The Efficacy of Residential Tree Plantings in Mitigating Urban Heat Island: An Analysis of the NeighborWoods Program in Austin, Texas

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Summary

This study analyzed the effectiveness of the NeighborWoods program in mitigating the UHI effect. Using a variety of methods the study helped to better understand the cooling and other mitigating effects of trees. Furthermore, the study analyzed the energy reduction benefits of NeighborWoods trees producing positive results.

Background

According to the City of Austin (CoA), the population of the city increased from 680,000 to 865,000 in just 12 years. With more people comes more development. Developed and urbanized land brings more economic vitality and opportunity to a city; however, development can have negative environmental effects. One of the negative environmental effects that is coupled with urban development is known as the Urban Heat Island effect (UHI).

According to the Environmental Protection Agency (EPA), the Urban Heat Island effect explains the phenomena that developed areas are hotter than the surrounding rural areas. The heat from the urban areas negatively impacts cities, most specifically through increasing energy use and demand to cool down structures, air pollution, greenhouse gas emissions, human health issues relating to heat and pollution, as well as having a negative impact on water quality (Environmental Protection Agency, 2013). In order to mitigate the UHI effect and reap other tree planting benefits, the City of Austin, Austin Energy, and the non-profit TreeFolks have implemented a tree planting program called NeighborWoods.

Scope

This study analyzed the city limits of Austin, Texas, with a special emphasis on locations with NeighborWoods Tree Plantings. These locations are shown in Figure 1. The NeighborWoods tree plantings began in 2002. The study will analyze surface temperature imagery over the 13 years since NeighborWoods began.
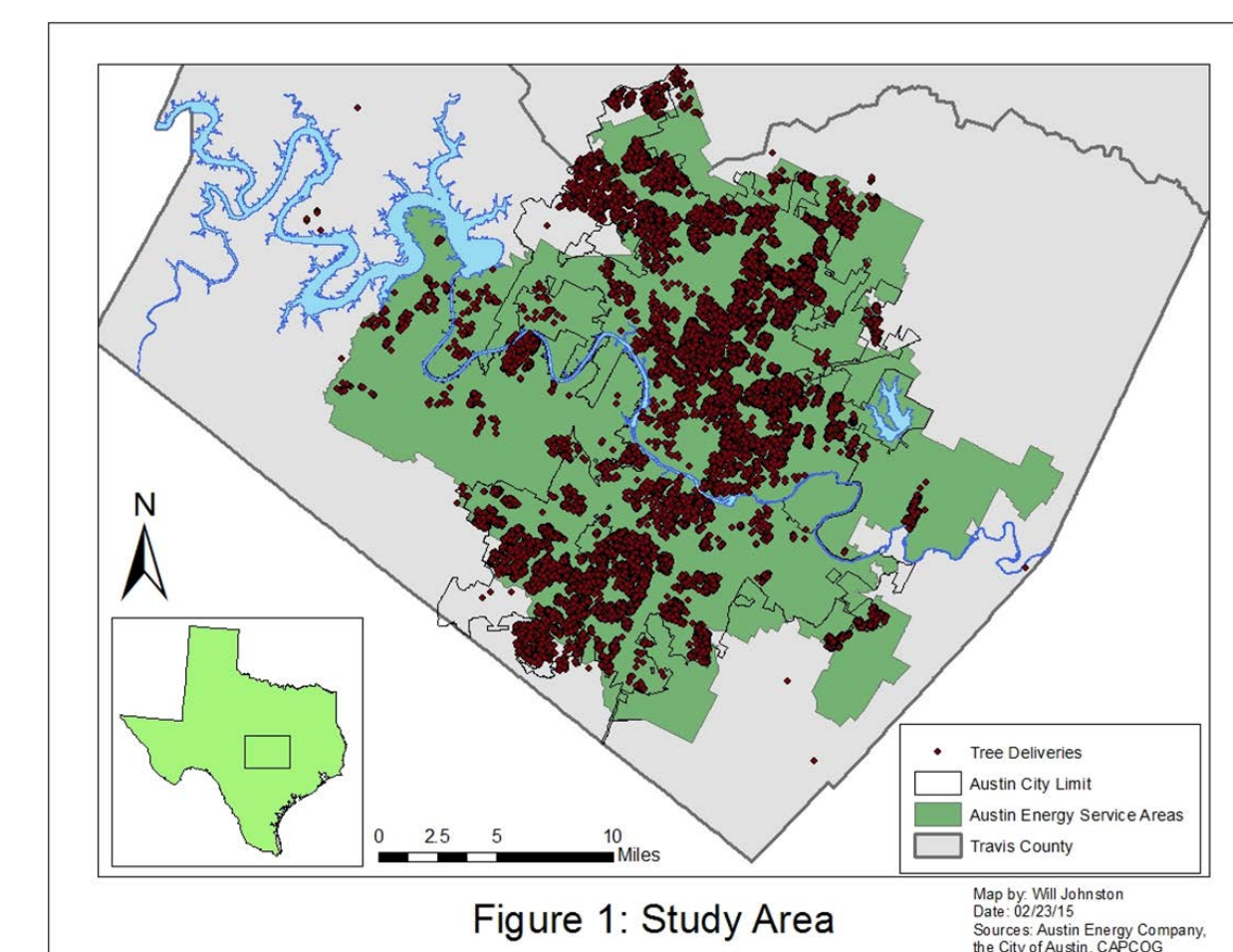

