UMBC | R1 DOCTORAL UNIVERSITY

Geographic Information Systems (GIS)

2025 Information Session

Introduction

Dillon Mahmoudi
Associate Professor
MPS GIS Graduate Program Director
Geography & Environemental Systems
dmahmoudi@umbc.edu

Ron Wilson
MPS GIS Associate Graduate Program Director
Senior Lecturer
rwilson@umbc.edu

Core Program Objectives

- ✓ Develop technical skills with a variety of GIS software and programming languages to **gain a platform independent-level of experience**.
- ✓ Learn to **code in R and Python to compliment the use of common GIS programs** to establish a robust set of skills for maximum preparedness.
- ✓ **Train students in the use of Generative AI** across the program to prepare students for the modern workforce.
- ✓ **Foster methodological problem-solving skills** to develop superior analytical and technical capabilities.
- ✓ Develop an **understanding of key concepts in GIS and critical geography** to gain a holistic view of mapping and mapping technologies.
- ✓ **Assess problems and solutions beyond face-value** to address the challenges we face today.
- ✓ Illustrate how to **critically and ethically assess work products** to recognize the limits of solutions and their impact on people and/or the environment.
- ✓ **Learn to balance objectivity and subjectivity** to maximize the acceptance and effectiveness of solutions.

A Little Bit About the Program Itself

GIS Programs – UMBC

Geographic Information Systems at UMBC

The Geographic Information Systems (GIS) program at UMBC is distinctive with its focus on applying GIS critically toward the improvement of:

- People's Lives & Livelihoods,
- Societal Engagement, *and*
- Environmental Conditions.

Our Master's program is designed to facilitate place-based analysis in decision-making, by encompassing relevant aspects of science, planning, and policy-making.

Critical GIS as a Core Principle

Critical GIS means thoughtful use of GIS to further human development and environmental sustainability by fusing:

- Geographic Theory & Concepts (Foundation),
- Science & Technology Studies (Impact),
- Programming Depth & Breadth (Versatility), *and*
- Communication (Eloquence)

These four elements form a technical program that engages students to become **fully rounded** in their education so that critical thought is instilled in every aspect of their work.

The Academic Program

- Classes are held at UMBC's Catonsville, MD campus.
- Classes convene primarily in-person.
- **Post-Baccalaureate Certificate in GIS:**
  - 6 Required Courses (18 Credits)
  - Includes Project Management & Leadership Course
- **Master's in Professional Studies (M.P.S.) in GIS:**
  - 10 Courses (30 Credits)
  - 6 Required Courses (18), with 4 Electives (12)
  - Includes Project Management & Leadership, with Capstone Project

Student Experience Across Their Tenure

- Courses are developed and **taught by practitioners** who draw on current, real-world situations and experiences… using real data that students will encounter after graduation.
- Courses seek to provide an **interdisciplinary approach** that uses modern tools, techniques and methods in solving problems.
- **Evening in person courses**, meeting once a week and held on Monday thru Thursday from 6:00 to 9:00 pm.
- **Training in Generative AI** is a focus for a cutting edge skill set. Seminars on the **impacts of GIS on society** build additional skills the modern workforce is using.
- **Students will engage with real clients** (outside organizations: government, non-profit, environmental, social, etc…) to work on projects in the local Baltimore Metropolitan Region.

Do we use Generative AI?
You bet! We train you…

Integrating Generative AI into GIS Education at UMBC – GIS Programs – UMBC

Use of Generative AI Across the Program

Various AI programs are employed across the classes, in one or more of the following ways:

1. Reduce the less productive manual work when crafting analyses.
2. Facilitate creativity in human-initiated solutions.
3. Assess multiple solutions, building on human initiation and refinement.
4. Assess the advantages and disadvantages of ideals, methods, or solutions.
5. Support learning by aiding students in understanding problem complexities.

Using Generative Artificial Intelligence (GAI) will teach students to harness the technology to **maximize their effectiveness**, and **set them apart from their peers** in entering the job market, particularly with a science grounding.

The Good Stuff!
A Few Examples of What Students Learn in Various Classes

Course Descriptions, with Syllabi – GIS Programs – UMBC

Professional-level Coding & Documentation

R Code Development

```
plot(nyc_trct["BLQ"])
summary(nyc_trct$BLQ)
hist(nyc_trct$BLQ, breaks= 50)

plot(nyc_trct["ALQ"])
summary(nyc_trct$ALQ)
hist(nyc_trct$ALQ, breaks= 50)

plot(nyc_trct["OLQ"])
summary(nyc_trct$OTHER_CMB)
hist(nyc_trct$OLQ, breaks= 50)

#or loop through each of the new LQ fields.
i<- 1 #set an index counter to access race group column names.
for (g in lqNames) { #loop through each of the new LQ names.
  plot(nyc_trct[[g]]) #plot our a thematic map of the LQs to view the geographic distribution.
  summary(nyc_trct[[g]]) #print out the summary statistics for a review.
  #plot the histogram to examine the frequency distribution with the geographic distribution.
  hist(nyc_trct[[g]], breaks= 50, #break the frequency bins up to a finer interval.
                      xlab= lqNames[i], #change the x-axis label name.
                      main= paste("Distribution of ", raceGroups[i], "LQ", sep= ' ')) #set the title.
  i= i + 1 #increment by 1 to access the the next race group in the list.
}

#covert n/a values to 0.
nyc_trct[c('WLQ', 'BLQ', 'ALQ', 'OLQ')][is.na(nyc_trct[c('WLQ', 'BLQ', 'ALQ', 'OLQ')])]<- 0 #if specific columns
nyc_trct[is.na(nyc_trct)]= 0 #if converting all n/a values to 0 in table.
```

```
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

Vignette Creation

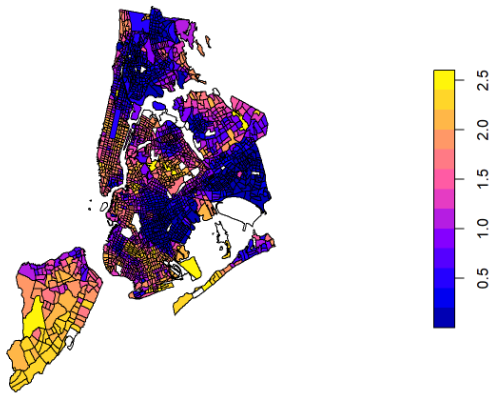
```
##  [21] "OTHER"       "RACE_TWO"    "RACE_THREE"    "RACE_GT_THREE"
##  [25] "White_LQ"
##  [29] "Black_LQ"    "Asian_LQ"    "Other_LQ"
```

When looking at the bottom of the listed variables, we can see that the result of our function was successfully added when we appended them. "White_LQ", "Black_LQ", "Asian_LQ", and "Other_LQ" are all included here.

Visualizing the Quotients

Here is where we visualize the result of the location quotients that we calculated. Using three different methods of data representation, an array of techniques are provided in order to give us the full picture of what the data is saying. The first one we use is the plot function that allows us to view the data on a map using graduated colors. This is helpful for visualization purposes and tells where there are trends in the data. The second method we use in the summary function, which shows us basic statistics of the data. This is a very precise method that allows us to see the exact numerical results. The third method used is a histogram that shows the frequency of each location quotient for the listed variable. This is helpful to see which location quotients are most common as well as the overall trend of the data.

