Spatial Street Light Distribution and Intensity in New Washington Heights Neighborhood, Greenville

John Michael Robinson

Earth and Environmental Science Department, Furman University, Greenville, SC 29613

I. Summary and Objectives

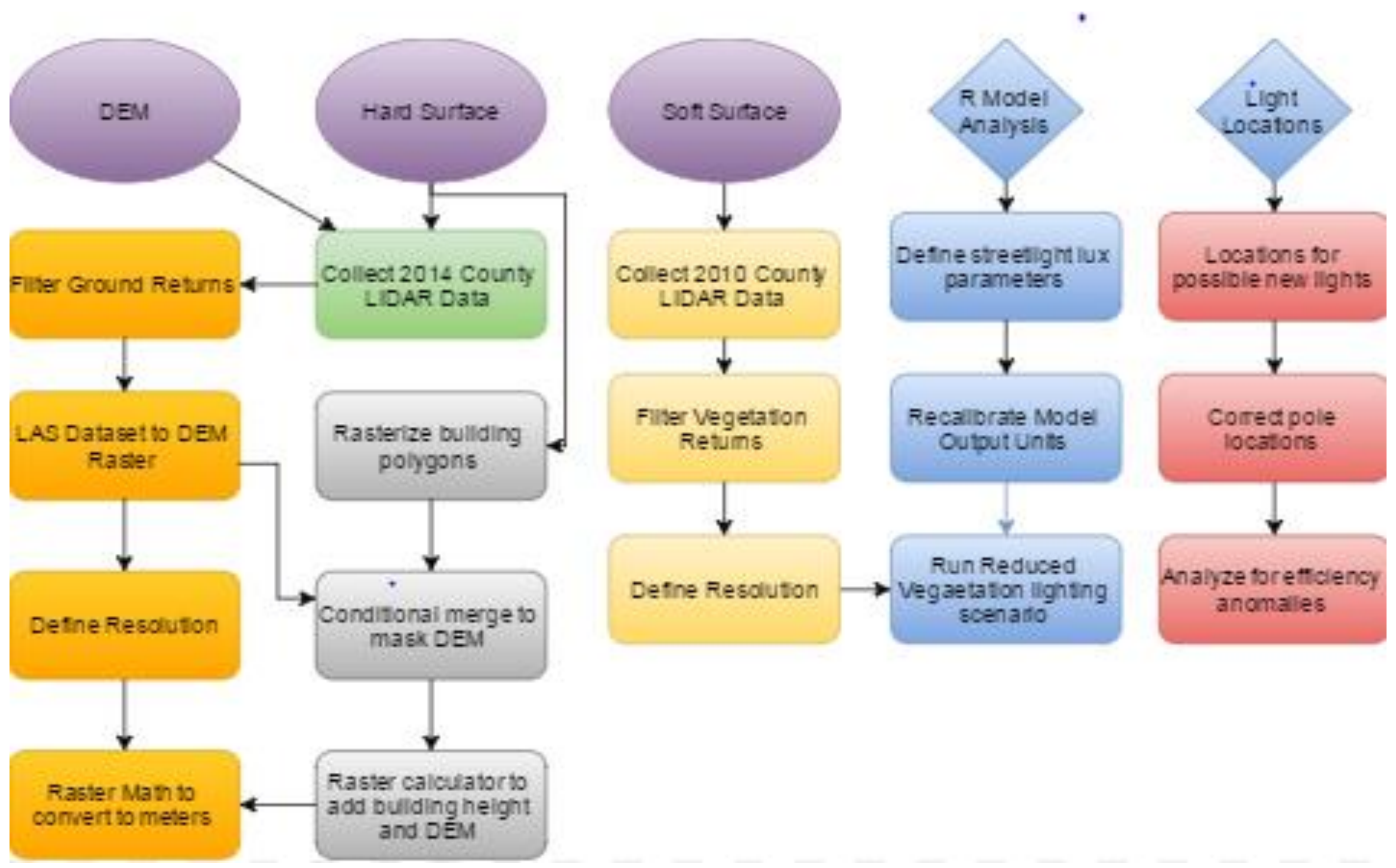
The primary goal of this project is to analyze the impact of a proposed lighting scheme in Greenville, SC's New Washington Heights neighborhood. Previous research (Chatterton 2013) of the community's street lighting shows unequal lighting distribution. I employed a model created by Bennie et. al. (2014) to create a 3-Dimensional analysis of the community using LIDAR and building footprint data, normalizing for topography variations and vegetation interference. I ran the model in R to measure light dispersion and intensity as a result of the proposed lighting scheme. The proposed lighting scheme addresses darkness gaps in the neighborhood's existing lighting scheme. It may have disruptive effects on nocturnal bird species flight patterns.

