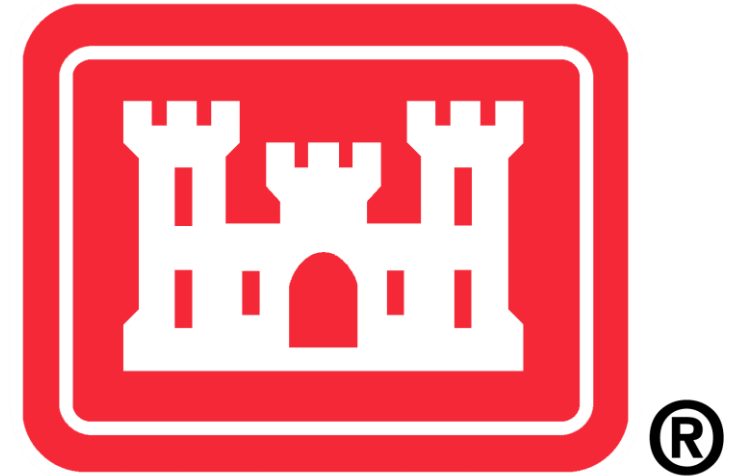


KENTUCKY GREEN INFRASTRUCTURE & OPEN SPACE ANALYSIS

Environmental Law Institute

October 31, 2023



Ky Silver Jackets

- U.S. Army Corps of Engineers – Interagency Group focused on flood risk management

Location of Project

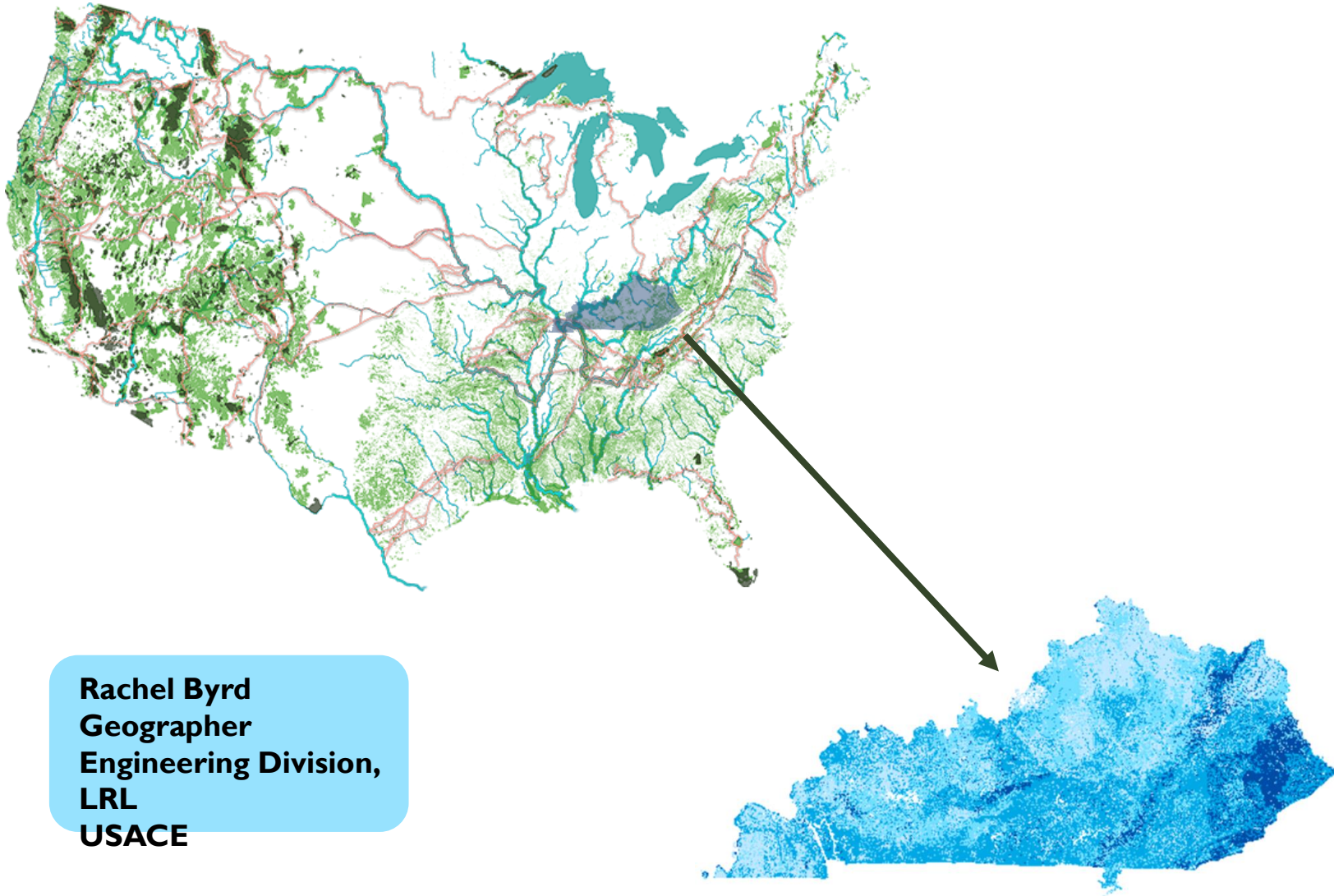
- State of Kentucky
- Focus areas- Louisville, Bowling Green, Paducah, Pikeville, Henderson County

Scope of Project

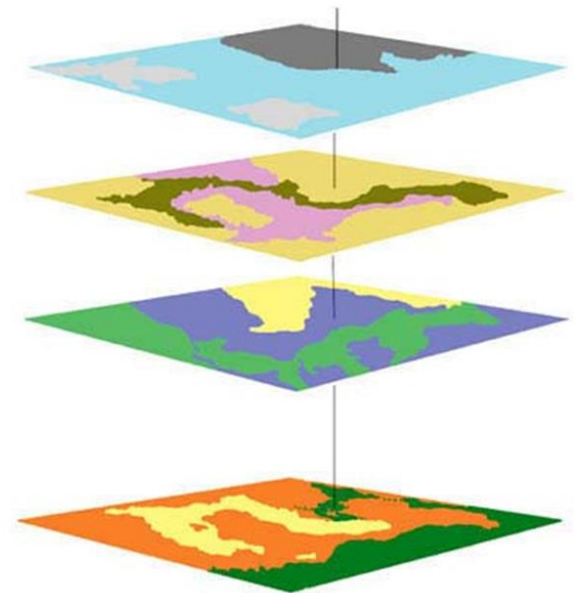
- Collect geospatial data and create model
- Model state and focus areas
- Display results in final report and at KAMM conference

INTRODUCTION

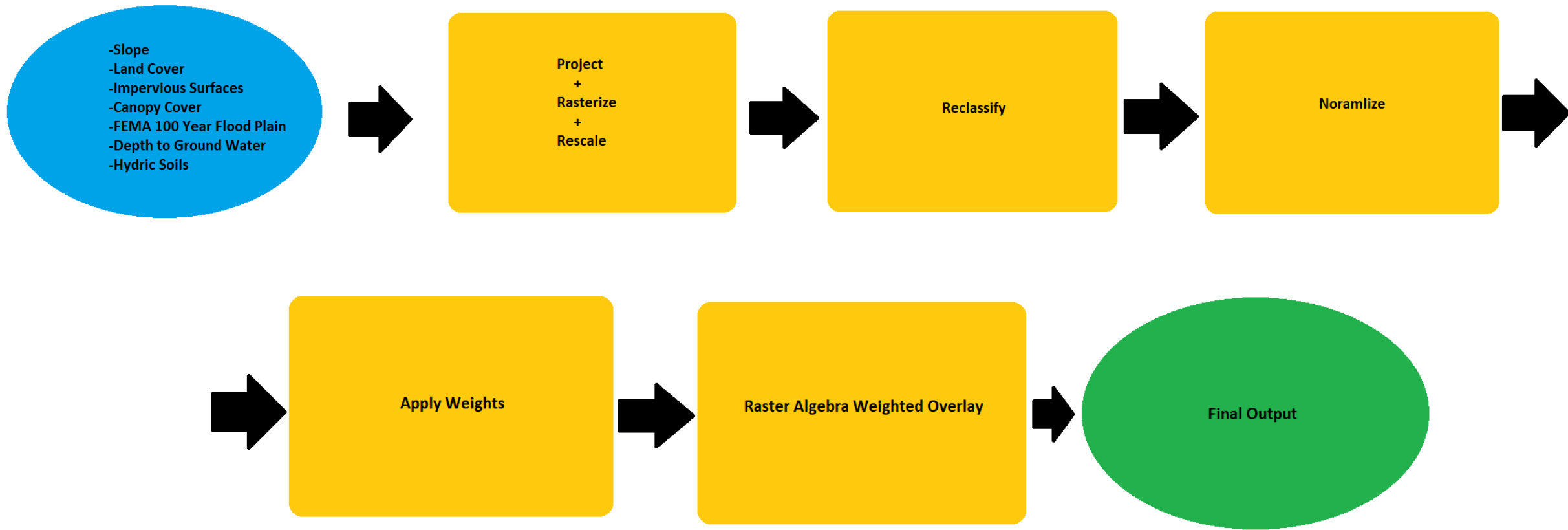
SUITABILITY MODELING FOR FUTURE GREEN INFRASTRUCTURE



GIS Suitability Modeling



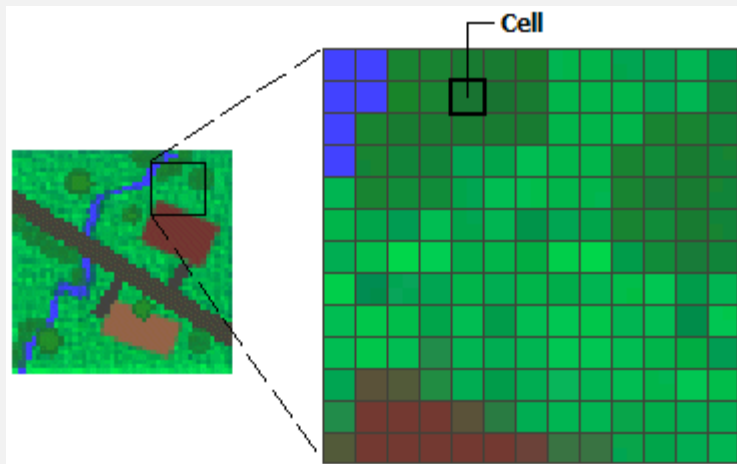
Rachel Byrd
Geographer
Engineering Division,
LRL
USACE



METHODOLOGY

- Weighted overlay analysis includes reclassifying the rasters to a common scale, ranking the class values in each raster, assigning each raster a respective weight as a percentage, and then overlaying the rasters on top of each other and calculating the total summed value for each cell in an output raster.

Weighted overlay is a form of suitability modeling where instead of getting a binary output you get a continuous output from suitable to not suitable or from a high index to a low index.



1	1	2	2	2	2	2	2
1	1	2	2	2	2	2	2
3	3	2	2	2	2	2	2
3	3	2	2	2	2	2	2
3	3	3	2	4	4	4	4
3	3	3	3	4	4	4	4
3	3	3	3	3	4	4	4
3	3	3	3	3	3	4	4

