



GEOG653 – Spatial Analysis



Lecture 2

1

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Outline

- Updates and Announcements
- Introduction to Spatial Analysis
 - Overview
 - Examples
- Demo



Outline

- Updates and Announcements
 - 9/7/2020 (Monday) is Labor Day.
 - The University will be closed and therefore, no classes on this day.
 - AGOL account created
 - ArcGIS Pro license pending.
 - Exercises #1, 2, and 3 have been posted.
 - Exercises are optional and for your practice only.
 - Lab 1 will be posted early (before Friday).



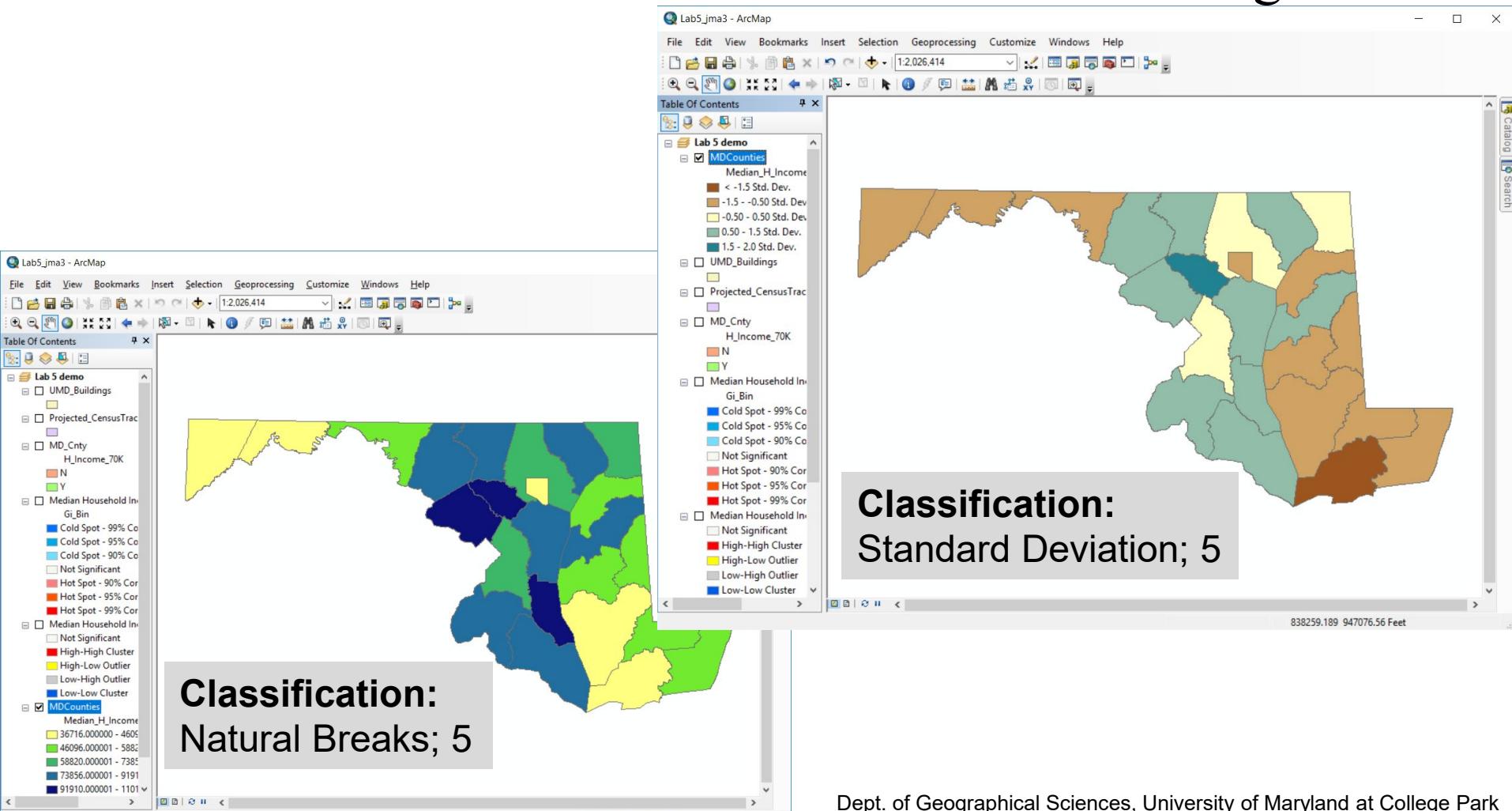
Introduction to Spatial Analysis

- Definition
 - Investigating the patterns that arises as a result of processes that may be operating in space.
 - O'Sullivan and Unwin
 - A process for looking at geographic patterns in data and at relationships between features.
 - Mitchell



Introduction to Spatial Analysis

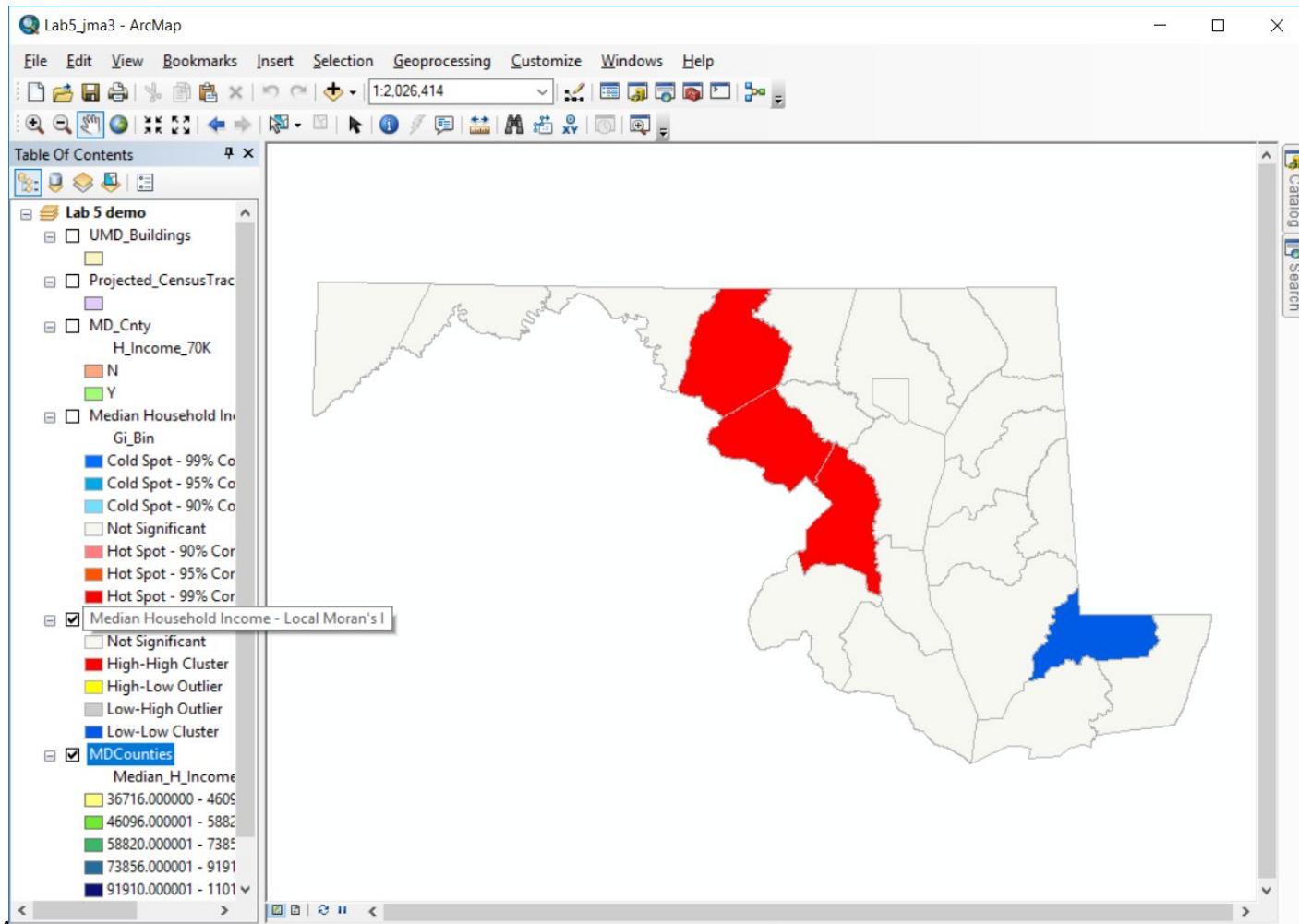
- Visualization can be misleading.
 - Same data with different visualization settings.





Introduction to Spatial Analysis

- Robust quantitative analysis is more reliable to discover spatial patterns.





Introduction to Spatial Analysis

- Types of Spatial Analysis
 - Based on ontology of the world
 - Vector vs. raster
 - Based on data types
 - Point, line, network, area, and surface
 - Based on analytical methods
 - Selection, cartographic, measurement, statistics, and models
 - Based on the spatial range of data to be included
 - Global vs. local



Introduction to Spatial Analysis

- How to analyze spatial data?
 - Spatial data manipulation
 - Buffer, overlay, transformation, query
 - Exploratory spatial analysis
 - Visualization, description, summary, measurement
 - Statistical spatial analysis
 - (more complex than traditional statistics; depending on scale)
 - Spatial autocorrelation, hypothesis testing



Examples: Spatial Analysis

- Examples of student's posters
 - Posters made for the final project
 - Examples have been posted on ELMS



Analyzing Priority Areas for Future Seafloor Research and Exploration off the California Coast

Jennifer Kraus, NOAA

GEOG653/Spatial Analysis/Spring 2019

Dr. Jiangao Ma



Introduction

Spatial information about the seafloor is critical for decision-making by marine research and management organizations. It is important for these agencies to convey where their data interests lie to better understand their individual objectives, mandates, and missions (Battista & O'Brien 2015). In order to effectively analyze data interests, a spatial framework and web-based tool was used to identify common spatial priorities among different organizations. Users are able to allocate a certain number of coins per cell and select a justification and product to associate with the input (Battista et al, 2017).

Objectives

For this project, I will analyze the prioritization data collected off the coast of California to answer the following:

- 1) Where are the most coins allocated? Where are the top justifications and products located?
- 2) How do the higher concentrations of cells change when considering total coins, top justification, and product? This will be done using a Kernel Density Analysis
- 3) What areas of the (combined) hotspots have not been previously surveyed?

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Study Area

This project will focus on the data collected off the coast of California, ranging out to the 200 nautical mile Exclusive Economic Zone (EEZ). The figure to the right shows the extent of the prioritization, the sections of northern, central and southern California (merged together for this project), and the grid cells used for the analysis (10 x 10 minute grid).



Data

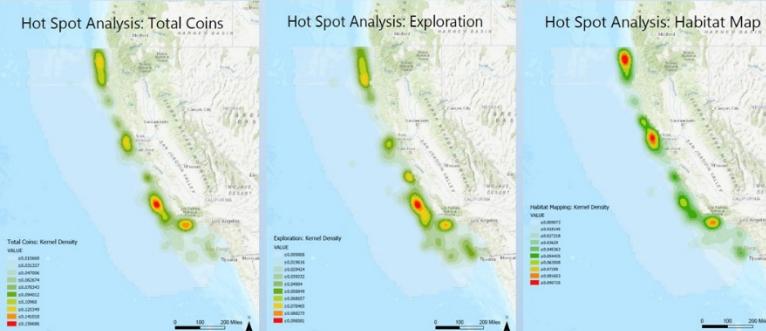
Most of the data used were produced in-house by NOAA's NCCOS Biogeography team. The prioritization grid and online tool was created by NCCOS using a GIS Web-based interface and digital atlas (Kendall et al, 2018). Results from the prioritization were provided as a data table with coin values for each grid cell (including 0-no input). These values corresponded with input from users on total coin number, coins per justification (ie exploration, fishing, cultural) and number of coins per product (ie habitat maps, sediment samples).

Dataset Name	Source	File Type
California Prioritization AOI	NOAA/NCCOS	Shapefile
Grid 10x10 minute	NOAA/NCCOS	Shapefile
Prioritization Results	NOAA/NCCOS	Table
Hydrography Map Footprint	NOAA/NCEI	Shapefile

Objective 1: Spatial allocation of total coins, top justification and product



Objective 2: Hot Spot Analysis using Kernel Density

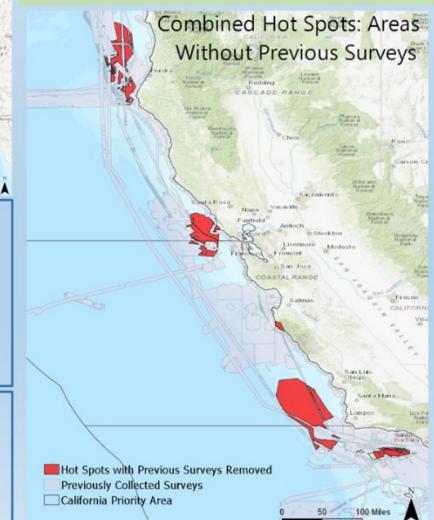


Data Analysis Methods

- 1) Tables for north, central, and south California were combined to get all of the prioritization input for California
- 2) Graduated symbols used to display total coins, top justification, and top product fields.
- 3) Table join: grid and coin data to get values per grid. Calculated top 5% and 10% (in excel) and displayed these as colored grids.
- 4) Kernel Density to calculate magnitude per unit area
- 5) Extract by Attribute values < or + 0.07 to extract hot spots
- 6) Int tool to convert floating point raster to integer
- 7) Raster to polygon: convert hotspot raster to polygon
- 8) Erase: remove bathy footprint from hotspot polygons
- 9) Final polygon: combined hotspots with previous surveys removed



Objective 3: Areas of high priority (combined hotspots) that have not been previously surveyed.



