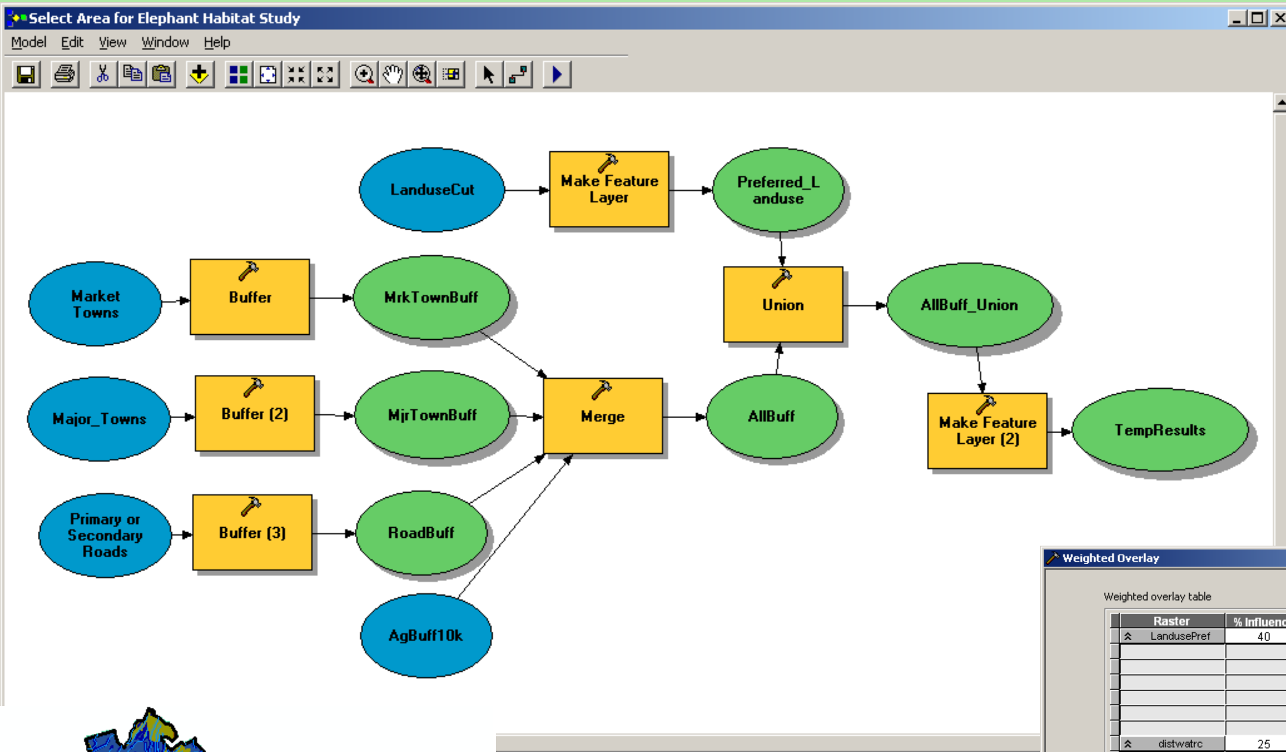
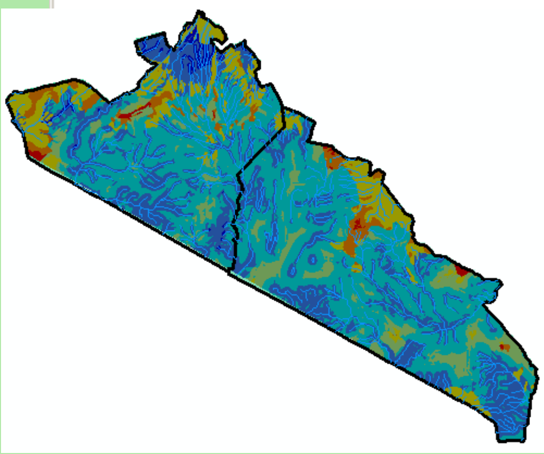
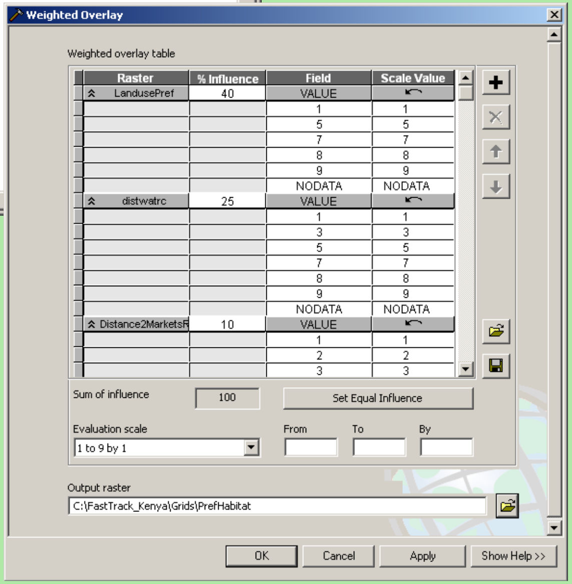
Suitability Modeling with GIS







Developed and Presented by Juniper GIS

Course Objectives

What is Suitability Modeling?

The Suitability Modeling Process

Cartographic Modeling

GIS Tools for Suitability Modeling

Demonstrations of Models

What is Suitability Modeling?

"…a generalized statement, or abstraction, of the important considerations in a real world situation"

– Joseph Berry

"Land suitability analysis involves the application of criteria to the landscape to assess where land is most and least suitable…"

– North Carolina Center for Geographic Information and Analysis.

"An organized set of overlays" – John Schaeffer

The concept of *Suitability Modeling* is very well expressed in *Design with Nature* by Ian L. Mcharg and is the theoretical basis for implementing modeling in GIS.

The Suitability Modeling Process

Determine the question to be studied

Define the criteria for the analysis

Determine the data needed to answer the question

Determine the GIS tools and procedures needed

Create the model

Analyze the results and improve the model

Make a decision

Cartographic Modeling

“The process of using combinations of commands to answer questions about spatial phenomena” – Michael Demers

“A cartographic model is a set of interacting, ordered map operations that act on raw data, as well as derived and intermediate map data, to simulate a spatial decision-making process” – C. Dana Tomlin

“Cartographic Modeling is the process of outlining the analysis flow, and is the key to implementing and testing a Suitability Model, usually, but not necessarily, through GIS tools” – John Schaeffer

Cartographic Modeling

Step 1: Determine criteria

Example – Our question is: “where is the best place for a passive solar home?”

Important considerations are:

- *aspect* of the land; due south is best
- *slope* of the land; steep enough to provide some protection without being too steep for building
- *distance to roads* for accessibility; close, but not too close
- *distance to streams* for aesthetics.

