Chapter 18. GIS MODELS AND MODELING

Applications: GIS Models and Modeling

Model

- A model is a simplified representation of a phenomenon or a system.
- Models using geographically referenced data are usually called “spatially explicit models.”

Classification of GIS Models

1. A model may be descriptive or prescriptive.
2. A model may be deterministic or stochastic.
3. A model may be static or dynamic.
4. A model may be deductive or inductive.

The Modeling Process

1. The first step is to define the goals of the model.
2. The second step is to break down the model into elements and to define the properties of each element and the interactions between the elements. A flowchart is a useful tool for linking the elements.
3. The third step is the implementation and calibration of the model.
4. The fourth step is to validate the model before it can be generally accepted.

The Role of GIS in Modeling

1. A GIS is a tool that can process, display, and integrate different data sources including maps, digital elevation models (DEMs), GPS (global positioning system) data, images, and tables.
2. A GIS can be used to build a vector-based or raster-based model.
3. A GIS has algorithms for conversion between vector and raster data.
4. The process of modeling may take place in a GIS or use a GIS to link other computer programs.

Binary Models

- A binary model uses logical expressions to select spatial features from a composite feature layer or multiple rasters. The output of a binary model is in binary format: 1 (true) for spatial features that meet the selection criteria and 0 (false) for features that do not.
- Siting analysis is probably the most common application of the binary model.

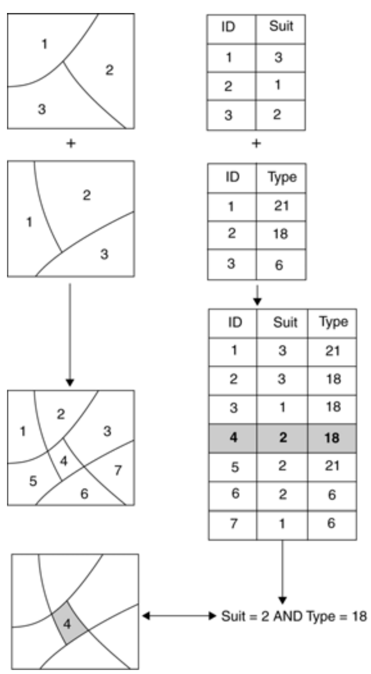

Figure 18.1
To build a vector-based binary model, first overlay the layers so that their spatial features and attributes (Suit and Type) are combined. Then, use the query statement, Suit = 2 AND Type = 18, to select polygon 4 and save it to the output.

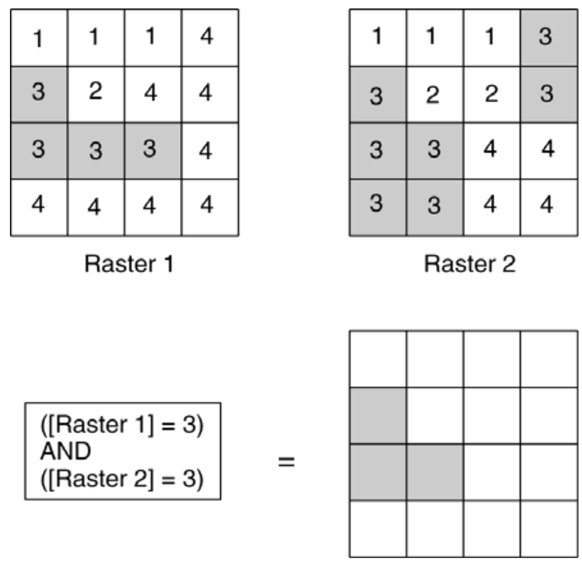

Figure 18.2
To build a raster-based binary model, use the query statement, [Raster 1] = 3 AND [Raster 2] = 3, to select three cells (shaded) and save them to the output raster.

Index Models

- An index model calculates the index value for each unit area and produces a ranked map based on the index values.
- An index model is similar to a binary model in that both involve multicriteria evaluation and both depend on overlay operations for data processing. But an index model produces for each unit area an index value rather than a simple yes or no.

The Weighted Linear Combination Method

- The weighted linear combination method is a common method for computing the index value.
- The method involves evaluation at three levels. First, the relative importance of each criterion, or factor, is evaluated against other criteria. Second, data for each criterion are standardized. Third, the index value is calculated for each unit area by summing the weighted criterion values and dividing the sum by the total of the weights.

