An Investigation into Soils, Slope, and Farmland Utilization in the Cleveland Quadrangle, SC, USA

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Abstract:

I decided to do a GIS project on the 7.5 Minute Cleveland Quadrangle because I intend to focus my senior thesis in the same area. My senior thesis will likely focus on napping the geology of the quadrangle, so I sifted through the soil as well as most current land use data to get a feel for the area before I actually go there. For this project, I looked at the soil types and slopes, as well as the land cover to determine how the land was being used in relation to the soils. I found close relationship between soil types and cropland utilization, since crops are very dependent on soil type. The usable farmland is also reliant on expansive low lying, flat areas. My analysis on urban development within the Cleveland Quadrangle, revealed that significant amount of development has occurred over potentially productive farmland.

I. Introduction:

For my GIS class term project, I looked into the relationship between the soils and land use in the Cleveland Quadrangle in Northern Greenville and Pickens Counties, SC, USA. This relationship included specifics involving various soil characteristics, including slope and ideal soil types, and sundry intricacies within the current land usage. A project involving these data is important because I intend to do a more thorough mapping project of the geology in this quadrangle for my senior thesis project; he exactness of the available data on the geology of the area is currently not very good, though I have found very general data through various government surveys and previous work by my professors who are very involved in the mapping of lithology and structural geology in the same area. For information and data on the soils of the area I looked toward the Greenville and adjacent counties' Soil Surveys conducted previously through government contracts, primarily through the South Carolina Department of Natural Resources. To find information on vegetation cover and other land cover data I looked at various aerial photographs, into the National Land Cover Dataset, as well as the South Carolina Department of Natural Resources available GIS data. I also needed various topographical elevation data from which I can help discern slope characteristics, which impact soil formation. I used GIS to help me visualize the relationships between these variables. By overlaying geology or soils with the vegetation, land use, and elevation data, I hoped to discern simple patterns. Without GIS, getting a better understanding of the spatial relationship between soil, elevation, urban land cover and slope factors would be very difficult. I am hoping that the results from this project will help jump-start my senior thesis research. The results from this project will also be of use to many others, who can use the information to gain a better understanding of not only the Cleveland area, but general relationships between geology, soils, vegetation, and land usage.

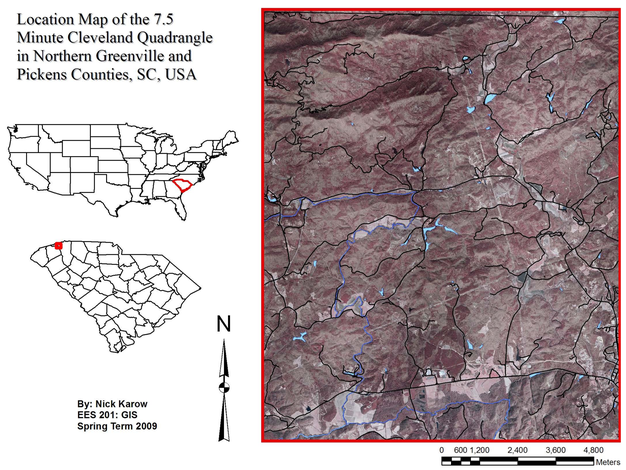


Fig. 1: This diagram shows the extent of my study area (7.5 Minute Cleveland Quadrangle) with the major streets overlaid on top.

II. Methods:

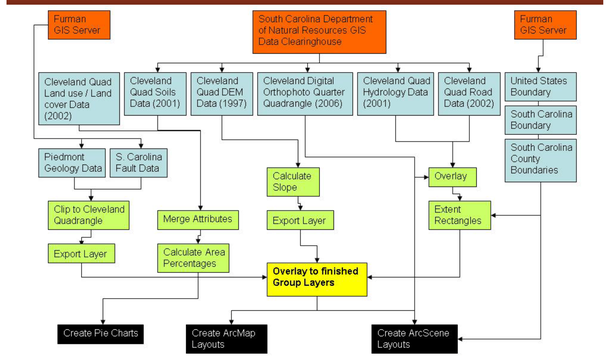
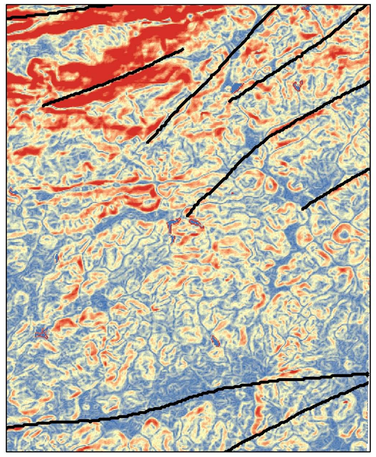


Fig. 2 Methodology involved in data collection and analysis.

