Spatial Analyst and Raster Analysis

Developed and Presented by Juniper GIS

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Spatial Analyst and Raster Analysis

Course Objectives

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

Topics:

Understanding Raster GIS

Demonstrating Spatial Analyst Interface and Operations

Grid functions for Spatial Analysis

Cartographic Modeling

Map Algebra

Raster Analysis Techniques

Opportunities to ask questions and participate

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

What is the Spatial Analyst extension?

Spatial Analyst provides raster functionality within ArcGIS and works with ArcView, ArcEditor, and ArcInfo.

- Adds menus and tools with basic raster functions to ArcGIS.
- Most functionality accessed as GRID requests or ArcToolbox tools.
- Works with Vector and Grid data formats.
- Full range of raster capabilities and analysis tools.
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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

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

- Terrain Modeling
- Population Modeling
- Modeling any numeric value
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**

Fire Hazard = [Fuel Density Hazard] + [Fuels Hazard] + [Slope Hazard] + 3
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
Creating Surfaces

Values extruded in the Z direction
Creating Surfaces

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)
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Working with Surfaces

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
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Working with Surfaces

Continuous raster surface of downtown Bend based on 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 - 4,000,000
Continuous population surface of downtown Bend based on 2000 census data.
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)
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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
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Surface Analysis - Contours
Surface Analysis - Contours

Population
- 0 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 60
- 61 - 70
- 71 - 80
- 81 - 90

Contour Values
- 0 - 500,000
- 500,001 - 1,000,000
- 1,000,001 - 1,500,000
- 1,500,001 - 2,500,000
- 2,500,001 - 3,500,000
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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
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”
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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 Grid Functions

Map Algebra
Spatial Analyst Demonstration
Spatial Analyst Capabilities
Raster Calculator

Mount Kenya Elevation
High: 4786.1
Low: 352.72
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
Neighborhood Analysis

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

Wedge:
- Wedge Start angle
- End angle
- Radius

Example of a wedged neighborhood: A wedge-shaped neighborhood is defined by a start angle, an end angle, and a radius. The wedge extends counterclockwise from the starting angle to the ending angle. Angles are specified in degrees, with 0 or 360 representing East. Negative angles may be used. The default is 0 to 90 degrees, with a radius of three cells.

Units can be defined in cell units or map units.
Types of Analysis

- Mean
- Median
- Sum
- Majority
- Minority
- Variety
- Range
- Standard Deviation
Building Expressions

About building expressions

Use the Raster Calculator to build expressions to weight rasters and combine them as part of a suitability model, to make selections on your data in the form of queries, or to apply mathematical operators and other functions.

- Use layers in the map or type the full pathname to grid datasets on disk, for example:
  
slope(c:\{spatial\}elevation)

  will use the elevation grid dataset in the location specified and calculate the slope. This expression:

  gridshape([landuse])

  will convert the grid layer landuse to a shapefile.

- If your input dataset is in your working directory, you only need to type the name of the dataset:

  focalmean(ingrid1, rectangle, 5, 5)

  ingrid1 resides in the working directory set on the General tab of the Options dialog.

For more information

Start by looking at this topic in the Desktop Help: The Raster Calculator

Tips

- To obtain usage information for Spatial Analyst functions, type the function into the Raster Calculator, select it, right-click and click Usage.
Raster Calculator/Grid Functions

Finding Help for Tools/Functions

ArcToolbox

Type in the keyword to find:

reg

Reclassify (sa)
Reclass by Table (sa)
Reconcile Version (management)
Region Group (sa)
Register As Versioned (management)
Remove Attribute Index (management)
Remove Domain From Field (management)
Remove Feature Class From Topology (management)
Remove Join (management)
Remove Rule From Topology (management)
Remove Spatial Index (management)
Remove Subtype (management)
Rename (management)
Repair Geometry (management)
Resample (management)

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+ Surface tools
+ Zonal tools

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### Spatial Analyst and Raster Analysis

#### Raster Calculator/Grid Functions

**Function/Tool Help Dialog**

#### Spatial Analyst

**RegionGroup**

- **Related topics**
  - expand all

Records for each cell in the output the identity of the connected region to which it belongs within the analysis window. A unique number is assigned to each region.

- Illustration
- Usage tips
- Command line syntax
- Scripting syntax
- Map Algebra syntax

RegionGroup(<grid>, {c_remap_table}, {FOUR | EIGHT}, {WITHIN | CROSS}, {excluded_value}, {LINK | NOLINK})

**Parameters**

<table>
<thead>
<tr>
<th>Expression</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;grid&gt;</td>
<td>An input integer grid whose cells define the zone values to be regrouped.</td>
</tr>
</tbody>
</table>
Syntax for Grid Functions

Functions consist of requests, inputs, parameters, and outputs, separated by commas.

< > indicates required parameter

{} indicate optional parameters

If parameters are skipped, insert # as a placeholder

Words in all caps are KEYWORDS

Syntax example

Slope(<grid>, <z_factor>, {DEGREE | PERCENTRISE})
Cartographic modeling is the process of outlining the analysis flow.

Step 1: Determine criteria.

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
Cartographic modeling is the process of outlining the analysis flow.

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 is the process of outlining the analysis flow.

**Step 4:** 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

\( A \times B \div C = D \)
Map Algebra Concepts

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>Good Aspect = 1</th>
<th>Bad-Slope = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bad Aspect = 0</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<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>
<th></th>
<th>Good Slope = 1</th>
<th>Bad-Slope= 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good Aspect = 1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bad Aspect = 0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Map Algebra Concepts

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>2</td>
</tr>
<tr>
<td>Streams</td>
<td>4</td>
</tr>
<tr>
<td>Slope</td>
<td>3</td>
</tr>
<tr>
<td>Aspect</td>
<td>3</td>
</tr>
<tr>
<td>Possible range</td>
<td>12</td>
</tr>
<tr>
<td>Sample Results</td>
<td></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</td>
<td>3342</td>
</tr>
</tbody>
</table>
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Demonstration 2: Finding Elephant Conservation Areas
What is Model Builder?

Graphical interface used to build tools to perform:

- Repetitive Tasks
- Suitability Models
- Process Models

“Capture a workflow”
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Working with ModelBuilder

What is Model Builder?

Provides a method to run several variations of the analysis.
Creating a Model

Created in a “Custom” Toolbox in ArcToolbox; built by dragging data and tools into the ModelBuilder window and setting properties.
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Working with ModelBuilder

Creating a Model

The different elements are manipulated from the context menu.

Opening a Tool opens the same dialog box normally accessed from ArcToolbox.
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Demonstration 3: Creating a Model for Elephant Habitat