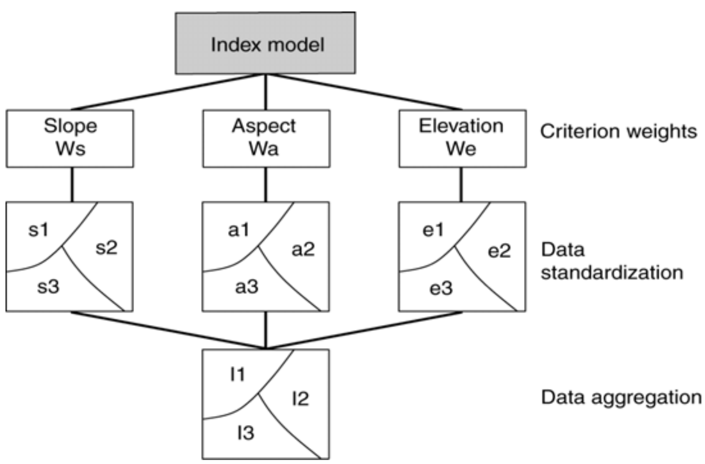

Figure 18.3
To build an index model with the selection criteria of slope, aspect, and elevation, the weighted linear combination method involves evaluation at three levels. The first level of evaluation determines the criterion weights (e.g., *Ws* for slope). The second level of evaluation determines standardized values for each criterion (e.g., *s*1, *s*2, and *s*3 for slope). The third level of evaluation determines the index (aggregate) value for each unit area.

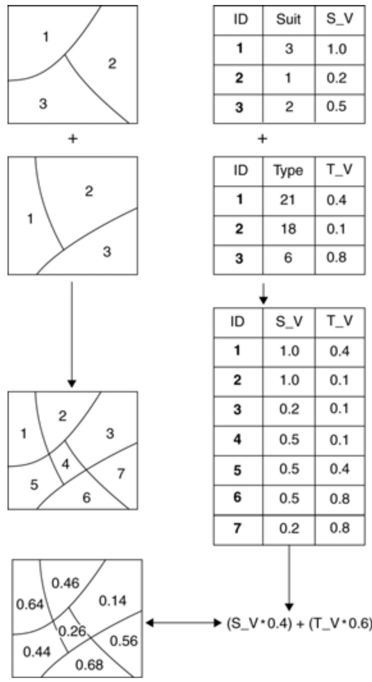

Figure 18.4
Building a vector-based index model requires several steps. First, standardize the Suit and Type values of the input layers into a scale of 0.0 to 1.0. Second, overlay the layers. Third, assign a weight of 0.4 to the layer with Suit and a weight of 0.6 to the layer with Type. Finally, calculate the index value for each polygon in the output by summing the weighted criterion values. For example, Polygon 4 has an index value of 0.26 (0.5*0.4 + 0.1*0.6).

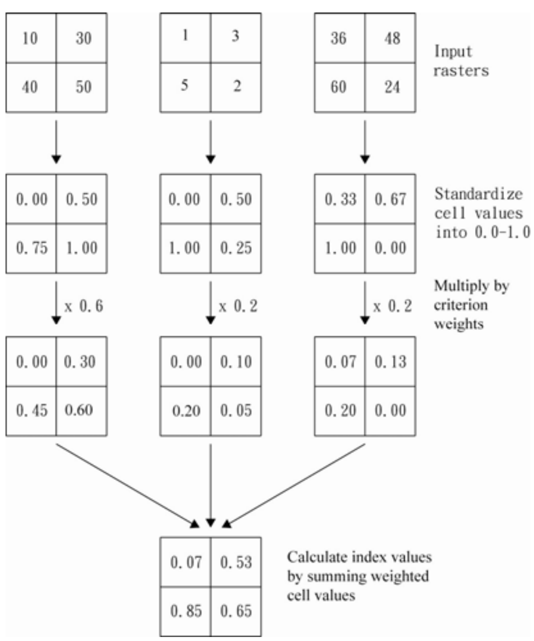

Figure 18.5
Build a raster-based index model requires the following steps. First, standardize the cell values of each input raster into a scale of 0.0 to 1.0. Second, multiply each input raster by its criterion weight. Finally, calculate the index values in the output raster by summing the weighted cell values. For example, the index value of 0.28 is calculated by: 0.12 + 0.04 + 0.12, or 0.2*0.6 + 0.2*0.2 + 0.6*0.2.

Applications of the Index Model

Index models are commonly used for suitability analysis and vulnerability analysis.

Regression Models

- A regression model relates a dependent variable to a number of independent (explanatory) variables in an equation, which can then be used for prediction or estimation.
- A regression model can use overlay operations in a GIS to combine variables needed for the analysis.
- There are two types of regression model: linear regression and logistic regression.

Process Models

- A process model integrates existing knowledge about the environmental processes in the real world into a set of relationships and equations for quantifying the processes.
- Environmental models are typically process models because they must deal with the interaction of many variables including physical variables such as climate, topography, vegetation, and soils as well as cultural variables such as land management.

California LESA model
http://www.consrv.ca.gov/DLRP/qh_lesa.htm
WEPP
http://topsoil.nserl.purdue.edu/nserlweb/weppmain/wepp.html
SWAT / SSURGO
http://waterhome.tamu.edu/NRCSdata/SWAT_SSURGO
BASINS
http://www.epa.gov/waterscience/BASINS/
Conservation Reserve Program (CRP)
http://www.fsa.usda.gov/
SWAT Input web page
http://www.brc.tamus.edu/swat/