Results and Discussion

- The most coins were allocated in the nearshore areas, primarily within 200km offshore.
- There are about 4 hot spots that were similar among total coins, the top justification (exploration) and desired product (habitat map).
- When previously surveyed areas are removed from the combined hot spot results, there is a total of 19,155 km² of high priority areas that have not yet been surveyed.
- The results of this study can provide agencies with insight as to where to focus their data collection and research, in order to better allocate limited resources (ie ship time and scientist availability) where data needs are highest.
- Published results will also encourage collaboration across (and within) organizations where data needs overlap.

References

- Battista, T., O'Brien, K. Spatially Prioritizing Seafloor Mapping for Coastal and Marine Planning. *Coastal Management* 2015, 43(1), 35-51. <https://www.tandfonline.com/doi/10.1080/08920753.2014.985177>
- Battista, T., Buja, K., Christensen, J., Hennessey, J., Lassiter, K. Prioritizing Seafloor Mapping for Washington's Pacific Coast. *Sensors* 2017, 17, 701. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5362017/>
- Kendall, M.S.; Buja, K.; Menza, C.; Battista, T. (2018) Where, When, What, and Why Is Bottom Mapping Needed? An On-Line Application to Set Priorities Using Expert Opinion. *Geosciences* 2018, 8, 379. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2636381/>



Examples: Spatial Analysis



Nebraska Wind Turbine Suitability Models

Max Andersen, MPSGIS Student



Introduction and Objective

Nebraska has the fourth highest wind capacity in the United States (1). In actual wind energy production, however, it lags far behind the neighboring states of Iowa, Kansas, South Dakota, and Colorado. This is primarily because the power utility companies in Nebraska are publicly owned and therefore can't take advantage of the same tax benefits as private companies in other states. In recent years, however, as wind energy technology has improved and become less costly, it has begun to make economic sense for public utility companies to sign contracts with private turbine owners. These private owners, in turn, sign leases to build the turbines on land owned by rural farmers, ranchers, and other community members (2).

In order to effectively develop wind energy production, it will be important to examine the state as a whole and identify areas that hold the greatest potential value. To accomplish this, two suitability maps were produced from a variety of input factors that help determine the best locations for wind turbines. To develop the models, work completed by Janke, Van Hoesen and Lelandrie, and Miller and Li in Colorado, Vermont, and two individual counties in Nebraska was consulted (3) (4) (5).

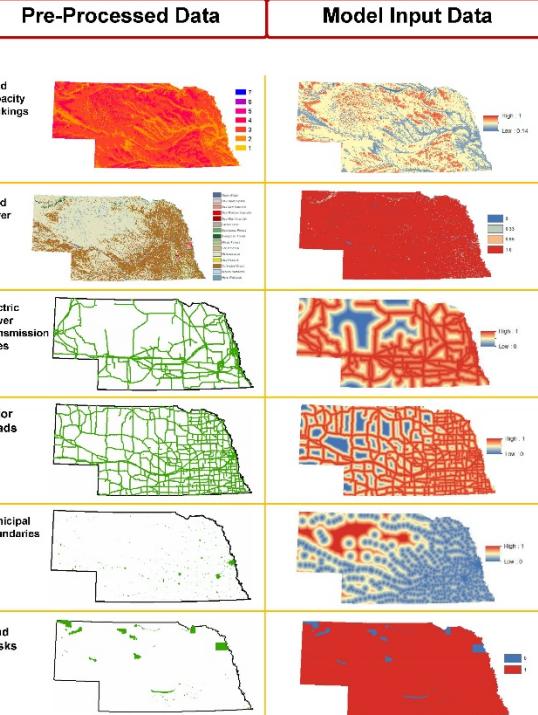
Study Area Overview



A majority of the residents of Nebraska live in the eastern part of the state near Omaha and Lincoln, which are the only cities with a population over 60,000. The central part of the state is dominated by row-crop agriculture, while the western portion (Sandhills) has a greater percentage of pasture and grassland. Small towns and infrastructure have typically developed following the Platte River or Interstate-80, as seen in the data to the right.

Processing Steps

- Fishnet:** First, the "Create Fishnet" tool was used in ArcMap to generate a polygon grid across the entire state. A cell size of 750 meters was chosen based on trial and error of the author's PC processing capabilities. The fishnet was used as a "container" to store input variable values. All input data were projected to NPSR 2007 Nebraska State Plane (FIPS 2000 – meters) and snapped to the fishnet so that cells were properly aligned.
- Categorical Data:** Wind Capacity data was provided as a polygon with 200 m resolution. Each cell was ranked as 1-7, with 7 being the highest capacity areas. This file was converted using the "Polygon to Raster" tool, changed to a 750 m resolution using the "Resample" tool (with Nearest Neighbor setting), converted again using the "Raster to Point" tool, and stored in the fishnet file using the "Spatial Join" tool. Land Cover data was provided as a 30 m resolution raster with 15 different categories. The resolution was changed using the "Resample" tool, converted using "Raster to Point", and stored in the fishnet using "Spatial Join".
- Distance Data:** Major Power Transmission Lines, Major Roads, and City Boundary data were retrieved as line and polygon shapefiles. They were converted to raster format by using the "Euclidean Distance" tool with 750 m cell size settings. The distance value for each cell was converted using the "Raster to Point" tool and stored in the fishnet by using the "Spatial Join" tool.
- Data Masks:** Federal-owned lands (such as National Parks and military bases), Native American land, and endangered species critical habitat areas were provided in shapefiles. They were used as masks to denote areas where wind turbine development could not take place. First, the files were combined using the "Merge" tool, converted using the "Polygon to Raster" tool with 750 m cell settings, converted to a binomial raster using the "Raster Calculator" tool so that cells that represented federal lands were given a value of 0, and cells with no data were given a value of 1, converted with the "Raster to Point" tool, and stored in the fishnet with the "Spatial Join" tool.
- Normalization:** The Land Cover categories were normalized by manually redefining the categories based on their suitability for turbine development. Areas such as "Open Water" were converted to 0, "High Intensity Development" and "Forested areas to 0.33, "Low Intensity Development" and "Wetlands" to 0.66, and "Barren land", "Herbaceous", "Pasture", etc., to 1 by using the "Select by Attribute" and "Create New Field" tools. Wind Capacity, Transmission Line Distance, and Road Distance were normalized by using the formula $x = \frac{x - \bar{x}}{x_{max} - \bar{x}}$. Road Distance was normalized by using the formula $x = \frac{x - \bar{x}}{x_{max} - \bar{x}}$. Mask data did not need to be normalized.
- Model Creation:** The simple model was produced by creating a new field in the fishnet attribute table and using "Field Calculator" to multiply each of the normalized variables with each other. This model was then converted using the "Polygon to Raster" tool. The weighted model was produced by converting each normalized variable to a raster first, and then using the "Weighted Sum" tool. The Wind Capacity variable was assigned a value of 3 and the Distance to Transmission Lines variable was assigned a value of 2. This identified the areas of "lowest hanging fruit", or areas with the highest capacity that would be the easiest to incorporate into the grid.

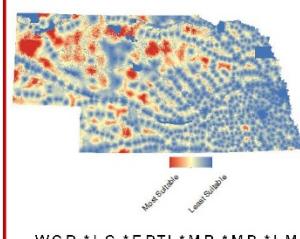


References and Sources

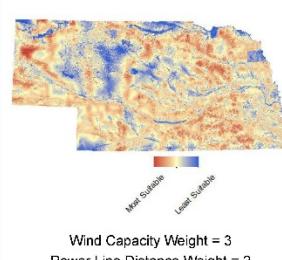
- (1) [Wind Energy Resource Development in the Western Great Plains](#) (2006)
 - (2) [The Impact of Wind Energy Development on Public Lands in the Western Great Plains](#) (2006)
 - (3) [Janke, Jason et al. "Integrating GIS modeling of wind and solar in Colorado." *Renewable Energy* 35.10 \(2010\): 2238-2234.](#)
 - (4) [Van Hoesen, John and Steven Lelandrie. "Using spatial renewable energy resources in Pueblo, Vermont: A GIS-based approach to supporting rural community energy planning." *Renewable Energy* 35.10 \(2010\): 2235-2237.](#)
 - (5) [Miller, Alan and Mathew L. "A geographic approach to assessing wind farm development in Northeast Nebraska, USA." *ISPRS International Journal of Geo-Information* 3.3 \(2014\): 868-879.](#)
- Wind Capacity Rating Data:
<http://www.energy.gov/eere/wind/wind-capacity-ratings-data>
- Land Cover Data:
<http://usda.fas.usda.gov/census/census2010/>
- Normalized Mask Data:
http://www.esri.com/arcgis/rest/services/USGS/National_Forest_Fire_Risk/MapServer
- Electric Power Grid Data:
http://www.esri.com/arcgis/rest/services/USGS/National_Forest_Fire_Risk/MapServer
- Major Roads Data:
http://www.esri.com/arcgis/rest/services/USGS/National_Forest_Fire_Risk/MapServer
- Endangered Species Critical Habitat Data:
http://www.esri.com/arcgis/rest/services/USGS/National_Forest_Fire_Risk/MapServer
- Polygons derived from Native American Lands Data:
http://www.esri.com/arcgis/rest/services/USGS/National_Forest_Fire_Risk/MapServer

Model Results

Simple Model



Sum-weighted Model



Discussion and Conclusions

- Both models predict a highly-suitable area near the western border of the state just north of the North Platte River. This is a low population area, but has infrastructure in place near it and a high wind capacity. This could be the most cost-effective area to target for wind turbine production.
- Small town municipal boundaries appear to play an exaggerated role in the simple model. It may be useful to normalize their impact by population density in future analysis.
- The sum-weighted model places a higher priority on wind-capacity rankings, so the majority of south-central Nebraska is ranked as very suitable, while only small pockets of it receive high rankings in the simple model.
- The models may suffer from multi-collinearity, as municipal boundaries, major roads, and electrical power transmission lines appear to be correlated. Further testing would be needed to verify this.
- Future analysis could include different weighting systems for the input variables and the inclusion of new variables, such as population density and line-of-sight analysis.



Examples: Spatial Analysis

Marine Traffic Behavior In and Through the Bearing Strait

Vector Line and Point Analysis of Automatic Identification System(AIS) data.



Masters student at University of Maryland & Cartographer at Marine Chart Division NOAA : Guillaume Aucter

Introduction

Boat shipping is the main avenue used for international goods trade, accounting for nearly 90% of total world trade. Marine traffic is fluid and will usually follow lines of least distance between destinations. International marine traffic is nonetheless impacted and limited by physical geography. The shape of shorelines and continents have a great impact on the path maritime traffic uses. There exist throughout the world several bottlenecks or "Strategic maritime passages" (2) These passages are important in geopolitics, usually the scene of convergent and dense marine traffic, and thus interesting areas to study.

Area of Interest

The Bering strait is one of these "Strategic Maritime Passage". It is situated in the arctic, geographically isolated and limited by seasonal freezing. It therefore has much less dense maritime traffic than many other strategic maritime passages. This trend is changing. With recent political development spurred in part by climate change and the potential for economic gains, the arctic has seen a large increase in vessel traffic in the last few years. The Bering Strait is 82km wide and separates the Pacific Ocean from the Arctic Ocean. An interesting political element is that the Bering Strait is divided by the United States/Russia maritime border. In addition to national and international commercial, military and scientific vessel traffic, the region also encounters extensive daily travel by locals. The challenging distances and isolation of this area of the world makes traveling by sea the medium of choice. The Strait is an underserviced and undercharted region that merits a closer look and attention.

Data for the Analysis

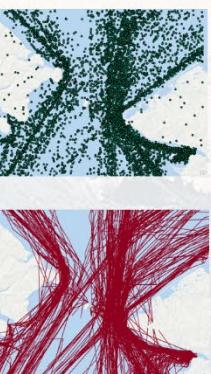
I will be using data called AIS. AIS stands for *Automatic Identification System*. Its intended and main use is to prevent ship collisions. Each ship possesses a tracking system that emits its ID, position, bearing and speed in real time. This enables ships to know exactly what neighboring ship they are communicating with or passing near and therefore is very effective in preventing collisions. Additionally, this source data may be analyzed to identify other correlations. This data has only recently been made available to the public but has already sparked quite interesting studies and application.

AIS data may either be land or satellite collected. The land based data is free and publicly available (<http://marinecastry.gov/ais/>) but shows limitations for the Alaskan region especially. The land AIS data for the arctic region is picked up by stations that are on American soil only and also in sparse locations.

