Esri International User Conference | San Diego, CA

Technical Workshops | **********

Python - Raster Analysis

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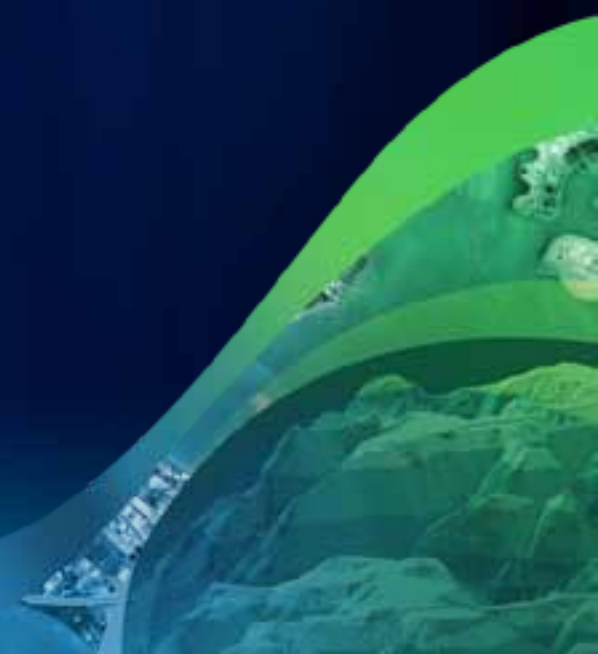


The problem that is being addressed

- You have a complex modeling problem
- You are mainly working with rasters
- Some of the spatial manipulations that you trying to implement are difficult or not possible using standard ArcGIS tools
- Due to the complexity of the modeling problem, processing speed is a concern

Outline

- Managing rasters with management tools and performing analysis with Map Algebra
- How to access the analysis capability - Demonstration
- Complex expressions and optimization - Demonstration
- Additional modeling capability: classes - Demonstration
- Full modeling control: NumPy arrays - Demonstration
- Pre-10 Map Algebra

The complex model

Emerald Ash Borer

Originated in Michigan

Infest ash trees

100% kill

Coming to Vermont

The ash borer model

- Movement by flight
  - 20 km per year
  - Vegetation type and ash density (suitability surface)
- Movement by hitchhiking
  - Roads
  - Camp sites
  - Mills
  - Population
  - Current location of the borer (suitability surface)
- Random movement

Raster analysis

- To prepare and manage raster data
  - Displaying
  - Adding, copying, deleting, etc.
  - Mosaic, Clip, etc.
  - Raster object
  - NumPy, ApplyEnvironment, etc.

- To perform the analysis use raster analysis/modeling
  - Spatial Analyst
  - Map Algebra

What is Map Algebra

- Simple and powerful algebra to execute Spatial Analyst tools, operators, and functions to perform geographic analysis
- The strength is in creating complex expressions
- Available through Spatial Analyst module
- Integrated in Python (all modules available)

Importing Spatial Analyst

- Module of ArcPy site package
- Like all modules must be imported
- To access the operators and tools in an algebraic format the imports are important

```
import arcpy
from arcpy import env  # Analysis environment
from arcpy.sa import *
```

General syntax

- Map Algebra available through an algebraic format
- Simplest form: output raster is specified to the left of an equal sign and the tool and its parameters on the right

```
from arcpy.sa import  *
outRas = Slope("indem")
```

- Comprised of:
  - Input data
  - Operators
  - Tools
  - Parameters
  - Output

Input data

- Input elements
  - Rasters
  - Features
  - Numbers
  - Constants
  - Objects
  - Variables

outRas = Slope(“inraster”)

Tip: Names are quoted – if in workspace no path is necessary (or if using Python window and the layer is in the TOC)

Map Algebra operators

- Symbols for mathematical operations
- Many operators in both Python and Spatial Analyst
- Cast the raster (Raster class constructor) indicates operator should be applied to rasters

```
outRas = Raster("inraster1") + Raster("inraster2")
outRas2 = Raster("inraster") + 8
```

Map Algebra tools

- All the tools that output a raster are available (e.g., Sin, Slope, Reclassify, etc.)

```
outRas = Aspect("inraster")
```

- Can use any Geoprocessing tools

Tip: Tool names are case sensitive

Tool parameters

- Defines how the tool is to be executed
- Each tool has its own unique set of parameters
- Some are required, others are optional
- Numbers, strings, and objects (classes)

```
outRas = Slope("inraster", "PERCENT_RISE")
```