II. Introduction and Literature Review

Urban areas are centers of human activity around the clock. For centuries, municipalities have created urban lighting schemes to illuminate thoroughfares and deter crime (Hale et. al. 2013). Urban residents are grappling with light pollution as a result (Kuechly et. al 2012 and Barducci et. al 2003). The correlation between opportunistic crime and uneven light distribution is well-documented by Farrington and Welsh (2002). As lighting technology has developed, the ubiquity of artificial sodium and metal halide lights defines urban lighting districts across the world. Stone et. al (2015) document a similar correlation between artificial light pollution and effects on the flight patterns of nocturnal bird species. The unintended ecological consequences of artificial lighting threatens the ability of these nocturnal species to coexist harmoniously in urban ecosystems. Bennie et. al (2014) created a model to help city planners and ecologists balance the need for adequate street lighting with the realities of local ecology. The Bennie model accounts for topography variations, buildings, and vegetation as impermeable or semi-permeable blocks to light. For this study, we will use the Bennie model to identify the distribution and intensity of light in the New Washington Heights neighborhood of Greenville, SC. This neighborhood is located at the far Northeastern extent of the Greenville city limits adjacent to Poinsett Highway (US-276). Its current lighting scheme is inadequate. The community is forming a group to purchase additional lights to install on existing lighting infrastructure. With the help of the Bennie model and an R program, we will identify the community's areas of greatest need for improved lighting and model a scenario where enhanced tree trimming may augment the efficiency of the lighting scheme.

III. Methods

The flow chart below shows the methods involved in this research and analysis.