The second type of AIS data is satellite, which is the type used in this project. It is not limited by national borders or stations. The raw AIS data is extremely large and dense because it consists of a set of point data for each boat (shown top left) which can contain up to a point per boat per second.

The sheer size of the data set makes it impossible to check for absolute data accuracy but this is not a problem since the large amount of data should drown out the errors. With AIS data, the larger the dataset you use, the more accurate the result will be. This final project will use AIS data that has been filtered by boating seasons Summer of 2012, 2013 and 2014.

AIS data can easily be made as a line data by using the "date and time" attribute it possesses (shown bottom left)



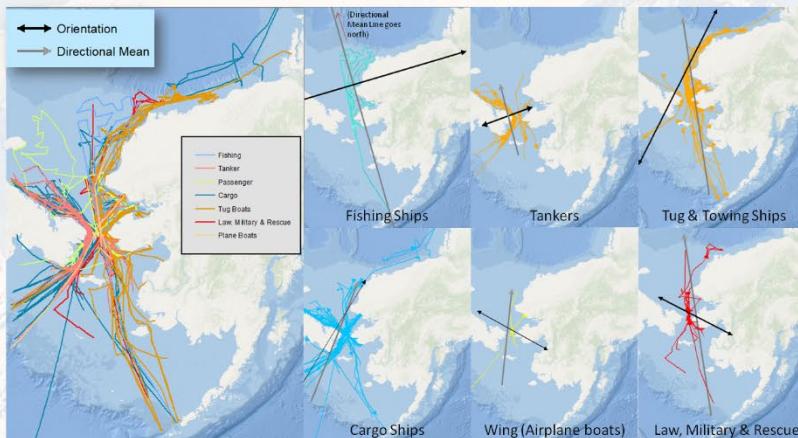
Objective of the Project

The objective of this project is to determine vessel traffic patterns around the Bering Strait. By including the element of quality (types of ships) we should be able to see clear patterns of behavior emerge. The objective is to use line and point analysis to answer the question: How does the passage of the Bering Strait affect vessel traffic?

References:

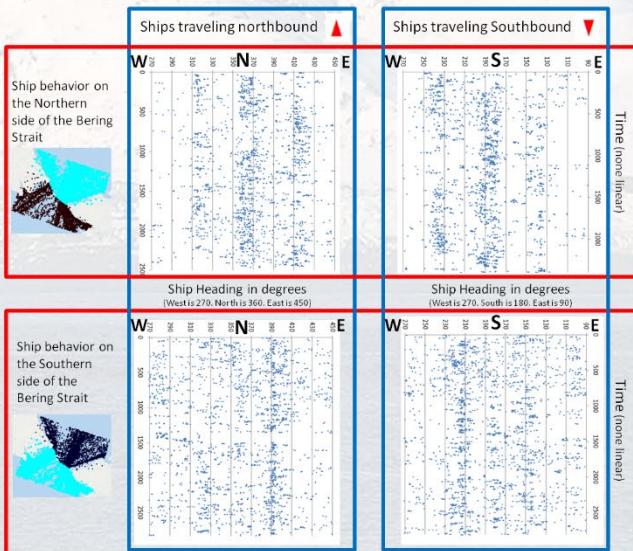
- [1] AIS Study in the Arctic Region 2015. http://www.cnts.ca.gov/downloads/CMT's-10-Year_Arctic_Vessel_Projection_Report_1.1.5.pdf
- [2] The Geography of Transport Systems. HOFSTRA university <https://people.hofstra.edu/geotrans/eng/ch1en/app1en/t1l2ex.html>
- [3] NOAA internal servers for the data. <http://oceandata.noaa.gov/>

Line Study of Ships Traveling Through the Bering Strait



Point Analysis of Ships in the Bering Strait

The following graphs express the exported attribute table of the AIS points directly surrounding the Bering Strait (up to 150km away). They are created based on each point's direction attribute (horizontal axis) and also time (vertical axis).



Analysis of the Line Data Results

Ship Type	Orientation	Orient adjusted
Tanker	8.29	4.998023
Wing	11.50	340.348802
Law	14.49	340.348802
Cargo	15.01	26.235091
Tug	20.85	25.957744
Fish	45.96	1.391047

Some of the short comings of the AIS data are quickly apparent when creating line data from the many points. Not all lines end up being perfectly attributed when joining with complex external tables of attribute. Nonetheless, and as I mentioned previously, the more AIS data you use, the better the results will be. In the line study (on the left and above here) we started with about 600,000 track lines! 500 of these lines go through the Bering Strait. 375 lines where attributed correctly and thus usable for this specific study. We can safely assume that these lines are a sample adequately representing the population. From these resulting lines some patterns emerge. First by visual inspection: We clearly see that most of these lines "hug" the shoreline and act in function of the shoreline. This shows that the Shoreline as a whole has a significant impact on the AIS lines. We can also note that different types of traffic do not show the same patterns.

By looking at the table (top right) we can make some assumptions. "Wing boats" and "law, military and rescue" ships show similar orientation and mean distances. This could be due to the level of "freedom" these ships have, showing a sort of randomness in their movement due to the nature of their travels. "Tug" and "Cargo" ships also show strong similarities. This similarity in behavior could be due to their important role and extensive travel through the communities strewn along the shorelines.

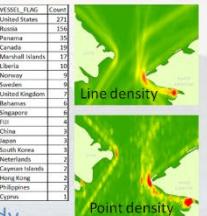
It is interesting to notice that "Tankers" and "Fishing" boats have almost the same orientation yet very different mean distances. We can assume that Tankers have many short lines because they are using direct routes around Russia (thus the "flat" orientation). Fishing boats have few but lone distance lines, showing a random local travel tendency.

The point graph (shown here on the left) can look overwhelming and chaotic at first but after a closer look, clear patterns start to emerge. If we focus on traffic on the "north side" (graphs located in the top red rectangle) we can see that the traffic leaving the Bering (top left graph) has three major shipping routs. The major one is almost exactly due north (360 degrees) This is the route going to the north slope of Alaska. The other two are almost exactly 45 and 135 degrees going North East and North West. These are respectively the American route going to Kivalina and Kotzebue and the Russian route going West. This exact same pattern is found for ships going south towards the strait except it is with opposite angles.(top right graph)

A different pattern is apparent for ships located on the southern end of the Strait (bottom red rectangle).

The graph on the bottom left shows a strong line going approximately 60 degrees North East. The same line reappears in the bottom right graph but once again in an opposite angle. The rest of the point data in the "southern side" graphs seem relatively random.

We can therefore assume that the traffic on the "northern side" is very regular and structured and focuses on a few distinct routes. The southern side is much less structured but still shows strong tendencies. If we focusing on the time aspect of the graphs we can see clear patterns as well. We see "groupings" of points passing the same Area at around the same time but a deeper study is necessary to find an apparent cause.



Conclusion & other Avenues of Study

It is very difficult to come to a categorical conclusion regarding the exact effect of the Strait on vessel traffic. On the other hand we were able to expose clear patterns. With the help of the line analysis we can see that the type of traffic greatly affects traffic patterns. Whether the traffic is tankers, cargo, tug boats etc, greatly changes its behavior around the Bering Strait. We have also seen with the help of the point data that vessel traffic behaves dramatically differently whether it is going to or leaving the strait and whether the ships are traveling south or north towards the arctic.

The complexity of the data used and the nature of the subject could, with a more mathematical approach, completely conclude that the Bering Strait greatly affects vessel traffic.

Other approaches in the GIS realm that could support this conclusion could be based on line or point density (shown here above right), these images already show a clear pattern with denser traffic and bottleneck areas in and around the Strait and clear "shipping lanes" coming and going through the Strait)

There is also a myriad of other attributes in the AIS data that could be interesting to study such as "ship tonnage", "ship size" or even "ship flag" (nationality of vessel shown in table above) We could also introduce the international border between Russia and the United states as a factor of ship behavior.



Examples: Spatial Analysis



Utilizing Network Analysis for Emergency Preparedness & Response

Renee Dauerer

Center for Geospatial Information Science, University of Maryland



Introduction

Hurricane Maria struck Puerto Rico on September 20, 2017, resulting in the worst storm to hit the island in over 80 years. The Category 4 storm sustained winds of 155 mph as it crossed the island, uprooting trees, downing weather stations and cell towers, and destroying roofs of homes. One hundred percent of the electricity on the island was cut off and access to clean water and food was extremely limited. Heavy rain and flash flooding worsened this devastation – streets filled with water and debris and in some areas, the floodwater rose more than 30 inches deep. [1]

Following the devastating losses accrued as a result of Maria, The Federal Emergency Management Agency (FEMA) released an after-action report – The agency experienced personnel shortages, lack of aid supplies, and difficulty coordinating logistics. In a letter included in the report, FEMA administrator, William “Brock” Long, stated that all emergency managers at all levels of government need to improve emergency plans and account for shortfalls that result in coordination and logistical breakdowns. [2]

Objectives

This research addresses how agencies and first responders can leverage Network Analysis for emergency preparedness and response.

Additionally, this research demonstrates what is possible using open data to create a network dataset, making evident the power and utility open source data can have. Specifically demonstrating what is currently available for downloading source data and subsequently generating network datasets.

Data Sources

Source Data	Processed / Derived Data	References
OpenStreetMap Roads	Network Dataset	Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org
OpenStreetMap Buildings		
OpenStreetMap Waterways		
OpenStreetMap Points of Interest		
NOAA High-Resolution Aerial Imagery 0.25 M GSD	Ground Truth	https://storms.ngs.noaa.gov/storms/maria/index.htm#H1018.3219-66.3904
Hospitals	Destinations	U.S. Department of Homeland Security (2019). Hospitals of Puerto Rico, HydroShare, http://www.hydroshare.org/resource/56d616e529e14f7d2e016374d8df9f
Fire Stations	Destinations / Origins	U.S. Department of Homeland Security, Homeland Infrastructure Foundation-Level Data (HIFLD)
FEMA Damage Assessment	Destroyed Buildings	The FEMA Geospatial Response Office, https://disasters.geoplatform.gov/publicdata/

References

- [1] E. Schwartz, "Quick facts: Hurricane Maria's effect on Puerto Rico," Mercy Corps, Sep. 23, 2019. [Online]. Available: <http://www.mercycorps.org/articles/united-states/hurricane-maria-puerto-rico> [Accessed: Oct. 28, 2019].
- [2] A. Hernandez, "FEMA admits failures in Puerto Rico disaster response, in after-action report," The Washington Post, July 12, 2018. [Online]. Available: https://www.washingtonpost.com/national/fema-admits-failures-in-puerto-rico-disaster-response-in-new-after-action-report/2018/07/12/b7900228-8636-11e8-9e80-403a221946a7_story.html [Accessed: Oct. 28, 2019].

Study Area: San Juan, Puerto Rico



Candidate Shelter Locations



Decision makers can utilize GIS to determine candidate shelter locations in the event of an emergency. In this scenario, the following requirements were used to identify two potential shelter areas during a disaster such as Hurricane Maria.

Requirements		
Within 0.25 Miles of Major Roads		
At least 0.1 Miles away from Waterways (excludes Ocean)		
Building Area Greater than or Equal To 200,000 Square Feet		

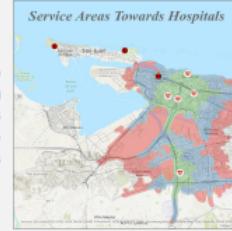
Identified Location	Area
Puerto Rico Convention Center (TOP)	400,922.0625 sq. ft
Multipurpose de Plaza Las Américas (BOTTOM)	312,784.875 sq. ft

OD Cost Matrix



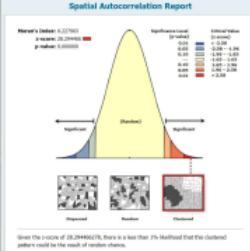
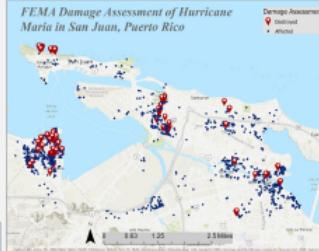
First responders need to determine how to allocate resources. In this scenario, GIS was utilized to create an OD Cost Matrix. Fire stations were used as origins and the mean centers of completely destroyed building clusters acted as the destinations. Network Analysis calculated three optimal destination points for each fire station.

Service Areas



Creating service areas is a useful tool with Network Analysis. It is significantly more useful and realistic than a buffer because it incorporates the actual roads of a study area. Using GIS, analysts can create two types of service areas: away from an origin, or to a destination. Cutoffs are used to calculate the service areas based on designated times or distances. For this scenario, both methods of Network Analysis service areas were generated. The top graphic shows the output of generating areas at 1, 2, and 3 minutes away from each fire station. The second graphic shows which areas are closest to each hospital at 1, 2, and 3 minutes going towards each location. These analyses show that the service areas for each, do not generally overlap each other.