```
plot(nyc_trct["White_LQ"])
```




```
summary(nyc_trct$White_LQ)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
```

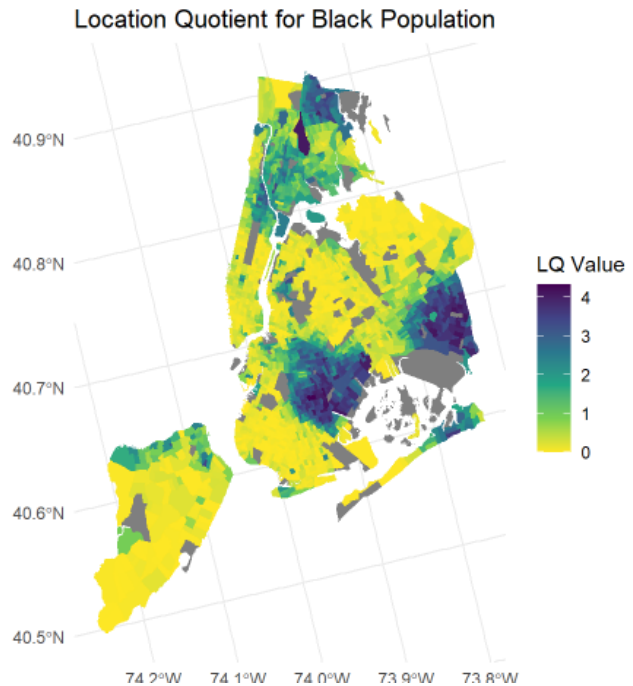
As an example of learning R in **GES 666: Just Maps – Critical & Ethnical Aspects of Mapping**, students learn R coding to *(i) clean, (ii) review, (iii) process, and (iv) structure data* for making professional and superior maps.

Visualizing Location Quotient for the Black Population

The following code visualizes the Location Quotient (LQ) for the Black population within the census tract dataset. It uses ggplot2, a powerful data visualization package in R, to create a spatial plot where LQ values are represented with an inverted Viridis color scale. This scale emphasizes lower LQ values in lighter shades and higher values in darker shades, showing progression. As the LQ_Black variable is used in the fill, the boundary color is set to NA, as it dominates the plot. The theme_minimal function applies a clean, minimalist aesthetic to the plot, removing unnecessary background elements for improved clarity. The labs function is used to set the title and label the fill legend, enhancing the interpretability of the plot.

From the map, it is observed that in Brooklyn, Queens Village, and near the New York Botanical Garden, there are high LQ values. In the percentage map, these areas show large clusters compared to other regions. This plot enhances insights into spatial dynamics, highlighting concentrations of the Black population and thus supporting the analytical goal of assessing racial distributions.

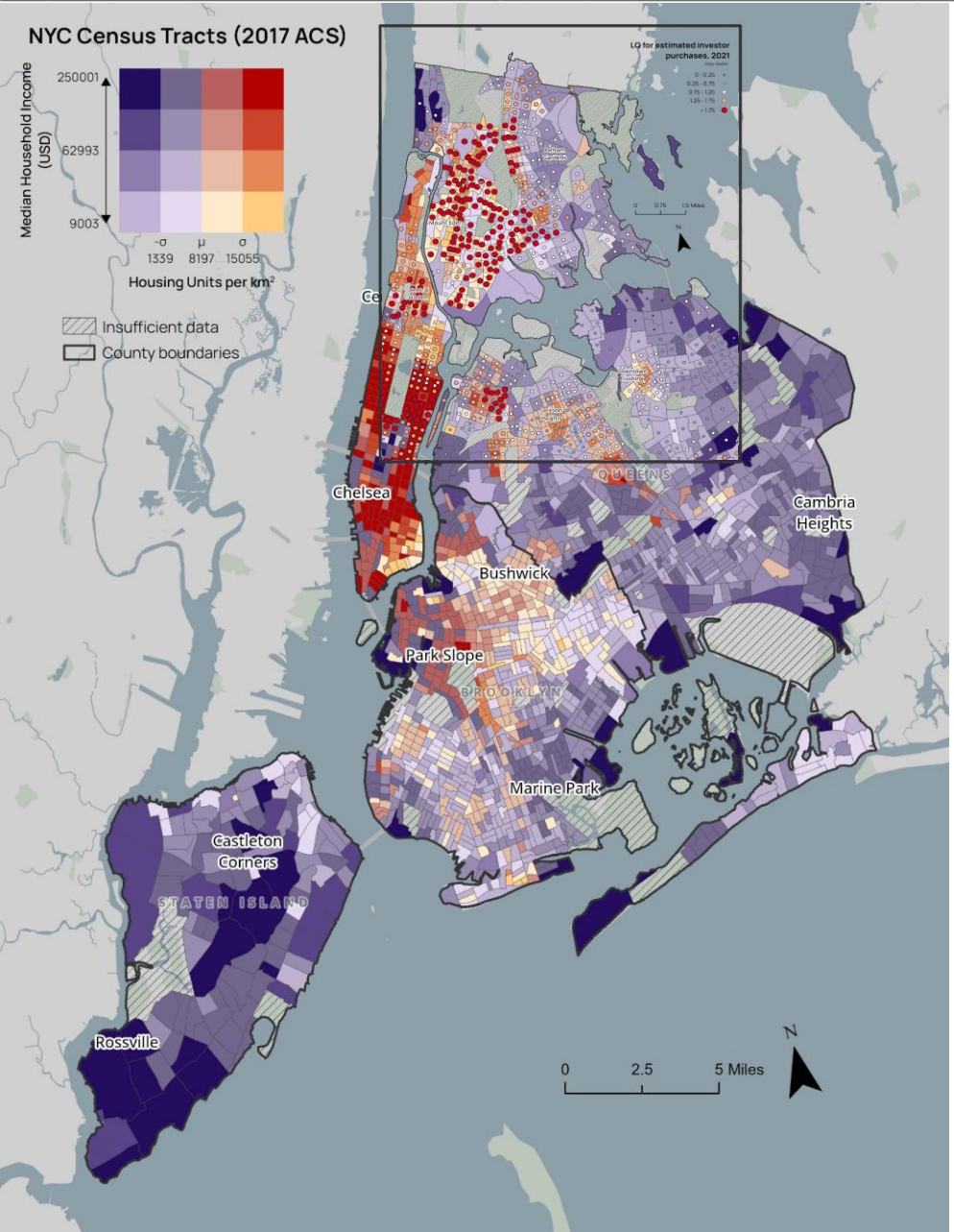
```
ggplot(trct) +
  geom_sf(aes(fill = LQ_Black), color = NA) +
  scale_fill_viridis_c(direction = -1) +  # Color scale for LQ values
  theme_minimal() +
  labs(title = "Location Quotient for Black Population",
       fill = "LQ Value")
```



In **GES 666: Just Maps – Critical & Ethnical Aspects of Mapping**, as student demonstrates his mastery of creating an R vignette to highlight the analysis of data in New York City. The student learned to:

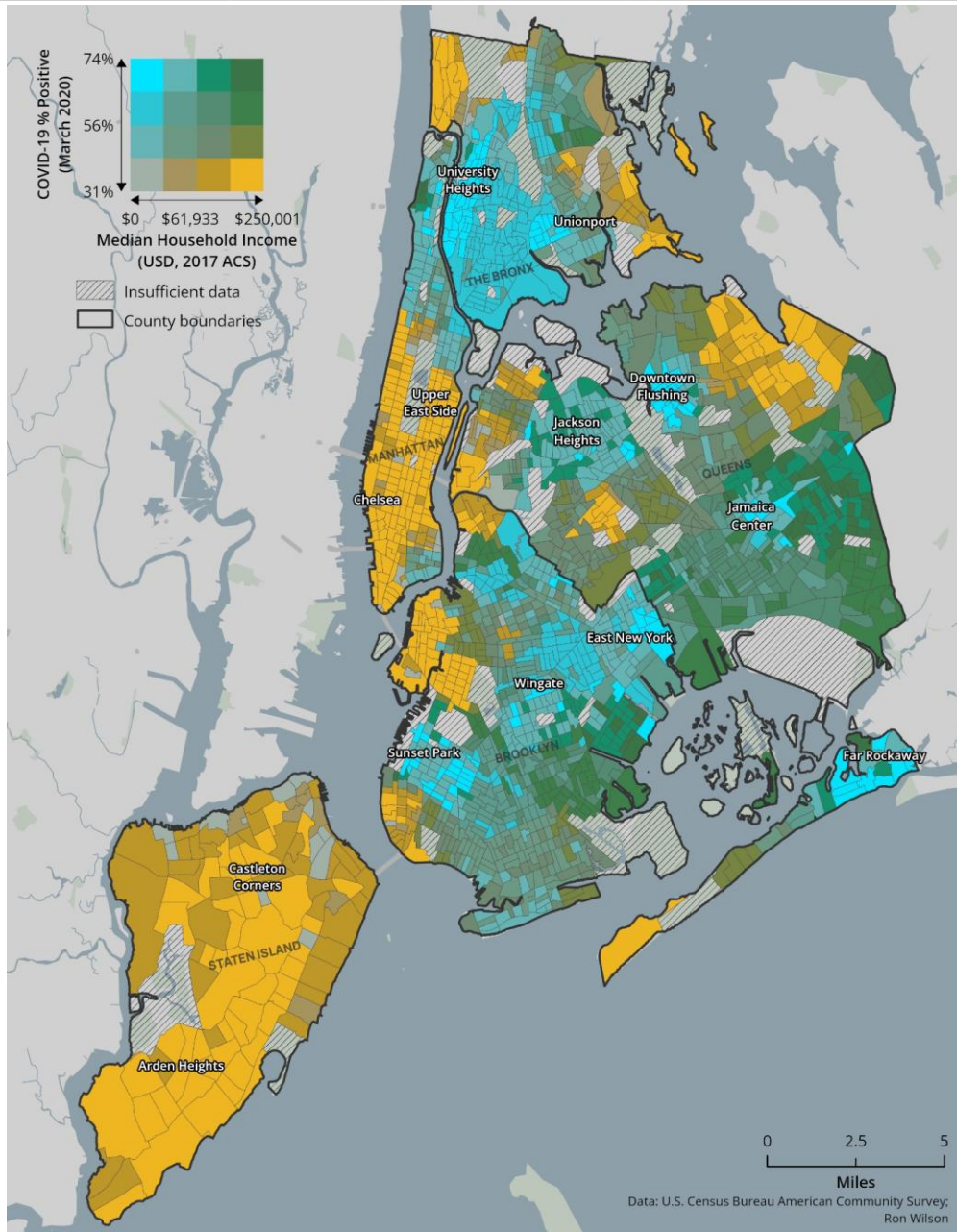
- *Create an R Vignette, with Table of Contents*
- *Structure a template with R-Markdown*
- *Process Data with SF Geography Tools*
- *Use GGPLOT library for Advanced Visuals*

The resulting vignette equips students with essential skills to produce clean and professional work in a modern format. Students master code, graphics, and narrative integration in one framework.



In GES 666: Just Maps – Critical & Ethical Aspects of Mapping, students learn the principle of graphical excellence in making profession quality maps. Bivariate mapping is a complex analytical mapping technique that can reveal multiple geographic relationships.

Here, students learn how to assess the various gradations of two-way relationships and the multitude of subtle patterns that can be revealed with bivariate maps.

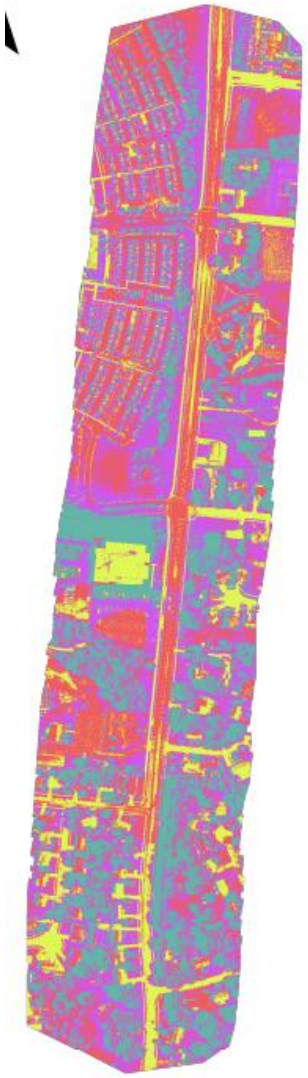


Maps by Harrison Deford, 2022

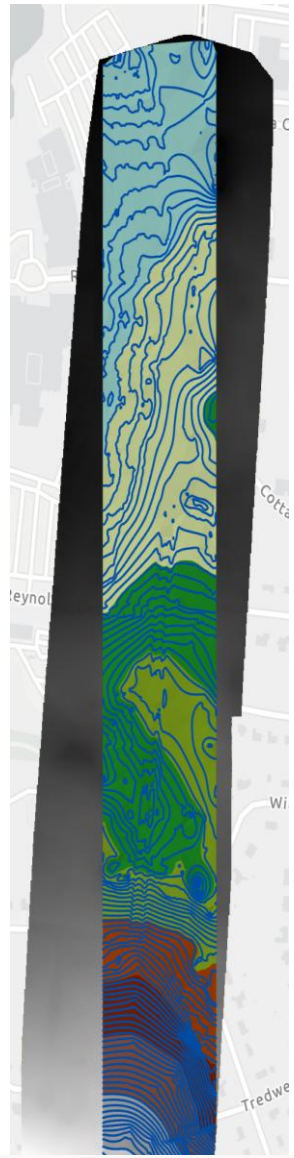
As an example from **GES 776: Application for Remote Sensing**, students process aerial imagery to produce an ortho rectified mosaic and digital elevation model, then use digital image classification techniques to classify the mosaic to separate land cover types and produce a statistical report. With this exercise, students learn to:

- *Process UAS-based imagery using Pix4D software where they will perform:*
  - *Aerial triangulation*
  - *Measure ground control points*
  - *Generate mosaic and DTM*
- *Compile planimetric (vector) and topographic maps*
- *Perform digital image classification using supervised and unsupervised classification*
- *Assess product horizontal and vertical accuracy.*

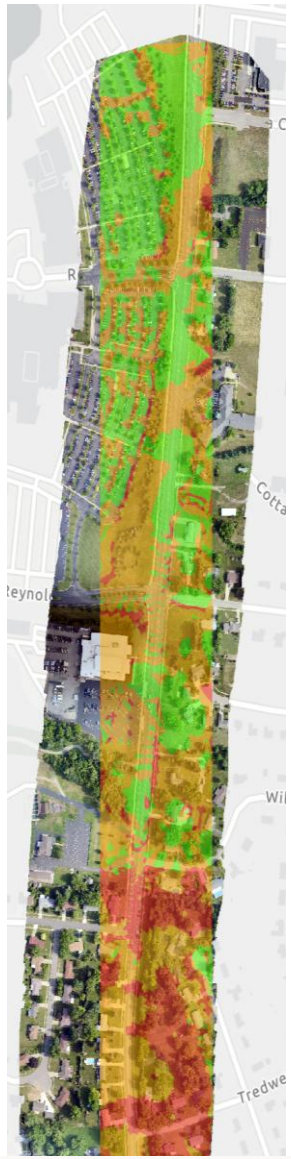
Ortho Imagery prepared in Pix4D



Digital Image Classification



TIN & Contours in ArcGIS Pro

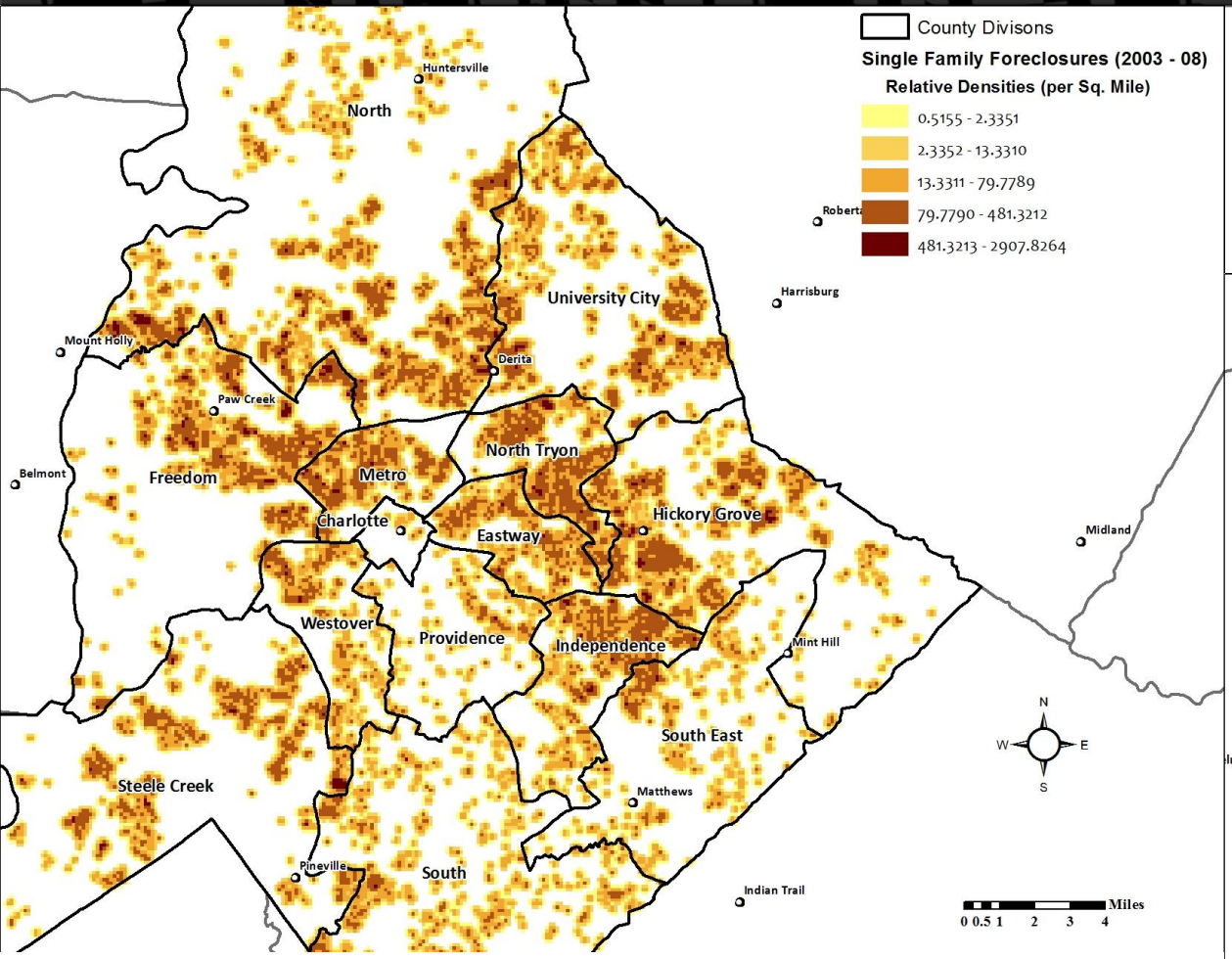


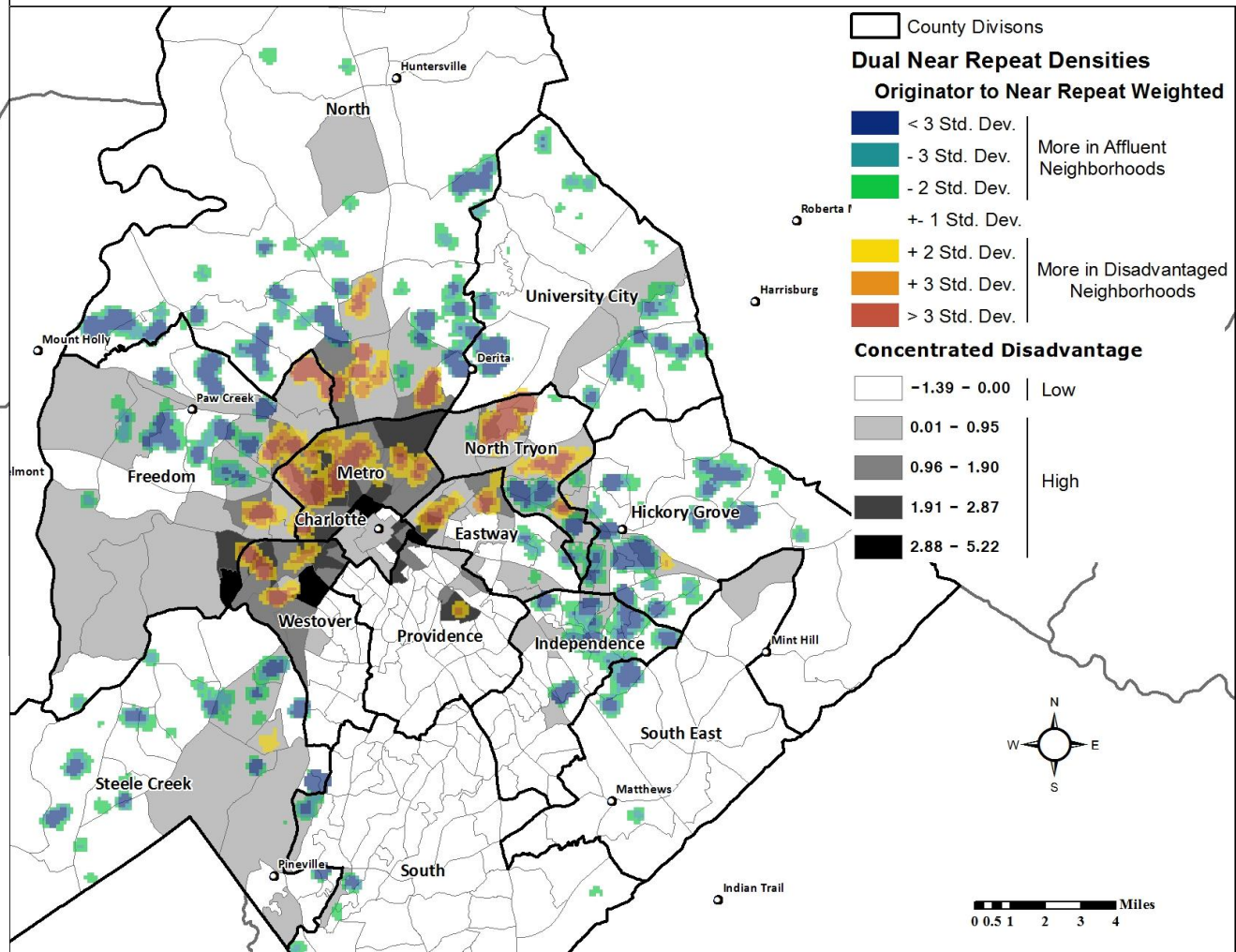
Slope Analysis

Maps by Ron Wilson, 2009

Kernel Density Estimation of Foreclosures.

