Spatial Analyst and Raster Analysis

Developed and Presented by Juniper GIS
Spatial Analyst and Raster Analysis

Course Objectives

Provide an Introduction to Spatial Analyst and Raster GIS for Conservation Analysis

Topics:

The Spatial Analyst Extension
Understanding Raster GIS
Cartographic Modeling
Map Algebra
Raster Analysis Techniques

This PowerPoint is available at JuniperGIS.com\GIS Links\Presentations
Spatial Analyst and Raster Analysis

What is the Spatial Analyst extension?

Spatial Analyst provides raster functionality within ArcGIS and works with all license levels.

- Adds tools for raster functions to ArcGIS.
- Most functionality accessed as Map Algebra, Python, or ArcToolbox tools.
- Works with Vector and Grid data formats.
- Full range of raster capabilities and analysis tools.
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
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Raster \ Vector Comparison

Raster-Vector Data Model

Raster
Vector
Real World
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**Raster \ Vector Comparison**

**Raster is Faster**

- Generally processes quicker
- But can generate large files

**Vector is Corrector**

- Looks more like what we are used to seeing
- Can provide more “detail”
What is Raster GIS?

Well suited for working with continuous data

- Elevation
- Precipitation
- Population
What is Raster GIS?

Well suited for working with data derived from remote sensing applications

RS data already in cell form – pixilated
What is Raster GIS?

Raster GIS is well suited for modeling complex processes and allows operations such as:

Map Algebra

Surface Interpolation and Surface Analysis

Hydrologic Modeling

Viewshed Analysis

Distance and Proximity Analysis

Resampling

Reclassifying
What is Raster GIS?

Raster GIS is also designed to interpolate data by creating Surfaces based on numeric values.

- Terrain Modeling
- Population Modeling
- Modeling any numeric value
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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
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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

![Raster Calculator](image)
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Interpolating & Creating Surfaces

Spatial Analyst can be used to create and model surfaces from point or other data.

Uses several interpolation methods

IDW – inverse distance weighting

Spline

Kriging

Other methods
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Interpolating & Creating Surfaces

Surfaces can be created from any numeric value

- Elevation
- Population Statistics
- Property Values
- Precipitation
- Well Depths
Values extruded in the Z direction
Continuous surface mesh draped over extruded values
Elevation surface of the downtown Bend area showing parcels for reference.
Continuous elevation surface of the downtown Bend area from a Digital Elevation Model (DEM)
Vector map of Bend showing parcels classified by property values.

**Property Values**
- 0 - 100,000
- 100,001 - 250,000
- 250,001 - 500,000
- 500,001 - 750,000
- 750,001 - 1,000,000
- 1,000,001 - 1,500,000
- 1,500,001 - 2,000,000
- 2,000,001 - 14,000,000
Working with Surfaces

Continuous raster surface of downtown Bend based on property values
Continuous population surface of downtown Bend based on 2000 census data.
Surface Analysis

Surface Analysis Operations

Slope – Rate of change

Aspect – Direction of slope

Contours – Lines of equal value

Hillshade – Illumination of the surface

Viewshed – What can be seen from a point(s)

Visibility – points can be seen

Cut Fill
Surface Analysis - Slope
Surface Analysis - Aspect

Aspect Angle
- Flat (-1)
- North (0-22.5)
- Northeast (22.5-67.5)
- East (67.5-112.5)
- Southeast (112.5-157.5)
- South (157.5-202.5)
- Southwest (202.5-247.5)
- West (247.5-292.5)
- Northwest (292.5-337.5)
- North (337.5-360)
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Surface Analysis - Hillshade
Surface Analysis - Contours
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Working with Grid Layers — Terminology

Grid
A data layer in Raster format, composed of cells
ESRI’s specific raster format
Grids can be converted to/from vector
Grids can be viewed as an image layer w/o Spatial Analyst

Cells
One square pixel or raster. Any size.
Size is an indicator of accuracy/resolution
Normally has one value
Working with Grid Layers — Terminology

Zone
All cells in a grid with the same value. They do not have to be contiguous.

Regions
Zones where all the cells are contiguous. These are analogous to “polygons.