Damage Assessment



Number	Percentage
Residential	84.5%
Commercial	13 (One Church)
Total Buildings Destroyed	84

Category	Number	Percentage
Residential	71	84.5%
Commercial	13 (One Church)	15.5%
Total Buildings Destroyed	84	100%

After Hurricane Maria, FEMA conducted a damage assessment and created a dataset indicating which buildings were affected or destroyed after the storm. This research utilized that dataset to determine the percentage of destroyed buildings that were residential vs. commercial in the study area. Additionally, spatial autocorrelation was used to determine if destroyed buildings vs. affected buildings were clustered together. The results of this statistical analysis found that there is less than a 1% likelihood the clustered pattern is a result of random chance with a z-score of 28.3 and a p-score of 0.00. The map above visually demonstrates this clustered pattern.



Examples: Spatial Analysis



Introduction:

Tornadoes are the most violent weather phenomenon in the U.S. The U.S. sees more tornadoes than any other country. Tornadoes come in many different sizes and intensities. Some are very narrow, while others can be 2 miles wide! The Fujita (F) Scale was developed to measure the intensity of tornadoes, based on the damage they cause. At the low end, an F0, could bring down trees and powerlines. At the high end, an F5 will completely blow away a well constructed house and leave nothing but an empty foundation. In 2007, the Fujita scale was enhanced. The new EF-scale is very similar to the F-scale, except that it uses more indicators and reduces the wind speeds for each category.

The graphic below illustrates the new tornado scale.



- Show the regions in the Central and Eastern U.S. that are most prone to strong (F/EF-2 or stronger) tornadoes
- Show which areas have received the most fatalities from tornadoes, and how they compare to areas that are most prone to tornadoes.
- Illustrate areas that may be ill-prepared
- Show whether tornado alley(s) may be shifting due to climate change

Methods:

- Project/re-project all data to USA Contiguous Lambert Conformal Conic projection.
- Select, and create a new shapefile of, tornadoes that were F/EF-2 or stronger and occurred in 1979 or later.
- Conduct a Kernel Density analysis of tornado paths, using a 1 km cell size.
- Conduct a Getis-Ord Gi* Hot Spot Analysis of tornado intensities and number of fatalities.
- Conduct an Anselin Local Moran's I Clusters-Outliers Analysis of intensity and fatalities.
- Conduct Global Moran's I Spatial Autocorrelation analysis to determine clustering of strong and fatal twisters.
- Do a Kernel density of tornadoes that occurred in 1979-1998, and 1999-2018 and see if there is a shift in patterns

Data:

All tornado data was obtained from NOAA National Weather Service, Storm Prediction Center. The data consists of 2 shapefiles (line and point) of tornadoes from 1950-2018, with magnitudes 2 to 5 (on F/EF Scale). The shapefile of U.S. state boundaries was obtained from NOAA.

ESRI ArcGIS Pro was used for all GIS Analysis and base maps. All Data includes Tornadoes that are F/EF-2 or stronger.

References:

- The NOAA National Weather Service, Storm Prediction Center. <https://www.spc.noaa.gov/tornacs/>
- Study, U.S. Tornado Frequency Shifting Eastward from Great Plains. Northern Illinois University, 17 Oct. 2018. newsroom.niu.edu/2018/10/17/study-u-s-tornado-frequency-shifting-eastward-from-great-plains/. tornado Alley map comes from Accuweather.com.
- Tornado image comes from <https://www.spc.noaa.gov/faqs/tornado/tornacs.htm>
- Tornado EF-scale diagram was obtained from the Storm Prediction Center of the National Weather Service via Google Images.

Do most dangerous Tornadoes occur in Tornado Alley?

Spatial Analysis of strong tornadoes, and of resulting fatalities in the United States. By Alexander Leikin, GEOG 653 student.



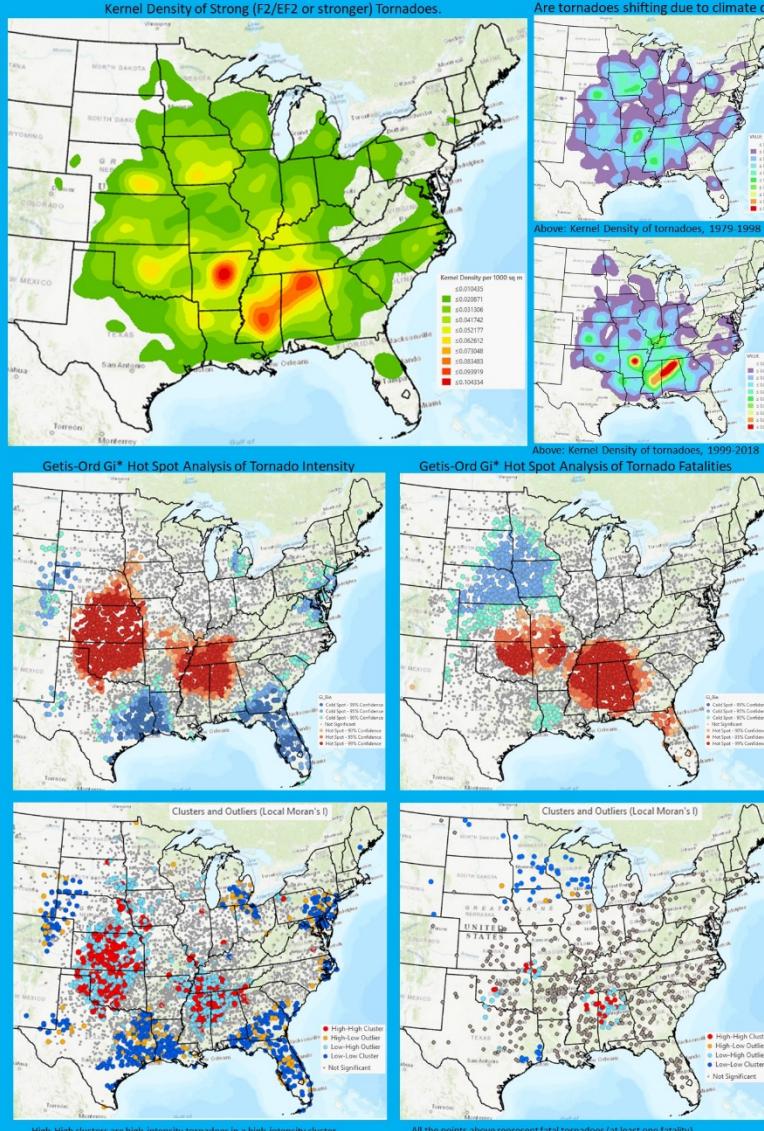
Image from NOAA Storm Prediction Center/NSSL

Results Discussion:

- Tornadoes are clearly clustered, with some areas experiencing more frequent and intense tornadoes. However, the mixing of weaker vs. intense twisters is random. Fatal tornadoes are highly clustered.
- The Kernel Density analysis shows a clear hotspot in central Arkansas and central Mississippi to northern Alabama. Tornado Alley has significantly lower densities.
- The Getis-Ord Gi* Hot Spot Analysis of Tornado Intensity shows two hot spots of high tornado intensity. One of those is in Tornado Alley (mostly Oklahoma to southern Nebraska). The other one is in the Southeast, mostly northern Alabama, Mississippi, and parts of Tennessee.
- The Getis-Ord Gi* Hot Spot Analysis of Tornado Fatalities shows some hot spots in Tornado Alley, but a much larger cluster of high values of fatalities in the Southeast, especially Mississippi, Alabama, and Tennessee.
- Southern Miss., southern Ala., parts of Tenn., and parts of Arkansas have high fatalities but are outside the cluster of high intensities, suggesting these areas poorly prepared for tornadoes.
- Parts of Tornado Alley have a hot spot of intensity but a cold spot of fatalities (i.e., parts of Kansas and Nebraska), suggesting these areas are well prepared for tornadoes.
- Northern Florida is concerning; it's a cold spot for intensity (primarily less dangerous F2 twisters) but a hot spot of fatalities.
- Local Moran's I Clusters and Outliers Analysis shows a cluster of high intensity tornadoes in Tornado Alley (southern and central Oklahoma to southwest Iowa) AND in the Southeast (central and northern Mississippi, northern Alabama, southwest Tennessee, parts of southeast Arkansas).
- Local Moran's I Clusters and Outliers Analysis shows a greater number of fatal tornadoes outside of Tornado Alley, with a cluster of high fatalities in Alabama and Mississippi, and in parts of Oklahoma, southeastern Kansas, and southwest Missouri.
- Local Moran's I Clusters and Outliers Analysis shows intense tornadoes occurring outside of hot spots, including one that struck UMD College Park in 2001, and many twisters that occur in hot spots are weaker.
- There is some shift in tornado distributions between 1979-1998 and 1999-2018. There is a significant increase in the Southeast (especially Ala. and Miss.) and a decrease in northern states.

Conclusion:

- The idea that the worst Tornadoes are in Tornado Alley in the central Plains is inaccurate. There are actually two high-risk areas, one is in Tornado Alley, the other is in the Southeast.
- The Southeast U.S., particularly parts of Alabama and Mississippi, experience the most frequent and the deadliest tornadoes.
- Builders, Residents and Policymakers in Tornado hot spots, and especially in the Southeast (particularly Alabama and Mississippi) need to ensure that houses have basements, or access to safe rooms, and have stronger building codes.



All the points above represent fatal tornadoes (at least one fatality).
 High-High clusters are high-fatality tornadoes in a cluster of high-fatality tornadoes.
 High-Low outliers are high-fatality tornadoes in a low-intensity cluster.
 Low-High outliers are low-intensity tornadoes in a high-intensity cluster.
 Low-Low clusters are low-intensity tornadoes in a low-intensity cluster.



Examples: Spatial Analysis



Assessing the Impact of 2018 Wildfires on Seasonal Variations in Air Quality and Pollutant Levels in the State of California.

Afolarin Lawal, GEOG 653 (Spatial Analysis) Fall 2019

Introduction

According to the California Department of Forestry and Fire Protection, in 2018 there had been an estimated 1,618,033 acres burned with about 310 wildfire incidents with greater than 10 acres in burn area. In addition, 93 fatalities were recorded with 23,145 structures damaged in the process. Wildfires are a large source of particulate pollution in western states (Liu et al., 2017), but with raging debate on the effects of climate change and global warming, the short- and long-term effects of the annual fires on the citizens is worth investigating. The pollutants discharged as a result of wildfires can pose a health risk to inhabitants of affected counties, especially among the younger and older generations. Unfortunately, these could also affect the public health of neighboring states as well, as winds direction and topography can aid pollutant transport (Malia et al., 2015).

Objectives

The objective of this project is to assess the level of various pollutants across the seasons of the year 2018 in a bid to determine which counties are less conducive for extended outdoor activities, primarily as a result of wildfire pollution. This is of particular importance to young and old people who are more at risk of developing respiratory problems as a result of bad air quality and air pollution. For the purpose of this project, citizens below the age of 15 and above the age of 55 are deemed "Sensitive", as I feel they are more vulnerable to the effects of pollutants than other age groups.

Data

The primary data for this project are:

- I. Daily pollutant data (in concentration values) gotten from air monitoring stations scattered across the state of California. These pollutants are Ozone (O_3), Carbon monoxide (CO), Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Particulate Matter 10 (PM_{10}) and Particulate Matter 2.5 ($PM_{2.5}$).
- II. Demographic information for the year 2017 clipped to the state of California.

Methods

For the purpose of this project, the year 2018 was broken down into four seasons; Winter: January, February and December; Spring: March to May; Summer: June to August; and Fall: September to November.

The pollution data was broken down into its constituent season based on the above description and aggregated by mean values by Station or Site ID per pollutant. This mean values were then normalized to account for the various scale of concentration values across the pollutants. For example, the range of PM_{10} concentration values for winter is around $59 \mu g/m^3$ SC while the range of Ozone for the same season is $0.036 \mu g/m^3$. This normalization allows the magnitude of various pollutants to be directly compared irrespective of the scale of measurements. Subsequently, the normalized pollution values were interpolated and added to form a general pollution map for the state of California for each season.

Result and Discussion

- Although the above maps doesn't exactly tell which of the pollutants are dominant, it provides an overview of the general air quality and pollutant level of the counties in the California. The circular symbols represent the ratio of "sensitive" population in each county to the total county population.
- This ratio was derived by adding the number of people aged below 15 and above 55 for each county, then dividing the result by the total county population.

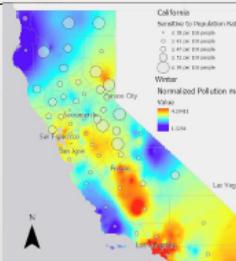


Figure 1. Winter Normalized Pollution Map

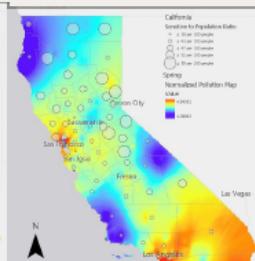


Figure 2. Spring Normalized Pollution Map

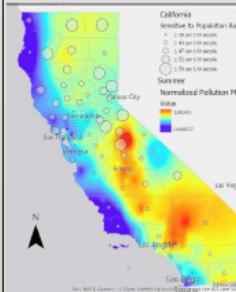


Figure 3. Summer Normalized Pollution Map

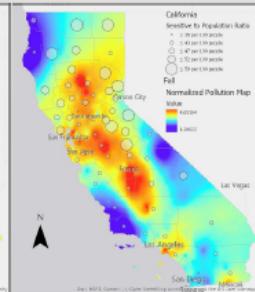


Figure 4. Fall Normalized Pollution Map

Result and Discussion continued

- Figure 1 shows that during the winter, most of the counties in the south were very polluted. These counties include, Imperial, Orange, Los Angeles and Fresno. The only good news is that these cities have a relatively low sensitive population.
- During the Spring, the southern parts of the state had a slight increase in intensity of the pollution. The counties affected were the same as those during the winter season. In addition, San Francisco, Marin and San Jose also had an increase in pollutant from winter to spring. The pollutants here are majorly Carbon monoxide and Sulphur dioxide which could be influenced by high vehicular movement and industries within the region.
- The Summer and Fall seasons indicate a northward shift in the pollutants. Central California were mostly affected by in the Summer while during the Fall season, more of the northern counties were engulfed. This trend was also perfectly captured in the hotspot analysis of the $PM_{2.5}$ pollutants as shown in Figure 5 and 6.
- $PM_{2.5}$ is one of the deadliest pollutant primarily due to its microscopic nature (about 3% the diameter of human hair) which enables it to penetrate the lungs of humans easily, causing breathing and respiratory illnesses.