Soil

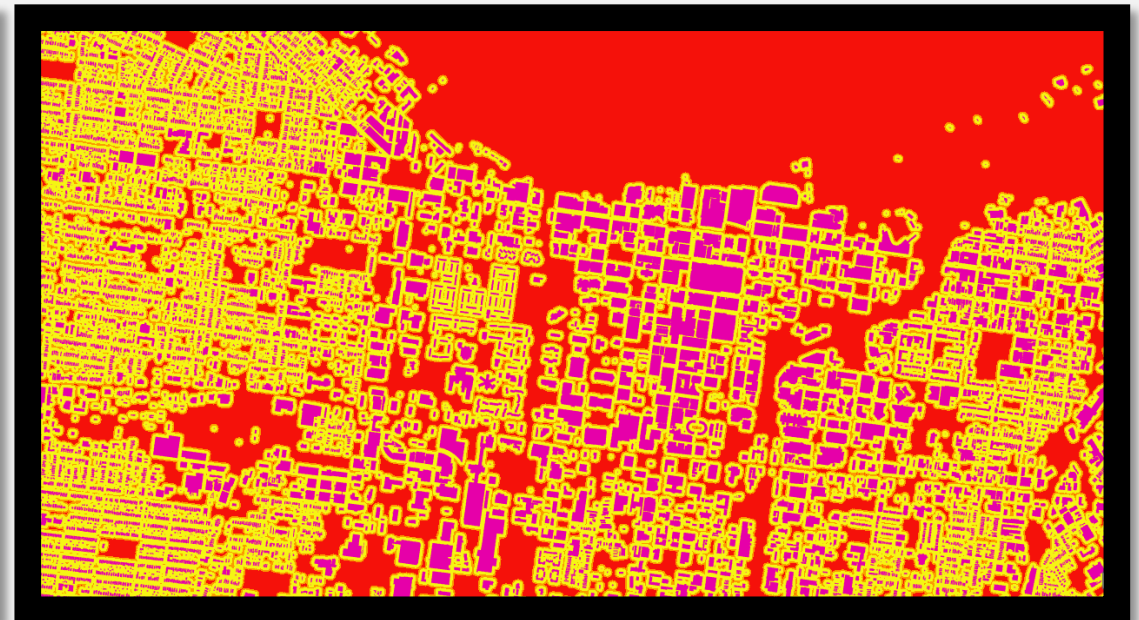
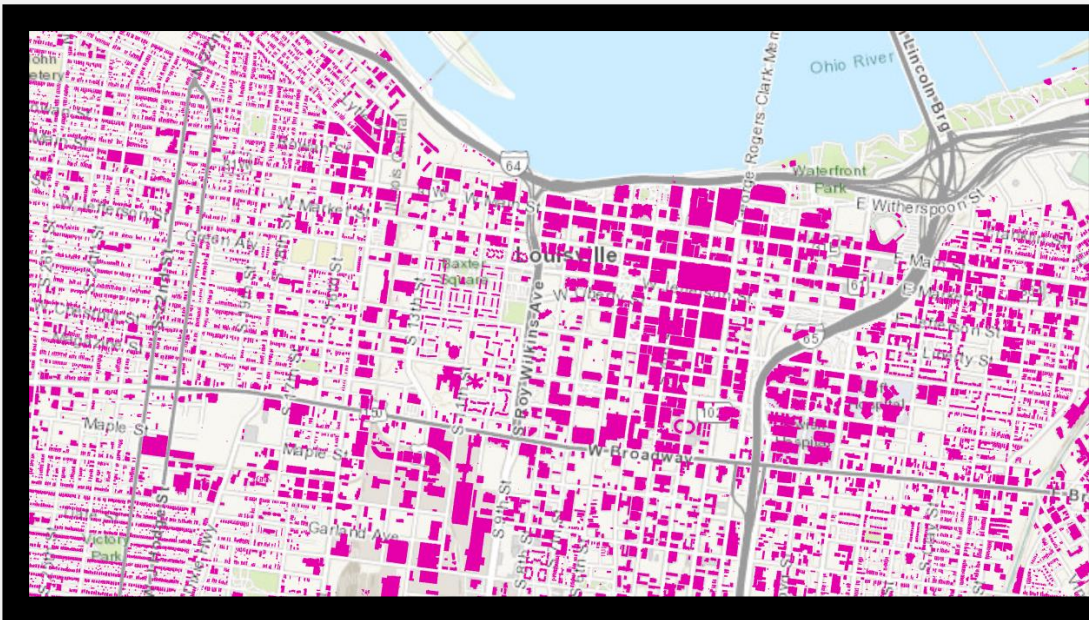
a	a	b	b	b	b	b	b
a	a	b	b	b	b	b	b
a	a	c	c	b	b	b	b
a	a	c	c	c	b	b	b
a	a	c	c	c	c	b	b
a	a	a	c	c	c	c	c
a	a	a	c	c	c	c	c
a	a	a	a	c	c	c	c

Land Use

19	20	20	21	20	20	20	21
20	20	21	20	20	18	20	21
20	21	20	20	18	17	20	20
21	21	20	18	15	16	20	20
21	20	20	15	13	15	18	20
20	20	15	13	11	13	15	20
18	15	10	10	10	13	15	18
15	13	10	8	10	11	13	15

Topography

- Weighted Overlay in GIS is a means of conducting multicriteria analyses by categorizing and ranking values from a variety of thematic datasets, creating a transparency for each dataset, and then overlaying the transparencies together to create a composite image. This final composite image was then used to evaluate the suitable site for Future Green Infrastructure in the design scenario.

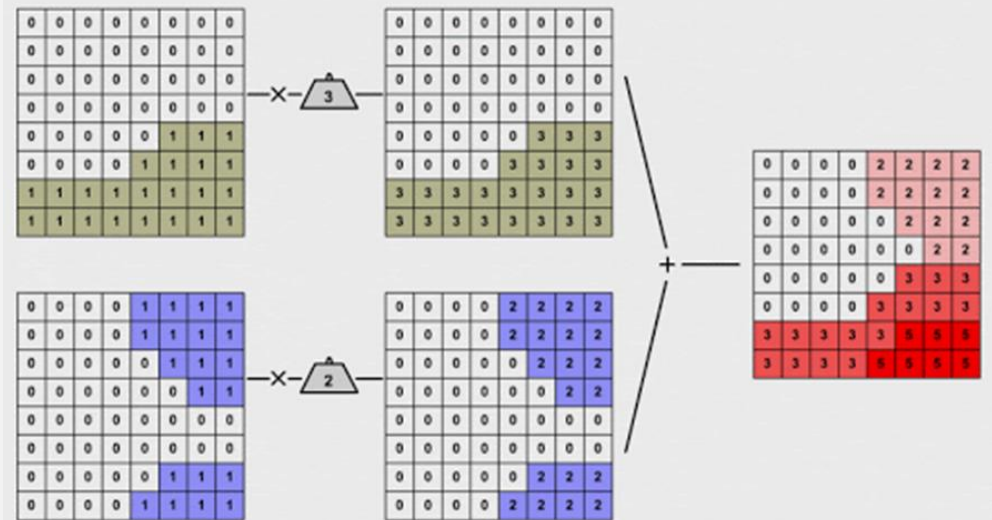
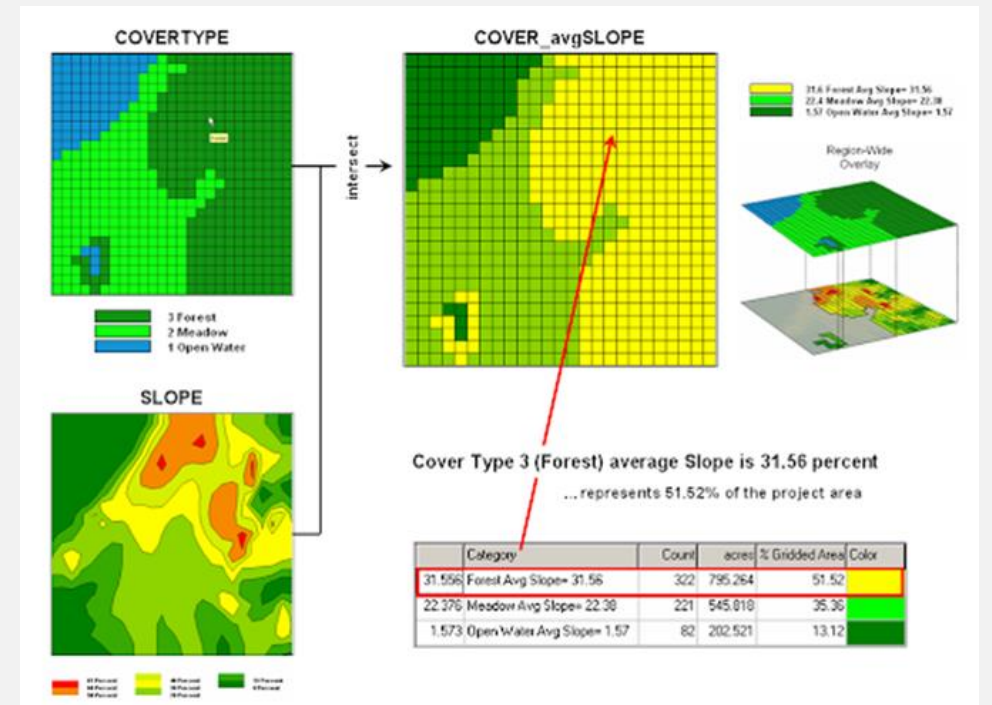


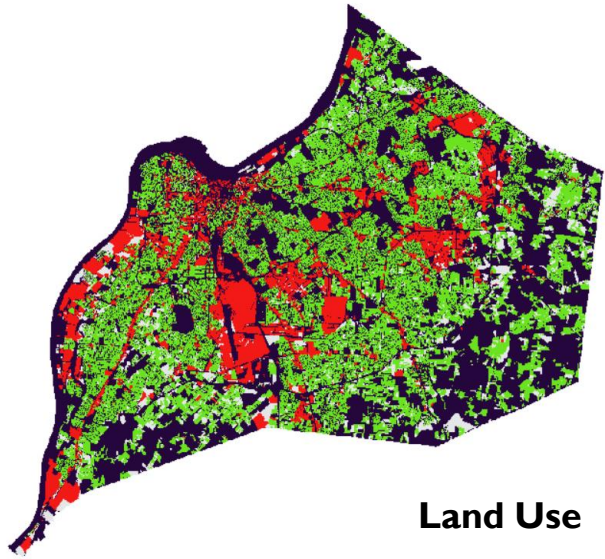
METHODOLOGY

- The resulting rasters must all have the same cell size, projection, extent, and be saved to the same file type, geoTIFF.
- Overall Score = (Criteria Score 1 X Weight 1) + (Criteria Score 2 X Weight 2) + (Criteria Score 3 X Weight 3)...

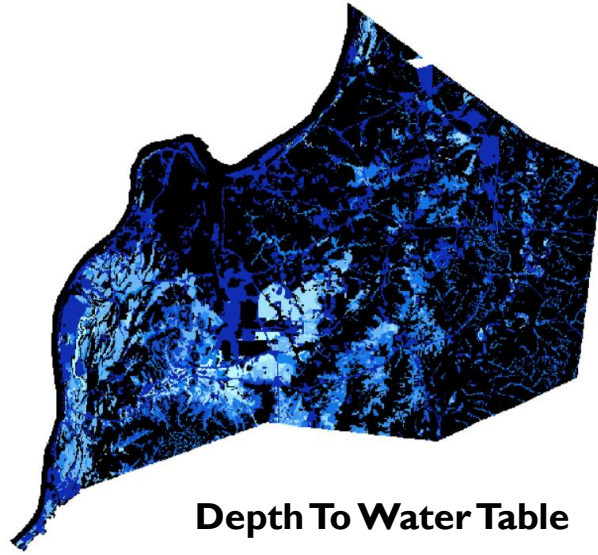
$$S = (C1 \times W1) + (C2 \times W2) + (C3 \times W3)$$

- Scoring the Grids
- Define % of influence
- Normalize sum of influence (0/1, 100%)
- Define Scale of Output