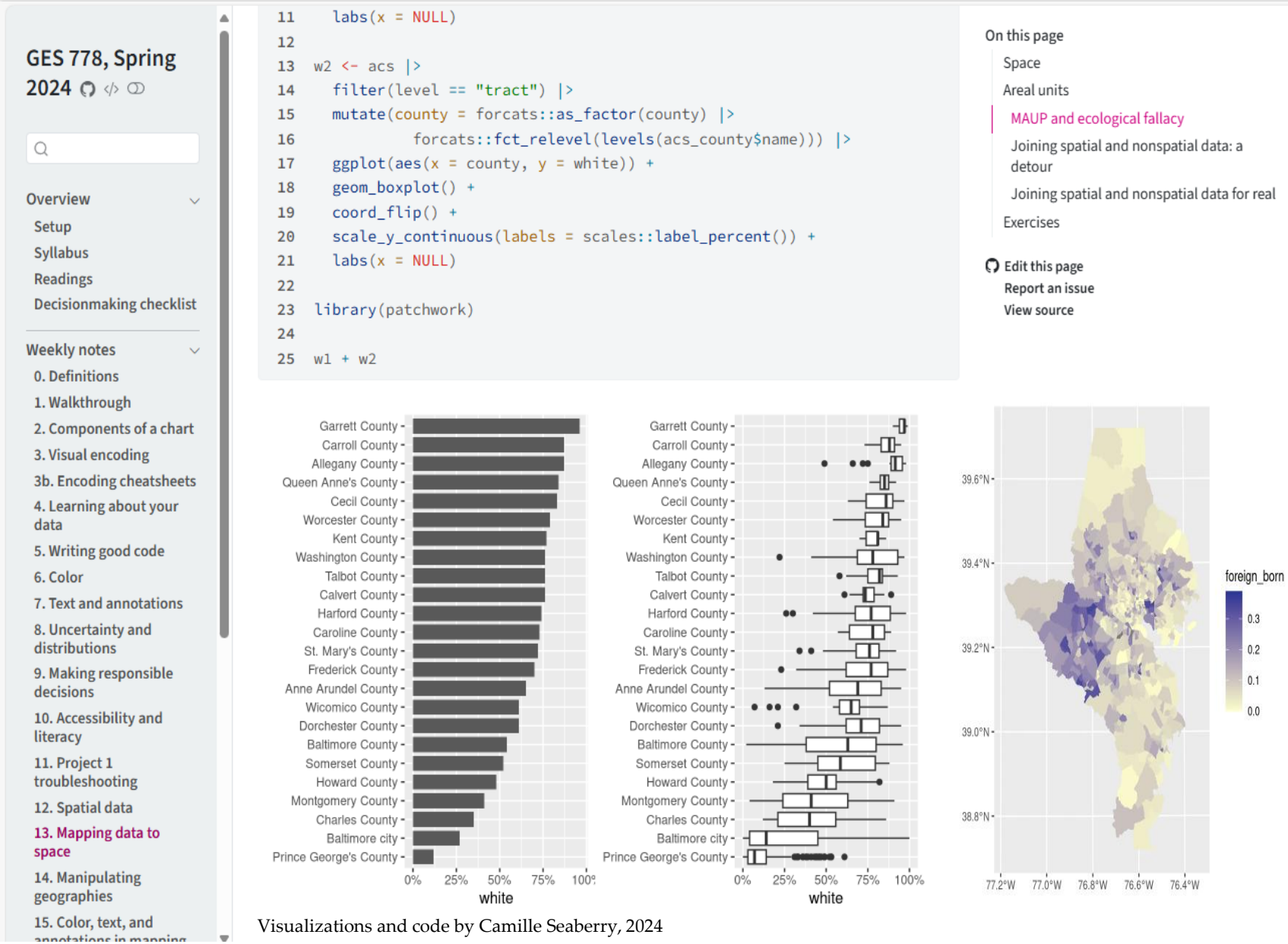
A density surface was created to identify the differences in concentrations of foreclosures that are occurring in close proximity in time and space.





Two density analyses reveal increasing and decreasing levels of foreclosures. In the above increasing density of foreclosures, and to the right are increasing and decreasing levels of foreclosures concentration to type of neighborhoods.

Here, students learn how set an analysis up to capture the correct scale of clusters, as well as simultaneously compare increases and decreases of foreclosures.



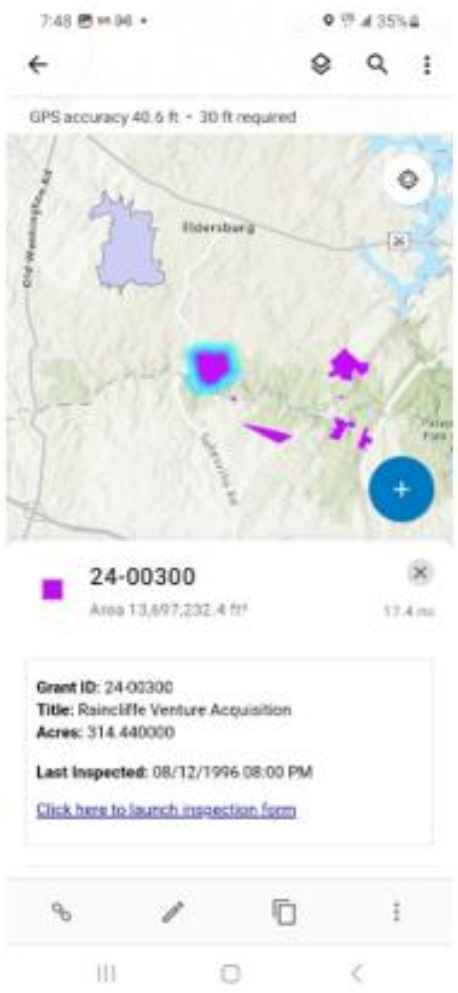
Visualizations and code by Camille Seaberry, 2024

In **GES 778: Advanced Cartography & Visualization**, students learn to take their mapping work from GES 666: Just Maps and extend into more advanced territory:

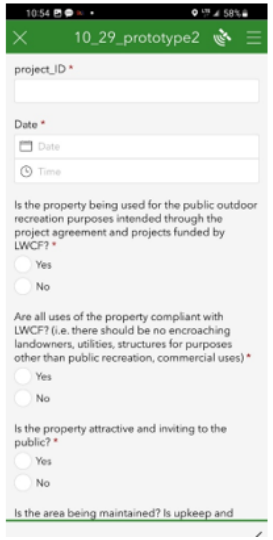
- *Learning R coding in Depth*
- *Create Advanced Visualizations*
- *Use more Advanced Tools & Libraries*
- *Develop Strong Data Science Coding*

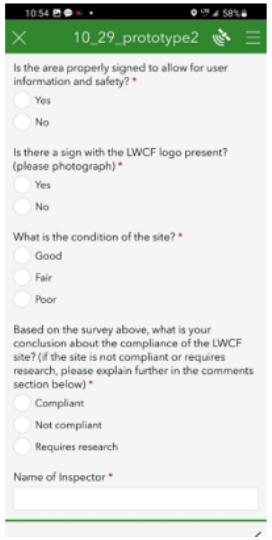
The result has students becoming fluent users in the R language, supported by Data Science principles to create products that are effective in communicating.

An Example from a Capstone Project (GES 778)



	A	B	C	D
1	type	name	label	hint
2				
3	text	Grant_ID	project_ID	
4	dateTime	Date	Date	
5	select_one inspections_Q1_922a4a	Q1	Is the property being used for the public outdoor recreation purposes int	
6	select_one yes_no	Q2	Are all uses of the property compliant with LWCF? (i.e. there should be	
7	select_one yes_no	Q3	Is the property attractive and inviting to the public?	
8	select_one inspections_Q4_f8c008	Q4	Is the area being maintained? Is upkeep and repair of structures and im	
9	select_one yes_no	Q5	Does staffing and servicing of facilities appear adequate?	
10	select_one yes_no	Q6	Is the property readily accessible and open to the public during reasona	
11	select_one yes_no	Q7	Is the area properly signed to allow for user information and safety?	
