

Demystifying the Fuzz: Building a Flexible Fuzzy Logic Tool

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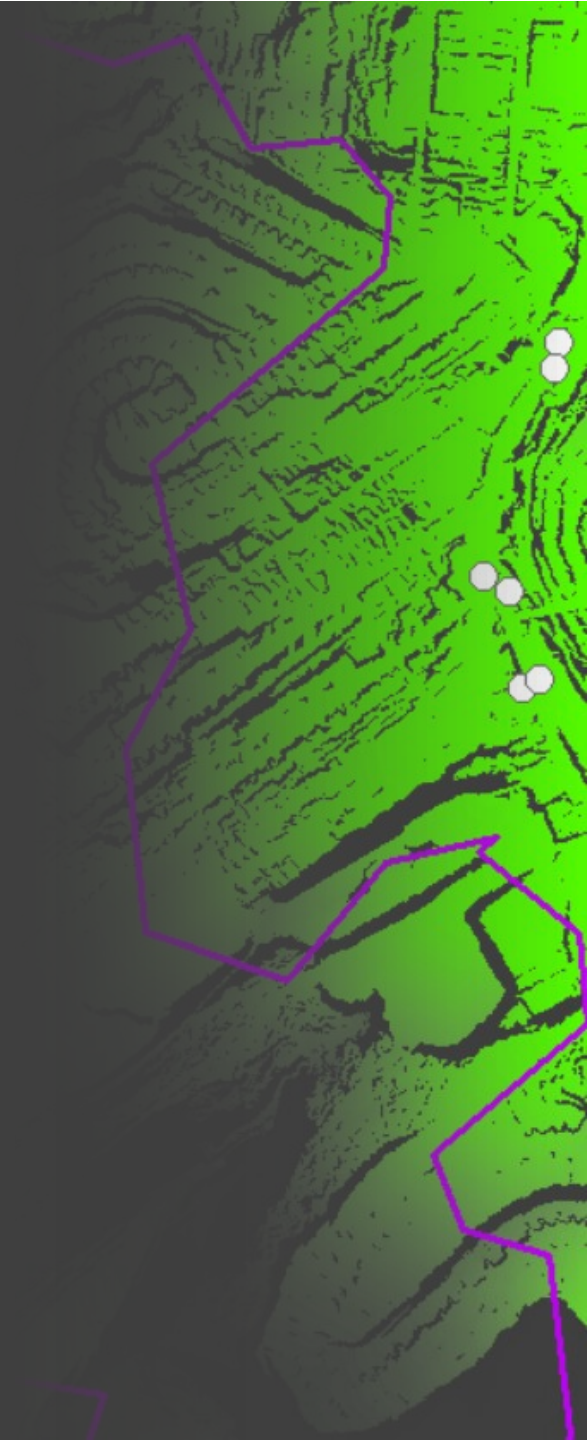
GEOG 596A, MGIS Capstone Proposal

April 2021

Advisor: Panagiotis Giannakis, PhD



1. Introduction
2. Background
3. Goal and Objectives
4. Proposed Methodology
5. Anticipated Results
6. Project Timeline
7. Presentation Venues
8. References
9. Questions



1. Introduction

Problem

Purpose

Solution

2. Background

3. Goal and Objectives

4. Proposed Methodology

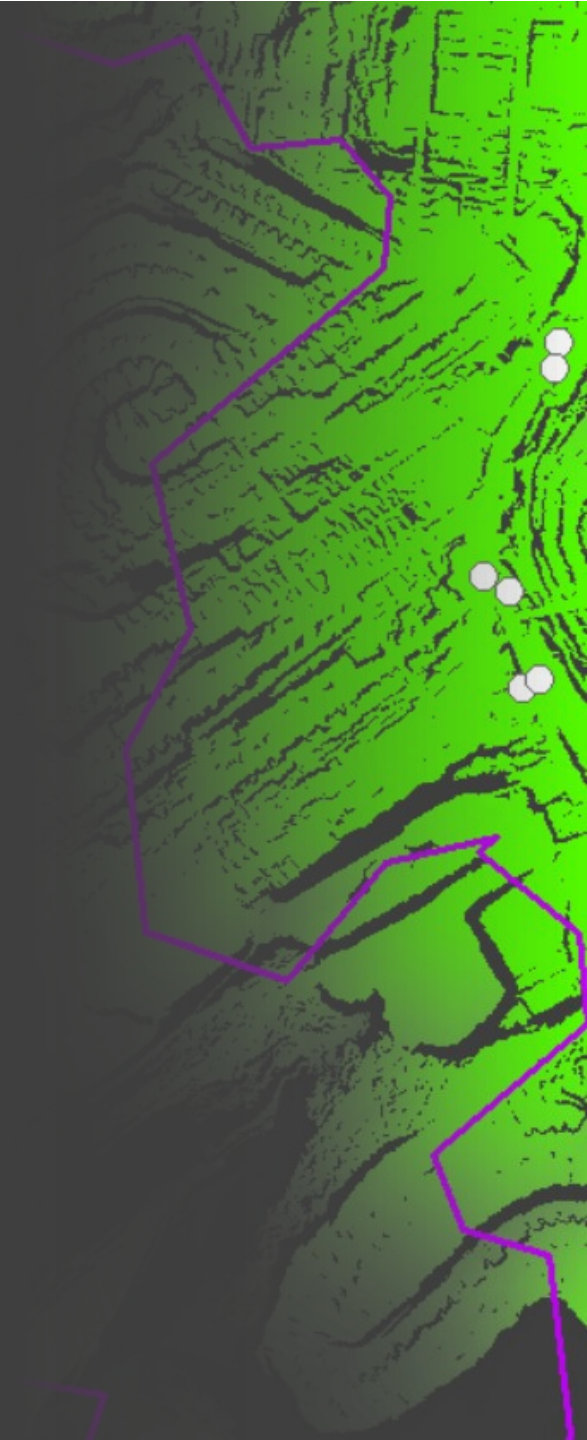
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Problem



Site selection is complicated

- Definite wrong answers
- Multiple correct answers



Problem

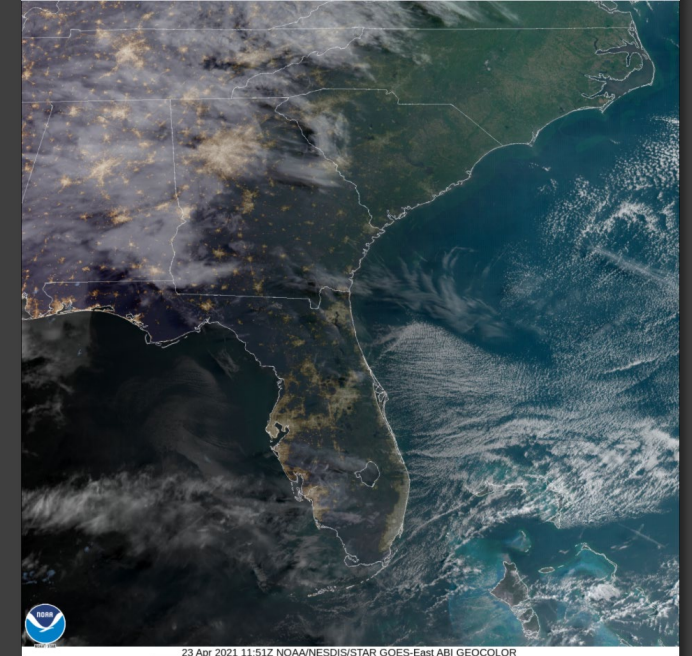


Criteria can change

- New data is discovered or made available
- Priorities shift

GOES-East - Sector view: Southeast

Images updated every 5 minutes.