Suitability Modeling with GIS

Cartographic Modeling

Step 2: Determine ranking and weighting

Slope: 0-5% = 2; 5-10% = 3; 10-15% = 4; 15-20% = 2; 20+% = 1

Aspect: 0-90 = 1; 90-135 = 2; 135-160 = 3; 160-200 = 4;
200-270 = 2; 270-360 = 1

Distance to roads: 0-20 meters = 1; 20-50 meters = 2;
50-100 meters = 3; 100-200 meters = 4;
200-500 meters = 2; 500+ meters = 1

Proximity to streams (aesthetics): 0-100 meters = 4;
100-200 meters = 3; 200-300 meters = 2; 300+ meters = 1

Suitability Modeling with GIS

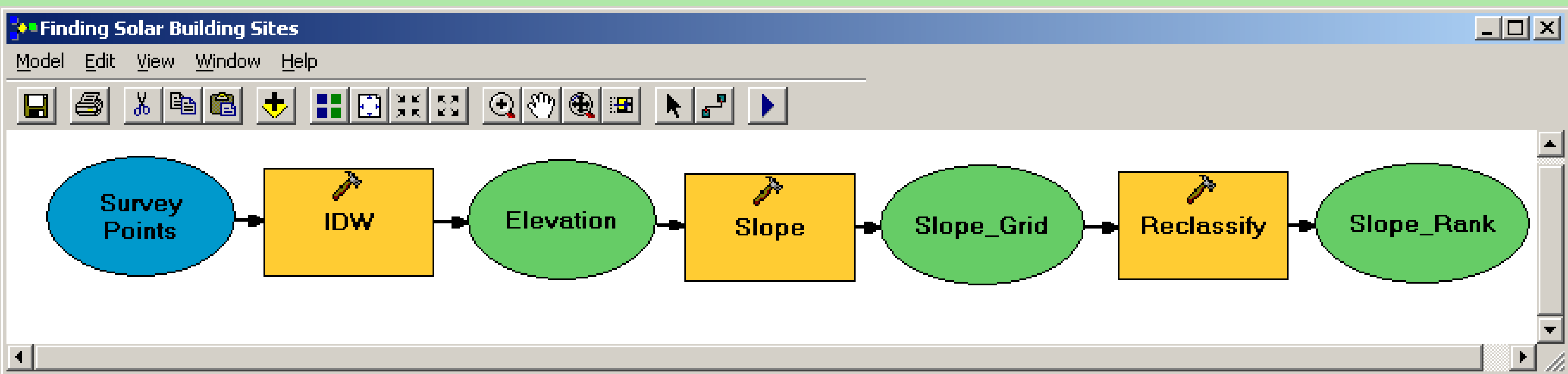
Cartographic Modeling

Step 3: Work back from each criteria to base data.

Slope desirability grid ranked from 1-4 would be derived from a slope grid

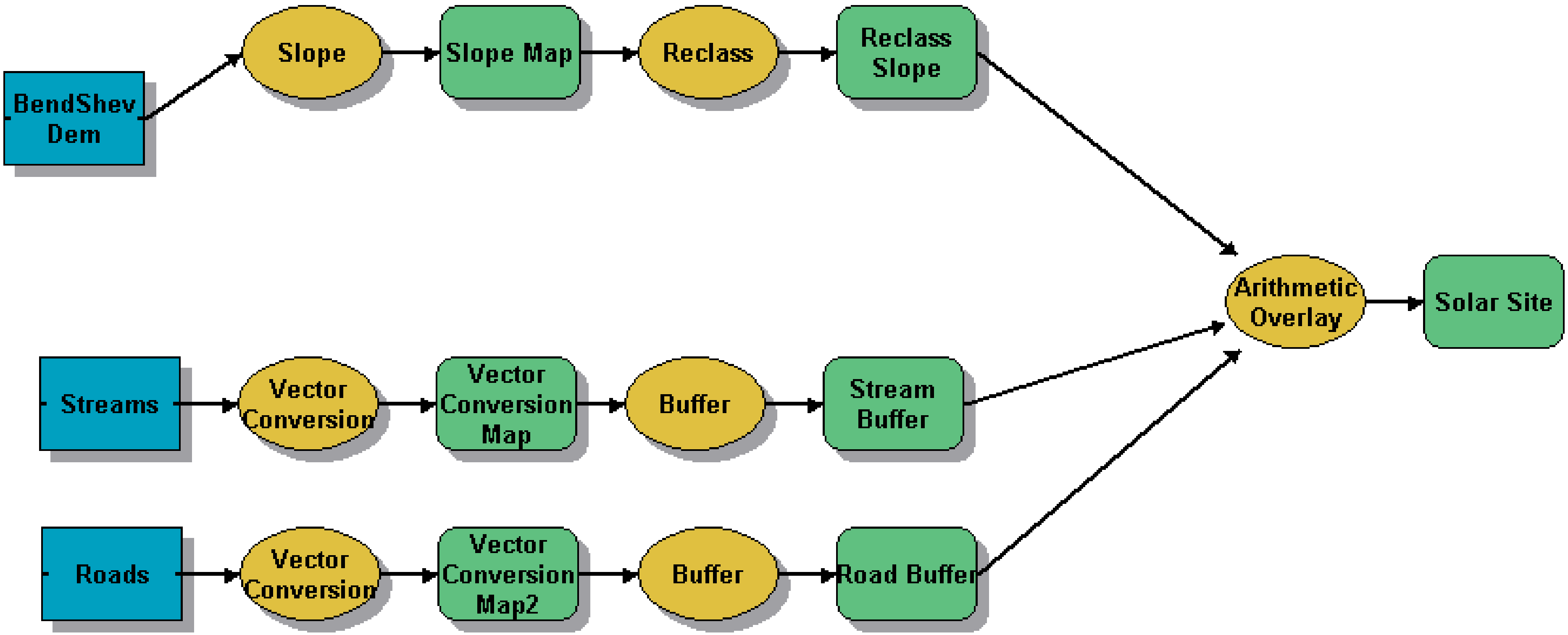
Slope would be derived from elevation grid

Elevation grid would be interpolated from point data.