Result and Discussion continued

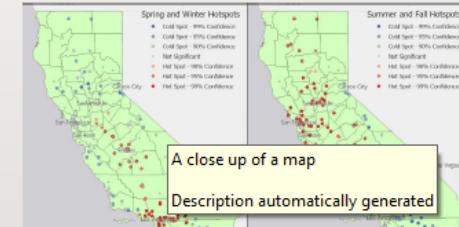


Figure 5. Spring and Winter Hotspots Analysis of $PM_{2.5}$ pollutants

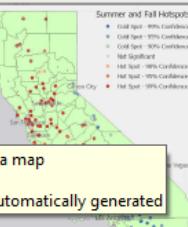


Figure 6. Summer and Fall Hotspots Analysis of $PM_{2.5}$ pollutants

A close up of a map

Description automatically generated

Season	County	Major Pollutants	Number of CM or Young people per 100 people
Winter	Orange	PM10, Ozone, CO, NO2	39
	Fresno	PM10, Ozone	42
	Los Angeles	PM10, Ozone, CO, NO2	39
	San Francisco	PM2.5	41
	Marin	PM2.5, PM10	33
Spring	Imperial	PM2.5, PM10, Ozone	42
	San Francisco	PM2.5, CO, NO2	34
	Marin	PM2.5	49
	Orange	PM2.5, PM10, NO2, Ozone	39
	Madera	PM2.5, PM10, NO2, Ozone	97
Summer	San Joaquin	PM2.5, NO2, Ozone	54
	San Bernardino	PM10, NO2, Ozone	47
	Madera	PM2.5, PM10, Ozone	44
	Kings	PM2.5, Ozone	91
	Stanislaus	PM2.5, PM10, XZD, CO	42
Fall	Yolo	PM2.5, NO2, Ozone	44
	San Joaquin	PM2.5, NO2, Ozone	43
	San Luis Obispo	PM2.5, NO2, Ozone	41
	Sacramento	PM2.5, CO	45

Figure 7. A table showing the 5 most polluted counties based on season. It also shows the major pollutants found in the counties as well as the number of sensitive populations per 100 people in the counties. Again, the winter and spring seasons contain majorly southern counties while summer and fall have mostly northern counties

References

- Liu, X., et al. (2017). Airborne measurements of western U.S. wildfire emissions: Comparison with prescribed burning and air quality implications. *J. Geophys. Res. Atmos.*, 122, 6108–6129. doi:10.1002/2016JD026215.
- Malia, D.V., J. C. Lin, S. Urbanski, J. Ehleringer, and T. Nehrkorn (2015). Impact of upwind wildfire emissions on CO, CO₂, and PM_{2.5} concentrations in Salt Lake City, Utah. *J. Geophys. Res. Atmos.*, 120, 147–166. doi:10.1002/2014JD022472.
- United States Environmental Protection Agency <https://www.epa.gov/outdoor-air-quality-data/download-daily-data>
- California Department of Forestry and Fire Protection (CAL FIRE) <https://www.fire.ca.gov/incidents/2018/>



Examples: Spatial Analysis



Assisting Western Snowy Plover Recovery Efforts: Analysis of Nest Spatial Patterns

Cynthia Hartley: Geography 653, Fall 2013



Background

The western snowy plover (WSP) (*Charadrius alexandrinus nivosus*) breeds along the North American west coast.¹ Loss of habitat, predation pressures, and disturbance have caused the decline of the coastal population and led to its listing as threatened in 1993 by the United States Fish and Wildlife Service (USFWS).² Yet despite two decades of protection, recovery efforts for the WSP continue to struggle.



WSP utilize dune backed beaches for breeding and create nests by digging scrapes. They lay three camouflaged eggs and the adult birds take turns incubating their eggs for approximately 28 days. During this time they rely on camouflage and distraction displays to keep their nest safe.³ In addition to natural causes such as weather and tides, nests fail due to repeated disturbance by humans, from being crushed by beach goers and vehicles, destruction by domestic dogs, and wild predators attracted by human activity.⁴

The beaches where WSP breed in Ventura County are not managed by a single entity. California State Parks is responsible for several of the beaches, Hollywood Beach is managed by Ventura County and Ormond Beach has several land owners (California State Coastal Conservancy, City of Oxnard and The Nature Conservancy). As a result management practices vary between locations. Strategies include placing predator enclosures over nests, erecting symbolic fencing, conducting docent programs and public outreach. Each location uses these techniques to varying degrees. Assessing spatial patterns of nest initiation and nest failures would help identify which strategies are working on which beaches, identify problems specific to different geographic regions and aid in land management decisions.

Objectives

1. Display the locations and relative densities of all WSP nests that have been recorded with GPS waypoints in Ventura County
2. Establish a methodology to show temporal changes in the spatial arrangement of WSP nest locations
3. Show mean center of nest clusters overall and yearly for each location
4. Determine if nest losses due to predation and vandalism vary between different beaches, cluster areas or are specific to different beach jurisdictions

Data

Aerial images of Ventura and Oxnard: obtained from CIRGIS⁵
Nesting data: USFWS permitted nest monitors locate and mark WSP nest locations with GPS waypoints and track nesting outcomes; succeed or fail (unknown, predicated, vandalized or natural causes). These data exist in a combination of USFWS reports, Excel spreadsheets for the years that predate report submission and shapefiles.

Study Area



Ventura County, California
Specific beaches: San Buenaventura State Beach, McGrath State Beach, Mandalay State Beach, Hollywood Beach and Ormond Beach.

Methods

Nest locations, nesting density and cluster areas: Waypoints for all nests from 2003-2013 were collated into Excel, imported into DNR-GIS⁶ and converted into an ArcGIS shapefile (Projection: WGS 1984 UTM Zone 11N, Datum: WGS 1984). The attribute data for nest outcomes was also collated into Excel, added to ArcGIS and linked with a table join to the waypoint shapefile and displayed on the aerial. Land jurisdictions are indicated in Fig1. Nesting densities were created with the Spatial Analyst "Kernel Density" tool. Nesting clusters were assigned within jurisdictional areas based on highest density areas (Fig 2). A polygon layer was created for clusters (not shown).

Mean Center of nest clusters: Mean geographic center was calculated for each cluster for the entire study period and for each individual year (Fig 3a). Some clusters contained too few nests or years of data so were not analyzed (San Buenaventura State Beach, Hollywood North and Ormond Salt Panne). To better display these results however, a temporal analysis conducted.

Temporal/Spatial Locations: The nest data was imported into ArcScene. Years were assigned as the Z value with the "Feature to 3D by Attribute" tool. The year data was displayed on the y-axis (fig. 3b) and the x-axis was aligned to the density display (fig 3a). Mean center for each year is displayed in both figures.

Clustering of Nest Predation and Vandalism: Two causes of nest failure were selected for analysis; predation and vandalism. Kernel density analysis on the selected data was done as in figure 3a and compared between jurisdictions (Fig 4).

Results

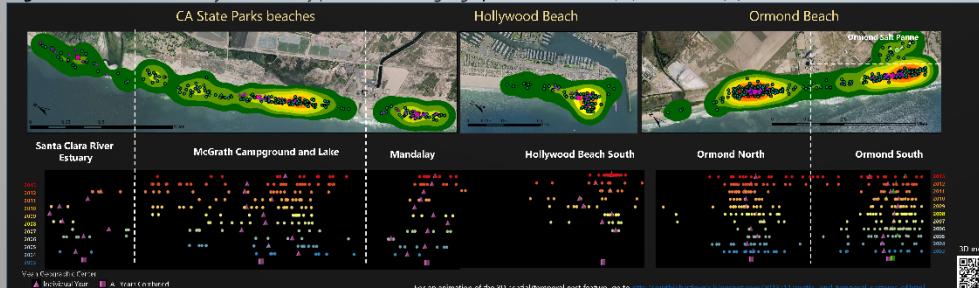


Fig 1. Nest Locations: WSP nests (●) in Ventura County, 2003-2013



Fig 2. Nest Density and Clusters: nest clusters identified from densest nest areas

Data



For an animation of the 3D spatial/temporal nest feature, go to https://cynthiahartley.s3.amazonaws.com/2013-11/spatial_and_temporal_patterns.mp4

Fig 3b. Temporal Patterns: Same data plotted in figure 3a, but year assigned to Z height in a 3D plot in ArcScene. For this figure the y-axis=year and the x-axis in figs 3a and 3b align. Mean geographic center annual (▲) and overall (■)

Fig 4. Kernel Density plots for failed nests due to either predation (top row) or human vandalism (bottom row) overlaid with nest locations (predated ●, vandalized ○). Results plotted by jurisdiction.

Predated Nests



Vandalized Nests

Conclusions

➤ Based on annual mean geographic centers, nesting patterns in some clusters have changed little over the years (e.g. Ormond South and Ormond North) and some change dramatically yearly (e.g. Santa Clara River Estuary and Mandalay). Other clusters could possibly be better described by breaking them down into smaller sub-clusters (e.g. Hollywood South and McGrath).

➤ Displaying the data in 3D using as the Z parameter is very useful in visualizing temporal/spatial patterns. By allowing site by site display of spatial data from multiple years it reveals multi-year patterns within nest clusters. Some areas are used for years and then abandoned, or the other way around. This would not be evident in a conventional 2D feature class.

➤ Differences in nest predation and vandalism are striking between the jurisdictional areas. Hollywood Beach has had relatively few losses to both, Ormond Beach has lost relatively few to vandalism but there are high losses to predation and CA State Parks has high losses to both. The reasons for this is probably a combination of management practices and geographic location. Hollywood Beach uses predator enclosures on each nest, Ormond Beach never uses enclosures and CA State Parks intermittently uses them. Higher vandalism at CA State Parks is not a surprise due to high visitor usage, but Hollywood Beach is a heavily used recreational beach yet has had few vandalism issues.

Next Steps

1. Re-assess nest clustering and repeat mean center analysis.
2. Analyze other causes of nest failure (abandonment, nature)
3. Identify changes in temporal use of nesting habitat and determine if there is a correlation to changes in nesting patterns (dredging, flooding, management practices, coast line changes, etc.)
4. Conduct the same analysis for the California Least Tern (CLT), also an endangered bird that nests in overlapping areas.
5. Assess influence the CLT might have on WSP nesting patterns.

References

1. Page et al. 1991. J. Field Ornithol 62(2): 245-255
2. Federal Register 1993 <http://www.fws.gov/ore/esa/birds/wsp/plover.htm>
3. Warner et al. 1986. Wilson Bulletin 98(1): 15-37
4. Page and Stenzel 1981. Western Birds 12 (1), 1-40
5. CIRGIS: Channel Islands Regional GIS Collective <http://www.cirgis.org/>
6. DNR-GPS: open source software: <http://cynthiahartley.s3.amazonaws.com/gis/tools/tutorials/extensions/DNRGamin.html>



Examples: Spatial Analysis



Urbanization effects on stream temperatures in the Gwynns Falls Watershed in Baltimore, Maryland

Hyunjin Kim University of Maryland, College Park



Introduction

Urban streams are important and sensitive systems for assessing impacts of watershed urbanization because of their extensive, direct connections to Impervious Surface Cover (ISC) (such as road surface, parking lots, rooftops, etc.), and their sometimes buried nature. Stream temperature plays a key role in many stream processes. ISC is an important urbanization indicator that has been shown to be related to stream temperature (Center for Watershed Protection, 2003). During the summer, in particular, impervious cover absorbs and stores solar radiation better than natural surfaces. When rainfall events occur, heated runoff from ISC is directly transported by road surfaces or stormwater drainage systems to urban streams (Arrington et al., 2003); then it causes stream temperature elevation. Imperviousness within a 50m buffer along the stream or within a 1.6km radius of the sampling site had more influence on stream conditions (Wang et al., 2001). Spatial patterns of stream temperature are associated with the distribution of fish. High water temperature can cause harmful effects on aquatic biota (Ward, 1985).

Objectives

- To identify an overall trend of stream temperature as a function of space (along the urban gradient).
- To identify effects of impervious covers and road density on stream temperature.
- To identify spatial patterns of fish abundance.