23 Apr 2021 11:51Z NOAA/NESDIS/STAR GOES-East ABI GEOCOLOR



DOR Property Parcels (SHP)

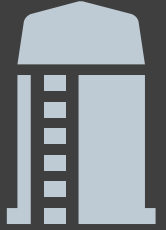
Update Frequency: Weekly

 [202101-capitalbikeshare-tripdata.zip](#)

 [202102-capitalbikeshare-tripdata.zip](#)

 [202103-capitalbikeshare-tripdata.zip](#)

Problem



Each criterion* doesn't exist in a silo

- Dependent on preferences of decision makers
- Dependent on other criteria in the analysis

*and its importance

Problem



Deadlines draw ever closer

- Too much data*, too little time
- Navigating a sea of knowledge
- Results before research

*and too many tools



200+ Spatial Analyst tools
in 25 toolsets (Esri, n.d.-a)



190+ Spatial Analyst tools
in 24 toolsets (Esri, 2020)

Purpose



Disparate problems can have a common solution

TRANSPORTATION

Sacramento's \$44 million plan to become the U.S. electric car capital

By adding electric buses, chargers, and hundreds of shared electric cars, Green City wants to help Sacramento plug in

By [Patrick Sisson](#) | Jul 17, 2018, 6:03pm EDT

MONEY

COVID-19 dining out: Restaurants take to the streets to create socially distanced dining rooms as nation reopens

[Jessica Guynn](#) USA TODAY

Published 5:02 a.m. ET May 21, 2020 | Updated 3:14 p.m. ET Aug. 10, 2020

Business

Seven "Avenues of Hope" will be Pittsburgh's development priorities

Courier Newsroom

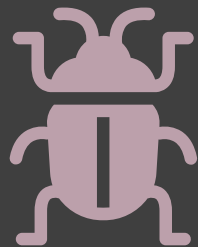
October 21, 2020



Solution

A flexible fuzzy logic tool

- User-selected data
- Hands-off automated processes
- Configured to handle various scenarios



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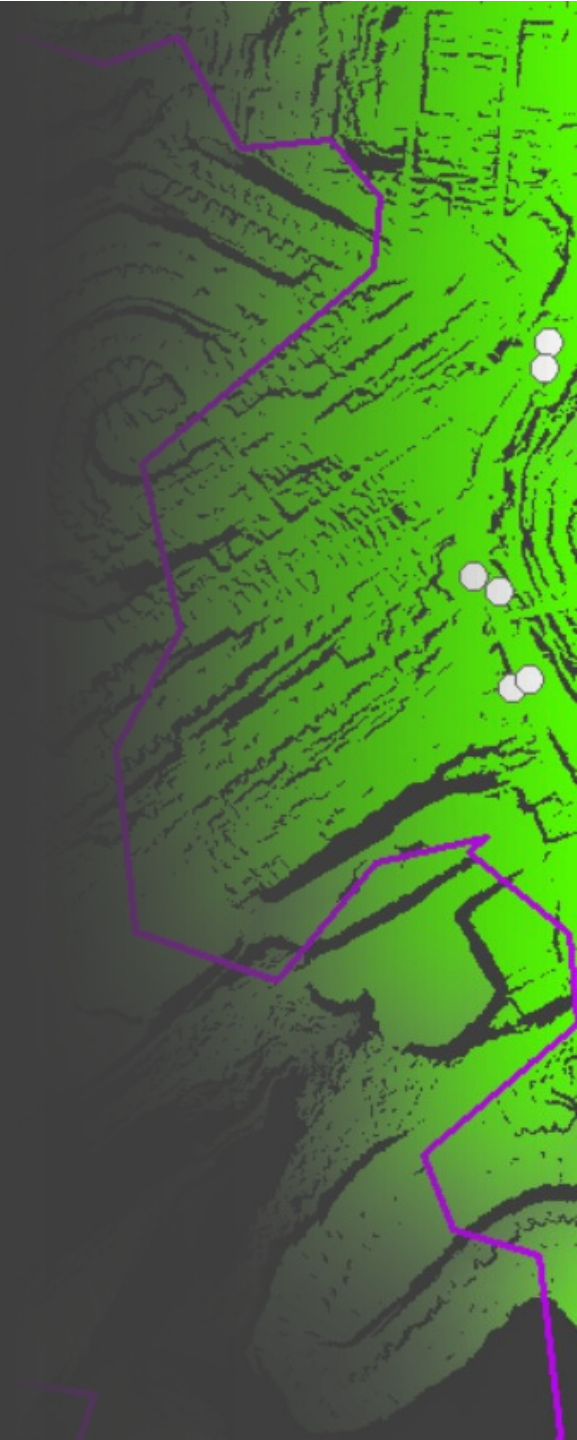
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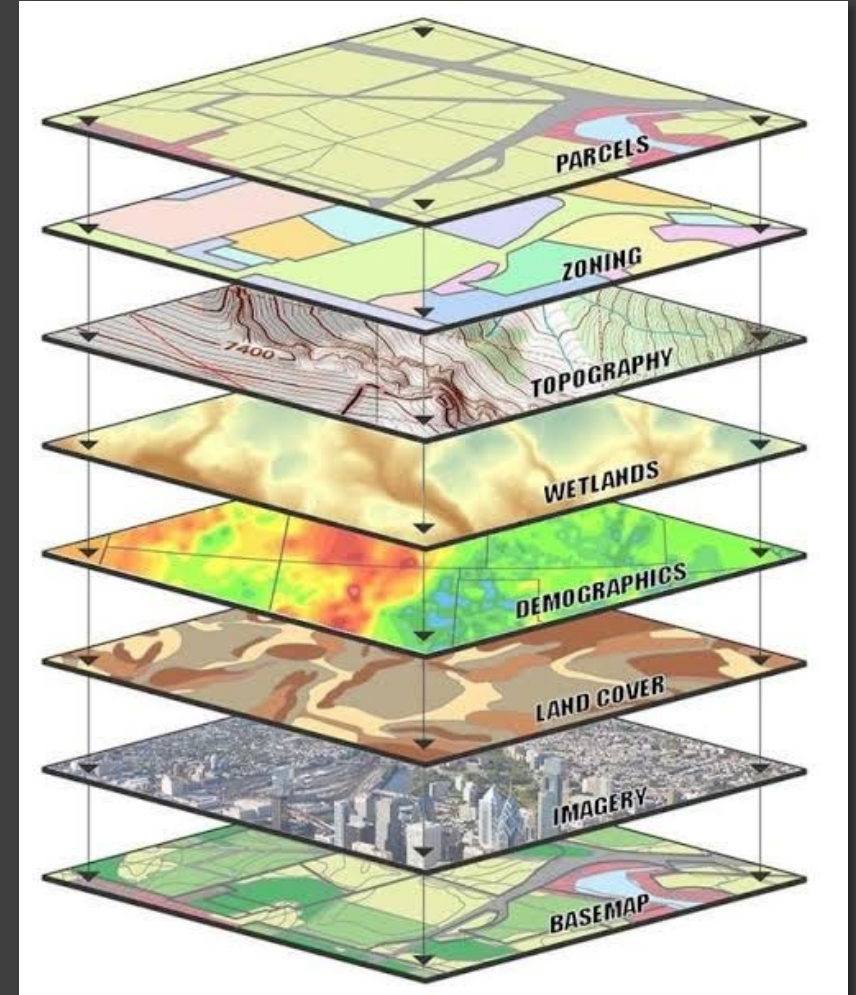
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Multi-Criteria Decision Analysis (MCDA)

Powerful way to leverage the combination of:

- Numerous, often conflicting, datasets
- Expert knowledge



Binary (Boolean) Logic

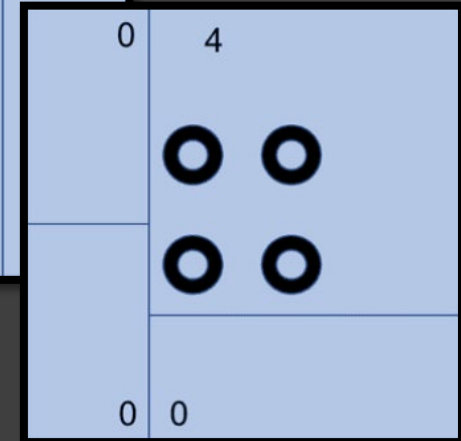
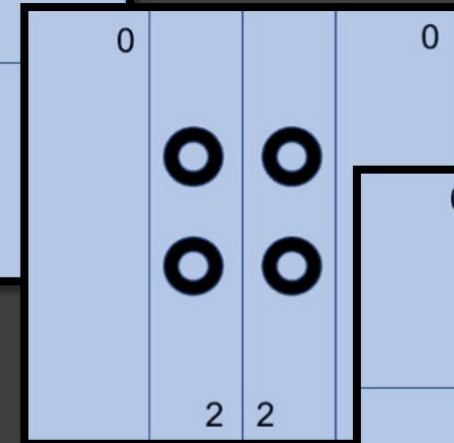
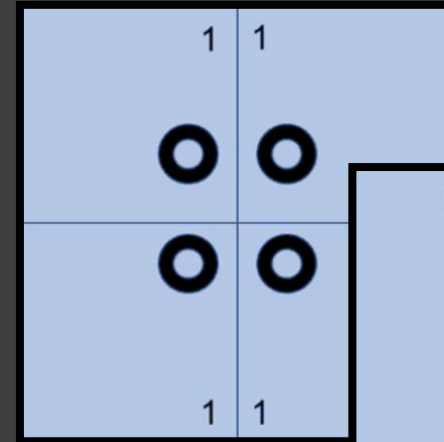
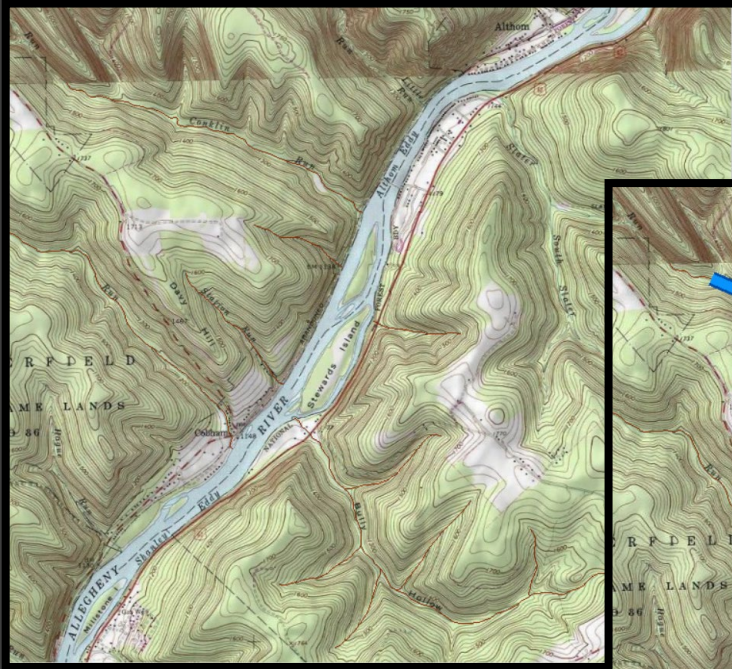
Defined membership

Limitations can be overcome with weighted overlay



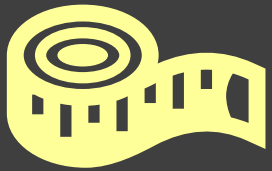
Fuzzy Logic

“There are inaccuracies in attribute and in the geometry of spatial data” (Esri, n.d.-b).



Fuzzy Logic

“Sources of inaccuracies, especially in the definition of classes, can cause imprecision in assigning cells to specific classes” (Esri, n.d.-b).



If measurements are 1 unit off,
are objects put in the wrong category?

Fuzzy Logic

“Addresses situations when boundaries between classes are not clear” (Esri, n.d.-b).