IV. Results and Discussion

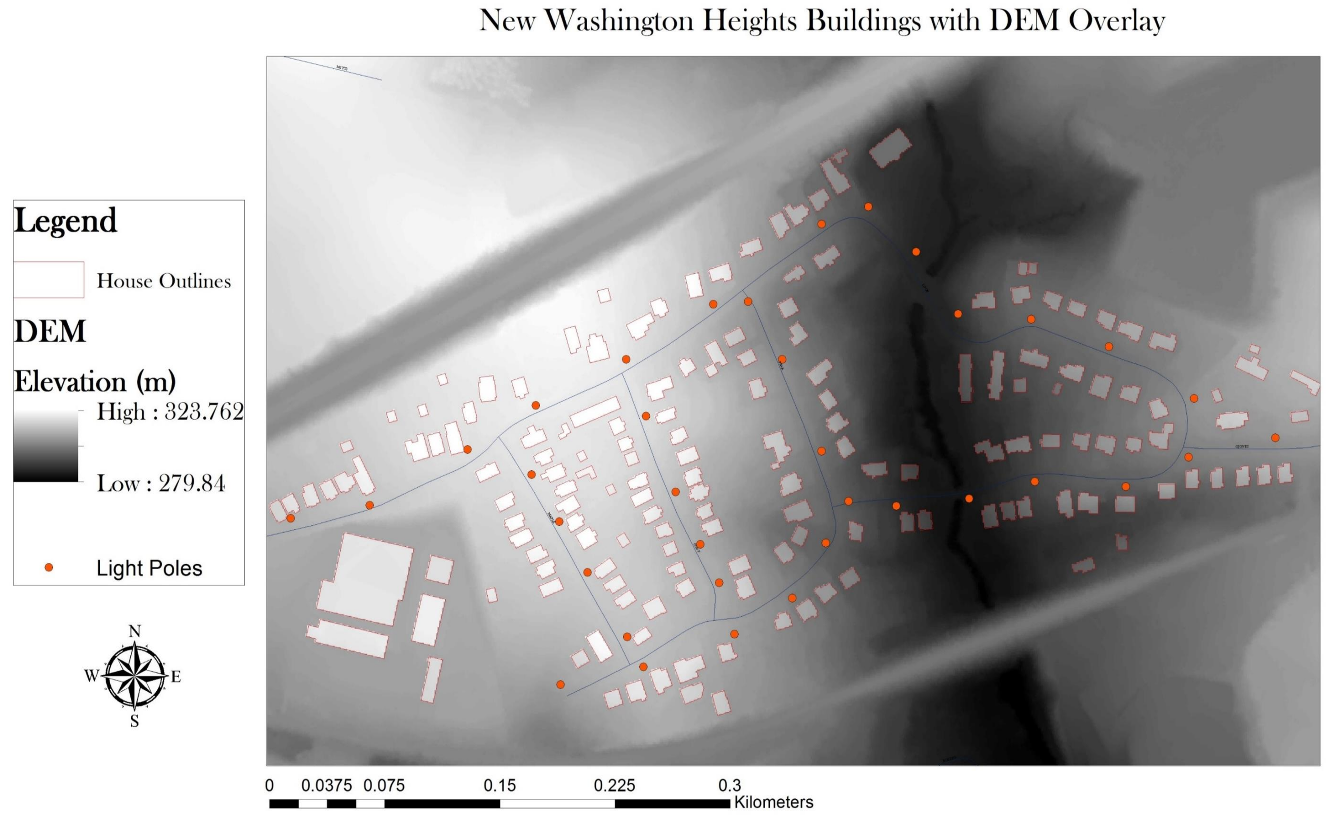


Fig. 1 Rasterized building polygons in the study area. DEM with light poles integrated as point features. Building footprint raster was cut to the neighborhood to mask the DEM.

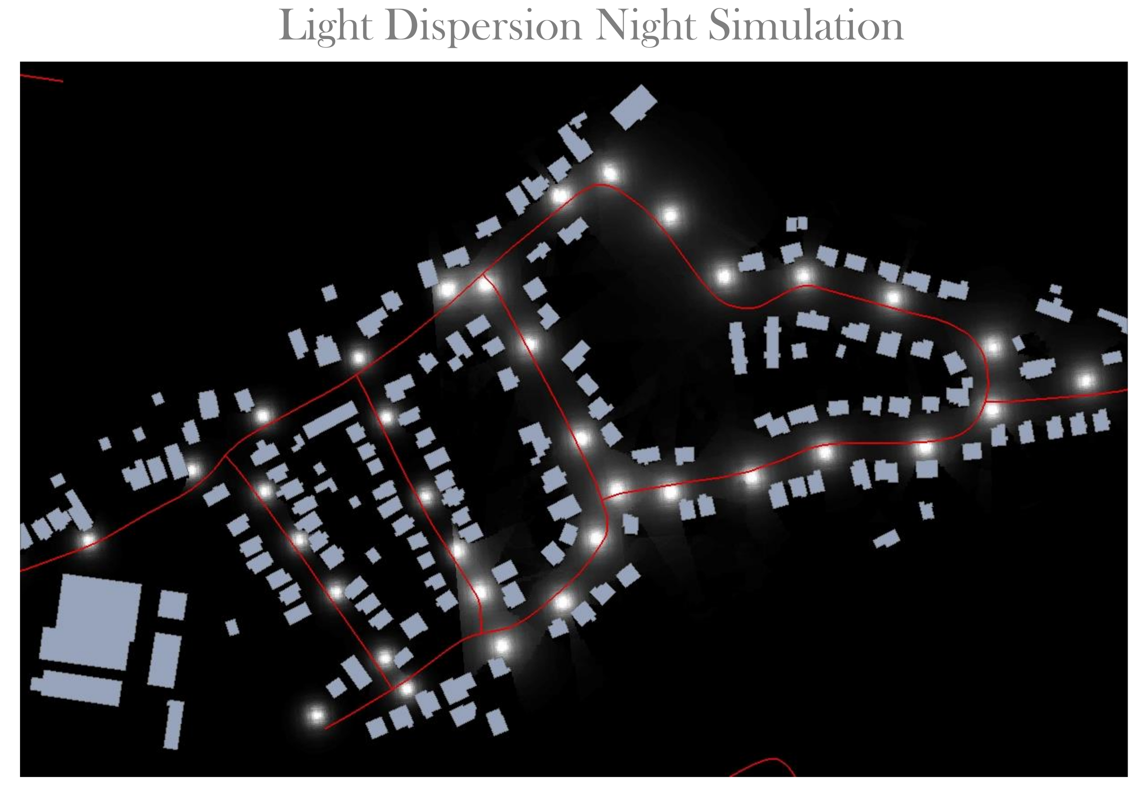


Fig 2. Night lighting simulation model shows localized uneven dispersion of light as a result of topography, vegetation, and buildings. Model rendered in ArcScene.