12	select_one yes_no	Q8	Is there a sign with the LWCF logo present? (please photograph)	
13	select_one inspections_Q9_fec05f	Q9	What is the condition of the site?	
14	select_one compliant	Q10	Based on the survey above, what is your conclusion about the	
15	text	Q11	Name of Inspector	
16	text	2	Q12	
17	image	inspections_image	Image	
18	hidden	GUID	GUID	
19				



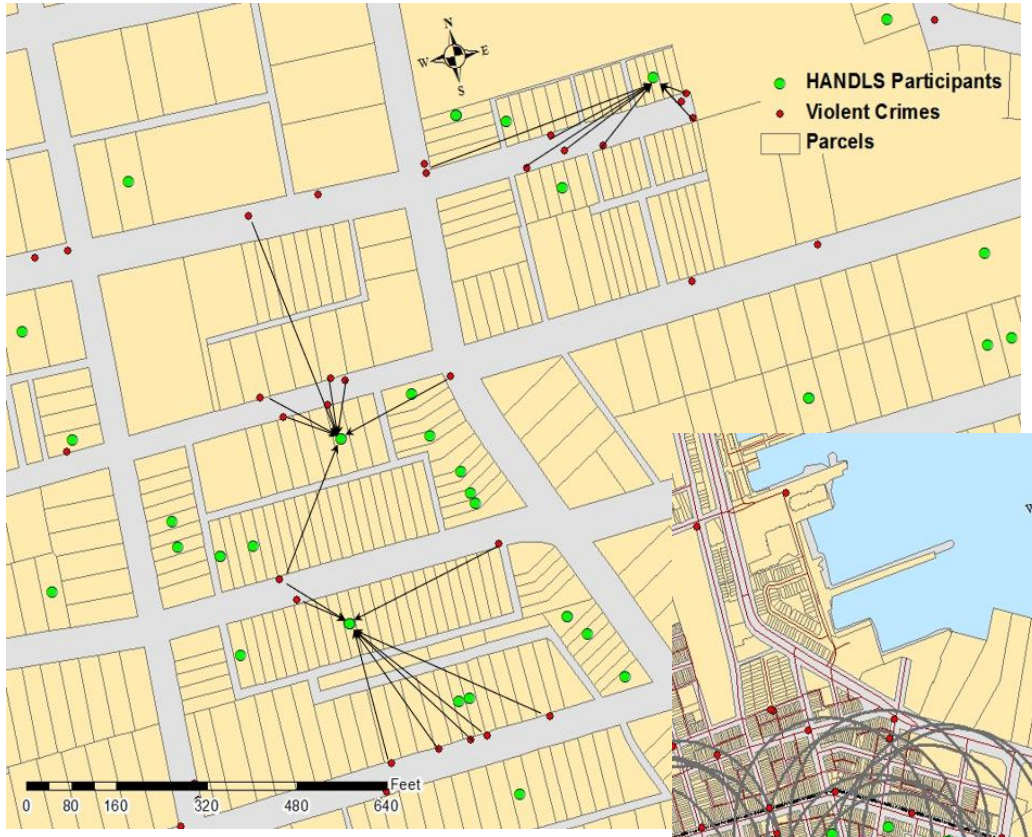


For the Maryland Department Natural Resources, a student created a field data collection for the purpose of streamlining a property inspection process that uses geographic data to support the scheduling visits. Project demonstrates combining multiple software tools, such as:

- *Survey 123*
- *Excel*
- *ArcPro & Model Builder*
- *ArcGIS On-line*

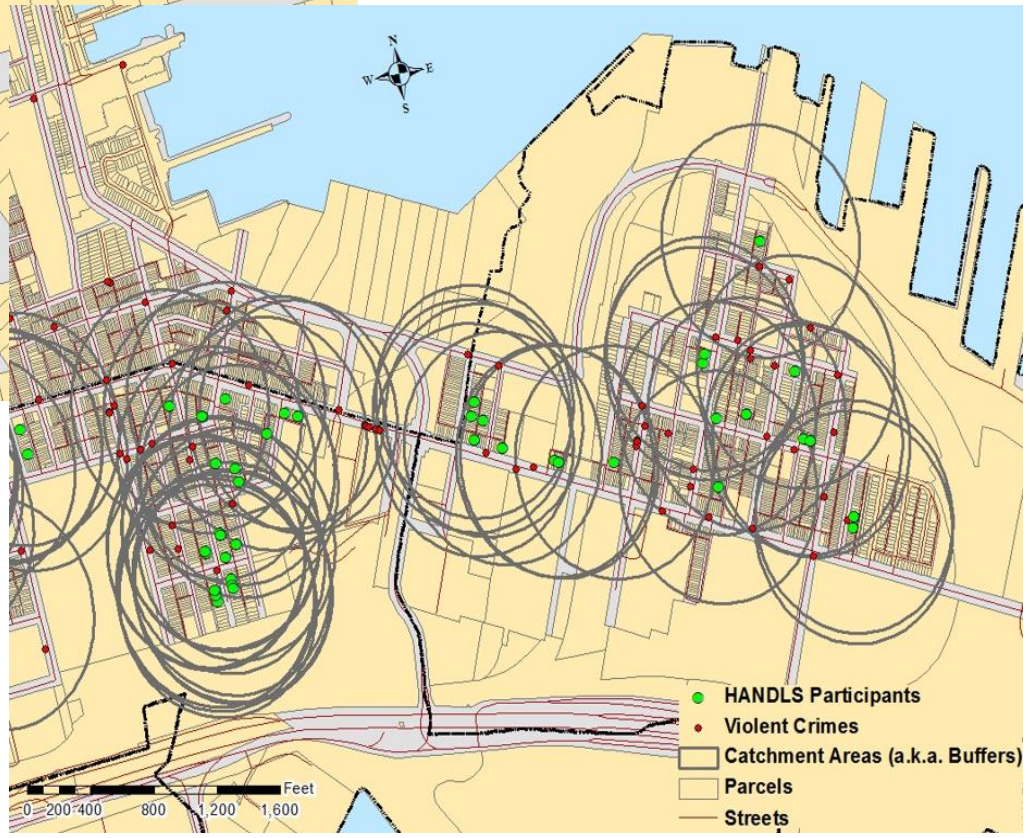
The new tool has reduced the time it takes to gather data by assembling all input data and corresponding geography to perform inspections off-line.

Application produced Elizabeth Oswald, 2024



Proximity

Density



Analysis and maps by Ron Wilson, 2021

In **GES 673: Processing Geographic Data**, students learn advance techniques and methods to *(i) clean, (ii) review, (iii) process, and (iv) structure data*. This class transforms students into highly capable users of GIS well beyond the standard.

In this example students learn to create catchment areas and event proximities that represent individual and group (shared) awareness spaces to accurately represent the impact of crime concentration in neighborhoods.

The catchment areas allow for more accurate measurement of crime concentration to assess the impact on perception.

Our Curriculum

Course Descriptions, with Syllabi – GIS Programs – UMBC

Procession of Classes

There is **no specific class order** students must follow, but students should try to get the following classes in early to get a **grounding in R & Python**:

- GES 666: Just Maps – Critical & Ethical Aspects of Mapping
- GES 668: Building Spatial Datasets
- GES 673: Processing Geographic Data