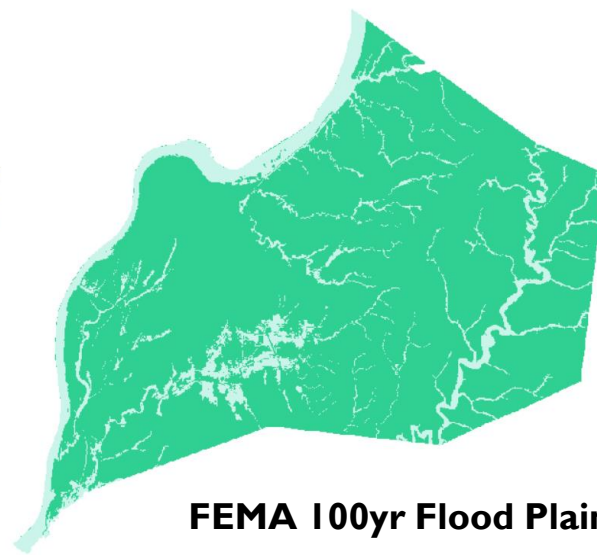




Land Use



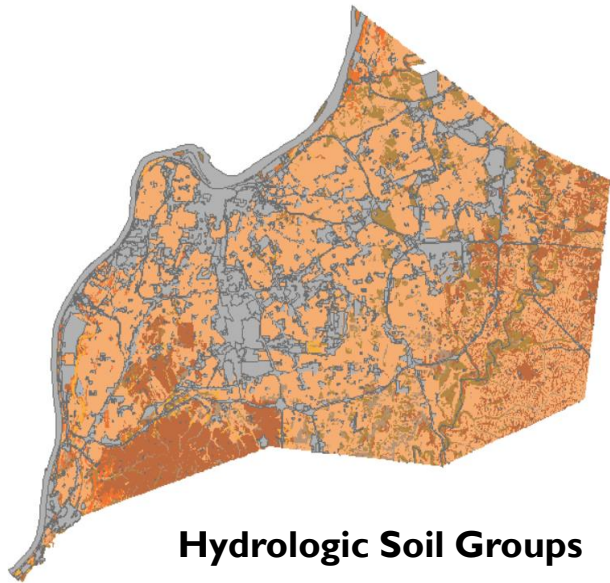
Depth To Water Table



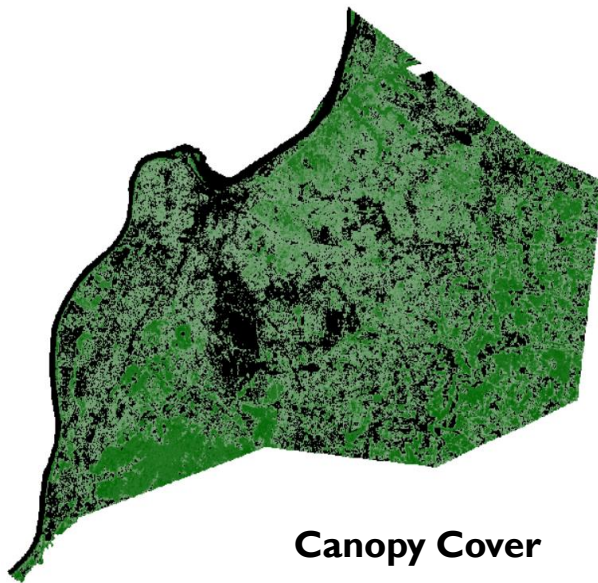
FEMA 100yr Flood Plain



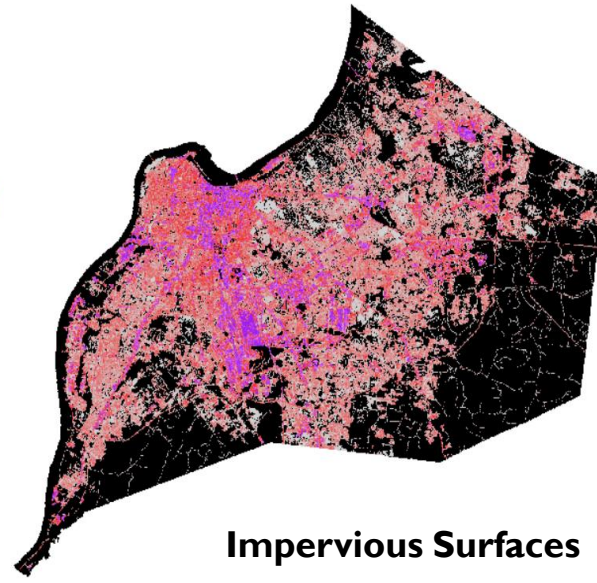
Public/Private Land



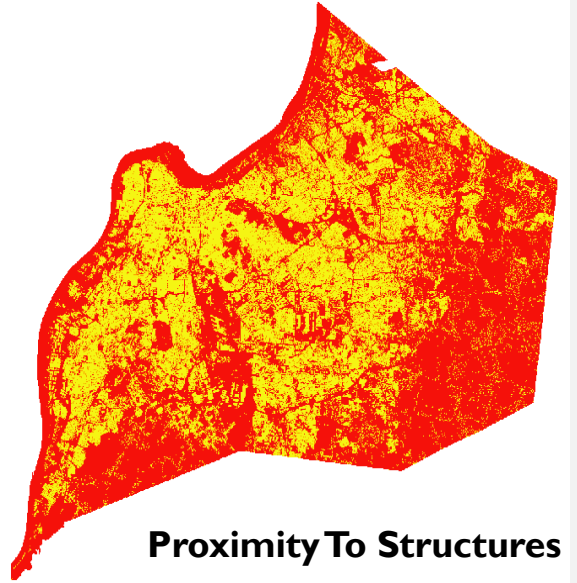
Hydrologic Soil Groups



Canopy Cover



Impervious Surfaces



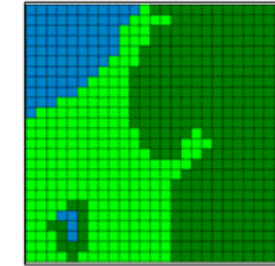
Proximity To Structures

SOLUTIONS

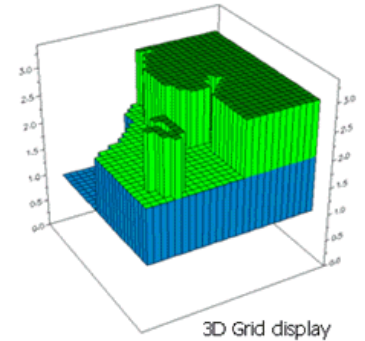
- Lots of Good Coffee & Relentless Determination
- Divide and conquer – 30 meter resolution
- Processing alternatives for different data types
 - Continuous Data – graded on a continuous scale ex: slope, imperious surface rating 0 -100
 - Interval Data – ranked in classed ex: high/medium/low, land use, soil type

Discrete versus Continuous Data

Covertypes map– values are independent and represent discrete categories (*independent numbers*); map values form sharp abrupt boundaries in geographic space (*abrupt boundaries*)



2D Grid display



3D Grid display

Discrete

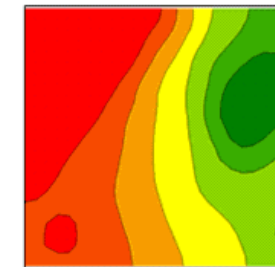
Continuous

<i>independent numbers</i>	<i>range of values</i>
<i>abrupt boundaries</i>	<i>spatial gradient</i>

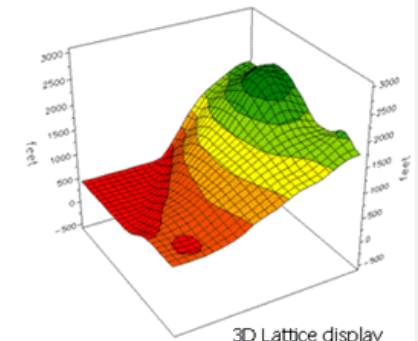
Discrete

Continuous

Elevation map– values form a continuous range with an absolute reference (*range of values*); map values form a continuous gradient in geographic space (*spatial gradient*)



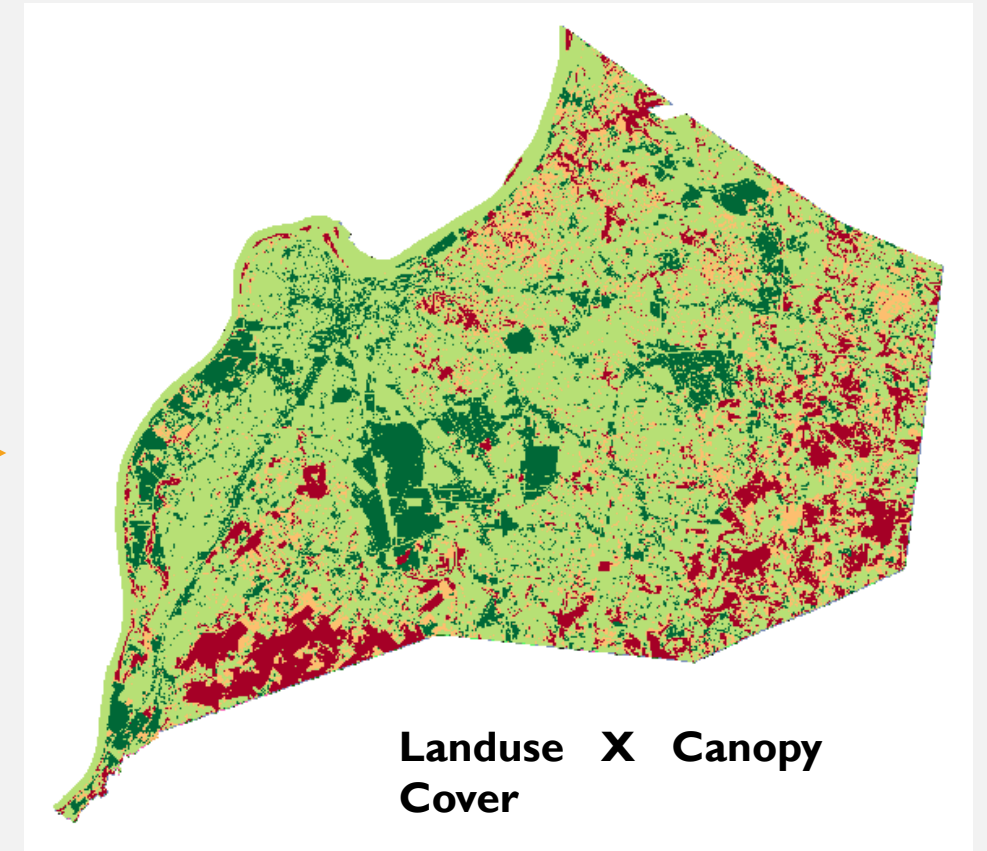
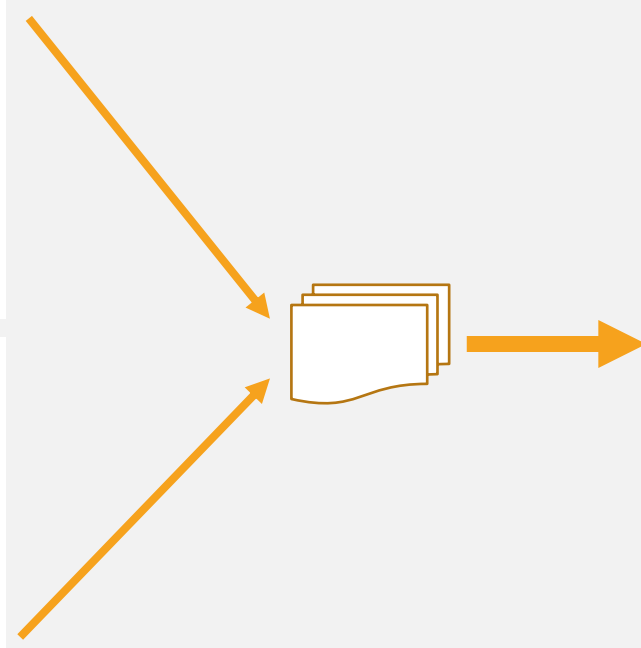
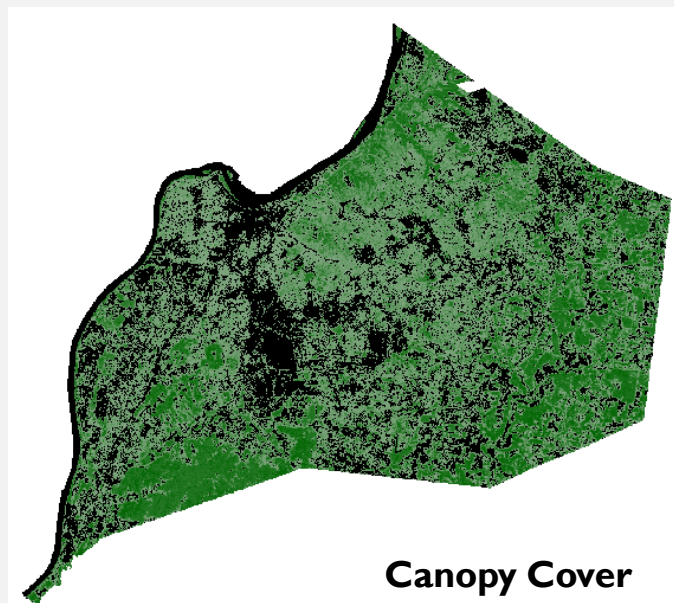
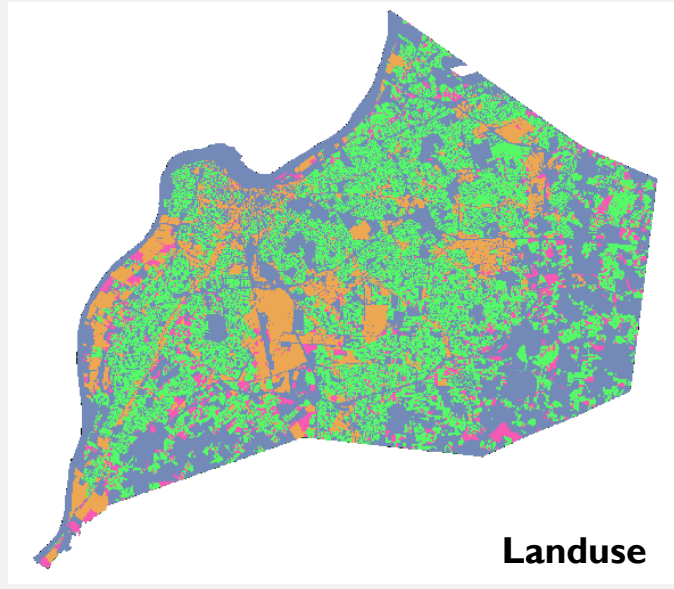
2D Lattice display