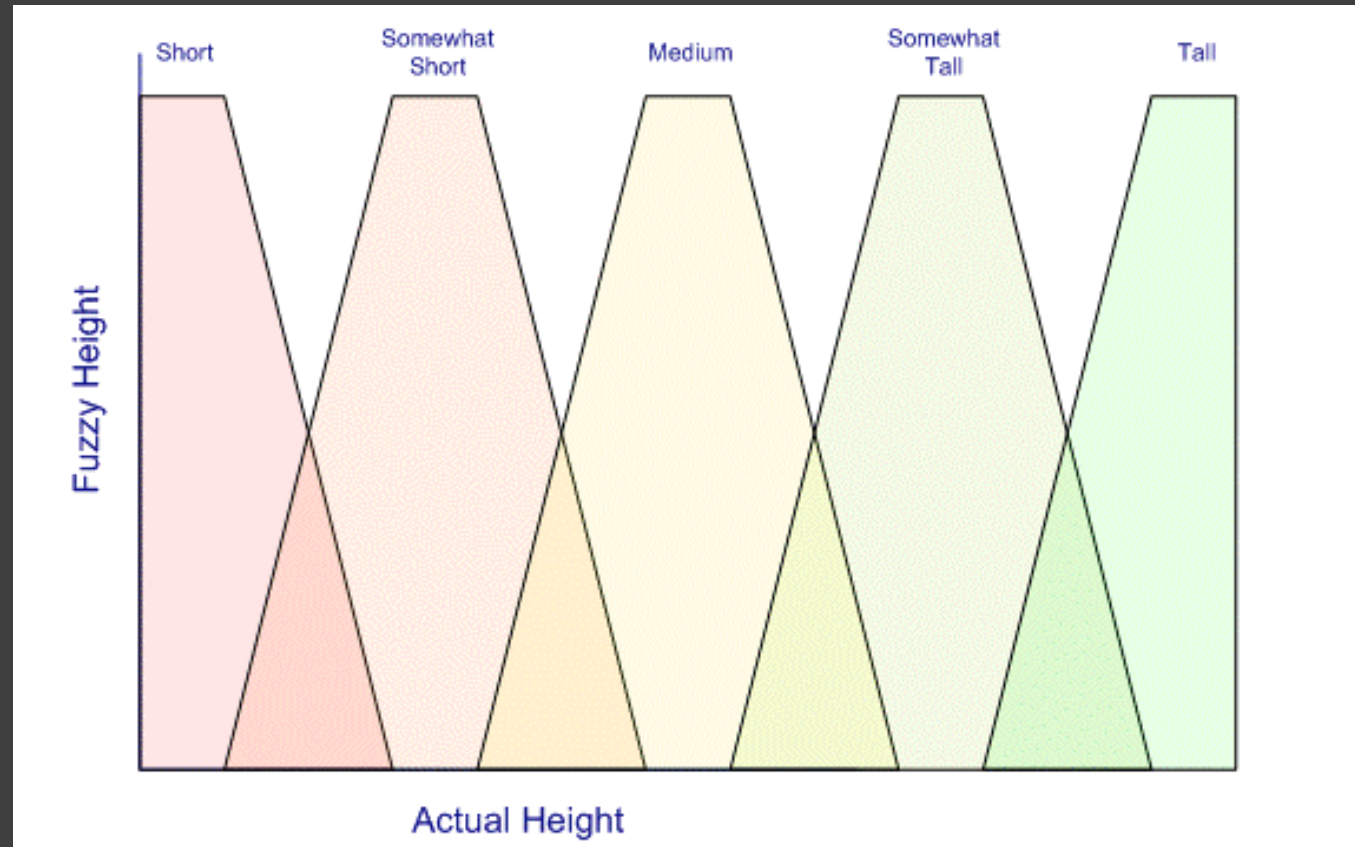


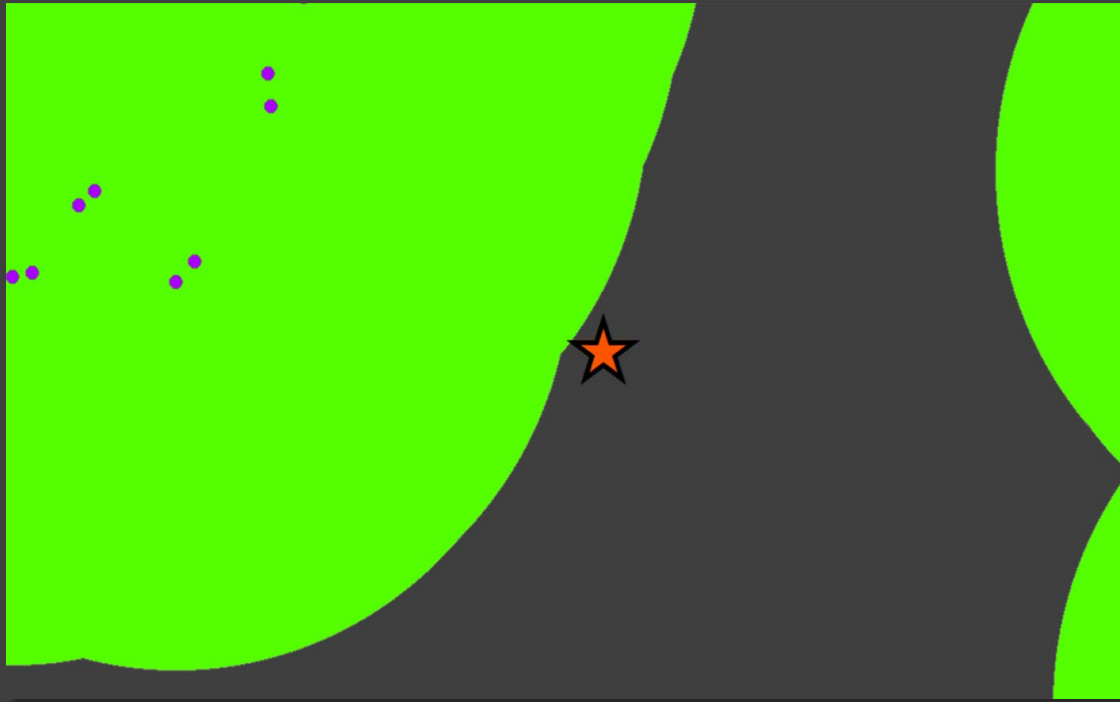
Image source:
Cochran (2013).

Reproduced here for educational purposes only.

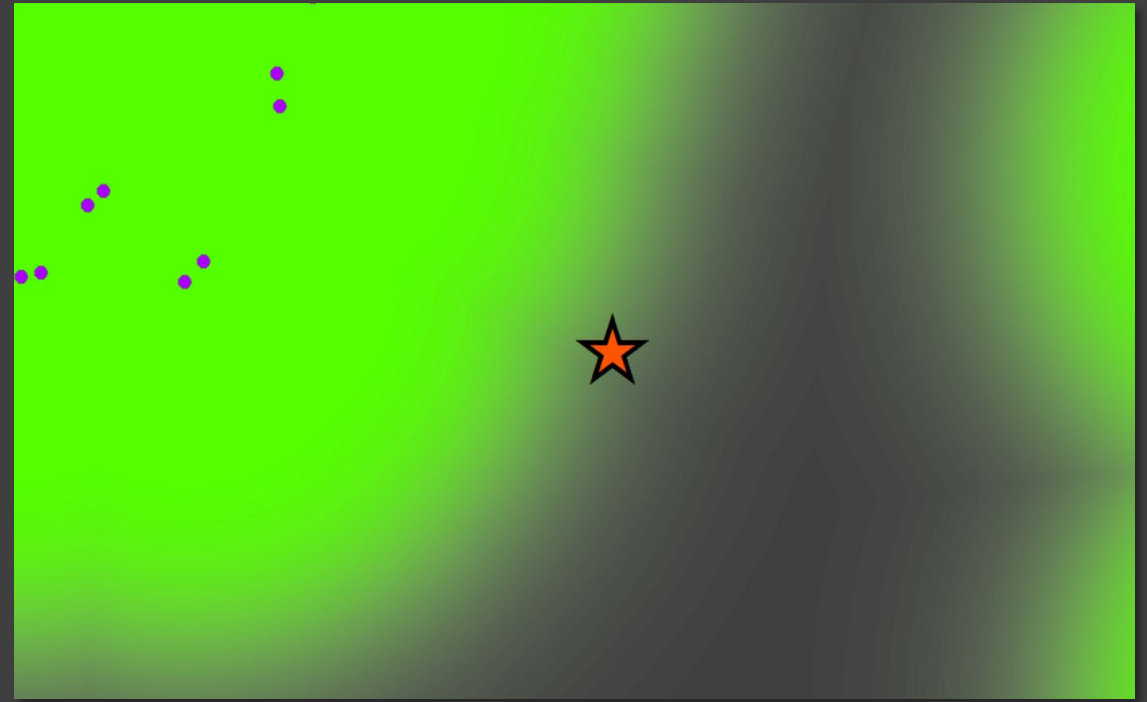
Fuzzy Logic

Is “somewhat close” somewhat acceptable?