- GES 675: Web-GIS Development

Exceptions are to a set of courses that build off of each other:

- GES 666 → GES 777 → GES 774 → GES 779
- GES 675 → GES 775
- GES 678 → GES 762

International Students: You need to take at least 3 classes in Fall and Spring semesters.

Required Courses – 18 Credits

The following course must be completed for the M.P.S. or Certificate option:

- ✓ GES 666: Just Maps – Critical & Ethical Aspects of Mapping
- ✓ GES 668: Building Spatial Datasets
- ✓ GES 673: Processing Geographic Data
- ✓ GES 675: Web-GIS Development
- ✓ GES 774: Statistics for Geographers
- ✓ GES 678: GIS Project Leadership & Management

Elective Courses – 12 Credits

Four of the following courses must be completed for the M.P.S. degree –all are 3 credits:

- GES 671: Launching Spatial Databases
- GES 680: Introduction to Satellite Image Analysis
- GES 762: GIS Project Capstone
- GES 770: Applications of Remote Sensing
- GES 771: Advanced Spatial Data Management
- GES 775: Advanced Web-GIS Development
- GES 777: Public & Crowd-sources Spatial Data
- GES 778: Digital Cartography & Visualization
- GES 779: Spatial Regression & Advanced Statistics

Course Offerings

Fall 2025 (Current)

- **GES 673**: Processing Geographic Data
- **GES 675**: Web-GIS Development
- **GES 678**: GIS Project Leadership & Management
- **GES 777**: Public & Crowdsourced Spatial Data

Summer 2026

- **GES 774:** Statistics for Geographers

Spring 2026

- **GES 666**: Just Maps, Critical & Ethical Aspects of Mapping
- **GES 668**: Building Spatial Datasets
- **GES 700**: Special Topics – AI in Geographic Analysis
- **GES 780**: GIS Project Capstone

Job Candidates After the Program

- ✓ **Proficiency in platform independent GIS software, R, and Python** that demonstrates flexibility in adapting to most work environments, appropriate for any career path.
- ✓ **Refined interpersonal skills** – ability to build positive relationships at all levels both internal and external to a work environment from in-person classes and working on local projects.