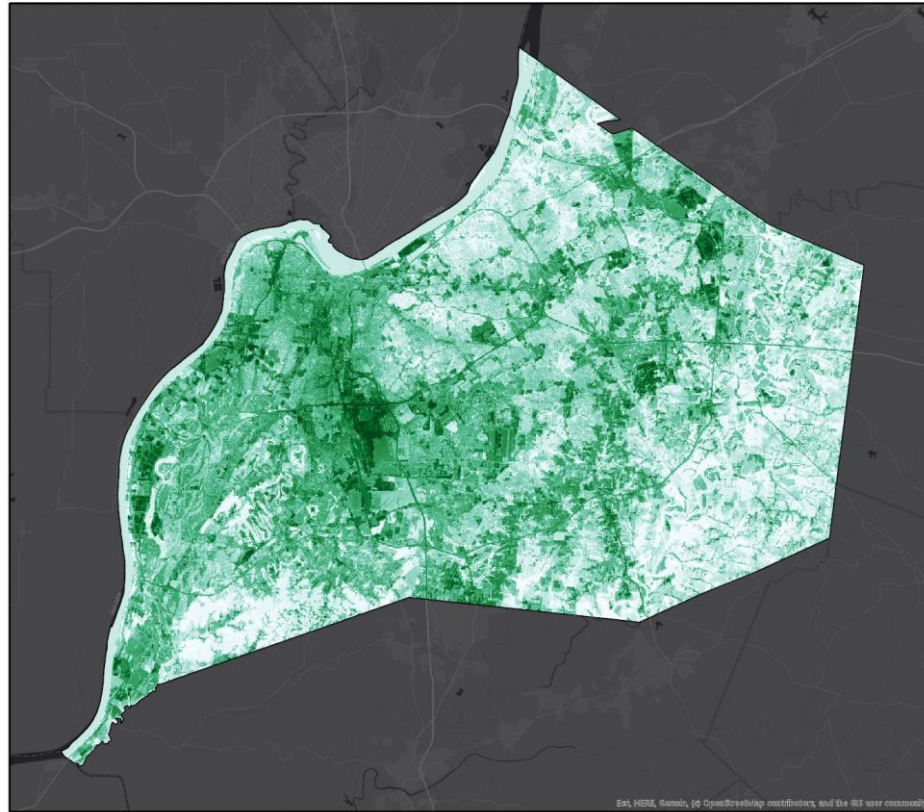


3D Lattice display

$$f = \left(\frac{X_i - X_{min}}{X_{max} - X_{min}} \right)$$

Example





**POTENTIAL FOR
FUTURE GREEN
INFRASTRUCTURE**
Jefferson, County Kentucky

This index is on a scale ranging from 0 to 1, with 1 indicating the strongest fit in terms of suitability with consideration of the weighted model variables.

Index: 0 to 1

Value

0.909159

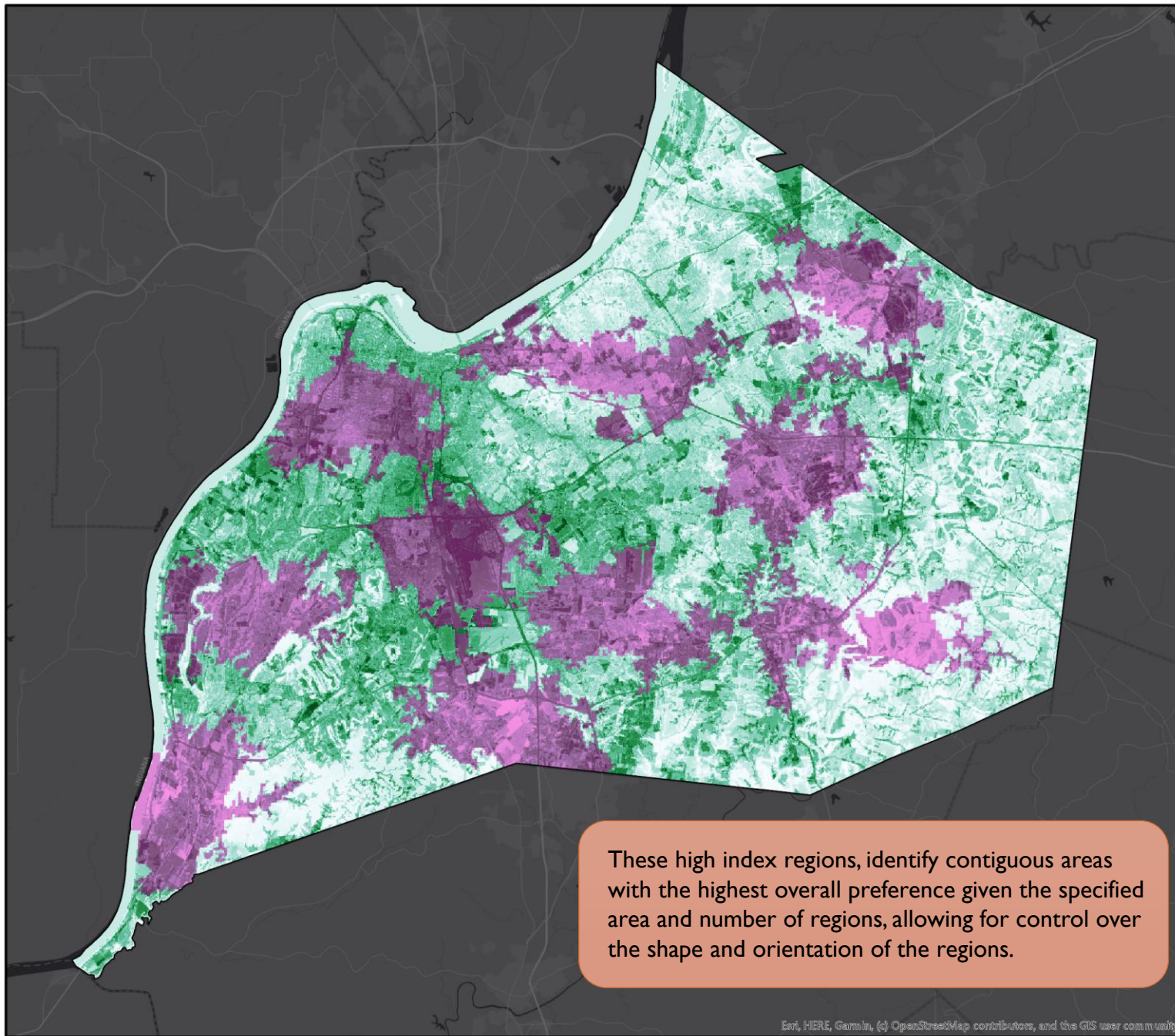
0.00160768

Jefferson County



This model contains the following variables equally weighted: Depth to Water Table, Land Use, Tree Canopy Cover, FEMA 100 Year Flood Plain, Impervious Surfaces

The boundary is Jefferson County. Data are normalized and set at 30 meter resolution with a projection in Kentucky State Plan 2011.



Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community



POTENTIAL FOR FUTURE GREEN INFRASTRUCTURE

Jefferson, County Kentucky

This index is on a scale ranging from 0 to 1, with 1 indicating the strongest fit in terms of suitability with consideration of the weighted model variables.

Index: 0 to 1

Value

0.909159

0.00160768

Jefferson County

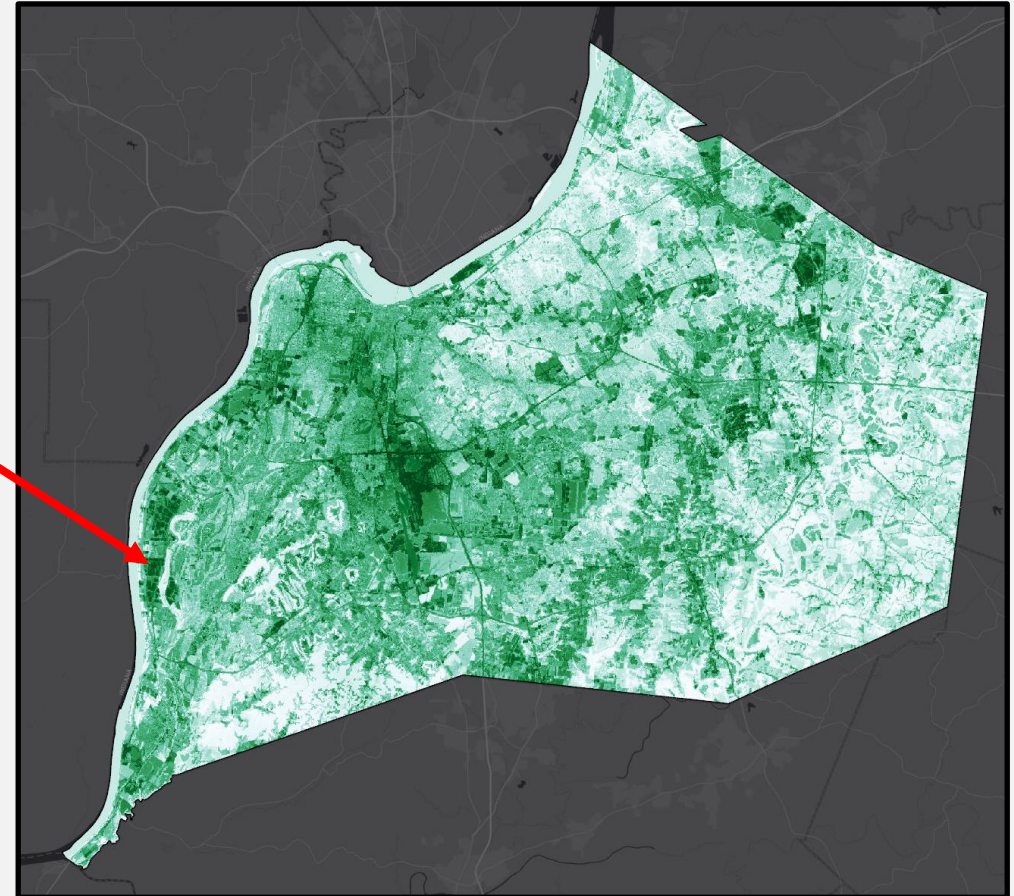
High Index Regions



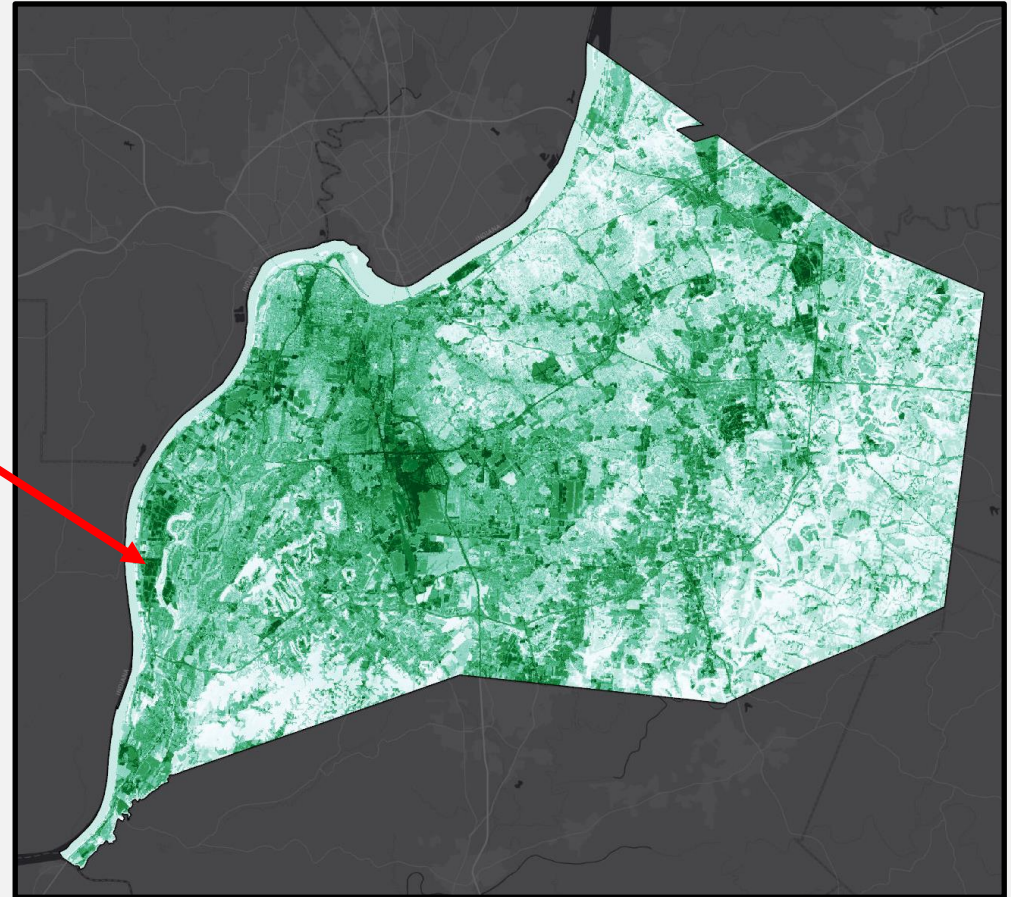
This model contains the following variables equally weighted: Depth to Water Table, Land Use, Tree Canopy Cover, FEMA 100 Year Flood Plain, Impervious Surfaces

The boundary is Jefferson County.
Data are normalized and set at 30 meter resolution with a projection in Kentucky State Plain 2011.