Crisp data



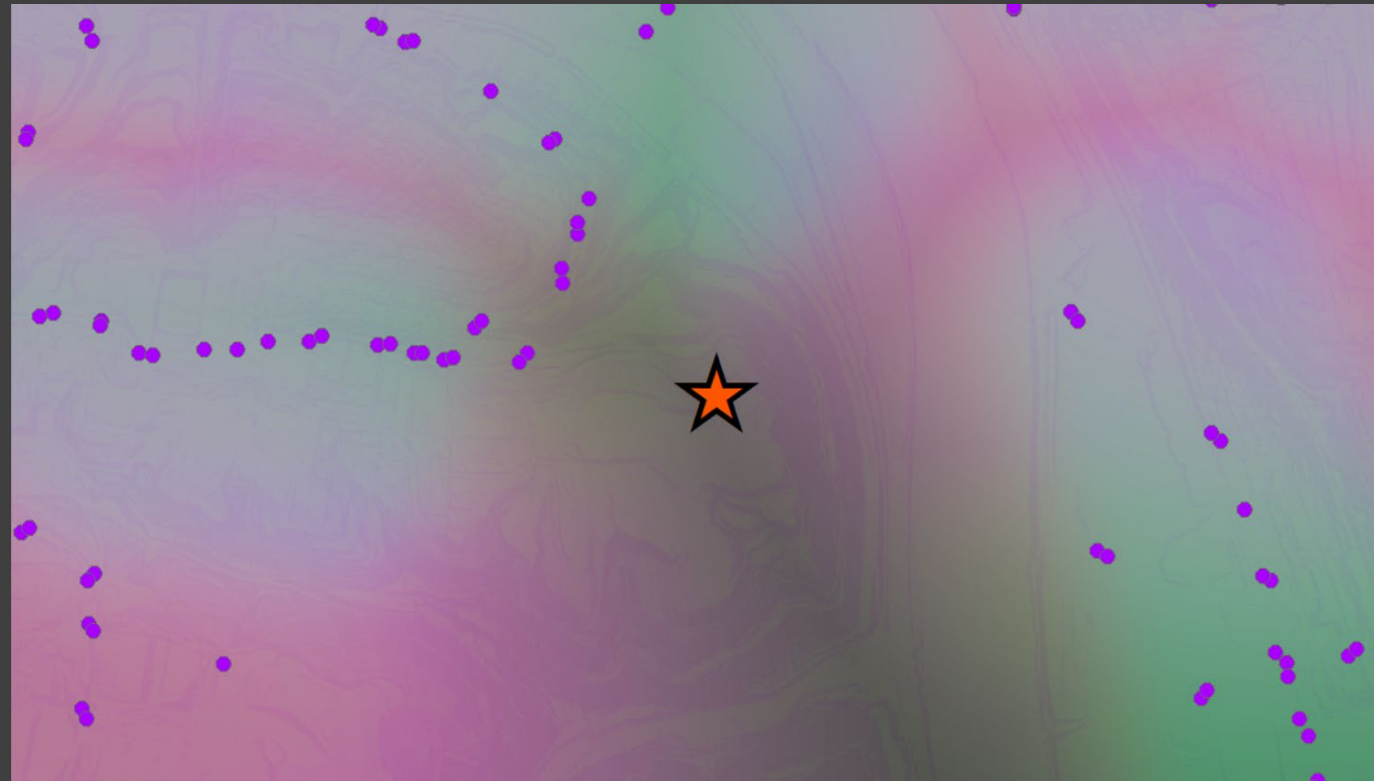
Fuzzy data



Fuzzy Logic

Fuzzy overlay to decipher membership

Overlapping fuzzy data



Automation

Reduce time spent completing tedious, repetitive tasks

Remove as many possibilities for human error as possible

```
=concatenate(  
CONCATENATE(text1, [text2], ...)
```

```
=upper(  
UPPER(text)
```

```
=vlookup(  
VLOOKUP(lookup_value, table_array, col_index_num, [range_lookup])
```

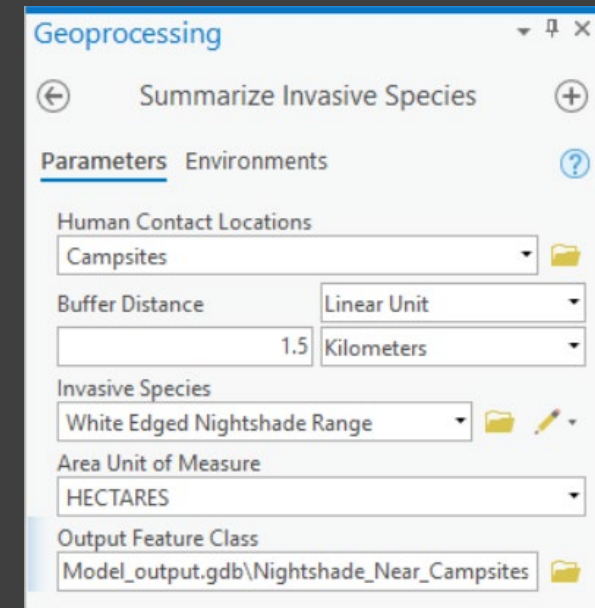


Image source:
Esri. (n.d.-c).

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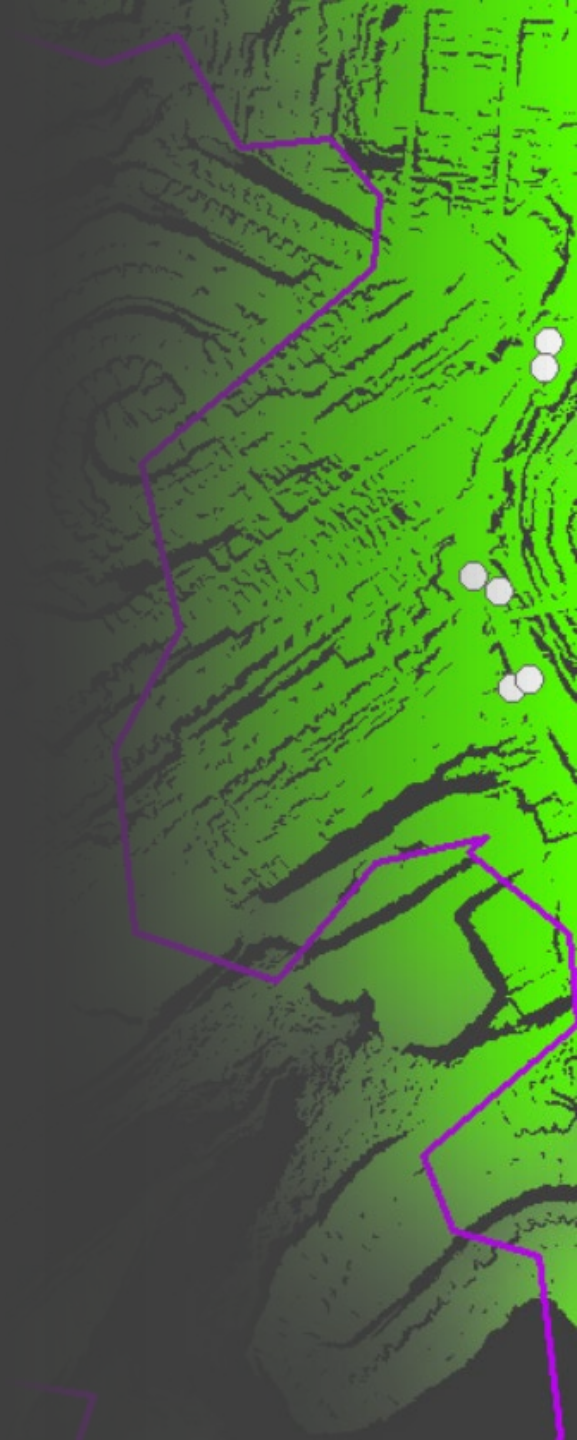
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Goal

Make fuzzy logic more accessible to GIS users outside academia

Objectives

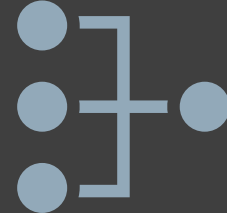
Develop a flexible fuzzy logic tool

Apply tool to answer real-world questions

Objective #1

Develop a flexible fuzzy logic tool

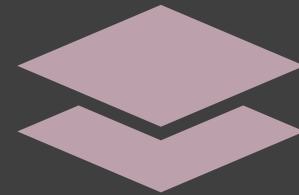
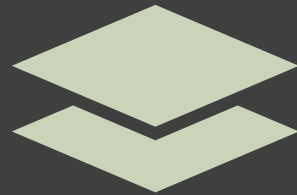
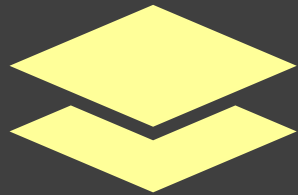
- **Combine preprocessing steps for spatial analysis with fuzzy membership and fuzzy overlay tools**



Objective #1

Develop a flexible fuzzy logic tool

- Allow users to choose layers for analysis



Objective #1

Develop a flexible fuzzy logic tool

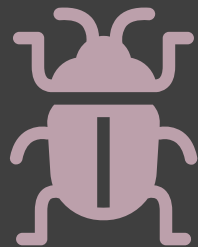
- Allow users to set membership domains for each layer



Objective #2

Apply tool to answer real-world questions

- Solve new problems in four proposed scenarios



Objective #2

Apply tool to answer real-world questions

- **Compare tool's outputs with previous decisions**
- **Re-evaluate previous decisions with new knowledge or updated criteria**

Objective #2, Scenario #1



Selecting sites for an affordable housing development

- Reverse previous trends of placing developments “out of sight, out of mind”
- Promote multi-use developments that mix residential and commercial uses
- “Excess heat and a lack of green space can affect mental well-being and increase anxiety” (Plumber & Popovich, 2020).