Cartographic Modeling

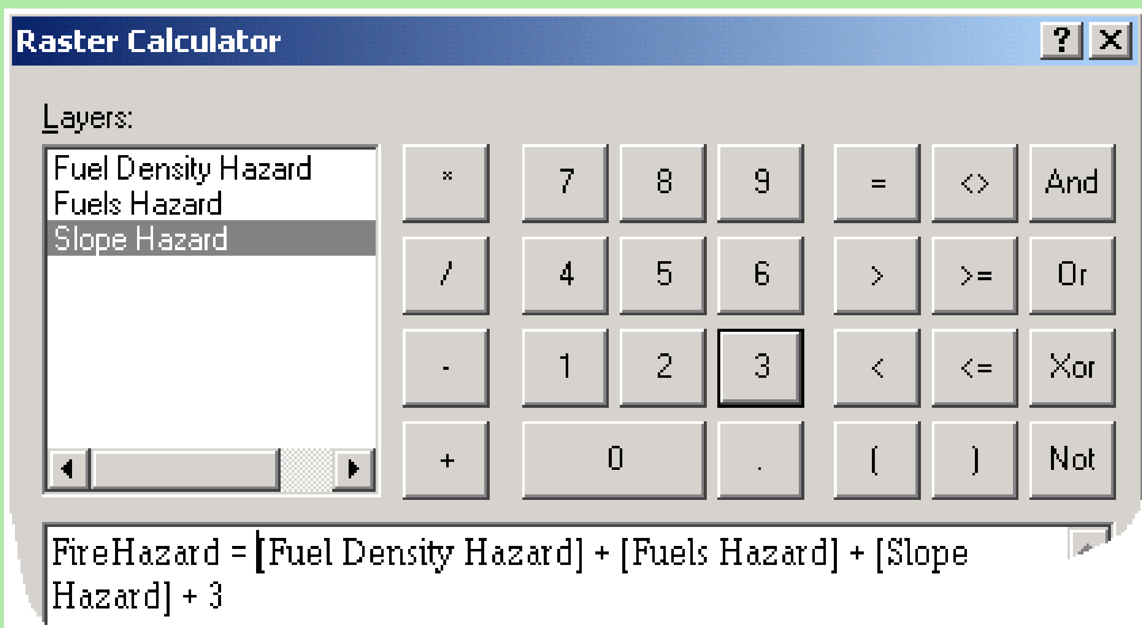
Step 4: Diagram the process flow.



Map Algebra Concepts

Map Algebra is the primary tool used in Raster Analysis to combine/compare several layers of data (criteria) to answer analysis questions.

Map Algebra does this by using math to add/subtract/multiply values in the different data layers.



Map Algebra Concepts & Suitability Models

Three types of suitability models can be created with Map Algebra

Binary Suitability – Good or Bad, no other choices

Ranked Suitability – Range of values from Bad to Good, but all criteria have the same value or weight

Weighted Suitability – Ranges of values from Bad to Good, but with different weights for each criteria, usually expressed as a percentage of the total value

Can be combined within a model – for example, binary suitability could be used to determine areas that are absolutely bad, and then this could be overlaid on the results of a weighted suitability analysis.

Map Algebra Concepts & Suitability Models

Pros and cons of suitability models types

Binary Suitability – Very easy, but no “in-between” choices; all layers have same importance

Ranked Suitability – Provides a high-low range, which will be a different range than the suitability scale, but can’t determine what factors contributed to the final value and can’t answer a yes/no question; all layers have the same importance

Weighted Suitability – Provides a high-low range with the same scale used for the data layers, but can’t determine what factors contributed to the final value and can’t answer a yes/no question; layers have different importance

Map Algebra Concepts & Suitability Models

Suitability scales – sometimes called preference scales

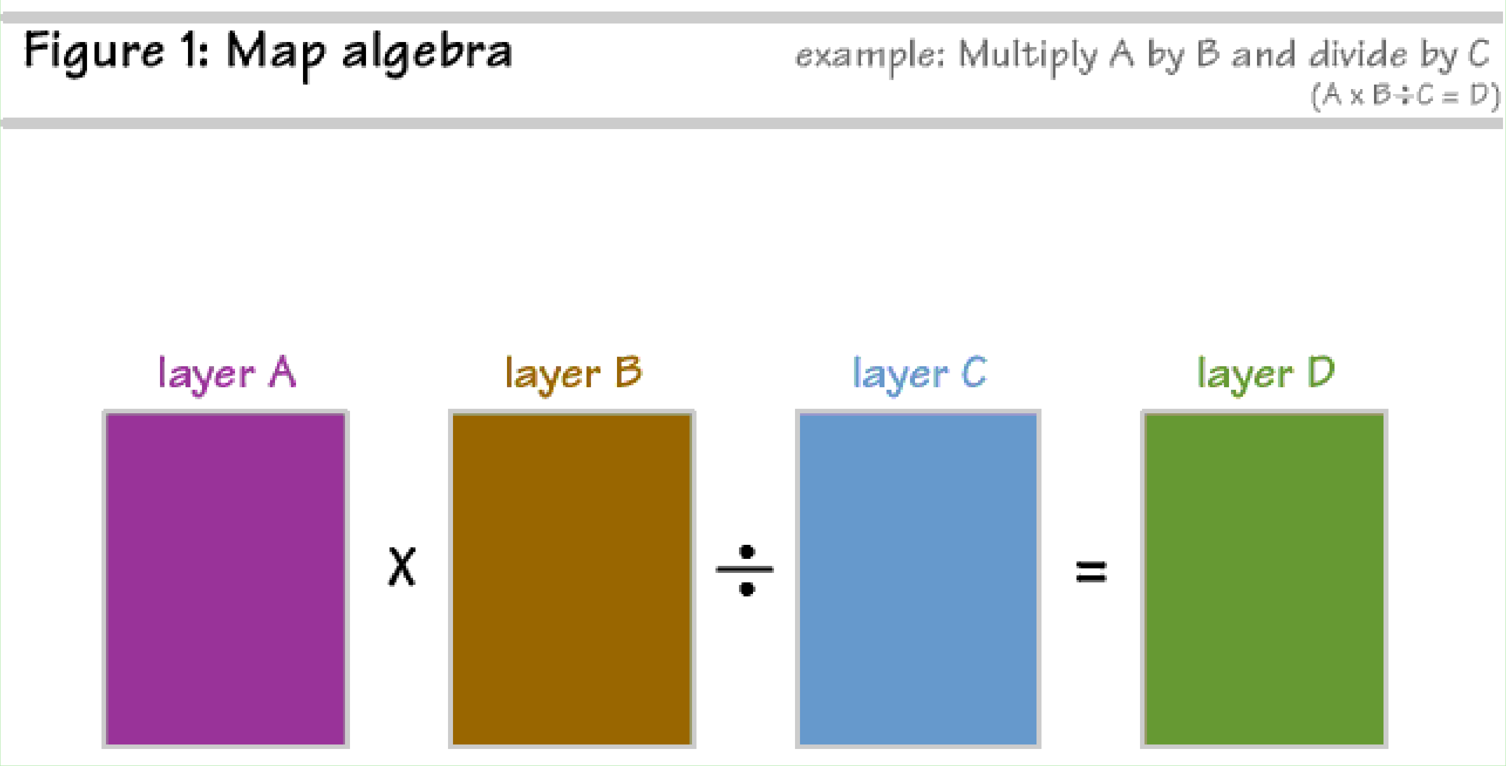
- Scales are used to assign significance (ranking) to the values for each criteria
- Common scales are 1-9 and 1-4
- Same scale must be used for each criteria, but not necessary to use complete range for each criteria
- Often requires changing measurement units to a uniform type of value, usually an integer indicating the relative rank

Map Algebra Concepts

Map Algebra requires grids have the same type of values

In other words you need to add apples to apples.