- ✓ Independent judgment and critical thought from **rigorous methodological training**.
- ✓ Practice in not just completing tasks, but **delivering work that is exceptional**.

Developing Superior Communication Skills

Being part of the Department of Professional Services (D.P.S.), an emphasis is placed on developing superior communication skills, which include:

- ✓ Writing analytical reports that adhere to **editorial-level quality**, needing little in the way of rewrites or copy-editing.
- ✓ Creating graphics that **achieve graphical excellence**, which demonstrate simplicity, elegance, and eloquence.
- ✓ Crafting documentation to support programming or analytical methods to **offer full transparency** to meet modern standards.
- ✓ **Integrating Generative Artificial Intelligence** (GAI) into your workflow to enhance your work, in a responsible and ethical manner.

Applying to the Program

Geographic Information Systems Master of Professional Studies

Geographic Information Systems Certificate

Admission Requirements

- **Four-year Bachelor's degree** from an accredited U.S. institution or an international credentialed equivalent.
- A **background in geography or spatial analysis is *not required***. Because GIS and geography has a footprint in nearly all disciplines, the use of GIS can be applied to any subject and we are looking for students in a diverse array of backgrounds.
- **Minimum undergraduate GPA of 3.0** on a 4.0 scale. Students with a GPA less than 3.0 may be admitted to the MPS program provisionally or to the Graduate Certificate program. International applicants will be evaluated based on equivalent standards for the country of their degree.
- The **GRE is *not required*** for admission to our program.
- For International students, **English proficiency scores *are required***:
  - Test of English as a Foreign Language (TOEFL): 99. iBT Breakdown: Writing (23), Listening (23), Reading (25), Speaking (28)
  - International English Language Testing System (IELTS) scores: Minimum score 7.0