Figure 1: Study Area

Methodology and Implementation

To analyze the effectiveness of the NeighborWoods program, ERDAS was used to remotely sense and analyze surface temperature, ArcGIS to analyze tree planting locations, and statistical analysis to analyze the impact of the UHI mitigation. This process is shown in Figure 2. Three focus dates where chosen around the same time of year from the beginning (2002), middle (2009) and end (2014) of the programs current duration as a way to look at the temperature and mitigation changes over this time. Data was accumulated from the City of Austin GIS recourses and the USGS Earth Explorer.
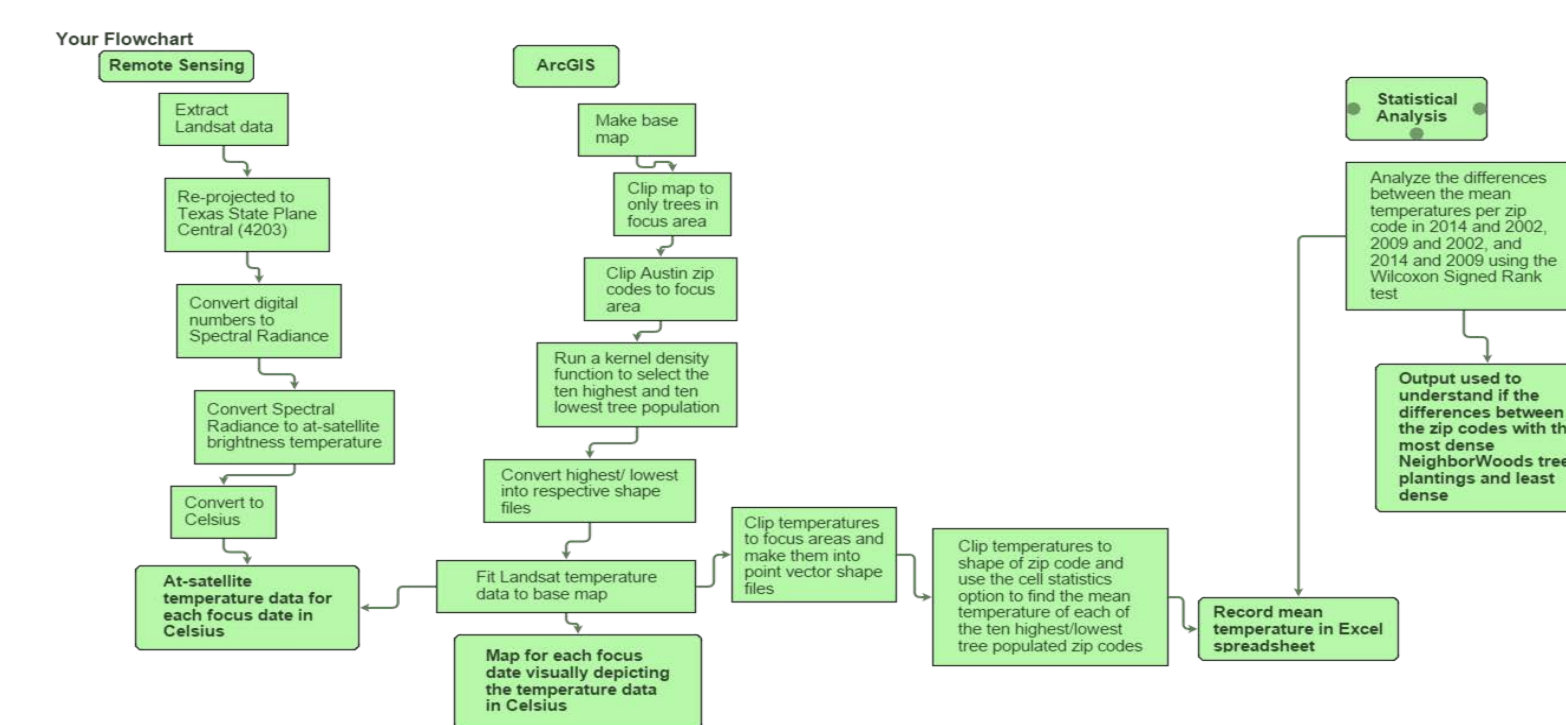