Tip: Keywords are in quotes and it is recommended they are capitalized

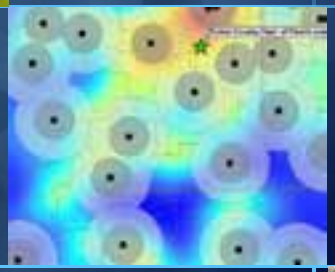
Map Algebra output

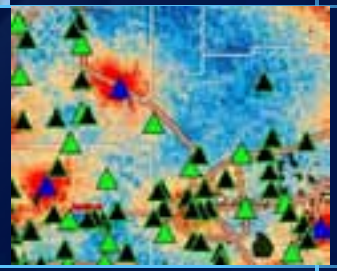
- Stores the results as a **Raster object**
- Object with methods and properties
- Generally, in Python window and scripting the output is **temporary**

```
outRas = Hillshade("inraster")
```

Access to Map Algebra

- **Raster Calculator**
  - **Spatial Analyst tool**
  - **Easy to use calculator interface**
  - **Stand alone or in ModelBuilder**
- **Python window**
  - **Single expression or simple exploratory models**
- **Scripting**
  - **Complex models**
  - **Line completion and colors**





Demo 1: Data management

Raster management tools

Raster Calculator

Python window

ModelBuilder

Simple expressions

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Complex expressions

- Multiple operators and tools can be implemented in a single expression

- Output from one expression can be the input to a subsequent expression

Tip: It is a good practice to set the input to a variable and use the variable in the expression

More on the raster object

- A **variable** with a pointer to a dataset
- Output from a Map Algebra expression or from an existing dataset
- The associated dataset is **temporary** (when created from Map Algebra) but has a save method
- A series of properties describing the associated dataset
  - Description of raster (e.g., number of rows)
  - Description of the values (e.g., mean)

Optimization

- A series of local tools (Abs, Sin, Cell Statistics, etc.) and operators can be optimized
- Work on a per-cell basis
- When entered into a single expression each tool and operator is processed on a per cell basis

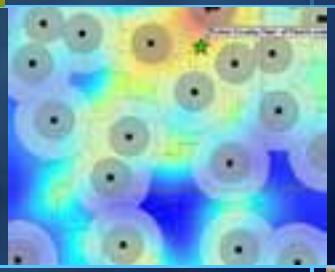
The iterative aspects of the ash borer model

- Movement by flight
  - Depends on the year how far it can move in a time step
  - “Is there a borer in my neighborhood”
  - “Will I accept it” – suitability surface
- Movement by hitchhiking
  - Based on highly susceptible areas
  - Nonlinear decay
  - Random points and check susceptibility
- Random movement
  - Nonlinear decay from known locations (NumPy array)

Demo 2: Movement by **hitchhiking**

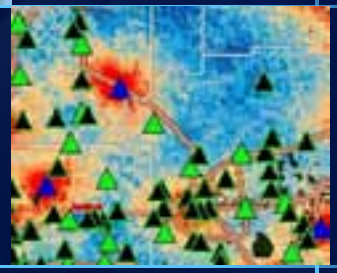
Roads, Campsites, Mills, Population,

and current location (suitability)



Complex expressions

Raster object



Optimization

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Classes

- Objects that are used as parameters to tools
  - Varying number of arguments depending on the selected parameter choice (neighborhood type)
  - The number of entries into the parameters can vary depending on the specific situation (a remap table)
- More flexible
- Query the individual arguments

Classes - Categories

- General
  - Fuzzy classes
  - Hf classes
  - KrigingModel classes
  - Nbr classes
  - Time classes
  - VF classes
  - Radius classes
- Composed of lists
  - Topo classes
- Composed of lists within lists
  - Reclass
  - Topo classes (a subset)
  - Weighted reclass tables

Classes - Categories

- Creating

  neigh = NbrCircle(4, “MAP”)

- Querying

  radius = neigh.radius

- Changing arguments

  neigh.radius = 6

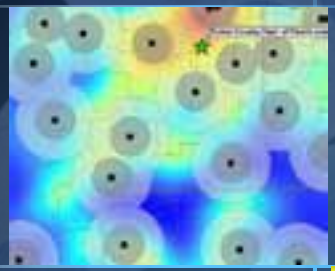
Vector integration

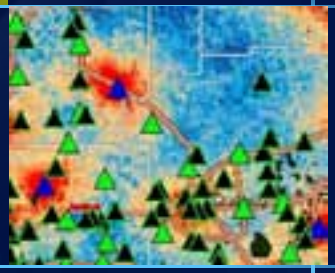
- Feature data is required for some Spatial Analyst Map Algebra
  - IDW, Kriging, etc.
- Geoprocessing tools that operate on feature data can be used in an expression
  - Buffer, Select, etc.