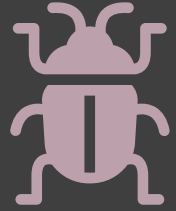
Objective #2, Scenario #1



Selecting sites for an affordable housing development

Proposed Criteria	Proposed Layers
Near job centers	Job centers (US Census On the Map)
Accessible to transit	Transit stops/stations
Within appropriate school walksheds	Schools
Not in food deserts	Grocery stores
Not geographically isolated	Elevation (slope)
Proximate to parks/greenspace	Parks
Not along major highways	Highways

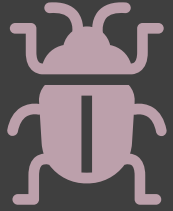
Objective #2, Scenario #2



Determining where to hang traps to detect the emerald ash borer (EAB)

- EAB is an invasive, highly destructive beetle without predators
- Costly to remove dead trees which have been infested
- Hanging traps requires time, equipment, and personnel

Objective #2, Scenario #2



Determining where to hang traps to detect the emerald ash borer (EAB)

Proposed Criteria	Proposed Layers
Ash trees	Tree canopy
Not too high elevation	Elevation
(Other ash tree indicators)	TBD — Soil, slope, aspect?
Near transit corridors	Highways/arteries, Railroads

Objective #2, Scenario #3



Selecting tree planting locations for carbon sequestration

- Meet net-zero carbon emissions goals
- Stabilize land and prevent erosion
- “Redlined neighborhoods ... consistently have far fewer trees and parks that help cool the air” (Plumber & Popovich, 2020).
- Poorly placed trees face competition with land use

Objective #2, Scenario #3



Selecting tree planting locations for carbon sequestration

Proposed Criteria	Proposed Layers
Existing greenspace	Parks
Room for growth	Parcel ownership
Unbuildable areas	Land use (zoning), Flood zones
Landslide/erosion-prone areas	Elevation (slope), Soil (drainage)
Previously redlined areas	Digitized HOLC maps

Objective #2, Scenario #4



Identifying top locations for electric vehicle (EV) quick-charging stations

- Meet net-zero carbon emissions goals
- Expand range of current EV fleet
- Accommodate residents and attract visitors who have made, or wish to make, the switch

Objective #2, Scenario #4



Identifying top locations for electric vehicle (EV) quick-charging stations

Proposed Criteria	Proposed Layers
Proximity to transit nodes	Interchanges, Arteries
Proximity to power grid	Utility lines
Adjacency to parking hubs	Parking infrastructure, Transit hubs
Adjacency to other amenities	Land use (zoning)
Distance from other stations	Station locations

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Technology

Data and Materials

Analysis and Methods

Challenges and Limitations

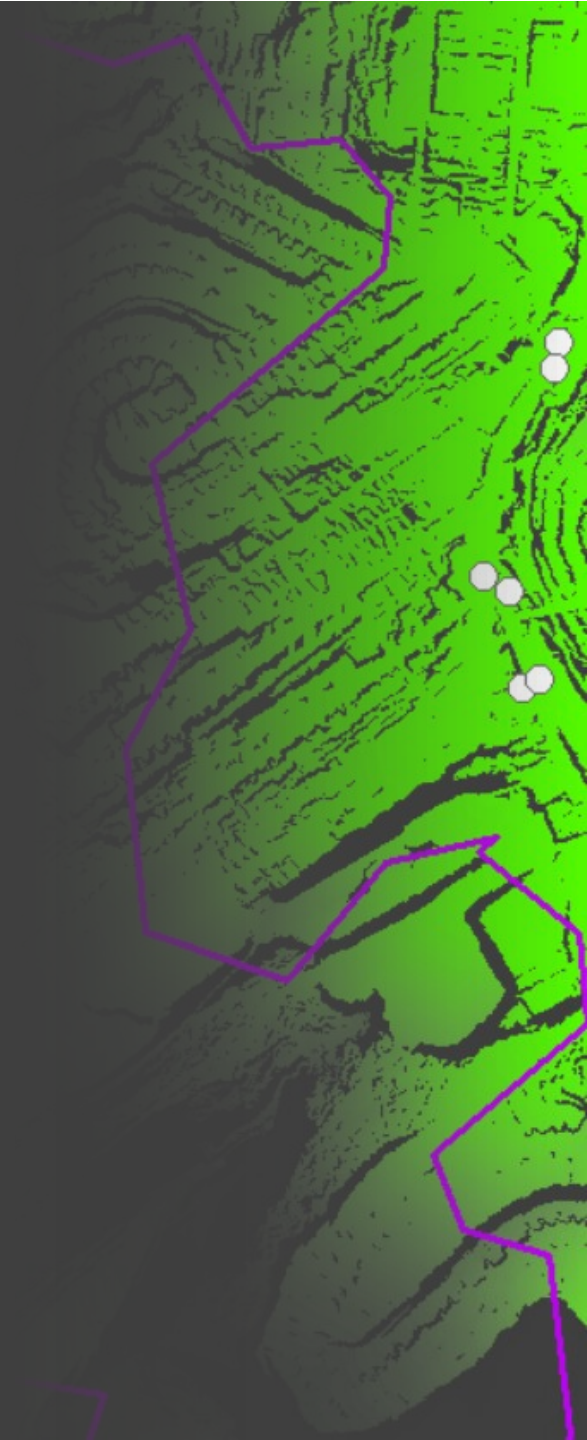
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Technology

ArcGIS Pro 2.7

- New standard
- Further leverage investment in proprietary software



ArcMap 10.8

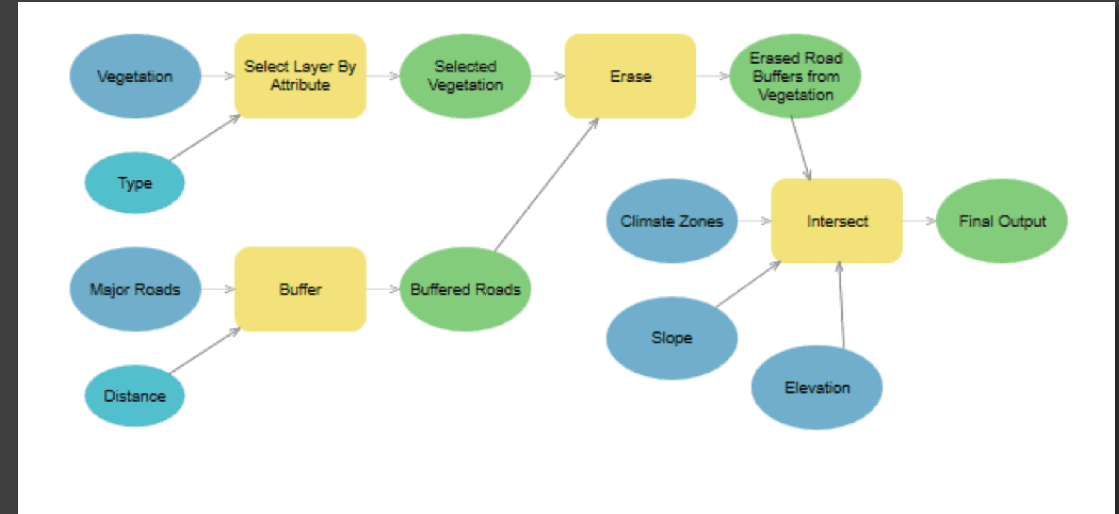
- Alternative version for those using legacy software



Technology

ModelBuilder

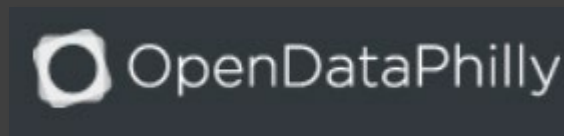
- Process and decision documentation
- More easily decipherable