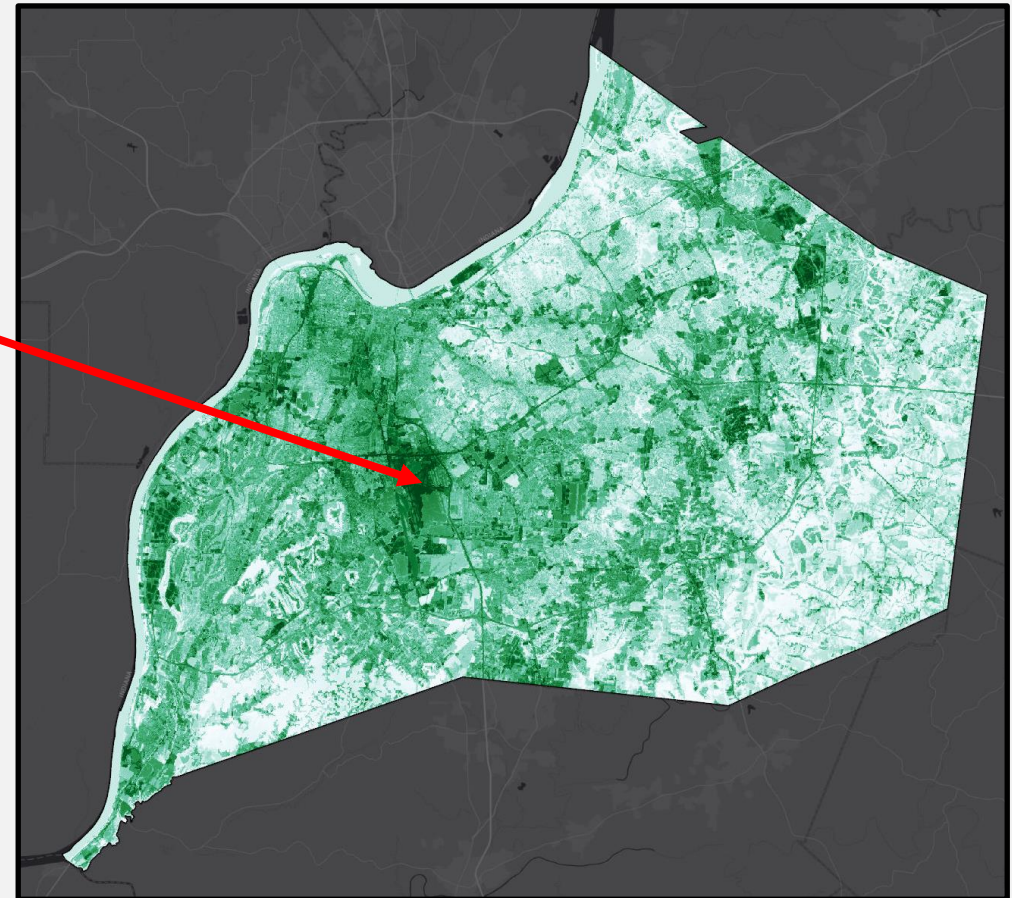
SAMPLE SITE #1



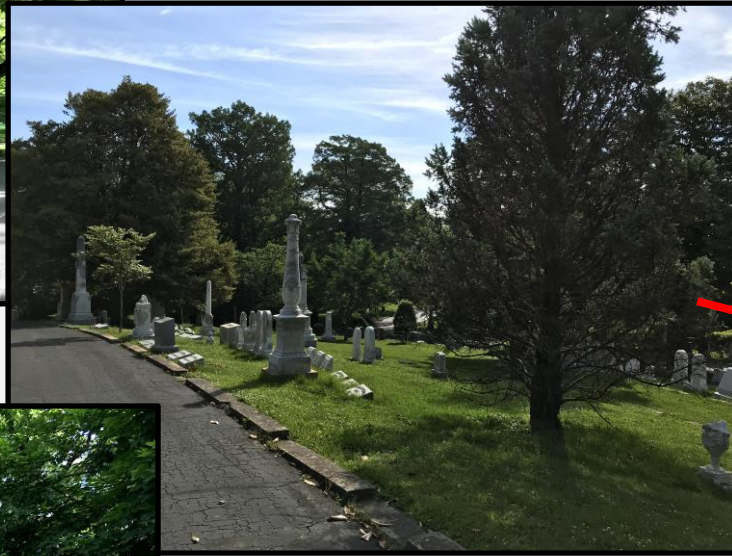
SAMPLE SITE #2

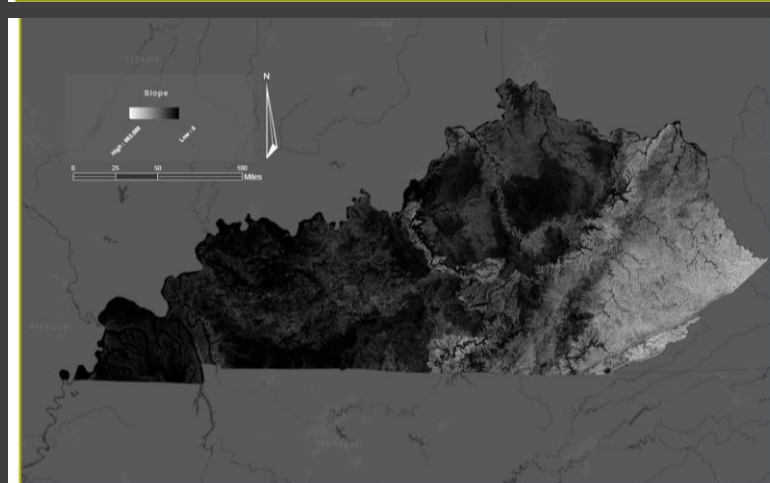
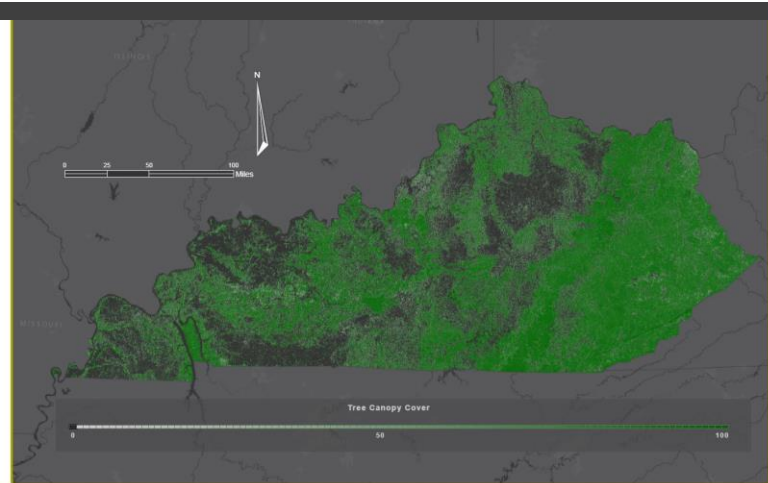
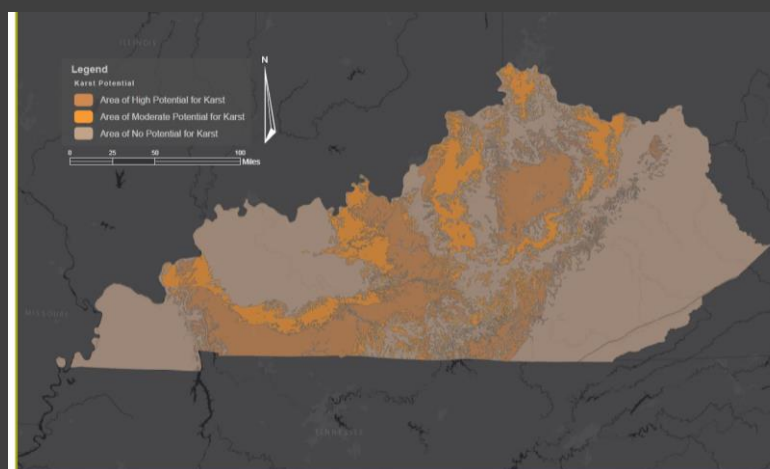
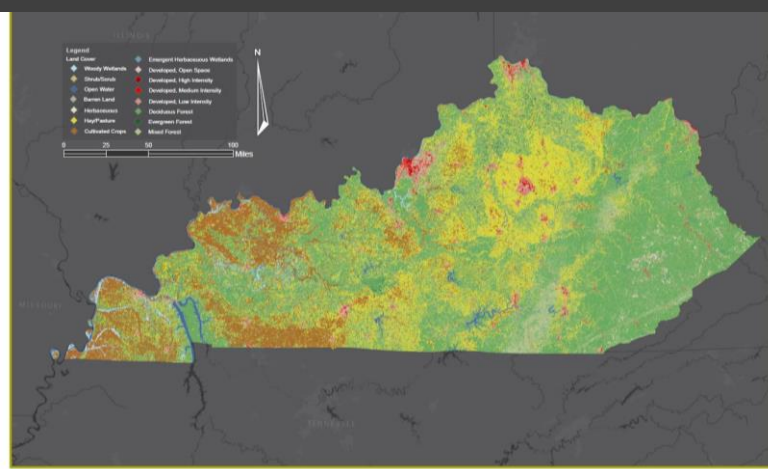
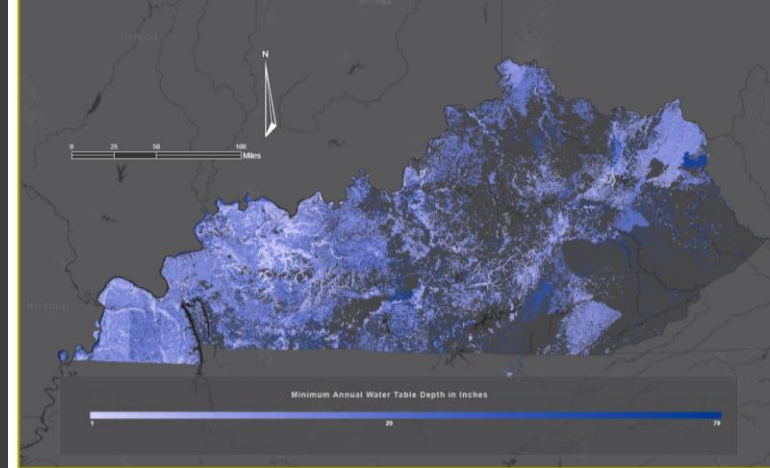
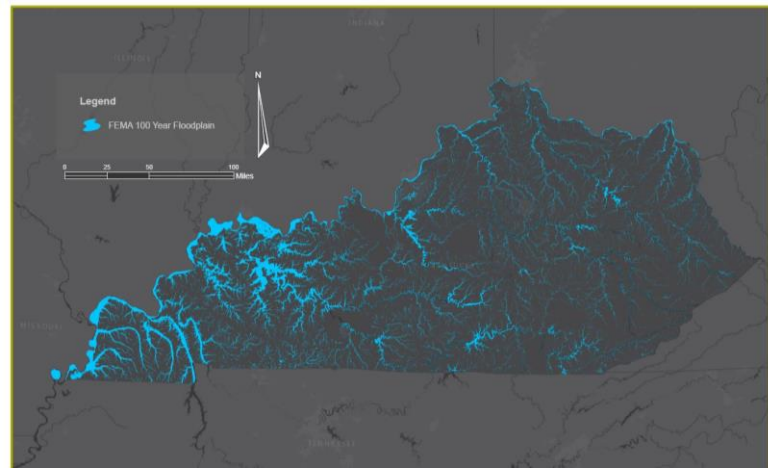