Different data types are usually reclassed before performing Map Algebra functions.



Map Algebra Concepts

Simple "Good/Bad" (Binary) suitability example using Addition:

Good areas (cells) in the input grid given a value 1.

Bad areas (cells) in the input grid given a value of 0.

If the grids are **Added**, then:

2 = Grid cells were "Good" for both criteria.

1 = Grid cells were "Good" in at least one of the criteria.

0 = Grid cells were "Bad" for both criteria.

	Good Slope = 1	Bad-Slope= 0
Good Aspect = 1	2	1
Bad Aspect = 0	1	0

Map Algebra Concepts

Simple "Good/Bad" (Binary) suitability example using multiplication:

Good areas (cells) in the input grid given a value 1.

Bad areas (cells) in the input grid given a value of 0.

If the grids are **Multiplied** then the 0 value cancels out all cells in the results grid that were bad in any of the input grids.

	Good Slope = 1	Bad-Slope= 0
Good Aspect = 1	1	0
Bad Aspect = 0	0	0

Suitability Modeling with GIS

Map Algebra Concepts

Multiple criteria ranked on an interval scale. (Ranked Suitability)

Cells/Features ranked 1-4 with 1 being least desirable, 4 most desirable.

If all the grids are **Added** then possible range of the results is 4-16.

All cells over a certain threshold value would be considered “Good”, or results could also be ranked on an interval scale.

Criteria & Ranking	Sample scores
Accessibility (1-4)	2
Streams (1-4)	4
Slope (1-4)	3
Aspect (1-4)	3
Possible range (4-16)	
Sample Results	12

Suitability Modeling with GIS

Map Algebra Concepts

Multiple criteria ranked on an interval scale.

Cells/Features ranked 1-4, but ranks are multiplied by 1, 10, 100, 1000.

This doesn't increase value; just adds "0" as placeholders.

Values are then added, but individual criteria can now be distinguished in the results.

Criteria/Ranking	Ranking * 1,10,100,1000	Sample scores
Accessibility (1-4)	Accessibility (1-4)	2
Streams (1-4)	Streams (10-40)	40
Slope (1-4)	Slope (100-400)	300
Aspect (1-4)	Aspect (1000-4000)	3000
	Possible range (1111-4444)	
	Sample Results	3342

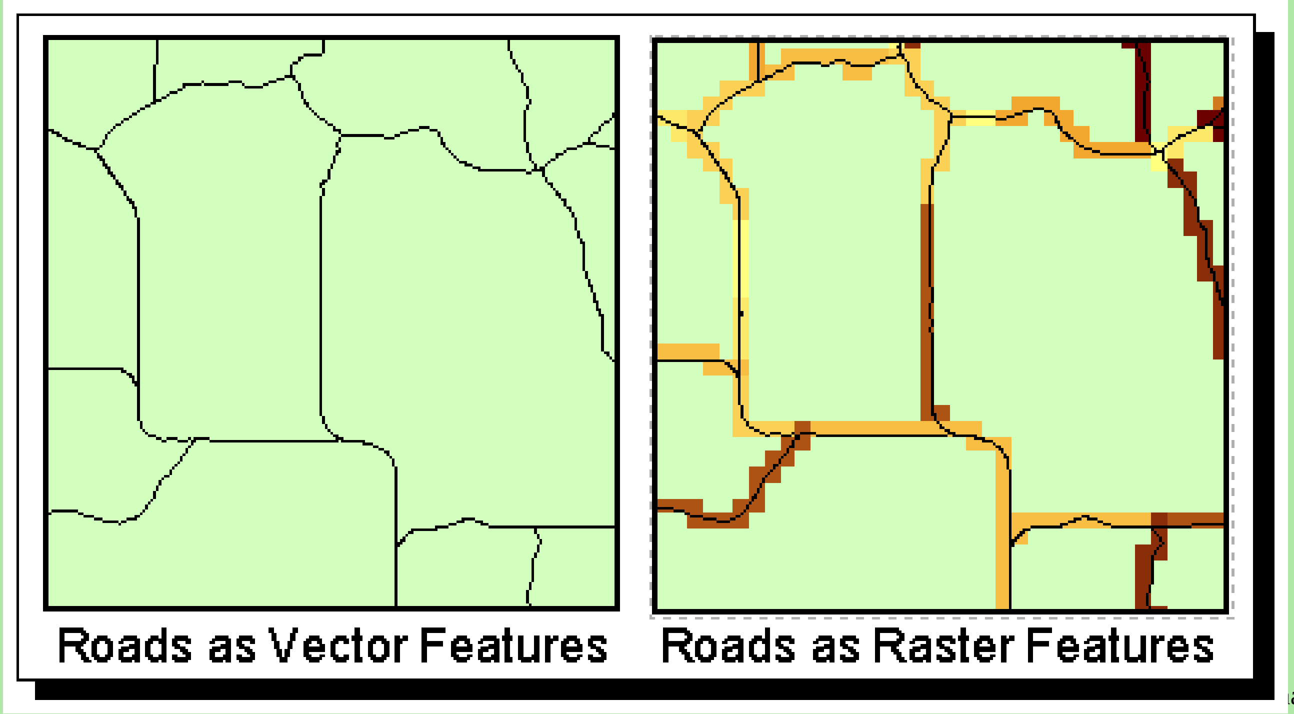
Suitability Modeling with GIS

What is Raster GIS?

