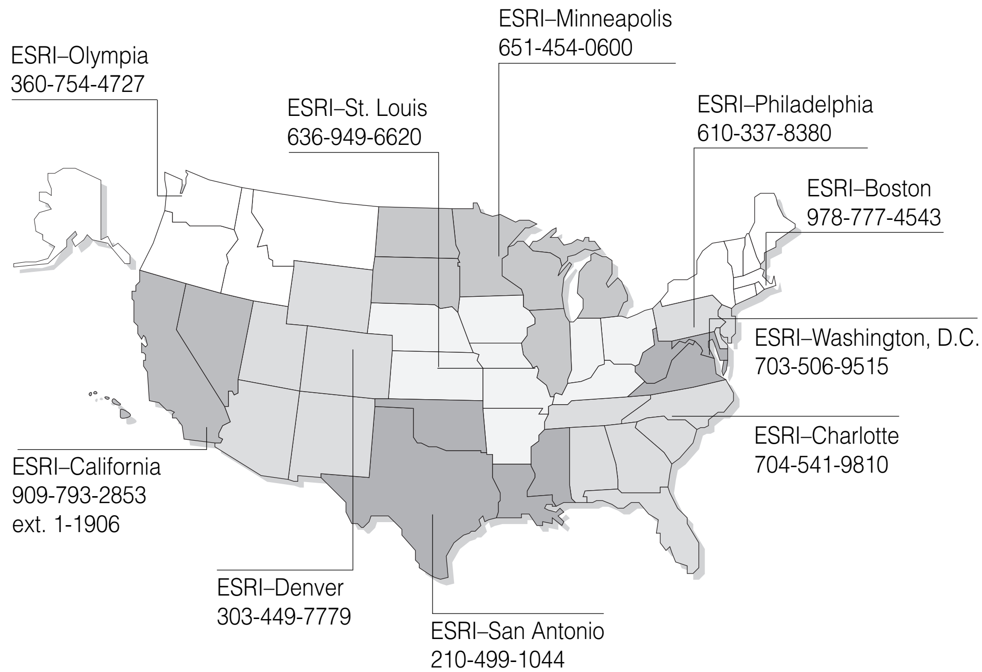

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