Data and Materials



Other open data portals



Analysis and Methods

1. Identify scenarios

2. Attain “expert knowledge” on layers and domains for each scenario
3. Acquire data from sources
4. Build fuzzy logic tool
5. Test tool in scenarios
6. Compare how results differed from real-world examples
7. Adjust as necessary
8. Package tool to be shared

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Challenges and Limitations

Attaining “expert knowledge”

Finding appropriate data in other cities

Lack of local knowledge



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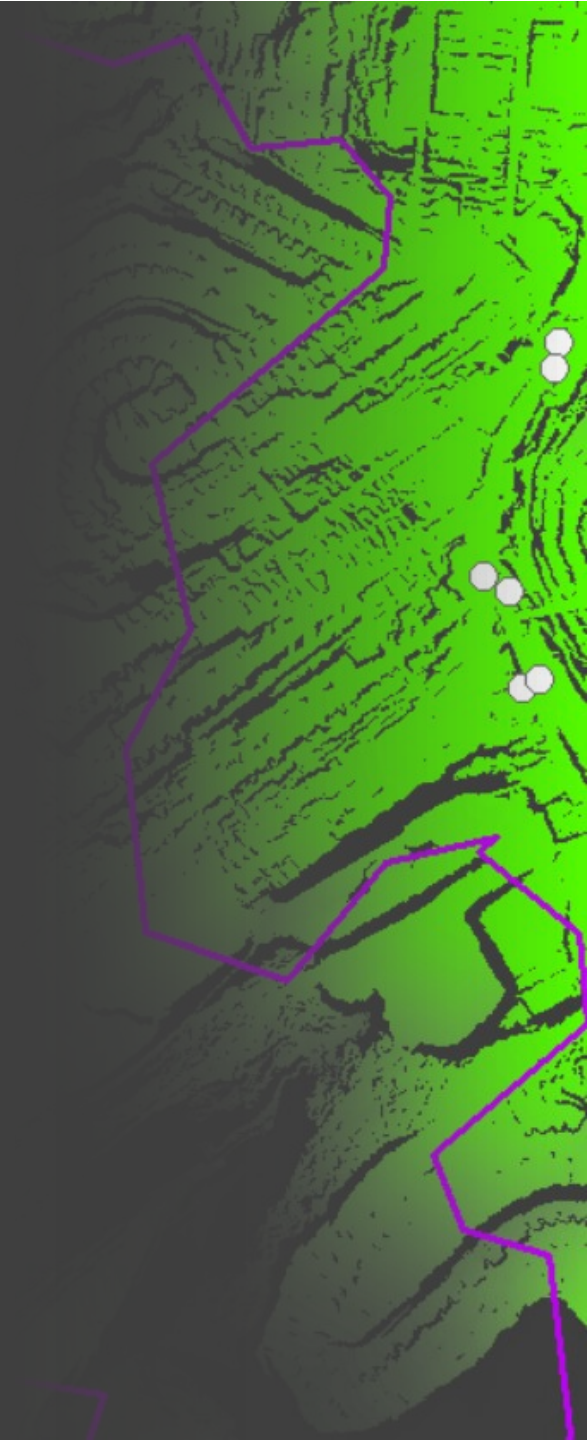
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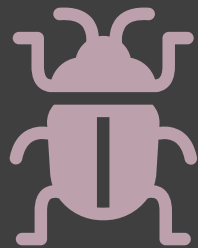
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Anticipated Results

Packaged, flexible fuzzy logic tool

Series of maps to demonstrate tool's flexibility and efficiency



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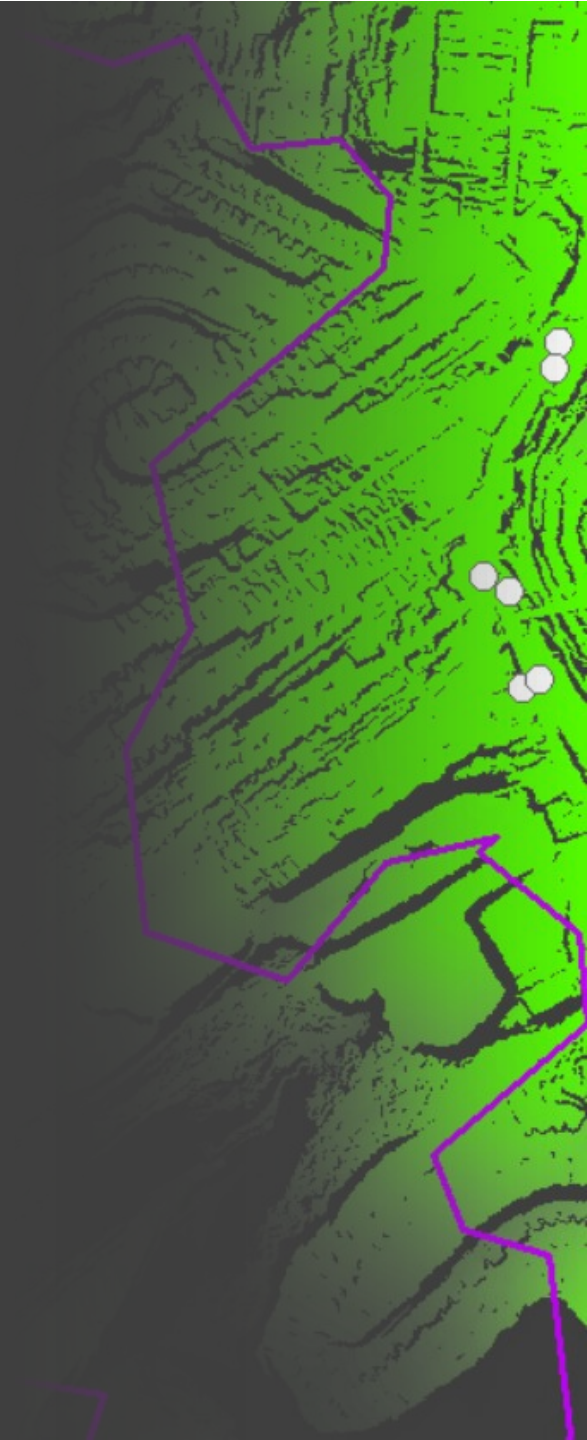
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Project Timeline

- April 2021: Present capstone proposal; submit write-up
- May-September 2021: Complete work (while completing Summer and Fall-1 MGIS courses)
- October/November 2021: Present final capstone project
- November 2021: Complete final presentation revisions and write-up
- December 2021: Graduate