III. Results and Discussion:

While looking through the data on both the soils and land usage polygons, I found a definite relationship between the use of cropland and the corresponding soil units on which the farmers have established their fields (Fig. 3). When looking into the types of soils in which crops are planted, I found the primary soils used for farmland are types of sandy loams[4]. In my study area of the Cleveland Quadrangle, there are three principle sandy loams: a fine sandy loam, a coarser sandy loam, and a sandy clay loam all have good characteristics for the growing of crops. The reason for choosing sandy loams stems from the fact that the grain size found in a sandy loam is conducive to plant growth, large enough to hold a significant volume of water and allow the flow of water toward the plant, yet small enough to retard the transmission of water away from the plant.

Soil Slopes in the Cleveland 7.5 Minute Cleveland Quadrangle



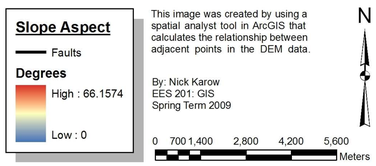


Fig. 4: Map shows the slope based on DEM (Digital Elevation Model) and mapped fault lines

Usage of Potential Farmland by Crops versus Development Based on Soil Types in the Cleveland Quadrangle

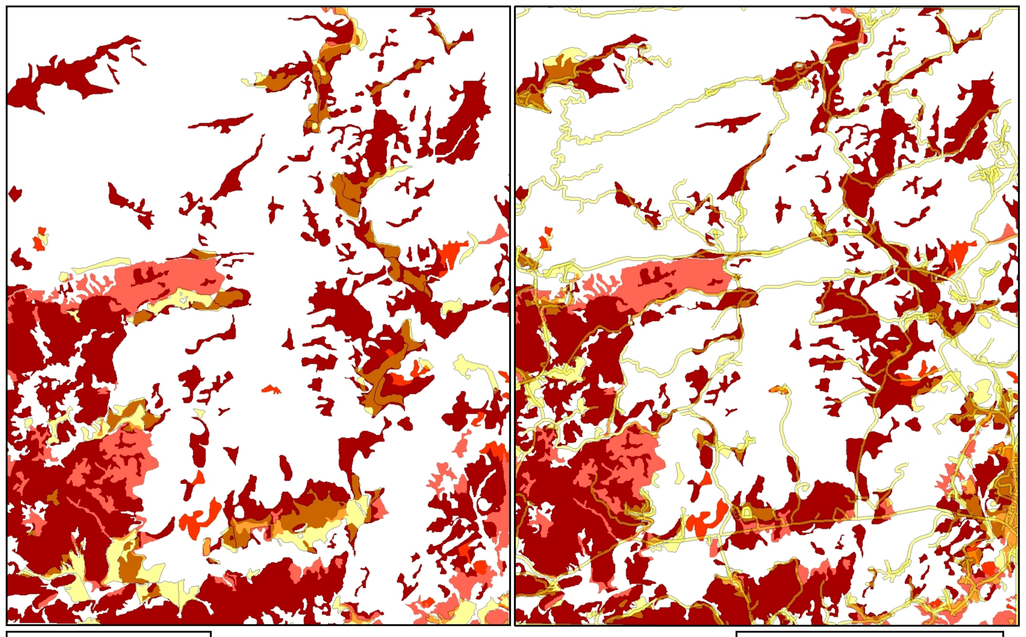


Fig. 3: Figure shows overlapping of good potential farmland soil with current cropland / pasture on the left and developed grounds on the right respectively.

III. Results and Discussion Continued

The fact that the soil is primarily made up of a loam means that the soil is likely to be nutrient rich since much loam, or silt, sized particle come from the flooding of streams which carries with it valuable nutrients[4]. The left map on Fig. 3 shows the areas that are used for cropland overlaid on the most suitable soil types. The right map on Fig. 3 show the developed areas overlaid on the potential farmland soils, in effect showing the loss of good farm soil to development of industry, roads, and residential establishments. An ideal type of soil for farming does not necessarily mean the thickness or slope is conducive to agriculture. Slope values were calculated from the digital elevation model data using GIS. The soil data I gathered had a slope attribute I could have feasibly categorized and developed as a display, but the quadrangle covers multiple counties and soil surveys. This creates a discrepancy in the categorization of the slope data. Since it would be very difficult to create polygons of integer value slopes, the creators of the soil data marked a range for a soil group (i.e. 5-10 degree slopes). Different surveys used different categories however, and they often overlap (i.e. 5-10 deg. category in one and another has a 2-8 degree slope category). Due to this discrepancy, slope was calculated using DEM data. In comparing the cropland usage polygons to the slope map, you can see that the relatively low lying, flat areas are consistent with soils conducive to crop production, whereas soils of steep slopes (a concentration of which is in the northwestern corner of the quadrangle) do not make very good farmlands, due simply to the steep slopes usually corresponding to a thinner soil as well as decreased infiltration rates and holding capacities. I included the major faults since they can also influence drainage patterns.