17

Study Area

Gwynns Falls watershed, Baltimore, MD



Characteristics

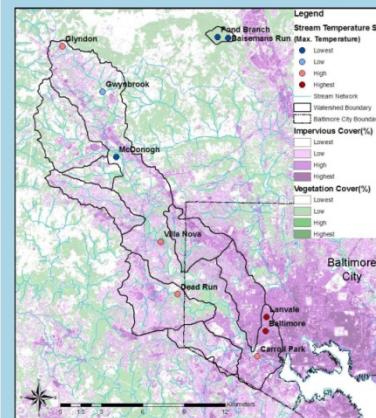
Urban-rural gradient along the watershed

Site	Area (ha)	Characteristic	Location
Baltimore	15	Urban pipe	Downstream
Lanvale	15	Urban pipe	
Carroll Park	1706.8	Urban stream	
Dead Run	1429.7	Urban stream	
Villa Nova	8417.5	Suburban	
McDonogh	7.8	Agricultural/spring	
Gwynnsbrook	1095.6	Suburban	
Glyndon	85.9	Suburban	
Baisman Run	380.7	Suburban/Forested	
Pond Branch	31.1	Forested	Reference

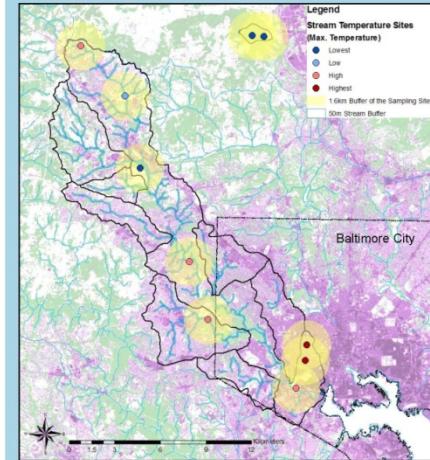
Methods

- Data
 - Stream temperature in summer 2004: Baltimore Ecosystem Study Long Term Ecological Research
 - Fish abundance: the number of individual fish from Maryland Biological Stream Survey (1995-1999)
- Spatial Analyses
 - GIS (ArcMap 9.3, ESRI)
 - Projection: NAD 1983 State Plane Maryland
 - Layers: % Impervious covers (30x30m), % vegetation covers (30x30m), roads and stream networks
 - Stream Buffer: A 50m buffer along the stream and a 1.6km radius buffer of the sampling sites
 - Road Density: Total length of roads within a 1.6km buffer
- Relationships between imperviousness and road density vs. stream temperature: simple regression analysis (Data Analysis Tool in MS Excel 2003)

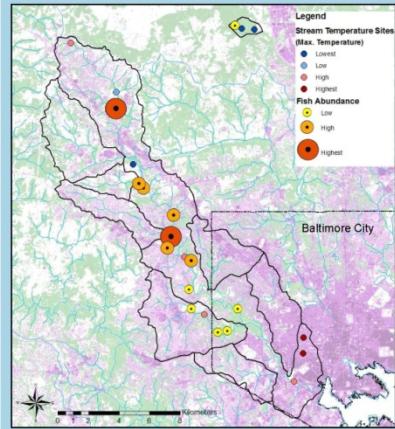
Stream temperature monitoring sites & Maximum temperatures in summer 2004



50m buffers along the stream & 1.6km radius buffers of the temperature monitoring sites



Fish Abundance (Maryland Biological Stream Survey, 1995-1999)



Results & Discussion

- Overall downstream warming trend in stream temperature in the Gwynns Falls watershed
- Urban buried streams showed extremely high water temperatures
- Strong positive relationship between ISC vs. Stream temperature ($R^2=0.84$, $p<0.01$): 0.33°C increase in max. stream temp with 1% increase in ISC
- 23-107 m of Road density within a 1.6km radius buffer comparing 8 m in a reference site
- Strong positive relationship between Road density vs. Stream Temperature ($R^2=0.78$, $p<0.01$): 0.26°C increase in max. stream temperature with 1m of road length increase within a buffer
- Fish abundance: 0-495 individual fish found at a site
- Overall, fish abundance decreases from upstream to downstream following the trend of stream temperature warming.

References

- Baltimore Ecosystem Study <http://besler.org>.
- Kim, H. J. 2007. Temperatures of urban streams: impervious surface cover, runoff, and the importance of spatial and temporal variations. M.S. Thesis. Marine, Estuarine, and Environmental Sciences, University of Maryland, Baltimore County.
- Maryland Biological Stream Survey <http://www.dnr.state.md.us/streams/mbss/>



Examples: Spatial Analysis



Washington, D.C. Spatial Crime and Police Station Analysis

Michael Bender – University of Maryland GEOG653

Abstract

Crime analysis is an analytical process providing useful statistics on crime patterns and trends. Crime can have a major effect on a population, especially in a major city. Analyzing crime in a specific study area can give citizens and police important information. Police stations must also be analyzed to show how they can improve their efficiency. It can show areas citizens might want to avoid and police where more force might need to be deployed. For a crime analysis proper data must be collected, analyzed, and evaluated. For this analysis Washington, D.C. is the study area. Crime narrowed down to assaults with a dangerous weapon from 2013-14 is the main data needed for the analysis. Police stations, neighborhoods, and streets data were also used for completeness and to provide the most useful information.

Introduction

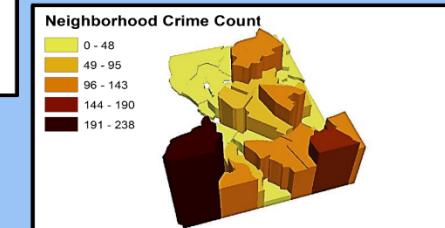
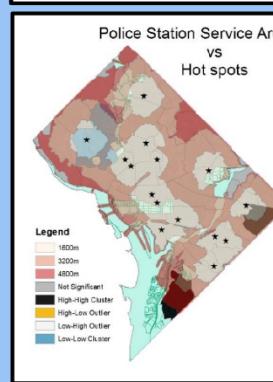
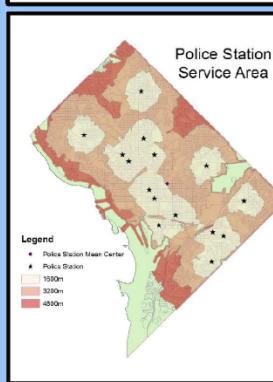
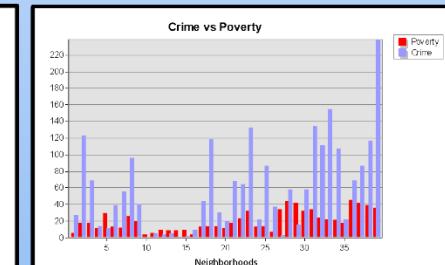
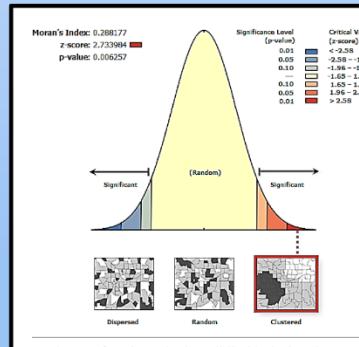
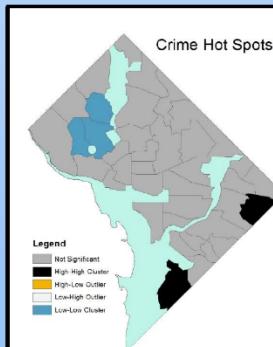
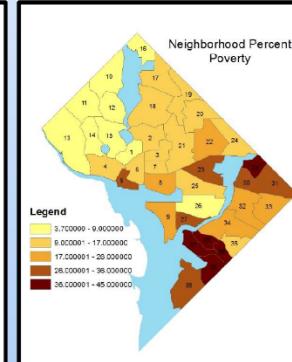
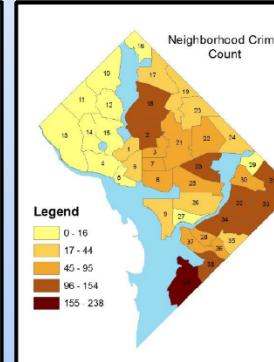
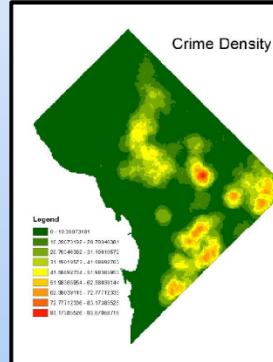
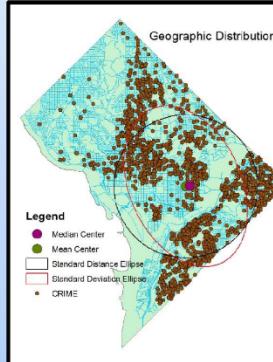
Although in the mid-2000s crime rates dropped to their lowest in 20 years it is still ever present in Washington, D.C. Since 1995, overall violent crime has decreased 50% to 1,330.2 violent crimes per 100,000 people. That number however, is three times the national average. To make matters worse law enforcement is poorly organized. Being the United States capital, the combination of federal and state agencies make coordination very difficult. They are also more experienced in crowd control and security rather than every day crime. From 2010 to 2012 criminal offenses had increased from 34,655 to 36,762. Clearly crime remains a significant issue for D.C. However, a crime analysis of the city can be a powerful tool to stop this trend of increasing criminal offenses. By thoroughly analyzing D.C. data there can be a determination of the most crime affected areas and valuable information can be provided to citizens and police forces. The main objective of this analysis is not only to provide useful information to the public, but also to determine the trends of crime in D.C. in order to knowledgably predict and prepare for the future.

Data

Data Name	Source	Data Type
DC Boundary	UMD	Shapefile (polygon)
DC Streets	UMD	Shapefile (line)
DC Crime 2013	data.dc.gov	csv
DC Crime 2014	data.dc.gov	csv
DC Police Stations	data.dc.gov	shapefile (point)
DC Neighborhoods	data.dc.gov	Shapefile (polygon)

Methods

- Spatial Analysis → Point Density
- Spatial Autocorrelation → Moran's I, Cluster Analysis
- Spatial Statistics → Mean Center, Median Center, Standard Deviation Ellipse, Standard Distance Ellipse
- Network Analysis → Service Area
- 3-D Analysis
- Data Management



Results and Conclusion

1. Crime is clustered in Washington, D.C. according to Moran's I
2. Crime throughout D.C. neighborhoods is heavily correlated with their percent poverty
3. There are two main crime hotspots in the south and southeast regions of the city around where poverty is the highest
4. Police coverage as is does not adequately impede on these hotspots
5. Police stations mean center is towards the center of the city where crime is less of a problem
6. Police are more involved in protecting more affluent areas of the city rather than poverty stricken areas
7. There needs to be better police coverage of the overall city, especially areas of poverty, whether that means more stations, less clustering of stations, or better placement of stations across the city



Examples: Spatial Analysis

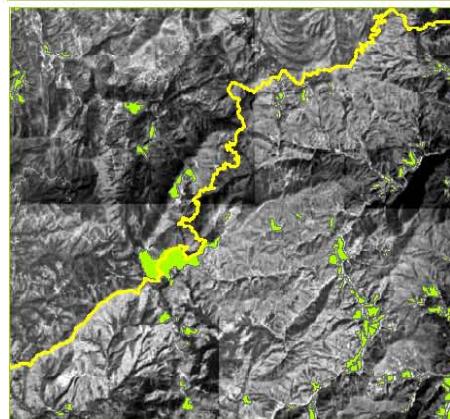
Aero-Medical Evacuation Sites on the Appalachian Trail

Introduction

The purpose of the study is to determine suitable landing areas to support aero-medical evacuation of distressed hikers on a segment of the Appalachian trail.



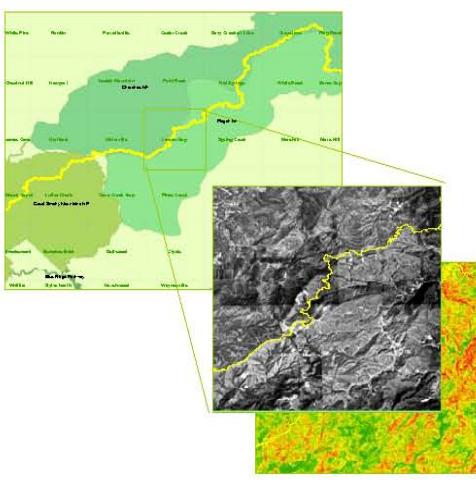
Method



Utilized 5 meter Orthoimagery to perform remote sensing of study area. Then created shapefile by manually digitize potential landing areas based on land cover. Those areas depicted in lime green are potential helicopter landing zones based on land cover.