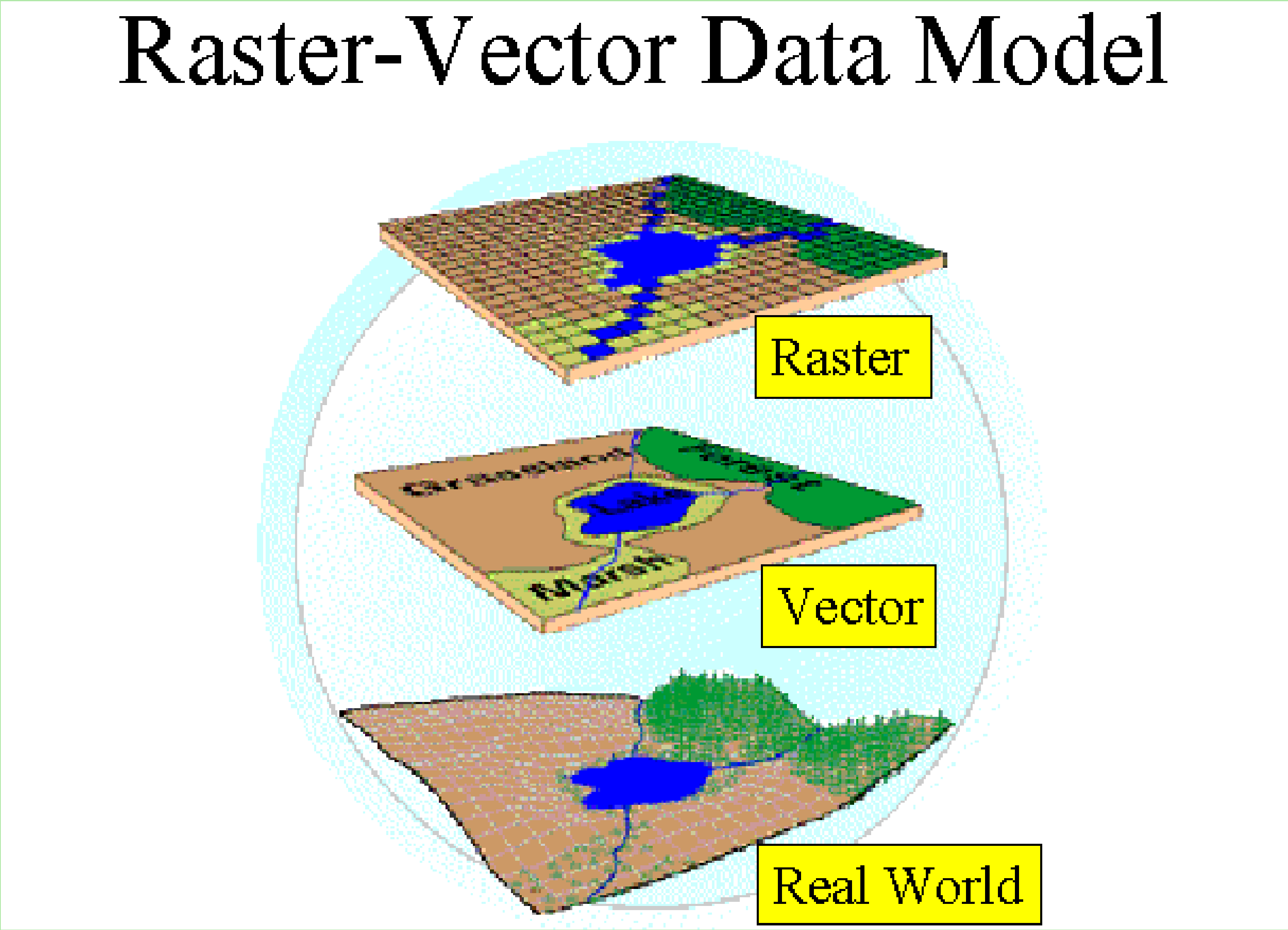
Works with cells – instead of Points, Lines, Polygons

Raster GIS divides study area into a regular grid of cells

- Each cell contains one value
  - Either integer or floating point



Raster \ Vector Comparison



Suitability Modeling with GIS

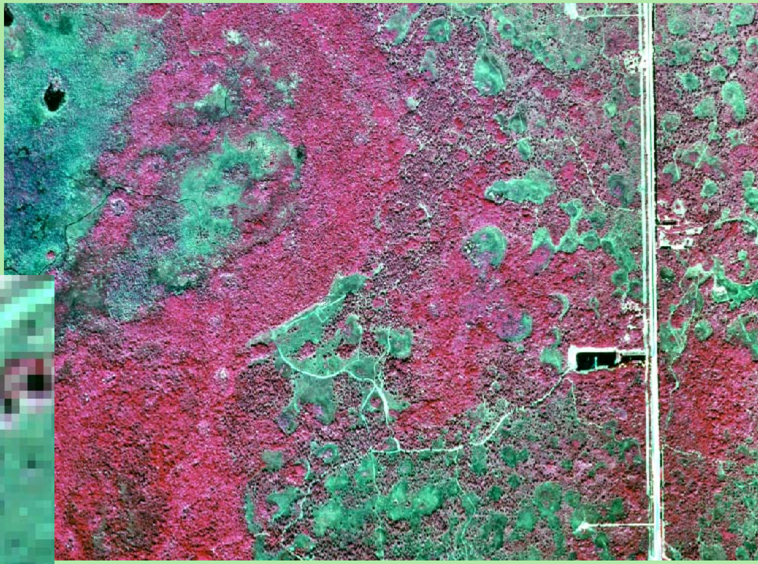
What is Raster GIS?

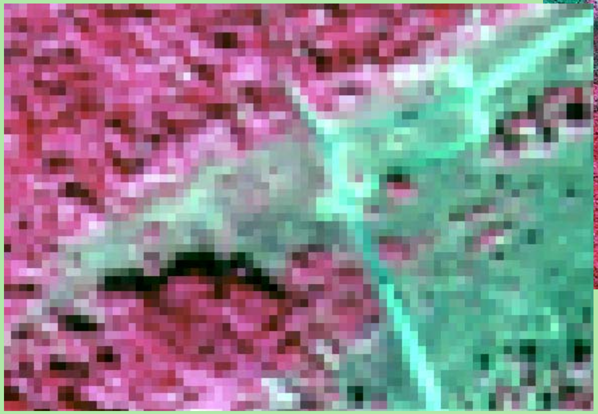
Well suited for working with continuous data

- Elevation
- Precipitation
- Population

Well suited for working with data derived from remote sensing applications

- RS data already in cell form – pixilated



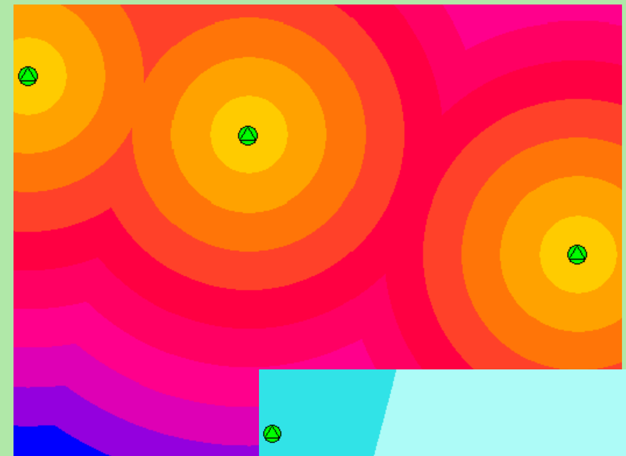


What is Raster GIS?