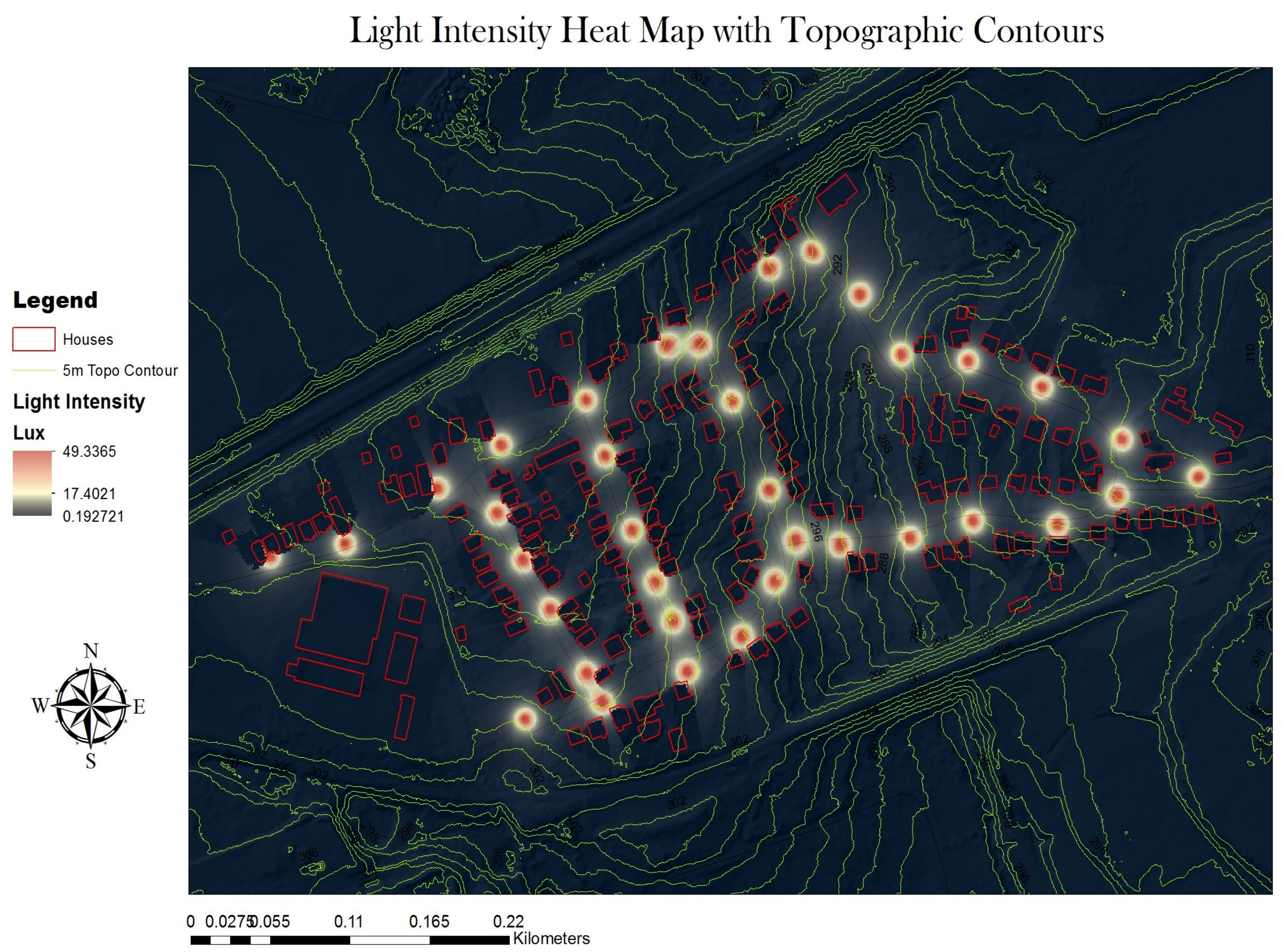


Fig. 3 Heat map showing the distribution and intensity of light (lux) in the neighborhood using topographic contour isolines (5m) to contextualize elevation.