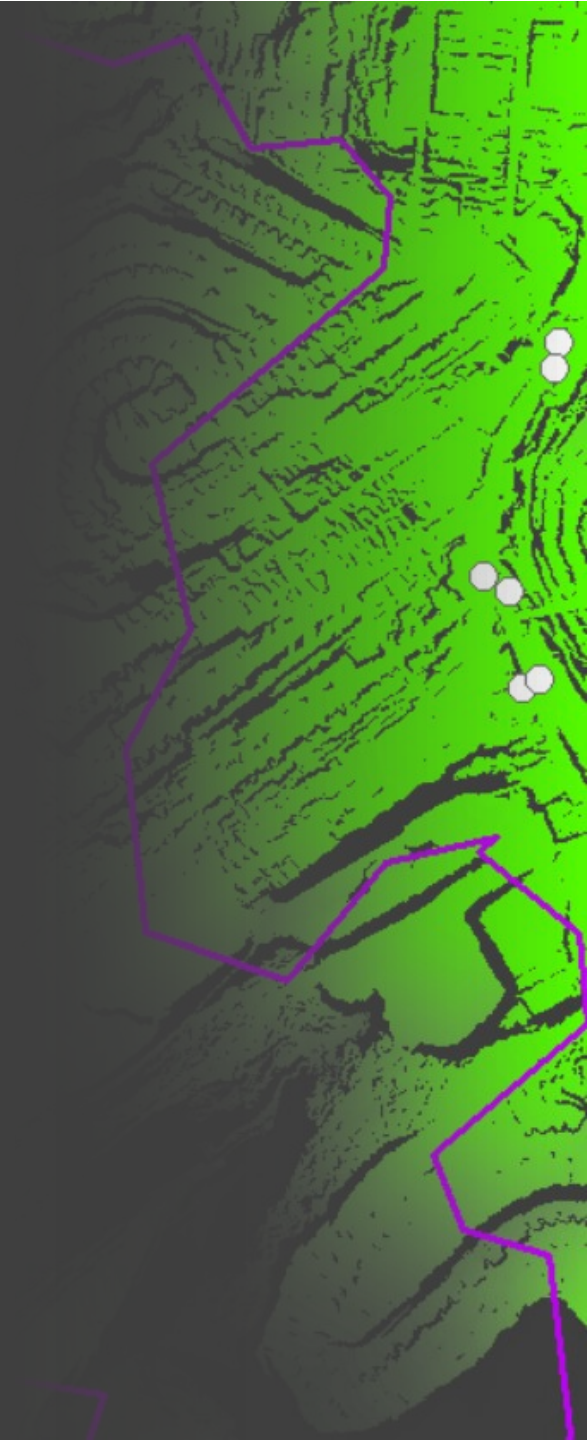
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- May 2021-January 2022: Complete work (while completing Summer and Fall-1 MGIS courses)
- January/February 2022: Present final capstone project
- February/March 2022: Complete final presentation revisions and write-up
- May 2022: Graduate

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Presentation Venues

American Association for Geographers (AAG) Annual Meeting

- New York City, NY — February 25–March 1, 2022

County Commissioners Association of Pennsylvania (CCAP) Pennsylvania GIS Conference

- TBD — May 2022

Presentation Venues

Western Pennsylvania Regional Data Center (WPRDC) User Group Meetings

- Virtual via Zoom — TBD

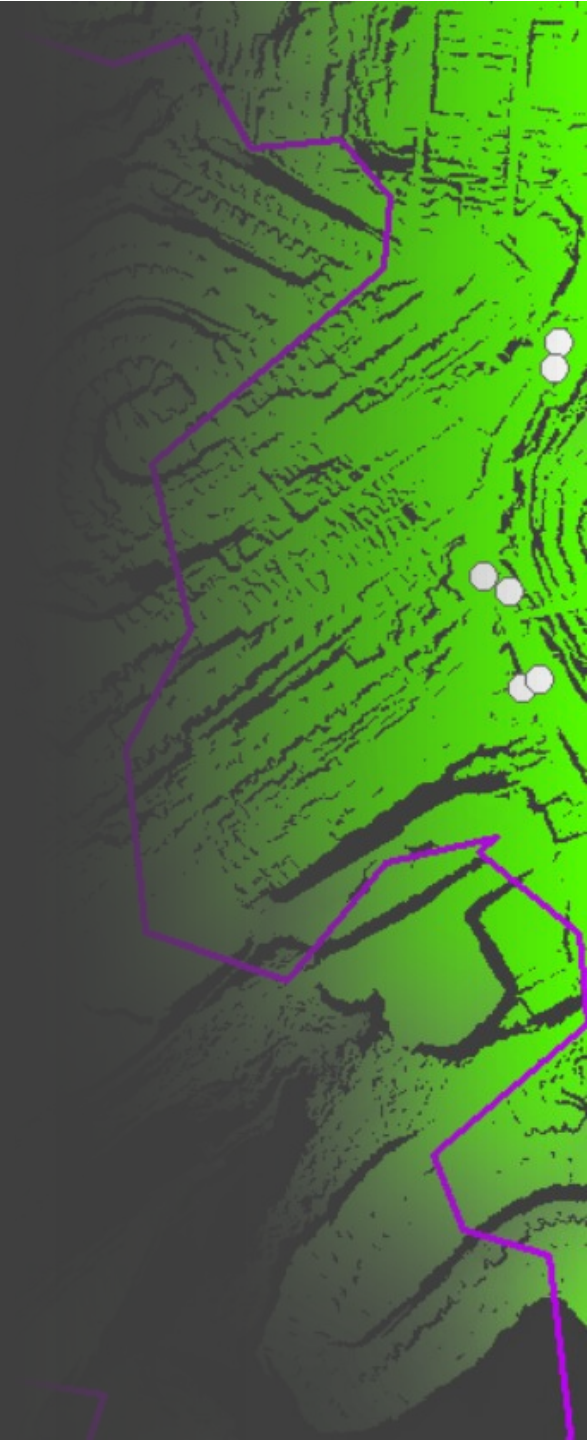
PSU MGIS Capstone Presentations

- Virtual via Zoom — November 2021, April 2022

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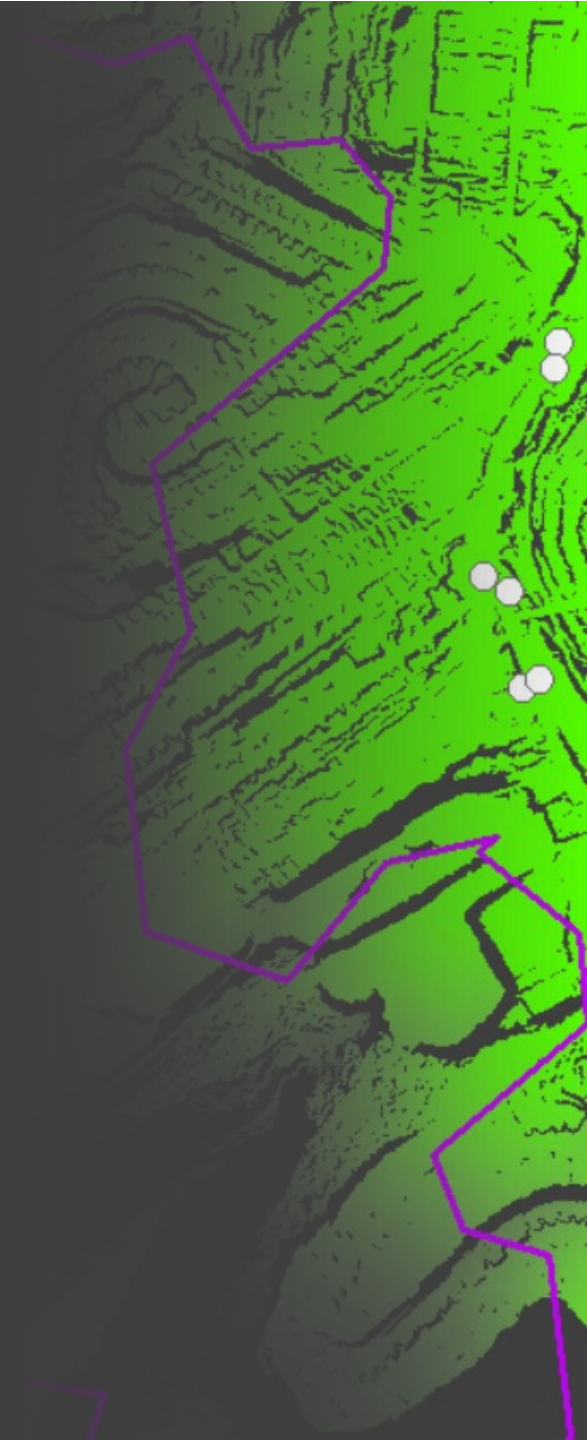
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Zoom Chat window!

Thank you!

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