The iterative aspects of the ash borer model

- **Movement by flight**
  - **Depends on the year how far it can move in a time step**
  - **“Is there a borer in my neighborhood”**
  - **“Will I accept it” – suitability surface**
- **Movement by hitchhiking**
  - **Based on highly susceptible areas**
  - **Nonlinear decay**
  - **Random points and check susceptibility**
- **Random movement**
  - **Nonlinear decay from known locations (NumPy array)**

Demo 3: Movement by flight





20 km per year

Vegetation type/ash density (suitability)

Classes

Using variables

Vector integration

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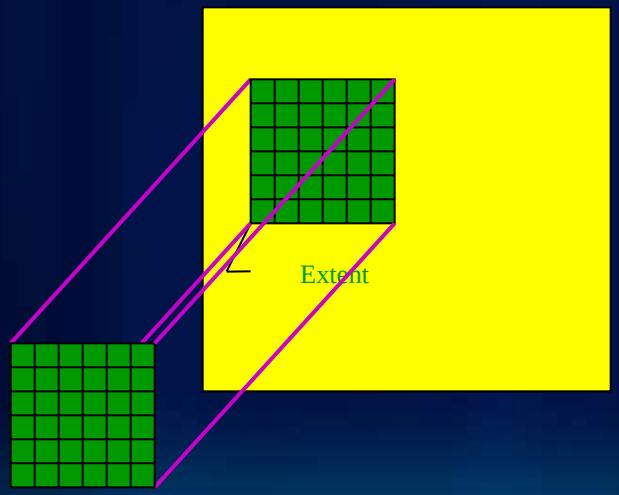
NumPy Arrays

- A generic Python storage mechanism
- Create custom tool
- Access the wealth of free tools built by the scientific community
  - Clustering
  - Filtering
  - Linear algebra
  - Optimization
  - Fourier transformation
  - Morphology

NumPy Arrays

- Two tools
  - RasterToNumPyArray
  - NumPyArrayToRaster



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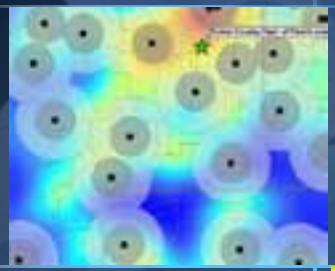


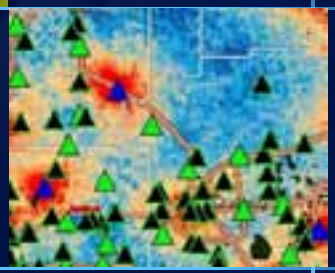
Demo 4: The random movement

Random movement based on nonlinear

decay from existing locations

Custom function

NumPy array



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Pre-10.0 Map Algebra

- Similar to Map Algebra 10.0
- Faster, more powerful, and easy to use (line completion, colors)
- Any changes are to take advantage of the Python integration
- Raster Calculator at 10.0 replaces the Raster Calculator from the tool bar, SOMA, and MOMA
- SOMA in existing models will still work

Summary

- When the problem become more complex you may need additional capability provided by Map Algebra
- Map Algebra powerful, flexible, easy to use, and integrated into Python
- Accessed through: Raster Calculator, Python window, ModelBuilder (through Raster Calculator), and scripting
- Raster object and classes
- Create models that can better capture interaction of phenomena

ArcGIS Spatial Analyst Technical Sessions

- **An Introduction - Rm 1 A/B**

Tuesday, July 12, 8:30AM – 9:45AM
Thursday, July 14, 10:15AM – 11:30AM

- **Suitability Modeling - Rm 1 A/B**

Tuesday, July 12, 1:30PM – 2:45PM
Thursday, July 14, 8:30AM – 9:45AM

- **Dynamic Simulation Modeling – Rm 5 A/B**

Wednesday, July 13, 8:30AM – 9:45AM

- **Raster Analysis with Python – Rm 6C**

Tuesday, July 12, 3:15PM – 4:30PM
Wednesday, July 13, 3:15PM – 4:30PM

- **Creating Surfaces – Rm 5 A/B**

Wednesday, July 13, 1:30PM – 2:45PM

ArcGIS Spatial Analyst Short Technical Sessions

- **Creating Watersheds and Stream Networks – Rm 6A**

Tuesday, July 12, 10:40AM – 11:00AM

- **Performing Image Classification – Rm 6B**

Tuesday, July 12, 8:30AM – 8:50AM

- **Performing Regression Analysis Using Raster Data – 6B**

Tuesday, July 12, 8:55AM – 9:15AM

Demo Theater Presentations – Exhibit Hall C

- **Modeling Rooftop Solar Energy Potential**

Tuesday, July 12, 3:30PM – 4:00PM

- **Surface Interpolation in ArcGIS**

Wednesday, July 13, 9:00AM – 10:00AM

- **Getting Started with Map Algebra**

Wednesday, July 13, 10:00AM – 11:00AM

- **Agent-Based Modeling**

Wednesday, July 13, 5:30PM – 6:00PM

Open to Questions

…Thank You!

Please fill the evaluation form.

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