Need to be specifically grouped with Regiongroup function if they are to be analyzed as a polygon-type region.
Working with Grid Layers — Data Values

**Value**

The numeric value of the grid cell

Values can be true numbers or codes

Integer (discrete) or Floating Point (continuous) grid

Some functions are “decimal dependent” (values are either integers or contain decimal values)
Zero vs. NoData

Zero is a valid value
   Can be used as a number, or a ranking, or a code

NoData means NULL
   Value is unknown or does not exist

Can GREATLY effect GRID functions

Can be used as a “mask”
Working with Grid Layers — Tables

.VAT

The feature attribute table for a GRID (Value Attribute Table)

Only accessible for integer / discrete grids

Contains Value and Count field with a record for each value, not each cell

The data is already “frequenced”. For each value, the count is already known
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Spatial Analyst Raster Calculator

Using the Raster Calculator

Used for Queries and Calculation

Provides access to Map Algebra

Map Algebra expression

The Map Algebra expression you want to run.

The expression is composed by specifying the inputs, values, operators, and tools to use. You can type in the expression directly or use the buttons and controls to help you create it.

- The Layers and variables list identifies the datasets available to use in the Map Algebra expression.
- The buttons are used to enter numerical values and operators into the expression. The ( and ) buttons can be used to apply parentheses to the expression.
- A list of commonly used tools is provided for you.
Spatial Analyst Demonstration
Spatial Analyst Capabilities
Raster Calculator
Spatial Analyst and Raster Analysis

Neighborhood Analysis

The Neighborhood Function on a Grid

Expression: FOCALVARIETY(INGRID1, RECTANGLE, 3, 3)
Neighborhood Analysis

“Minesweeper”
An example of classic 3-cell x 3-cell

Each number (cell value) indicates the number of bombs within a 3-cell neighborhood.
What happens when your analysis is faulty
Types of Neighborhoods

Rectangular (Window)

Circular

Annulus (Donut)

Wedge
Neighborhood Analysis

Types of Analysis

Mean…Median…Sum

Majority…Minority

Variety…Range

Standard Deviation
Cartographic modeling is the process of outlining the analysis flow.

Step 1: Determine Criteria.

Steps 2 & 3: 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
Cartographic modeling is the process of outlining the analysis flow.

Step 4: Work back from each criteria to base data.

Slope desirability grid ranked 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

Cartographic modeling is the process of outlining the analysis flow.

Step 5: Diagram the process flow.
Map Algebra Concepts

Map Algebra requires grids that 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.

Figure 1: Map algebra

example: Multiply A by B and divide by C

\[(A \times B \div C = D)\]
Simple “Good/Bad” Map Algebra 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.

<table>
<thead>
<tr>
<th></th>
<th>Good Slope = 1</th>
<th>Bad-Slope= 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Aspect = 1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Bad Aspect = 0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Simple “Good/Bad” Map Algebra 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.

<table>
<thead>
<tr>
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<th>Bad-Slope= 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Aspect</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bad Aspect</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Multiple criteria ranked on an interval scale.

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.

<table>
<thead>
<tr>
<th>Criteria &amp; Ranking</th>
<th>Sample scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>(1-4)    2</td>
</tr>
<tr>
<td>Streams</td>
<td>(1-4)    4</td>
</tr>
<tr>
<td>Slope</td>
<td>(1-4)    3</td>
</tr>
<tr>
<td>Aspect</td>
<td>(1-4)    3</td>
</tr>
<tr>
<td><strong>Possible range</strong></td>
<td><strong>(4-16)</strong></td>
</tr>
<tr>
<td>Sample Results</td>
<td>12</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Criteria/Ranking</th>
<th>Ranking * 1,10,100,1000</th>
<th>Sample scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accessibility</td>
<td>(1-4) Accessibility (1-4)</td>
<td>2</td>
</tr>
<tr>
<td>Streams</td>
<td>(1-4) Streams (10-40)</td>
<td>40</td>
</tr>
<tr>
<td>Slope</td>
<td>(1-4) Slope (100-400)</td>
<td>300</td>
</tr>
<tr>
<td>Aspect</td>
<td>(1-4) Aspect (1000-4000)</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>Possible range (1111-4444)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sample Results 3342</td>
<td></td>
</tr>
</tbody>
</table>
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Demonstration 2: Finding Elephant Conservation Areas