SAMPLE SITE #3



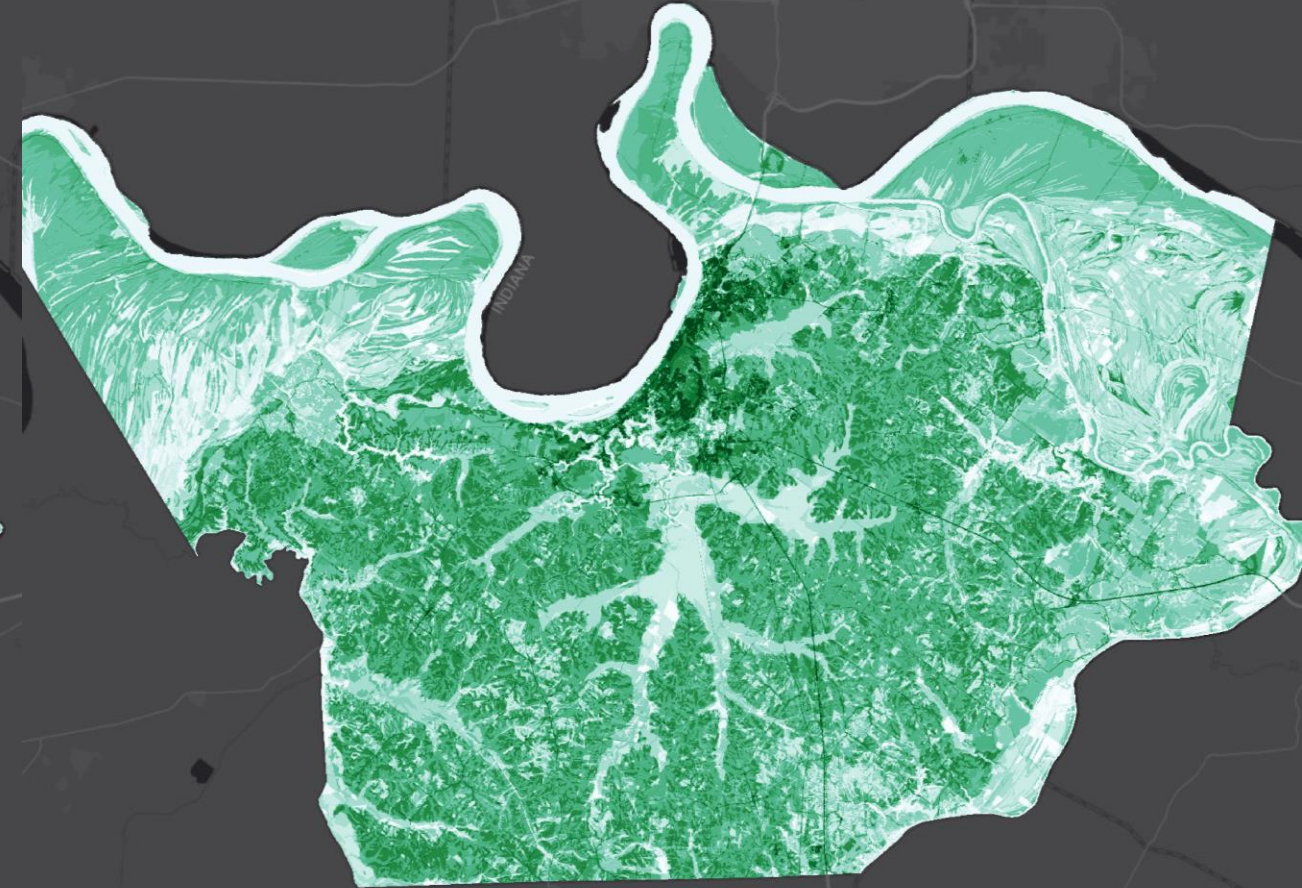
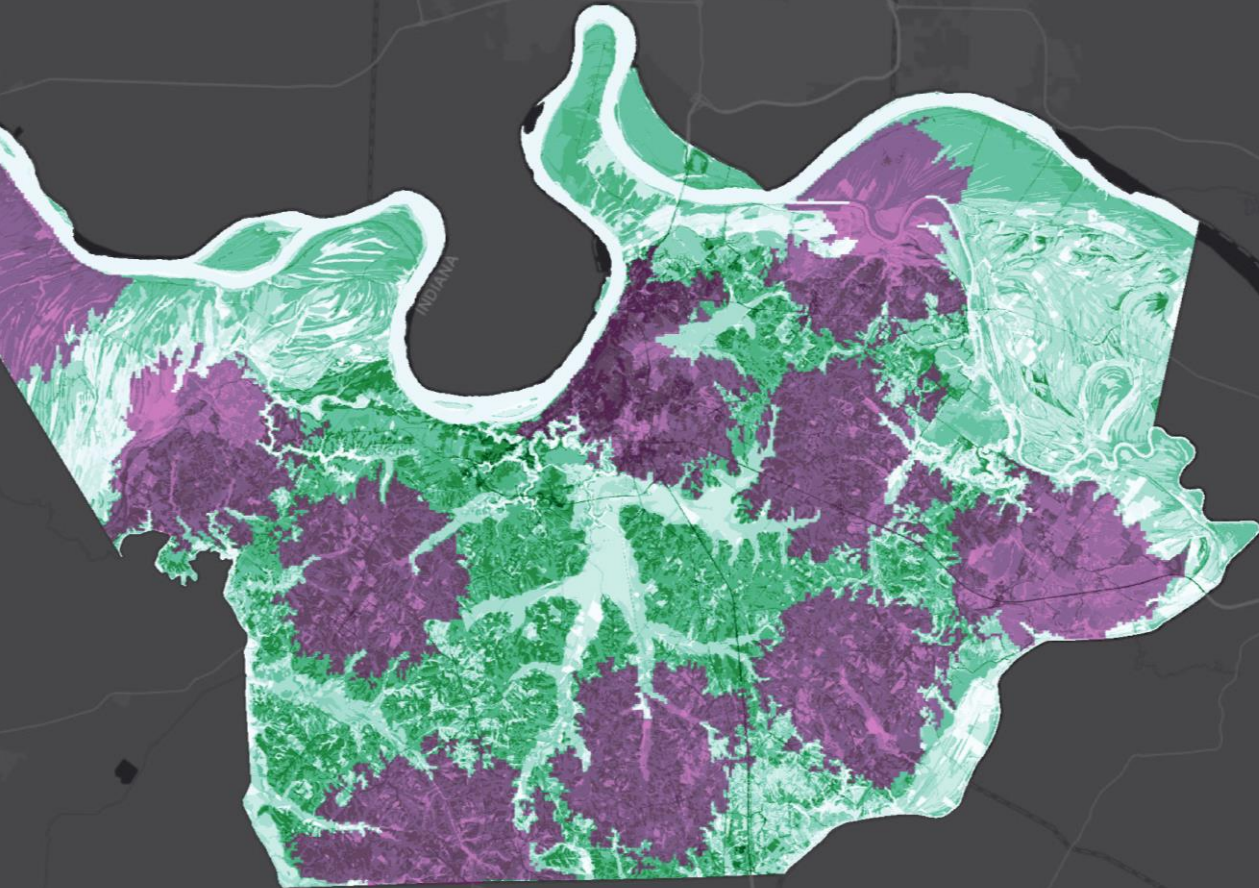
SAMPLE SITE #4



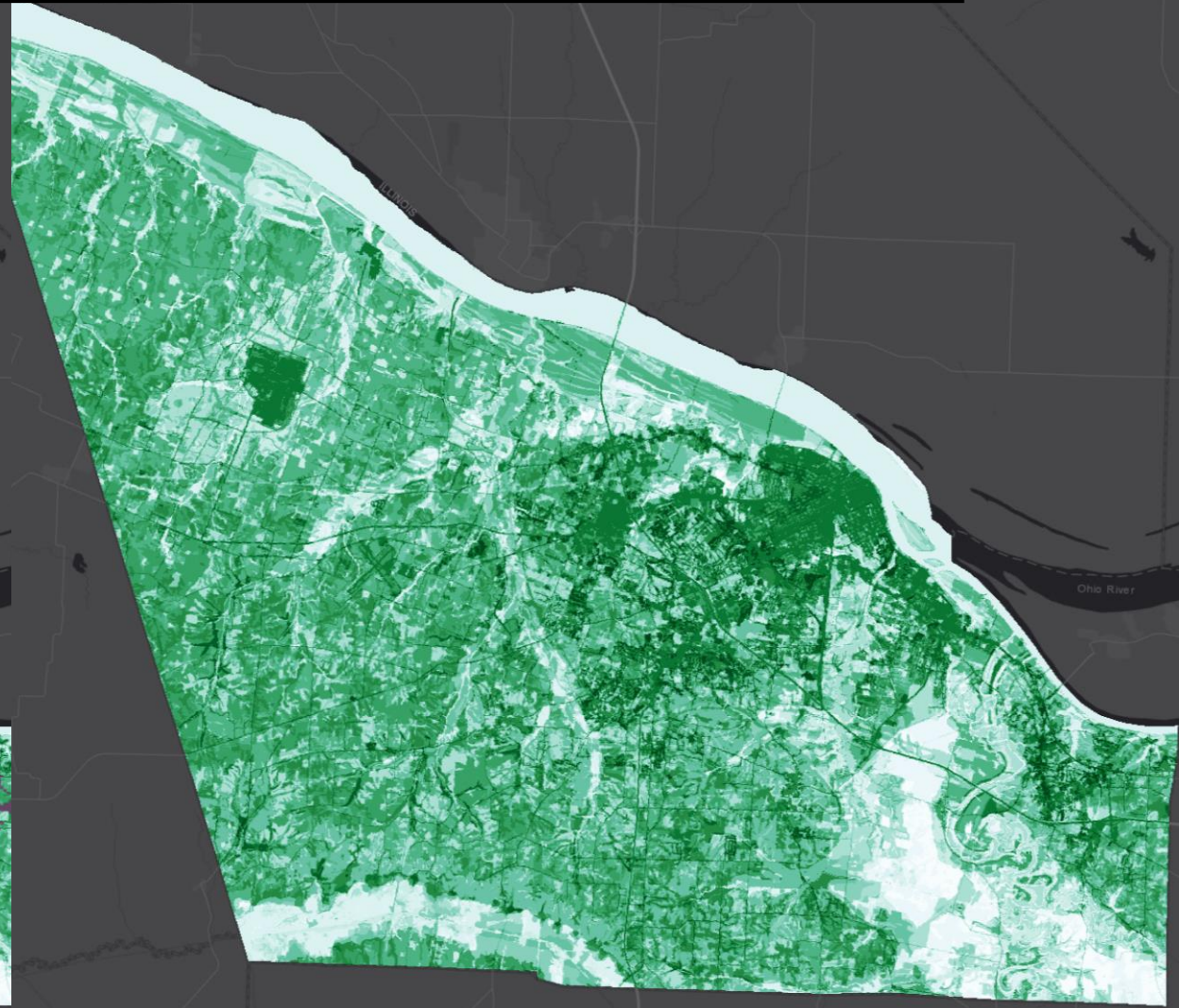


- State-wide/Focus Area analysis
- Selection process utilized ecoregions
- Less resolution with data
- Land cover vs land use
- No public/private land
- Karst data added