Raster GIS creates a variety of Analysis Grids

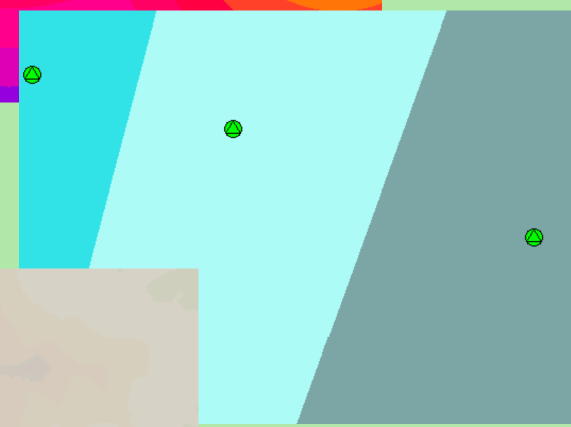
Distance Grids

    Continuous Buffer



Proximity Grids

    Assigns cells to specific locations



Density Grids based on points or values

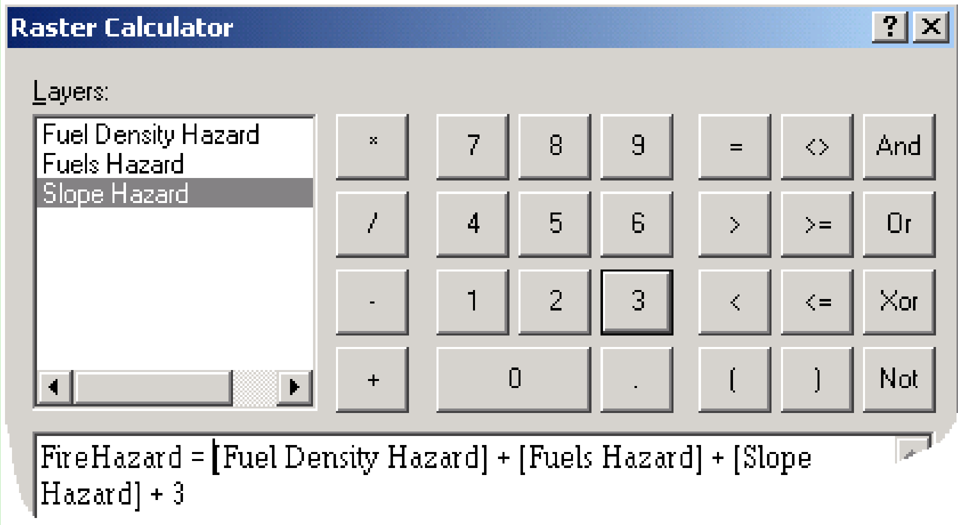
Viewshed Grids

Hydrology Grids

What is Raster GIS?

Raster GIS provides different types of analysis

- Map Algebra
    - Add/Subtract/Multiply grids to perform analysis
- Surface Analysis
- Neighborhood Analysis
- Cost Path/Friction Analysis



Working with Grid Layers — Data Values

Value

The numeric value of the grid cell

Values can be true numbers or codes

Attributes of Slope Hazard

ObjectID	Value	Count
0	0	566779
1	1	283863
2	2	30338
3	3	20159

Record: 1

Integer (discrete) or

Floating Point (continuous) grid

Some functions are “decimal dependent” (values are either integers or contain decimal values)

Attributes of hydrogrid

ObjectID	Value	Count
0	636.320007324219	26
1	639.599975585938	116
2	642.880004882813	177
3	646.159973144531	178
4	649.440002441406	270
5	652.71997070312 5	478

Record: 1 Show: All Selected

Map Algebra/Suitability Modeling Demonstration

Finding suitable Sites for a Passive Solar Home

Binary Suitability

Ranked Suitability

Weighted Suitability

Working with Map Algebra

Suitability Modeling and GIS Methods

Vector and/or Raster Techniques

Using Modelbuilder

Examples and Demonstrations

Testing the Results

Suitability Modeling and GIS Methods

Using Vector GIS techniques:

Relies heavily on buffering and overlays

Usually works by subtracting bad areas from the study area to show areas that are suitable

Usually provides a Yes/No answer, but could have a numeric ranking

Discrete results – could have high suitable areas adjacent to low suitable areas with no method to “blend” these areas

Suitability Modeling and GIS Methods

Using Raster GIS techniques:

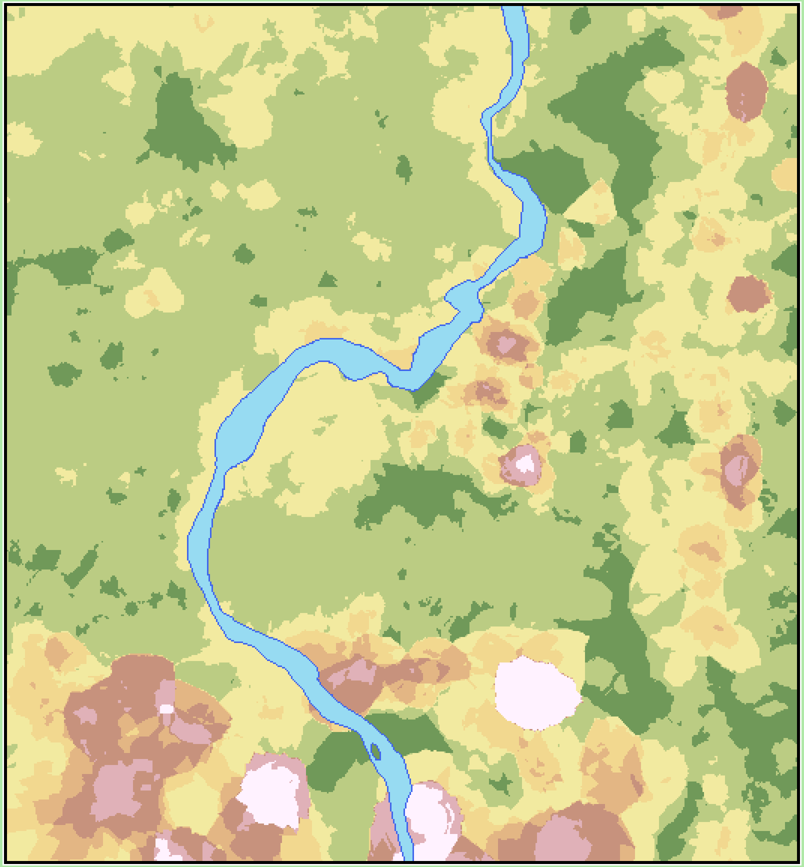
Relies heavily map algebra\overlays

Easy to reclass data to suitability or preference scales

Can provide yes/no, ranked, or weighted results

“Continuous” results – provides a “surface” of the results and can blend results based on neighborhood influences