IV. Conclusion:

Two conclusions were reached. Most of the cropland currently being utilized is within soil units that are conducive to the growing of crops. This means that with proper nutrient influx and a balanced water budget for the system, the farmland should be productive. This is a simple conclusion because the cropland would not be located where it is if the farms were not productive. The 7.5 Minute Cleveland Quadrangle really has remained relatively undeveloped, keeping the mixed upland forests as well as upland planted pines forests intact. It is safe to say that the quadrangle as a whole has a very high potential productivity as it relates to soil type and slope aspect. When looking at the pie chart of the relative percentage of area of each of the soil types in the quadrangle (Fig 5), one can see that the greatest area of soils is a complex at 27.5% of the total land area. However it can be seen that the second largest component of the soil area is made up of a sandy loam at 23.6%, an ideal soil type for the growing of crops. The potential farmland class can be expanded to include both the fine sandy loam category and the sandy clay loam category, making the potential farmland category a robust 35% of the total land area of the quadrangle potentially suitable for crop production. Second conclusion is that: when looking at the total land use of the Cleveland Quadrangle it becomes apparent that most of the area is covered by natural/replanted vegetation or water. When looking at the relative percentages of the industrial, commercial/services, and transportation/utilities lumped into one 'developed' class, we find they only take up about 0.18% of the total land area of the quadrangle, and the residential category only takes up 6.72% of the land area, making for a very pristine and natural region as it relates to the ecosystems of the area (Fig. 6).

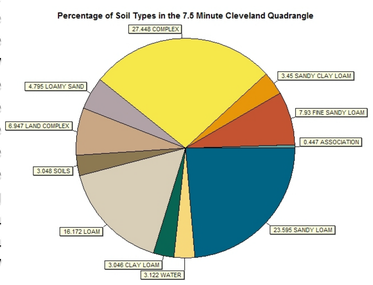


Fig. 6: Pie chart shows the relative percentages of the soil type by area in the 7.5 Minute Cleveland Quadrangle.

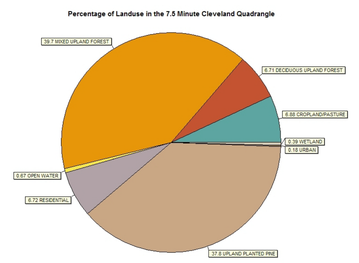


Fig. 5: Pie chart shows the relative percentages of the land use by area in the 7.5 Minute Cleveland Quadrangle.

Sources:

[1]Richard Hanning, 2006, Greenville County GIS Data, Greenville, SC.

[2]ESRI Data & Maps [CD-ROM], 2005. Redlands, CA: Environmental Systems Research Institute.

[3]Horton, J. W., 2001. Preliminary Digital Geologic Map of the Appalachian Piedmont and Blue Ridge, South Carolina, USGS.

[4]Ward, A. D., and Trimble, S. W., 2004. Environmental Hydrology 2nd Ed. CRC Press LLC.

[5]SCDNR GIS Data Clearinghouse https://www.dnr.sc.gov/pls/gisdata/quad.qselect?pcounty=greenville&ptilename=CLEVE accessed 13 February 2009

*All images and data were referenced to the North American Datum (1927) Universal Transverse Mercator projection Zone 17N, other than the extent rectangles for the United States and South Carolina which were referenced to the GCS North American Datum (1983)

Acknowledgments:

I would like to acknowledge the help of my classmates in the acquiring as well as the analysis of data for my project. I would also like to express my gratitude for the help of Dr. Suresh Muthukrishnan by giving his valuable insights and providing a few data sources for my project. I would also like to thank Dr. Weston Dripps for his lectures on soil properties given during the Spring term of 2009 in his Watershed class. Lastly I would like to acknowledge the South Carolina Department of Natural Resources and the United States Geological Survey for collecting and making the data available for the state of South Carolina and specifically the 7.5 Minute Cleveland Quadrangle.