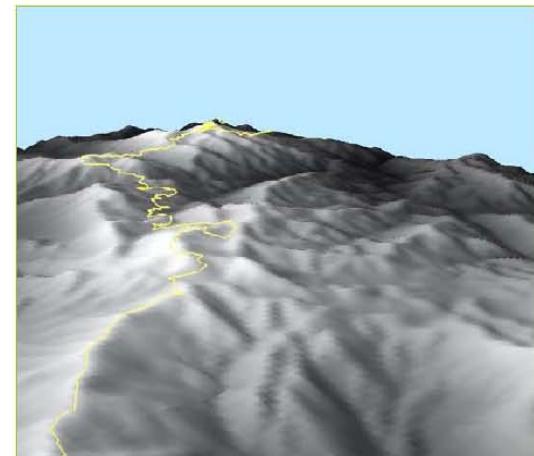
GIS Data

The data utilized to conduct the analysis include 5 meter Orthoimagery, 10 meter Digital Elevation Model, and vector overlays of the Appalachian trail centerline and park boundaries

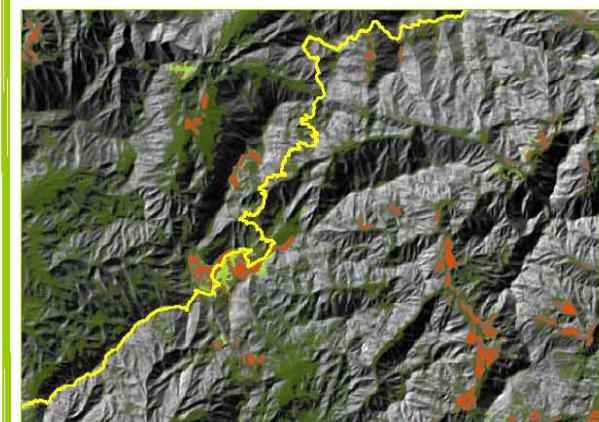


Conduct surface analysis of 10 meter DEM to determine slope. Areas depicted in dark green are areas of less than 15 degrees slope and are potential helicopter landing zones. The slope overlay is displayed 50 percent transparent over a hill shade of the DEM data. The DEM raster data was then converted to shape polygon for further analysis.

3D Terrain Analysis



Conclusion



An intersect of the land cover and slope overlays determine areas suitable for helicopter landing and medical evacuation of a casualties. Those areas depicted in orange are suitable landing areas.



Examples: Spatial Analysis

- More class project examples have been posted on ELMS.
 - Assignments > About Final Project > Final Project: Examples



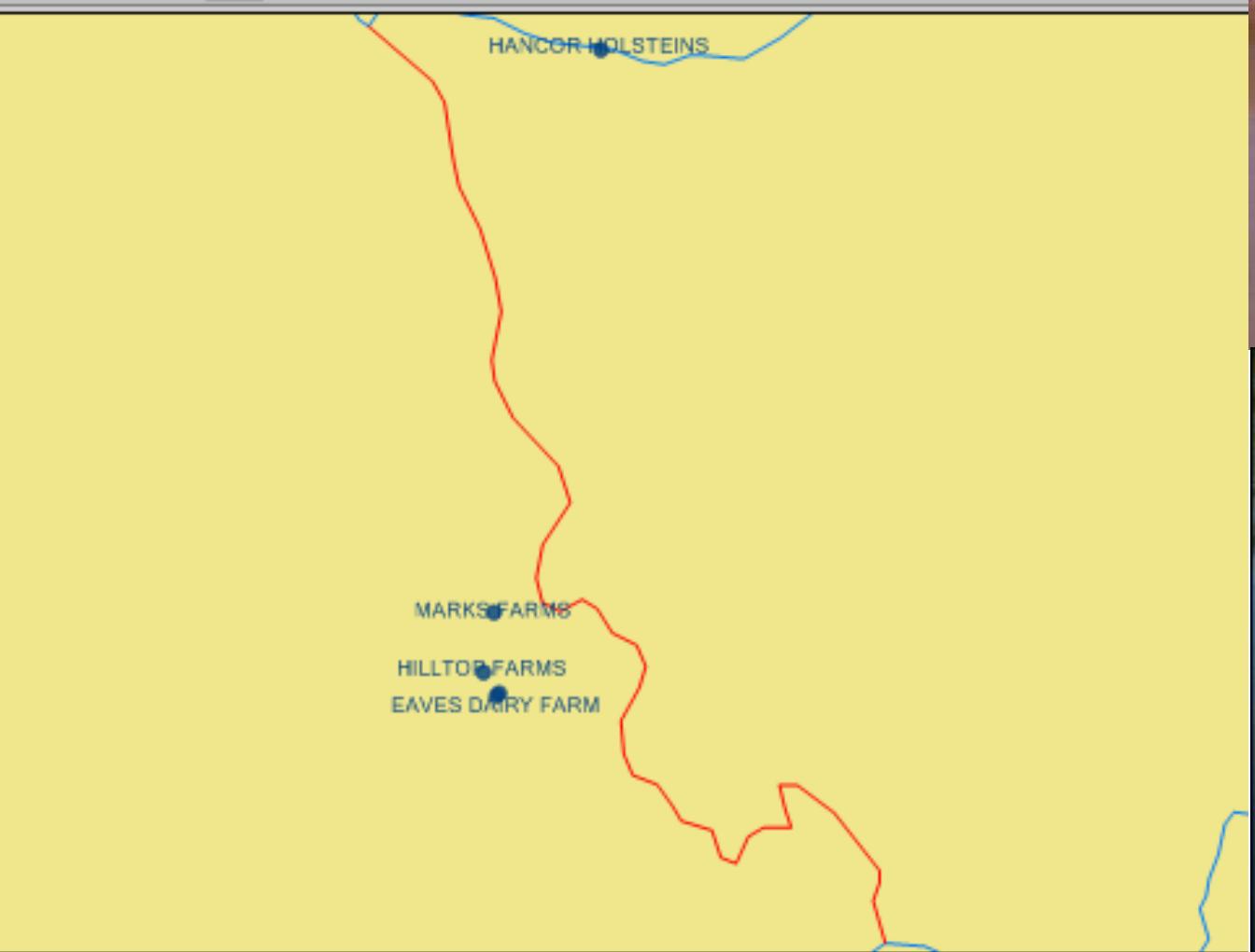
Examples: Spatial Analysis

- My GIS project while in grad school:
 - Siting analysis of farm-based anaerobic digester systems for distributed generation
 - Reminder:
 - GIS is just a tool. The research question is the most important part.
 - A GIS project needs to have a clearly spatial component.
 - A GIS project needs to be based on a real world issue so that it can be ACTUALLY useful.



Examples: Spatial Analysis

- Study Background
 - Animal waste is a BIG problem both environmentally and economically.
 - NYS is the 3rd largest dairy state
 - 7,388 dairy farms with 670,003 milk cows



Zoom Box

75°48.991' W:42°46.777' N

1:5400000

Right click below to export the querying results to Excel file (Windows XP users).

NAME	FEATURE LENGTH_ft
Black River Stream	23218.93





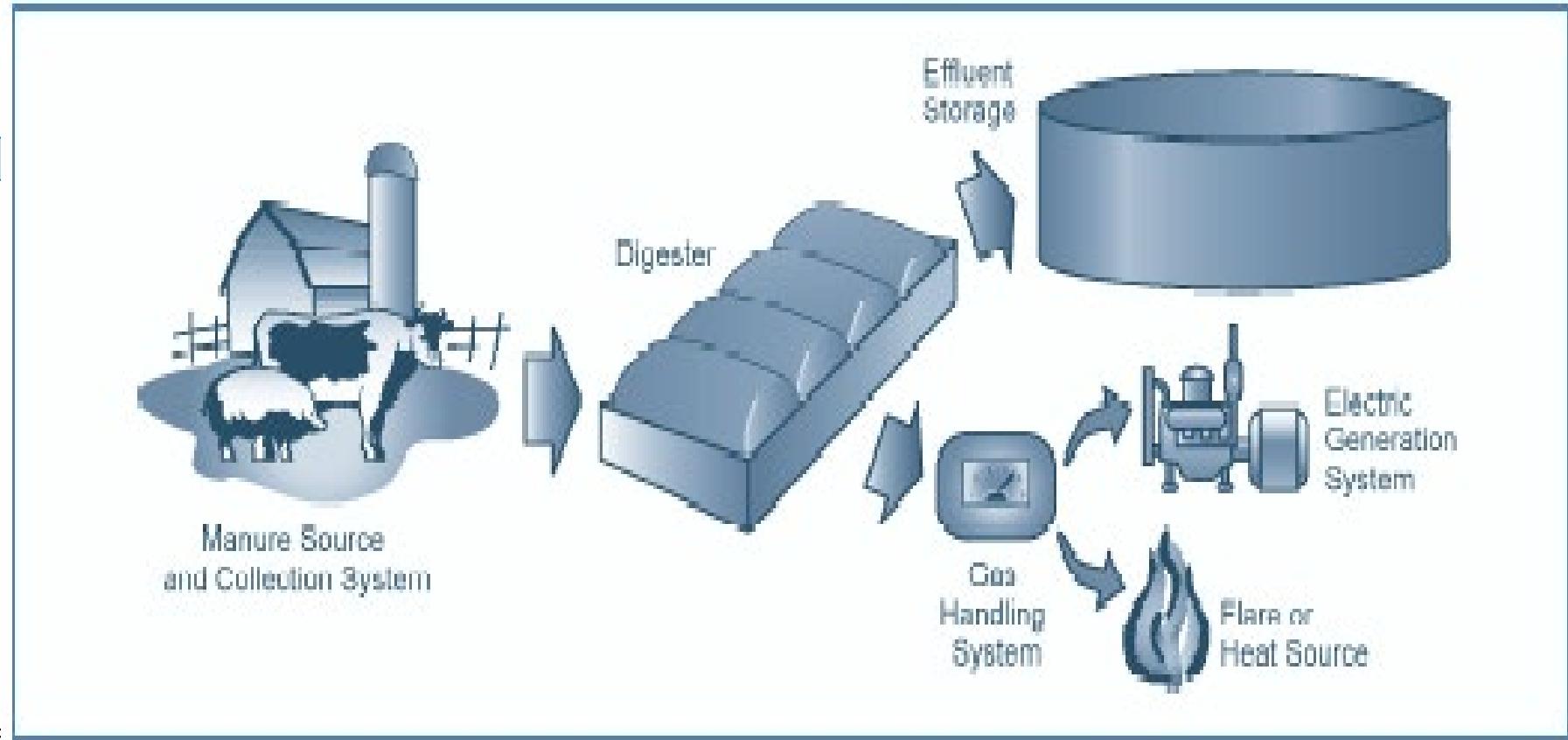
Examples: Spatial Analysis

- Study Background
 - Waste to energy through anaerobic digestion is a promising approach.
 - Biogas: 85 ft³/cow/day (60% CH₄)
 - Electricity: 140 Watts/cow
 - Growing interest from government, industry, and the public.



Examples: Spatial Analysis

- Study Background
 - A schematic diagram of farm-based AD system





Examples: Spatial Analysis



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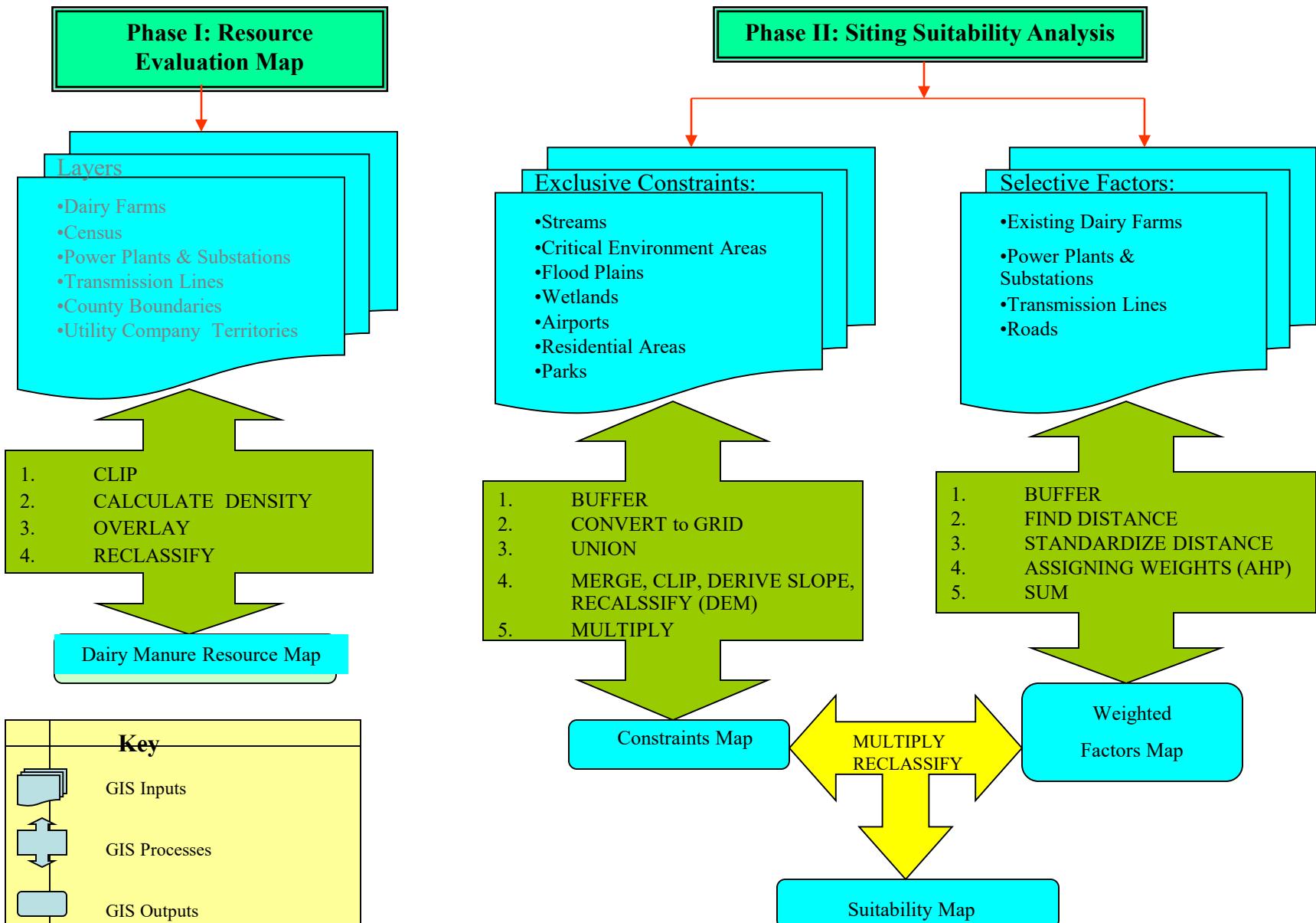