Final results usually converted to vector



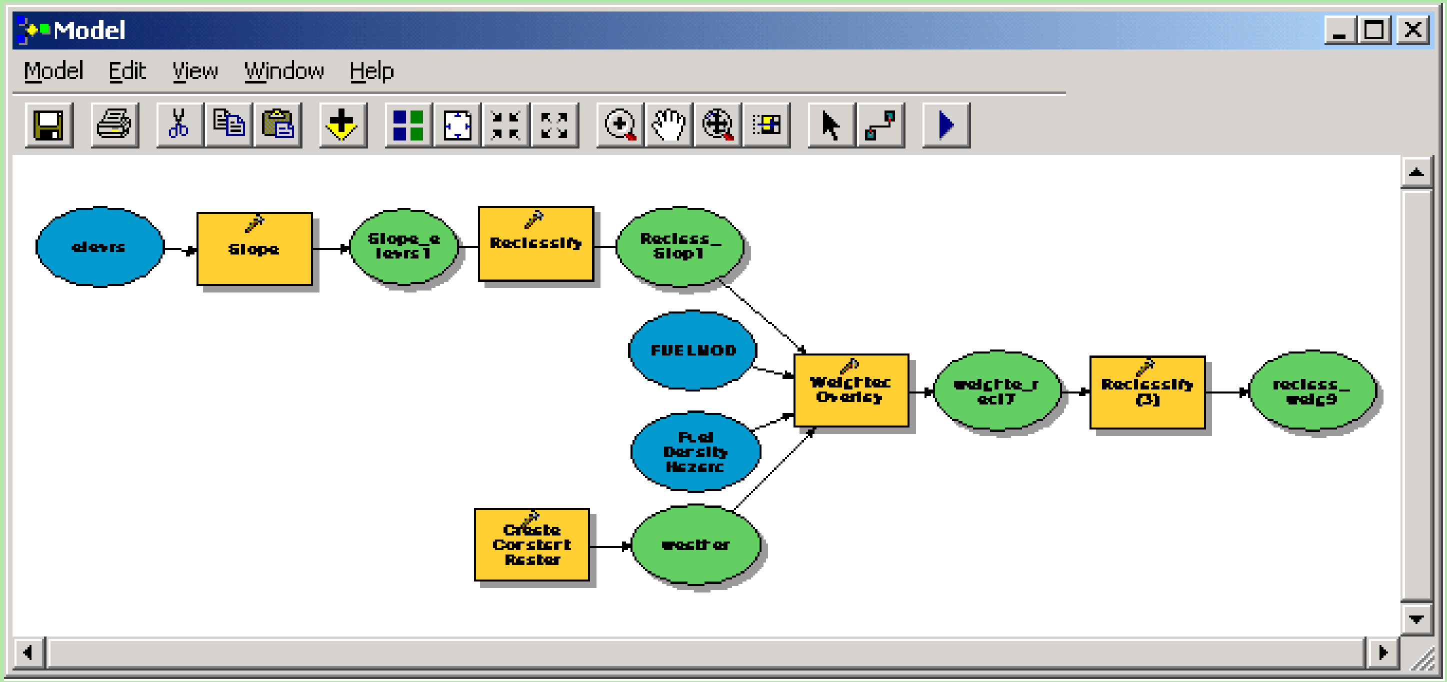
Suitability Modeling and GIS Methods

What is Model Builder?

Graphical interface used to build models of processes.

A way to “capture a workflow”

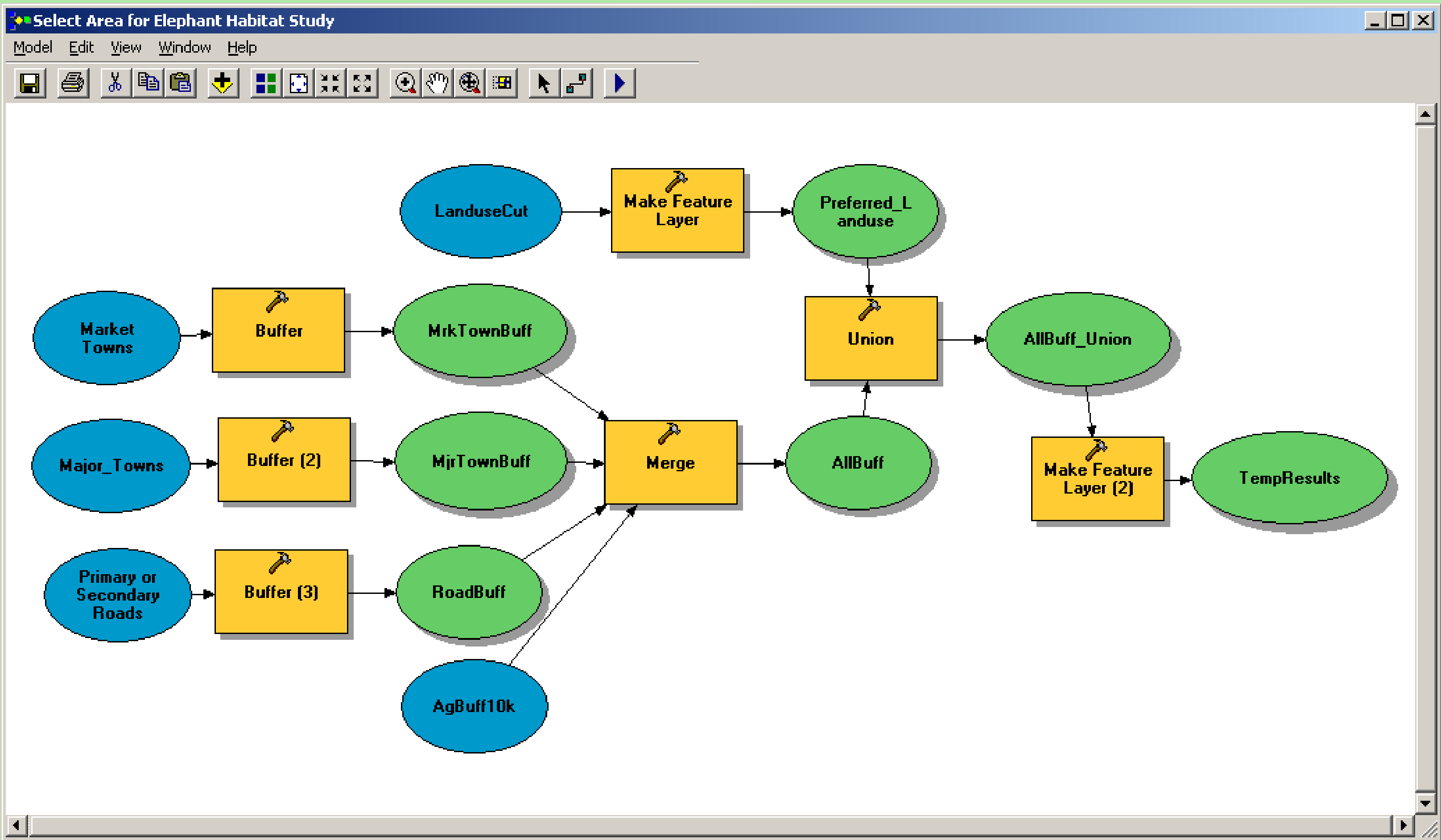
“Authoring environment” used to create tools



Suitability Modeling and GIS Methods

What is Model Builder?

Provides a method to run several variations of the analysis.