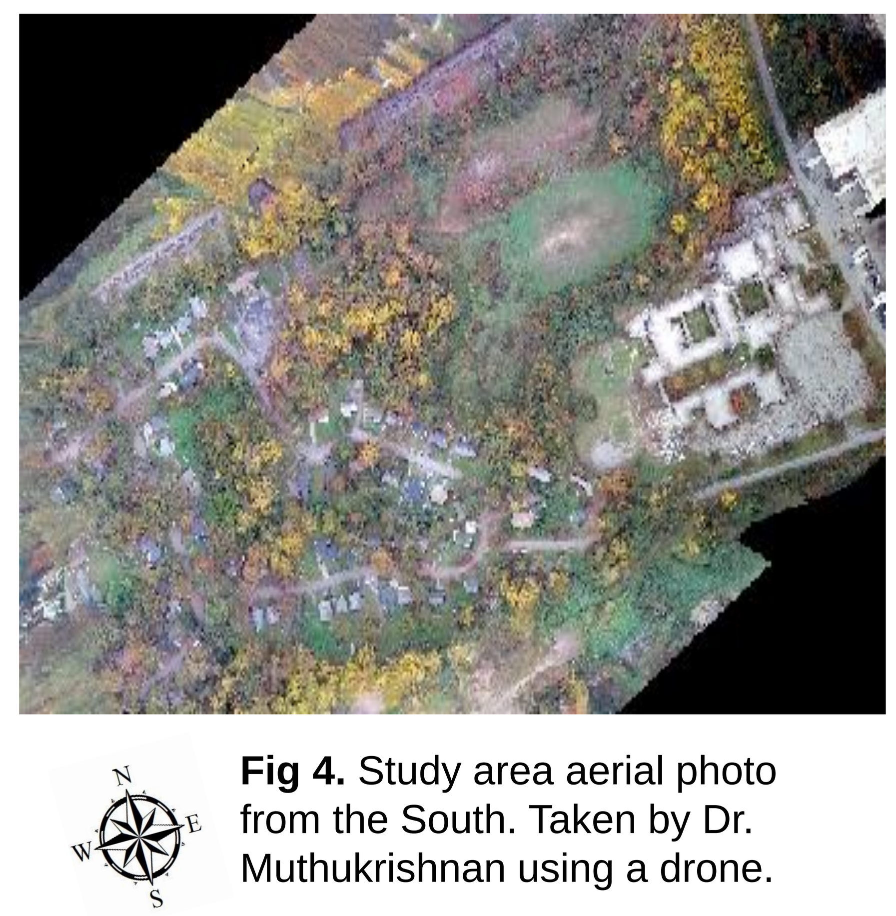


Fig 4. Study area aerial photo from the South. Taken by Dr. Muthukrishnan using a drone.