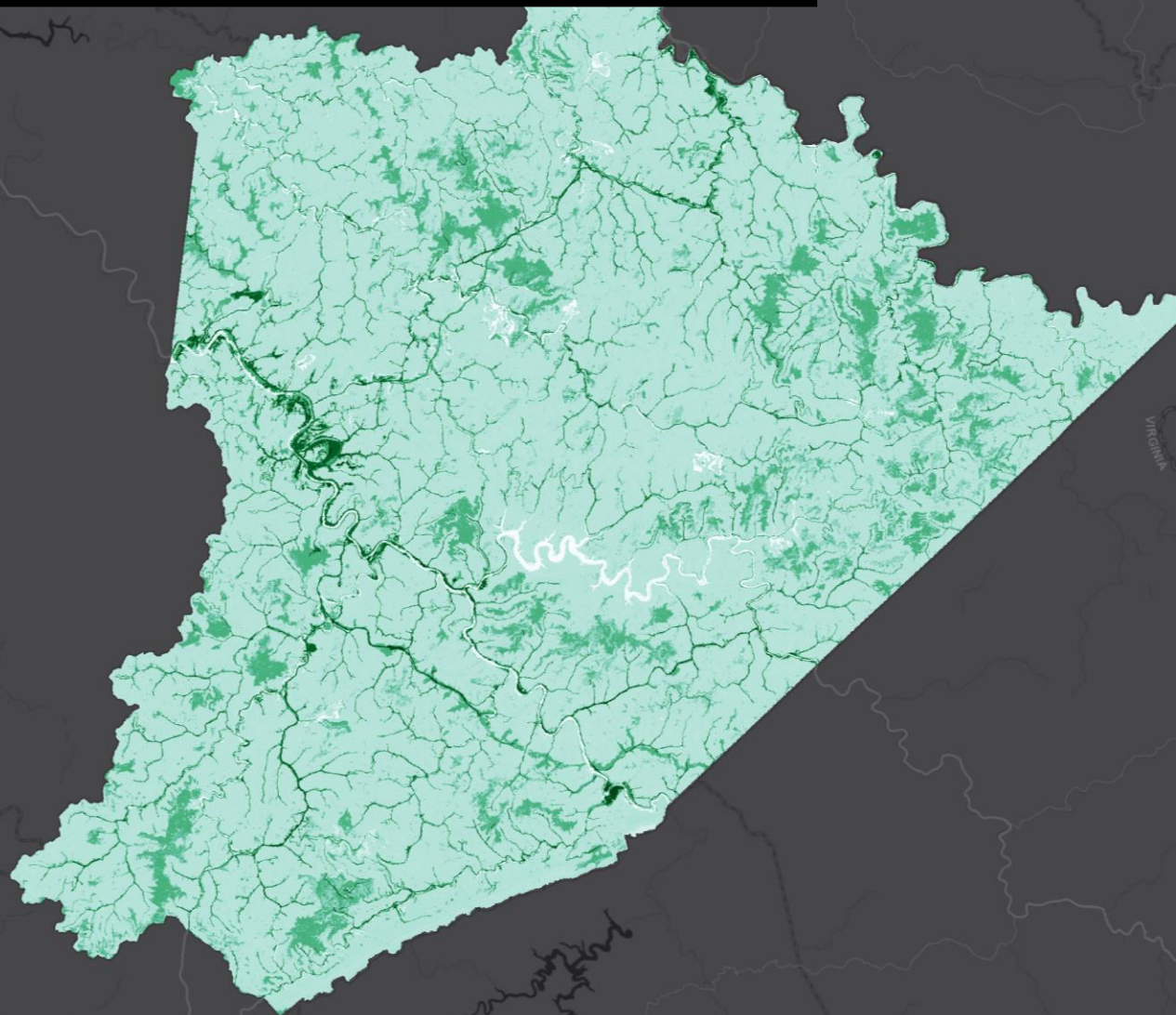
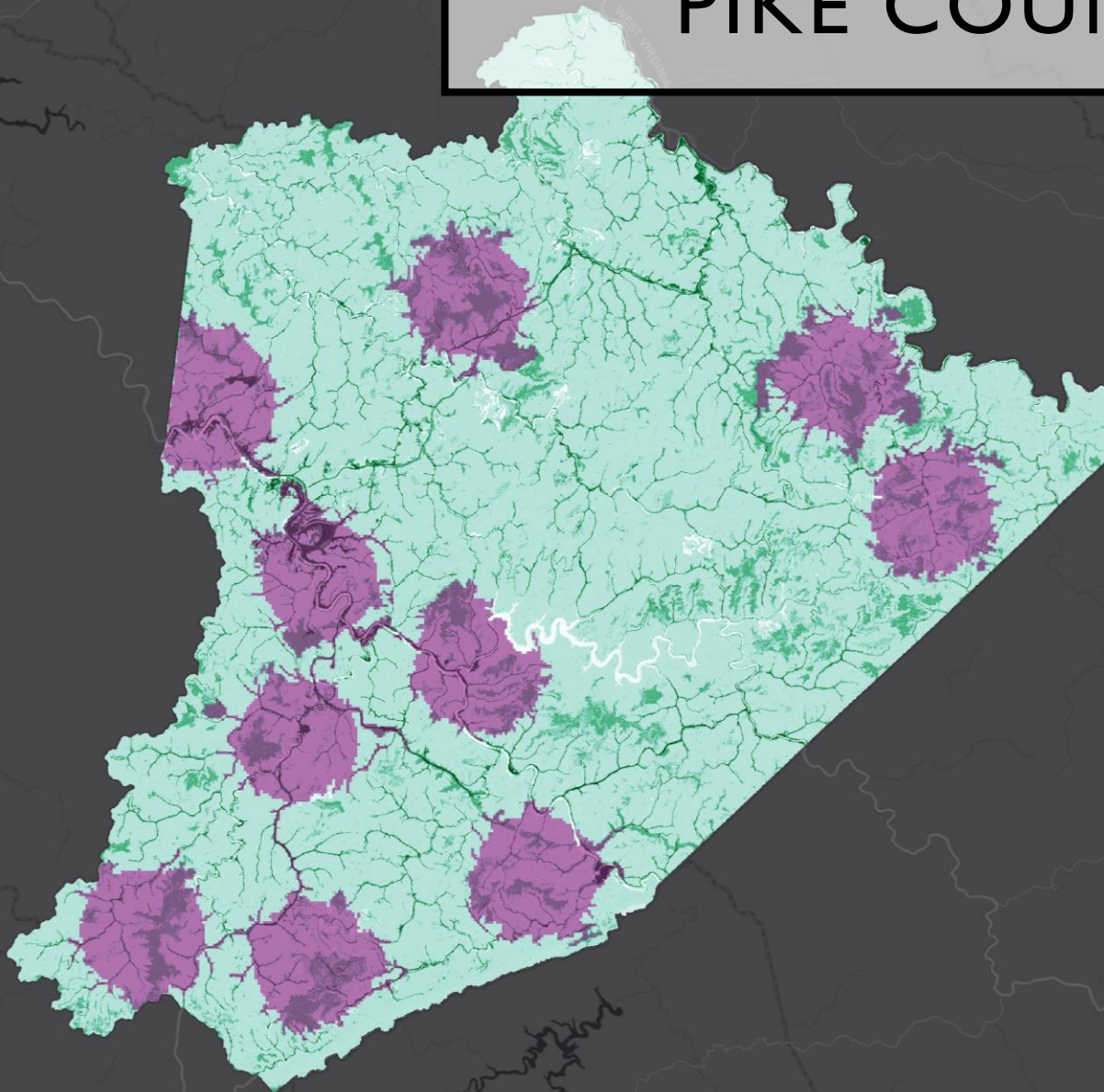
HENDERSON COUNTY



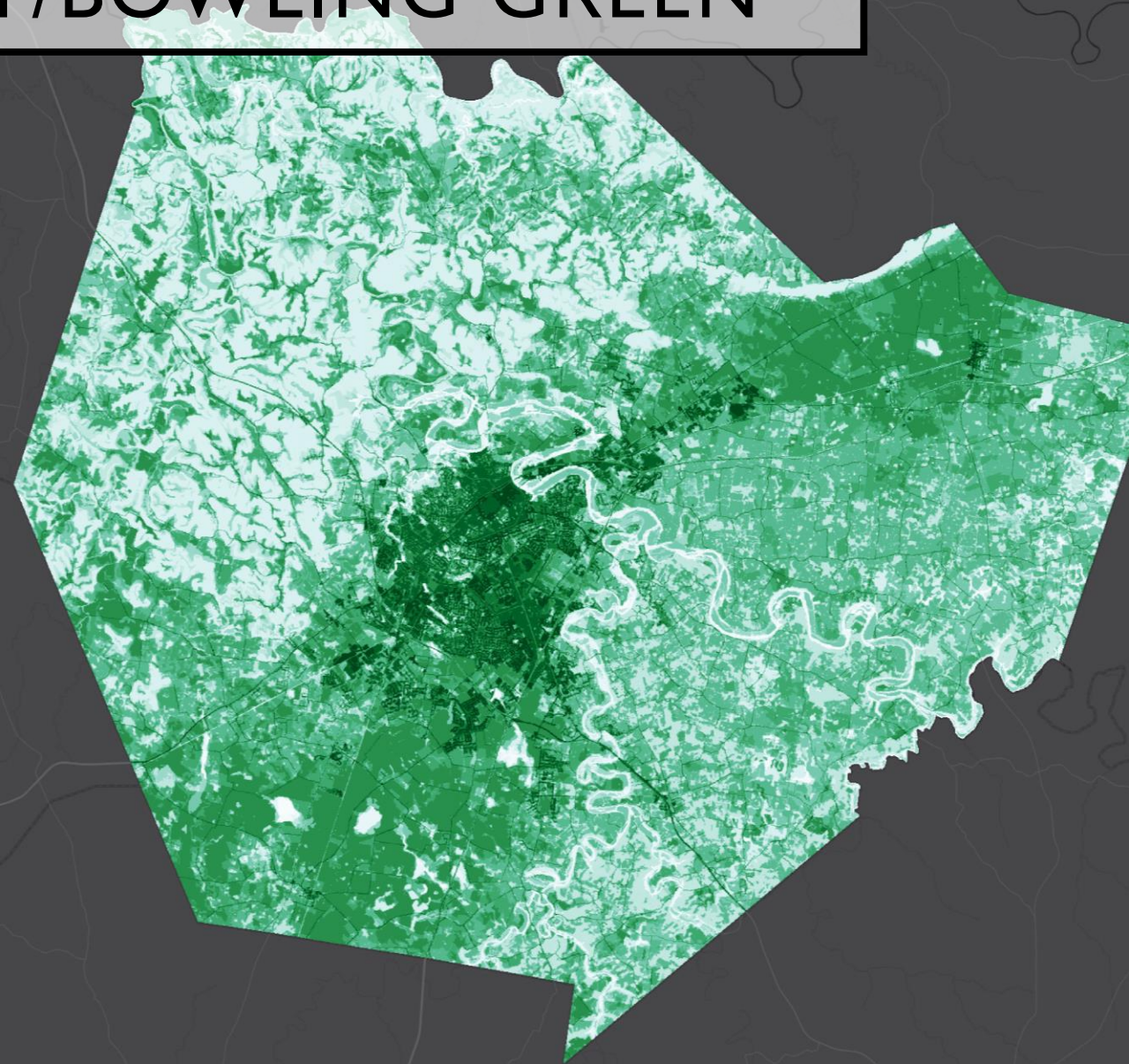
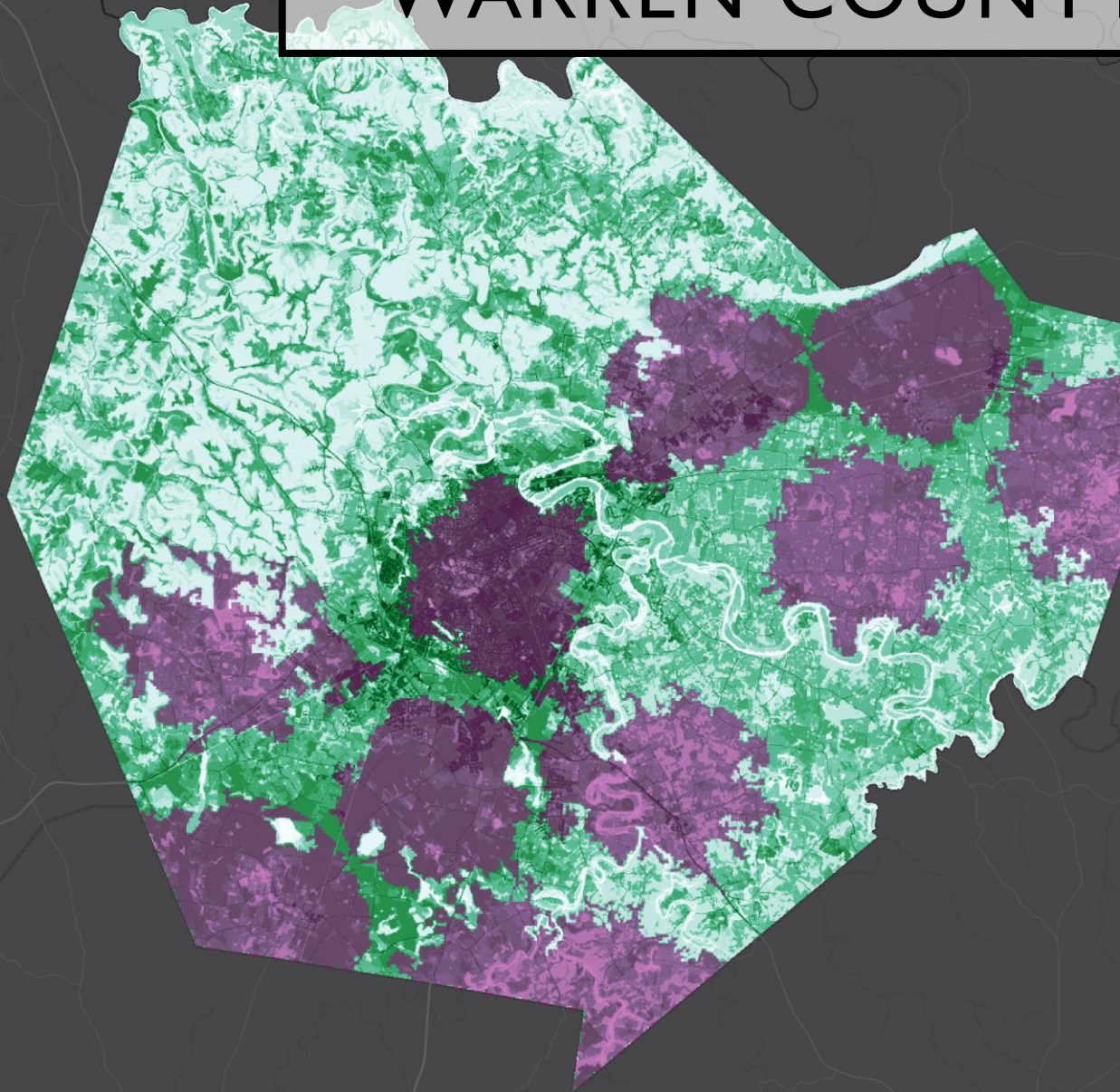
MCCRACKEN COUNTY/PADUCAH