Habitat Suitability Modeling Demonstration

Question: Possible places to create elephant habitat conservation zones

Criteria:

- Elephants prefer certain vegetation and areas; derived from Landuse types
- Elephants like water; derived from Landuse types
- Elephants don’t like to be near people; derived from distance to cities, villages, roads
- Exclude existing conservation areas such as parks and reserves

Weighting:

- Vegetation more important than closeness to people
- Distance to cities more important than distance to villages

Habitat Suitability Modeling Demonstration

Sample Suitability and Weighting

LUNUM	Land Use	Preference Scale
1	forest	9
2	woodland	8
3	bushland (dense)	7
4	bushland (sparse)	7
5	grassland	5
7	barren land (R)	1
8	swamp	8
9	waterbody	8
11	agriculture (dense)	1
12	agriculture (sparse)	1
13	plantation	1
14	town	1

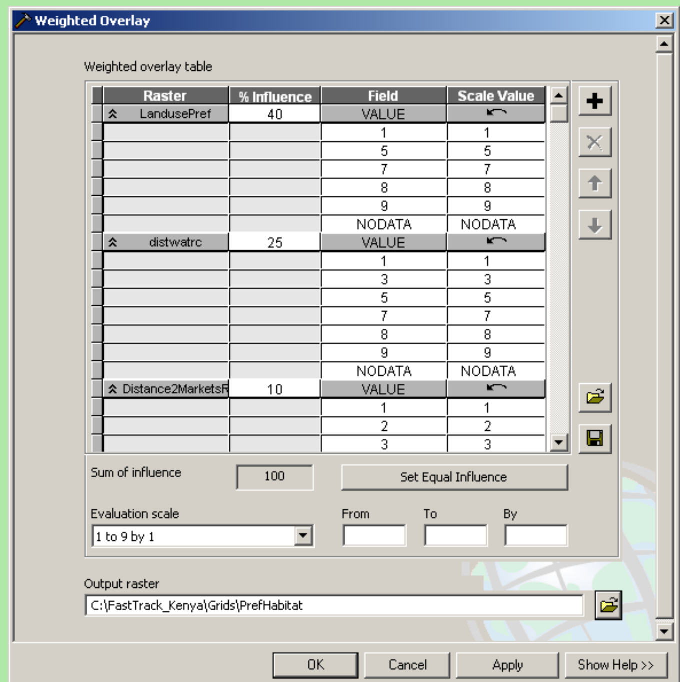
Criteria:

Elephants prefer certain vegetation and areas

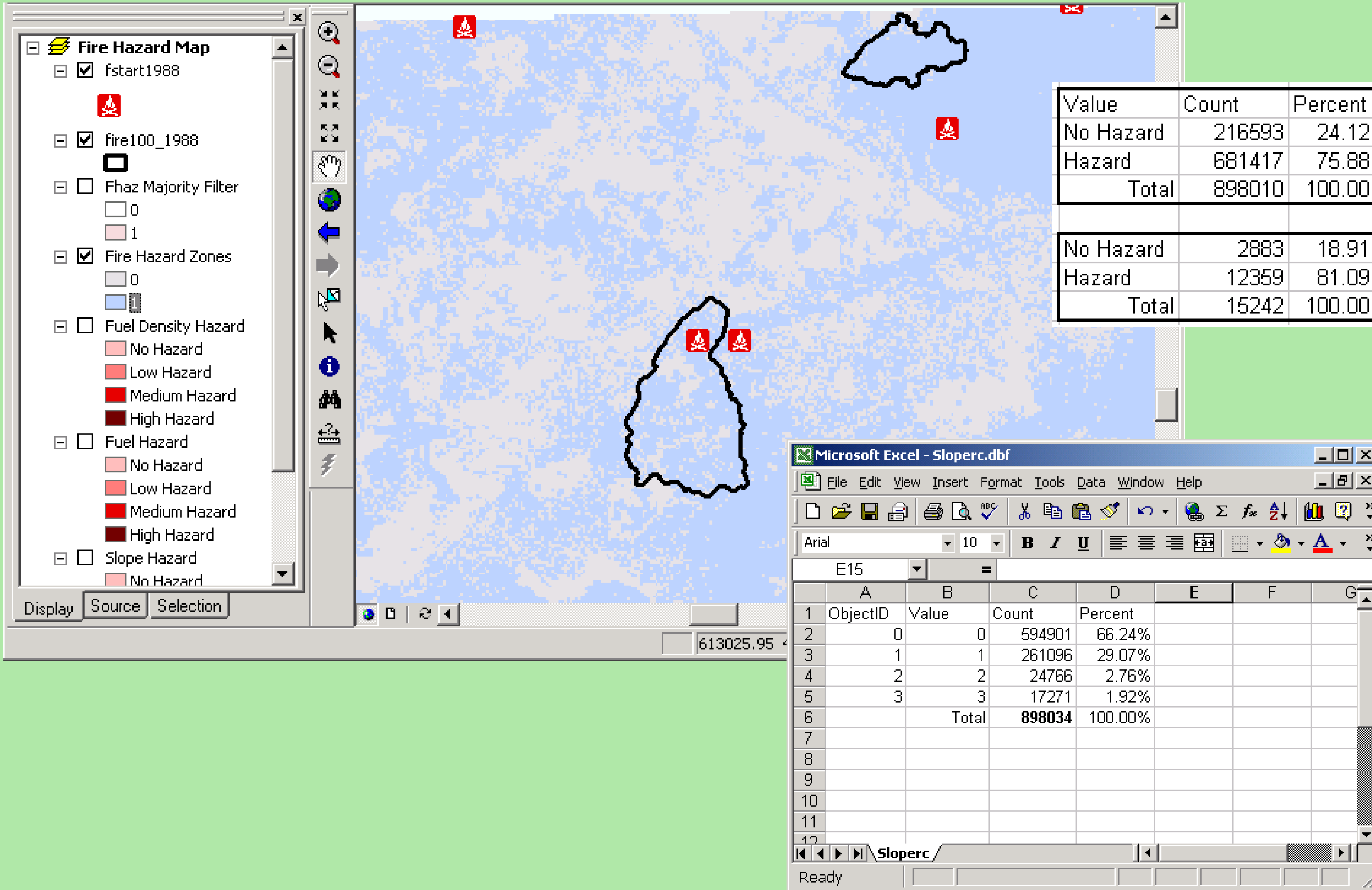
Weighting:

Vegetation more important than closeness to people

Distance to cities more important than distance to villages



Testing the Results of Analysis



Value	Count	Percent
No Hazard	216593	24.12%
Hazard	681417	75.88%
Total	898010	100.00%

No Hazard	2883	18.91%
Hazard	12359	81.09%
Total	15242	100.00%

ObjectID	Value	Count	Percent
0	0	594901	66.24%
1	1	261096	29.07%
2	2	24766	2.76%
3	3	17271	1.92%
	Total	**898034**	100.00%