Examples: Spatial Analysis

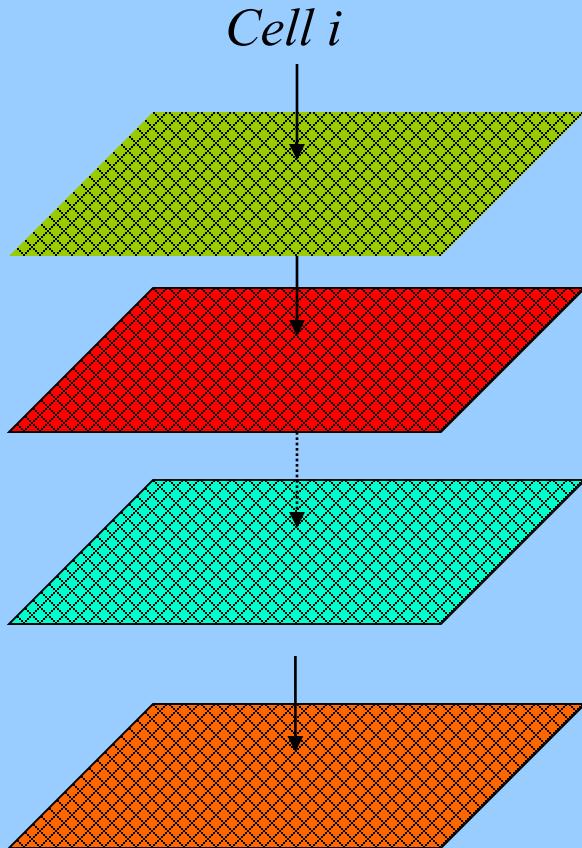
- Objective
 - Develop a GIS model for determining optimal sites for potential dairy farm-based distributed generation facilities
- Multi-criteria decision making analysis
 - Constraints (environmental)
 - Factors (technical and socio-economic)



Flowchart of GIS Database & Analyses



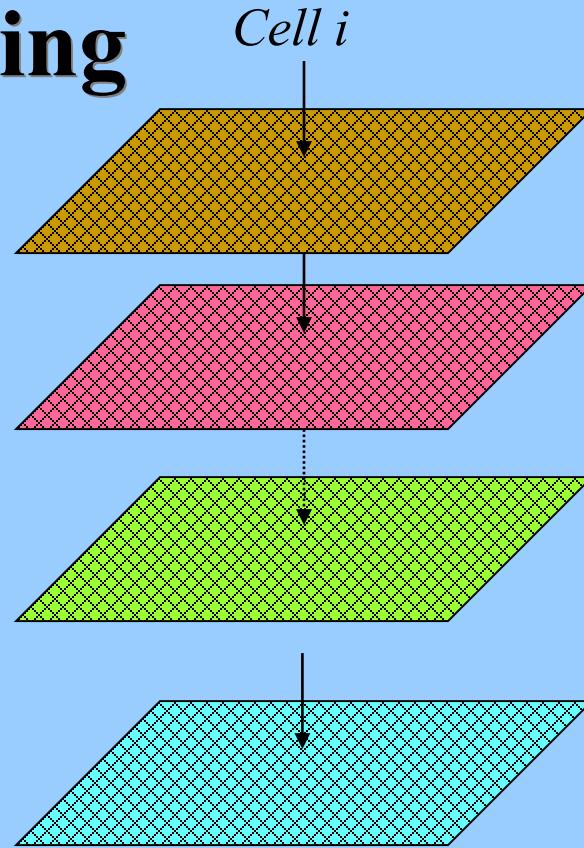
Layers of Constraints



Optimal Siting

$$\begin{matrix} C_1 & w_1 F_1 \\ \times & + \\ C_2 & w_2 F_2 \\ \times & + \\ \vdots & \vdots \\ C_m & w_n F_n \\ = & = \\ C & F \\ || & \end{matrix}$$

Layers of Factors



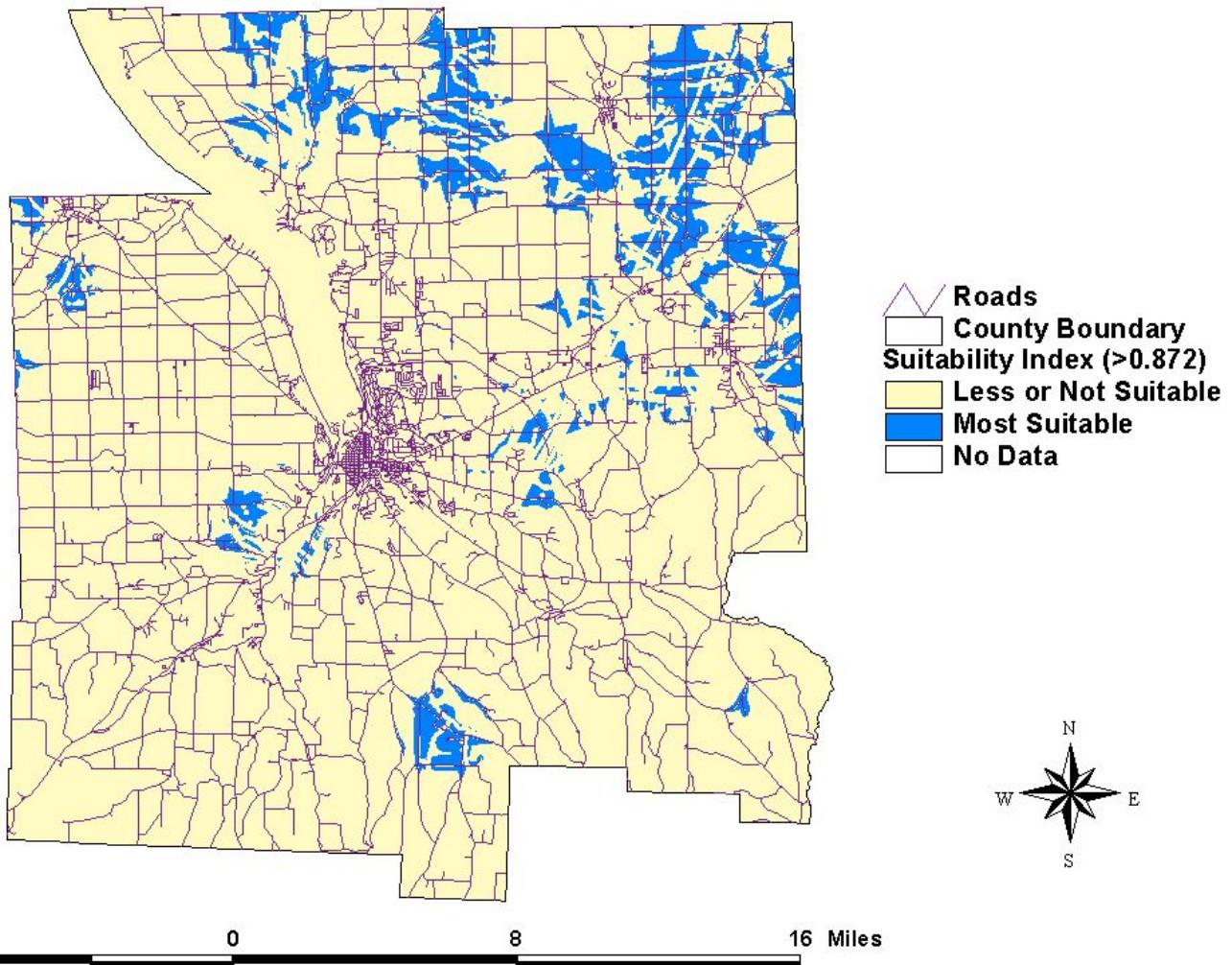
suitability map

Schematic diagram of calculating suitability map



Examples: Spatial Analysis

- Final Suitability Index Map

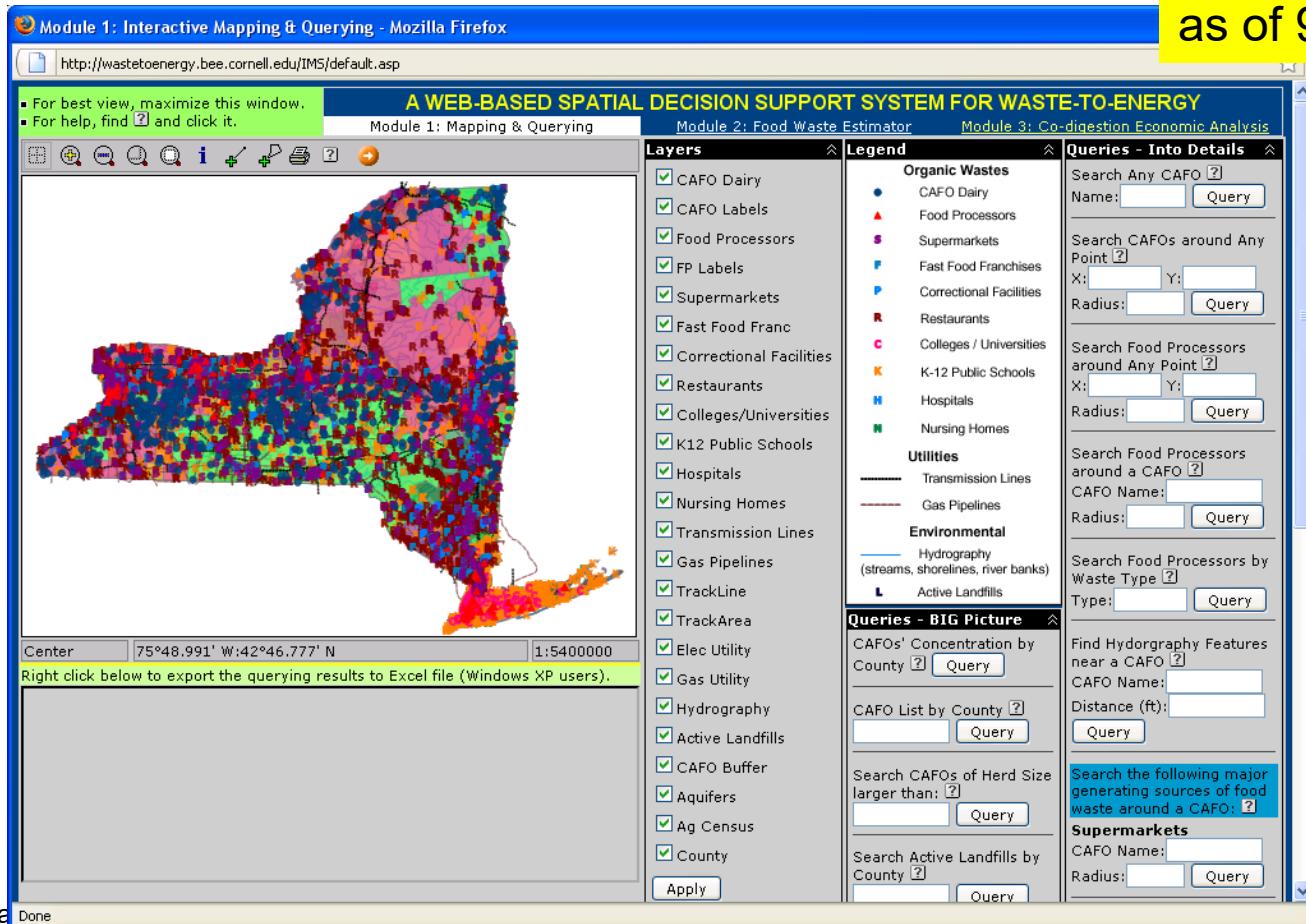




Examples: Spatial Analysis

- Next level
 - A Web-based Spatial Decision Support System
 - <http://wastetoenergy.bee.cornell.edu/>

The server is down
as of 9/5/2011.





Demo

- ArcGIS Pro vs. ArcMap
 - Network analysis
 - 3D Visualization and Analysis
- ArcGIS Online
 - Spatial Analysis
 - Web map and web mapping app



THE END

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