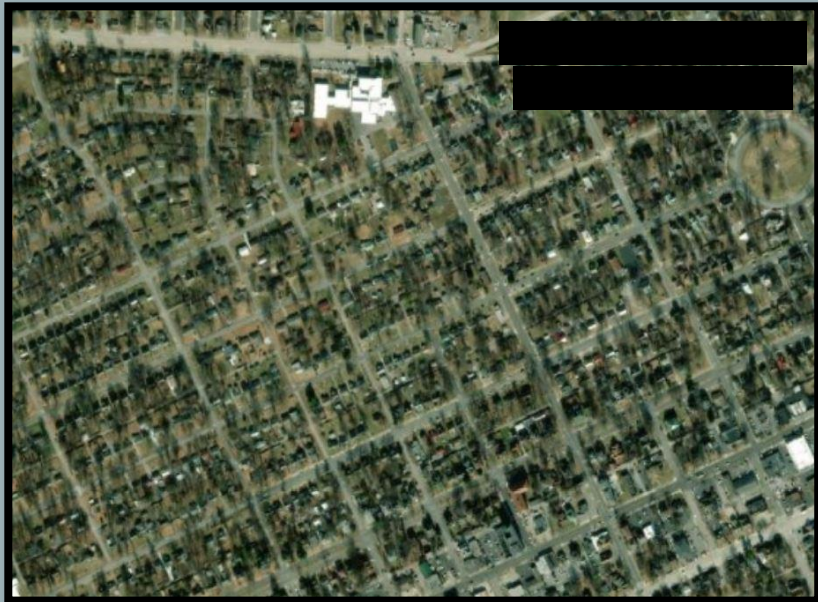
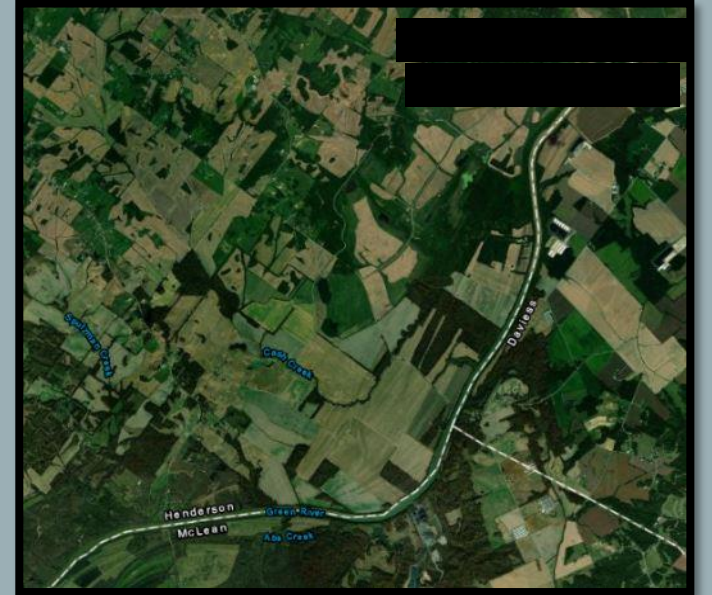
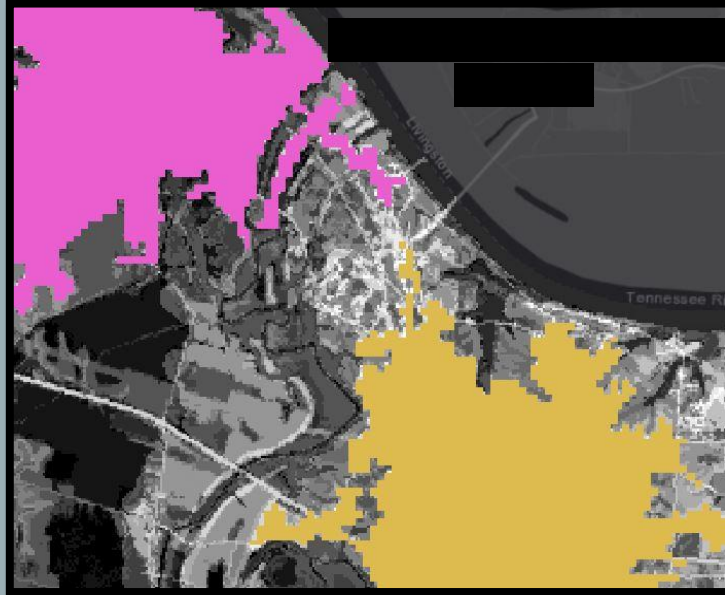


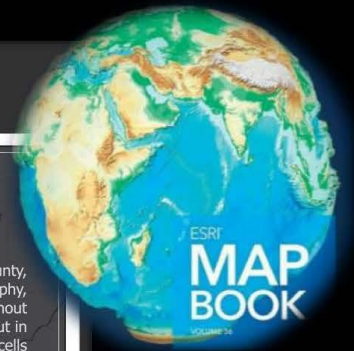
PIKE COUNTY/PIKEVILLE



WARREN COUNTY/BOWLING GREEN





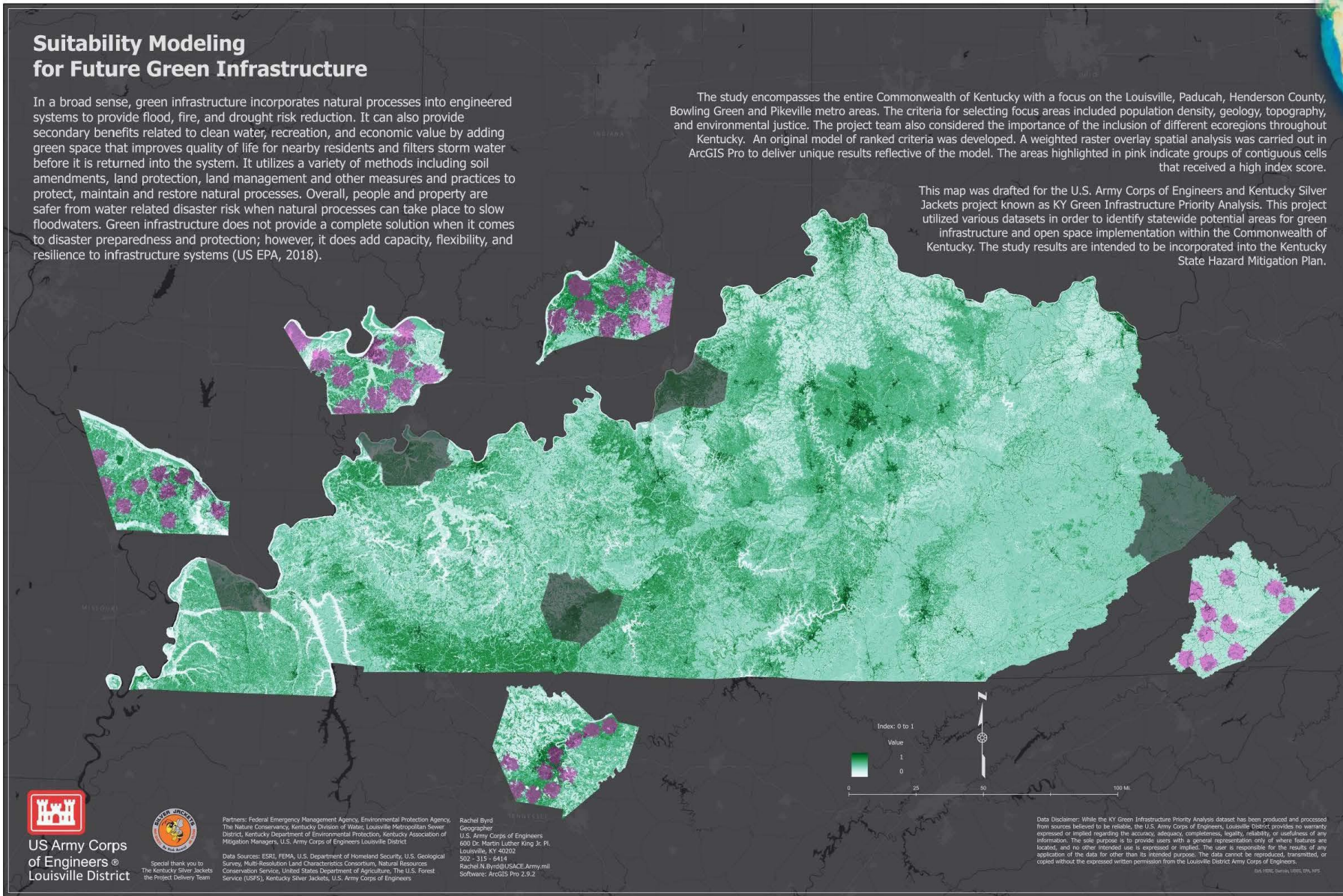


Suitability Modeling for Future Green Infrastructure

In a broad sense, green infrastructure incorporates natural processes into engineered systems to provide flood, fire, and drought risk reduction. It can also provide secondary benefits related to clean water, recreation, and economic value by adding green space that improves quality of life for nearby residents and filters storm water before it is returned into the system. It utilizes a variety of methods including soil amendments, land protection, land management and other measures and practices to protect, maintain and restore natural processes. Overall, people and property are safer from water related disaster risk when natural processes can take place to slow floodwaters. Green infrastructure does not provide a complete solution when it comes to disaster preparedness and protection; however, it does add capacity, flexibility, and resilience to infrastructure systems (US EPA, 2018).

The study encompasses the entire Commonwealth of Kentucky with a focus on the Louisville, Paducah, Henderson County, Bowling Green and Pikeville metro areas. The criteria for selecting focus areas included population density, geology, topography, and environmental justice. The project team also considered the importance of the inclusion of different ecoregions throughout Kentucky. An original model of ranked criteria was developed. A weighted raster overlay spatial analysis was carried out in ArcGIS Pro to deliver unique results reflective of the model. The areas highlighted in pink indicate groups of contiguous cells that received a high index score.

This map was drafted for the U.S. Army Corps of Engineers and Kentucky Silver Jackets project known as KY Green Infrastructure Priority Analysis. This project utilized various datasets in order to identify statewide potential areas for green infrastructure and open space implementation within the Commonwealth of Kentucky. The study results are intended to be incorporated into the Kentucky State Hazard Mitigation Plan.



Partners: Federal Emergency Management Agency, Environmental Protection Agency, The Nature Conservancy, Kentucky Division of Water, Louisville Metropolitan Sewer District, Kentucky Department of Environmental Protection, Kentucky Association of Mitigation Managers, U.S. Army Corps of Engineers Louisville District.
Data Sources: ESRI, FEMA, U.S. Department of Homeland Security, U.S. Geological Survey, Multi-Resolution Land Characteristics Consortium, Natural Resources Conservation Service, United States Department of Agriculture, The U.S. Forest Service (USFS), Kentucky Silver Jackets, U.S. Army Corps of Engineers

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Geographer
U.S. Army Corps of Engineers
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Louisville, KY 40202
502-315-6414
Rachal.N.Byrd@USACE.Army.mil
Software: ArcGIS Pro 2.9.2

Data Disclaimer: While the KY Green Infrastructure Priority Analysis dataset has been produced and processed from sources believed to be reliable, the U.S. Army Corps of Engineers, Louisville District provides no warranty expressed or implied regarding the accuracy, adequacy, completeness, legality, reliability, or usefulness of any information. The sole purpose is to provide users with a general representation only of where features are located, and no other intended use is expressed or implied. The user is responsible for the results of any application of the data for other than its intended purpose. The data cannot be reproduced, transmitted, or copied without the expressed written permission from the Louisville District Army Corps of Engineers.
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KY FLOODPLAIN EXPLORER TOOL

Considered a
“living tool”
collaboration with
The Nature Conservancy

Kentucky Floodplain Explorer

- Nutrient loading to Gulf of Mexico (nitrogen) -- from wastewater & urban runoff 0 to 100 i
- Nutrient loading to Gulf of Mexico (phosphorus) -- from wastewater & urban runoff 0 to 100 i
- Soils/Land Use**

 Agricultural productivity potential of soils in the floodplain 0 to 0.72 i
- Percent of floodplain in somewhat poorly, poorly, & very poorly drained soils 0 to 83 % i
- NRCS Watershed Vulnerability Index 3.301 to 12.868 i
- Soil erodibility index (K factor) 0.17 to 0.48 i
- Kentucky green infrastructure priority analysis 0.554 to 0.748 i
- % of watershed in cropland or pasture 0 to 100 i
- % of watershed in karst 0 to 100 i
- Habitat**

 Floodplains near protected 0 to 7,900 acres i

KY Floodplain

HUC 8s

Esri, HERE, Garmin, FAO, NOAA, USGS, EPA, NPS Powered by Esri

An aerial photograph of a river valley. The river flows from the top center towards the bottom right. The valley floor is a mix of urban development (grey buildings and roads) and green fields. Several areas are highlighted with semi-transparent green overlays, forming a network that follows the river and branches out into the surrounding landscape. The hillsides are covered in dense green forest.

THANK YOU!

- Laura Mattingly,
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- Rachel Byrd,
Rachel.N.Byrd@usace.army.mil
- Special thank you to the KY Silver Jackets team!