  - Pearson Test of English (PTE) Academic scores: 68
  - Scores must within 2 years of the application submission.
- **Two letters of recommendations**. Strong letters will highlight the specific things that make you a strong candidate.
- **Admission places an emphasis on the personal statement in making selections.**

The Personal Statement

- √ **Tells a story** of how you became interested in GIS.
- √ **Contains specific examples** and link to our curriculum courses in helping you achieve your academic goals or objectives.
- √ **Should not be hyperbolic**, *e.g.* overuse of adjectives or praising the program or the revolutionary power of geographic analysis on the world.
- √ Should **emphasize the relationship** between your career goals and how the Program will succinctly meet those goals.
- √ Shows **growth in skills and abilities**.
- √ Should demonstrate **how your background relates to GIS**, to either highlight the geographic training aspects of your background, OR how your career focus will be benefitted by mastering GIS.
- √ Length **need not be** longer than two pages in length.
- √ Writing quality **should be reflective** of you and **not GenAI**.

What's Left to Tell You – Learning More and Reaching Out

Media – GIS Programs – UMBC

Learning More…

For in-depth overviews and experiences in our program, the following videos are available:

Program Foundations & Philosophy:

- The Program – Critical GIS in the Applied Scene
- Generative AI in the Program – Beyond the Code, the Future of GIS Professionals

Student Perspectives of the Program:

- Ready for What's Ahead – Navigating the GIS Journey
- Mapping Success – A Glimpse into GIS Excellence

Reaching Out…

Further questions or requests for discussions about the program can be sent to any of the following:

- Prof. Ron Wilson – Assistant Graduate Program Director (rwilson@umbc.edu)
- Dr. Dillon Mahmoudi –Graduate Program Director (dillonm@umbc.edu)
- Admissions – Office of Professional Programs (gis@umbc.edu)