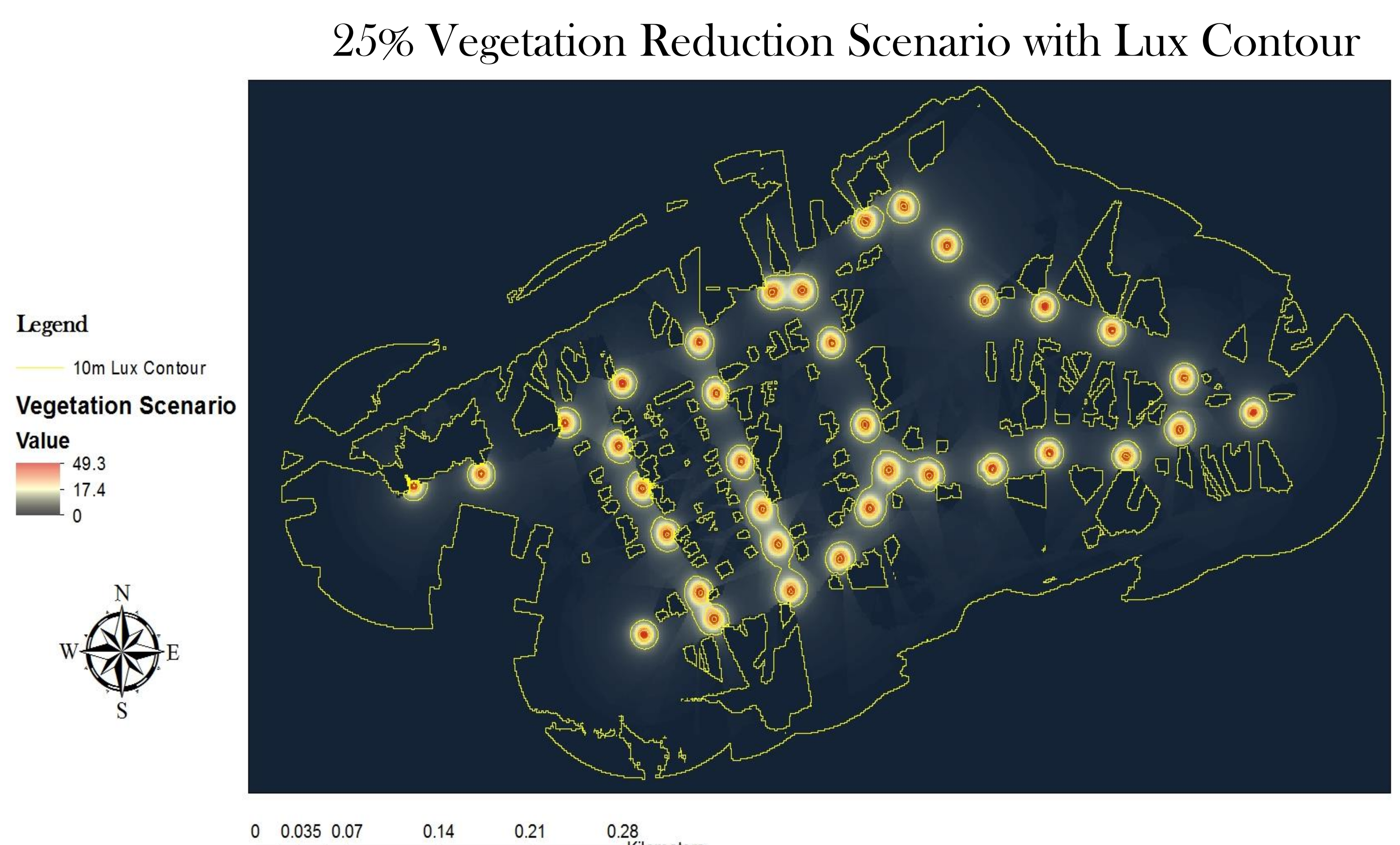


Fig. 5 Map showing results of reducing vegetation cover by 25%. Maximum lux values are concentrated immediately surrounding the streetlights (max=50 lux). Light begins to permeate between buildings in the central zone as a result of reduced vegetation.

V. Conclusion

At night, urban areas like Greenville are masked by a halo of artificial lighting. In the light dispersion scenario controlling for vegetation, buildings, and localized elevation changes, I identify three areas where lights are over-clustered, resulting in a minimally efficient lighting scheme. The first is located on the southeast corner of the middle loop. The second area appends the northeast corner of the same loop. The final area of over-clustering rounds the east side of the middle loop. The southern border of the neighborhood is less prone to building, elevation, and vegetation light-blocking. In these areas, fewer lights should be installed to achieve the desired lighting standard. The least efficient light placements are located on the three north-south roads in the neighborhood. Greenville city planners and the community lighting group can use this model to prioritize the installation points for the neighborhood. The randomized vegetation reduction scenario shows that trimming vegetation has a discernible impact on the distribution of light, especially in the central areas of the neighborhood. More aggressive vegetation removal scenarios would increase the size of the plane of light dispersion as well as the lights' intensity. Overall, this lighting scheme is connected and evenly distributed despite the neighborhood's variable topography from 280 to 320 meters. The easternmost loop of houses is the only area where light does not penetrate into the backyards of properties, leading to questions about the magnitude of light pollution in this scheme.

VI. Future Research

There are numerous opportunities for future research. The ecological impacts of the improved lighting scheme may necessitate additional planning before the community installs additional lights. Comparing the spatial distribution of bird nests in the immediate area and the most intense concentrations of light pollution will help city planners identify the areas of greatest ecological impact.

VII. Data Sources

1. Greenville County 2010 and 2014 LIDAR Data
2. Greenville County Planimetric and Transportation Data
3. Bennie, et al. R code for light dispersion and intensity
4. Greenville County existing utility pole infrastructure and hardware.

VIII. Acknowledgements

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IX. References

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