Figure 2- Remote Sensing, ArcGIS and Statistical Analysis methodology

The National Tree Benefit Calculator was used to calculate the quantitative amount of energy savings and carbon reduction produced by the NeighborWoods trees. All of the trees planted are categorized into 5 species types: large, medium, and small Broadleaf Deciduous trees, as well as large and small Broadleaf Evergreen trees. With assumptions taken into account, this process was done for each year until the end of the study's timeframe, 2014. This process is shown in Figure 3.
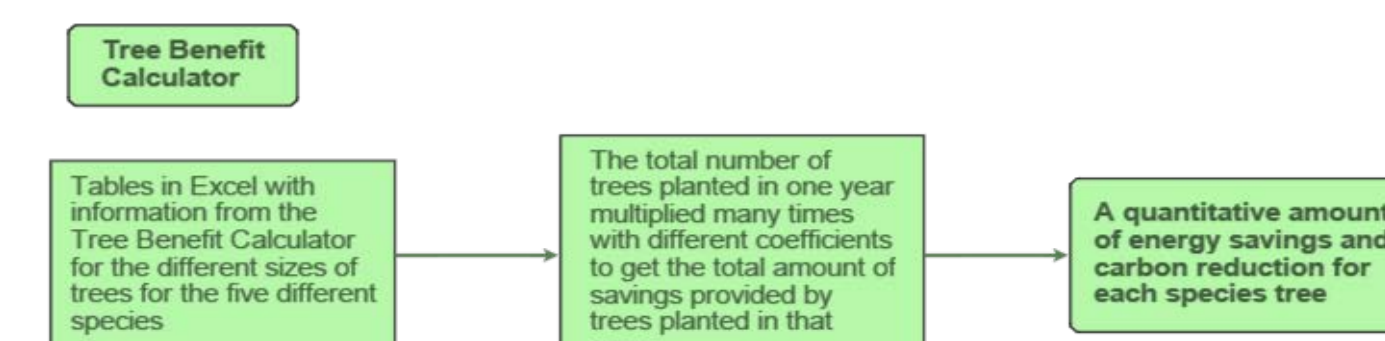

Figure 3- Tree Benefit Calculator methodology
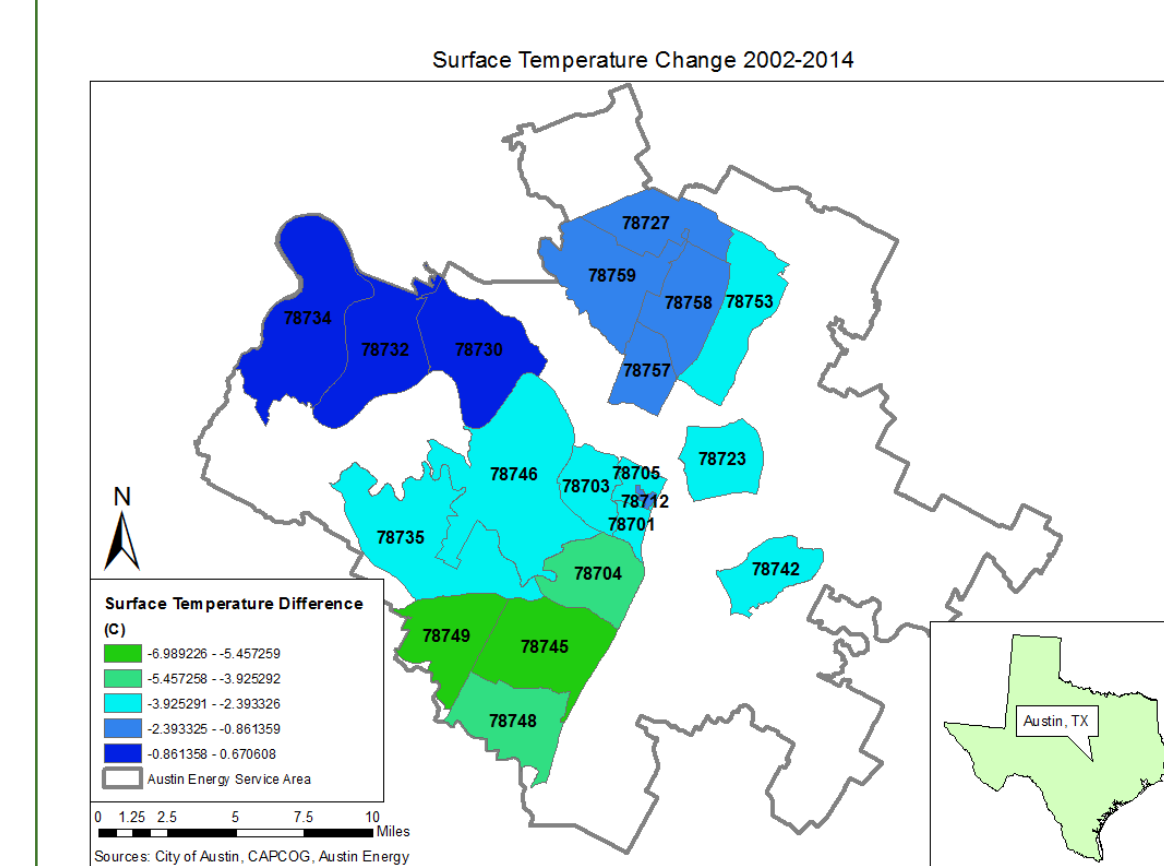
Results
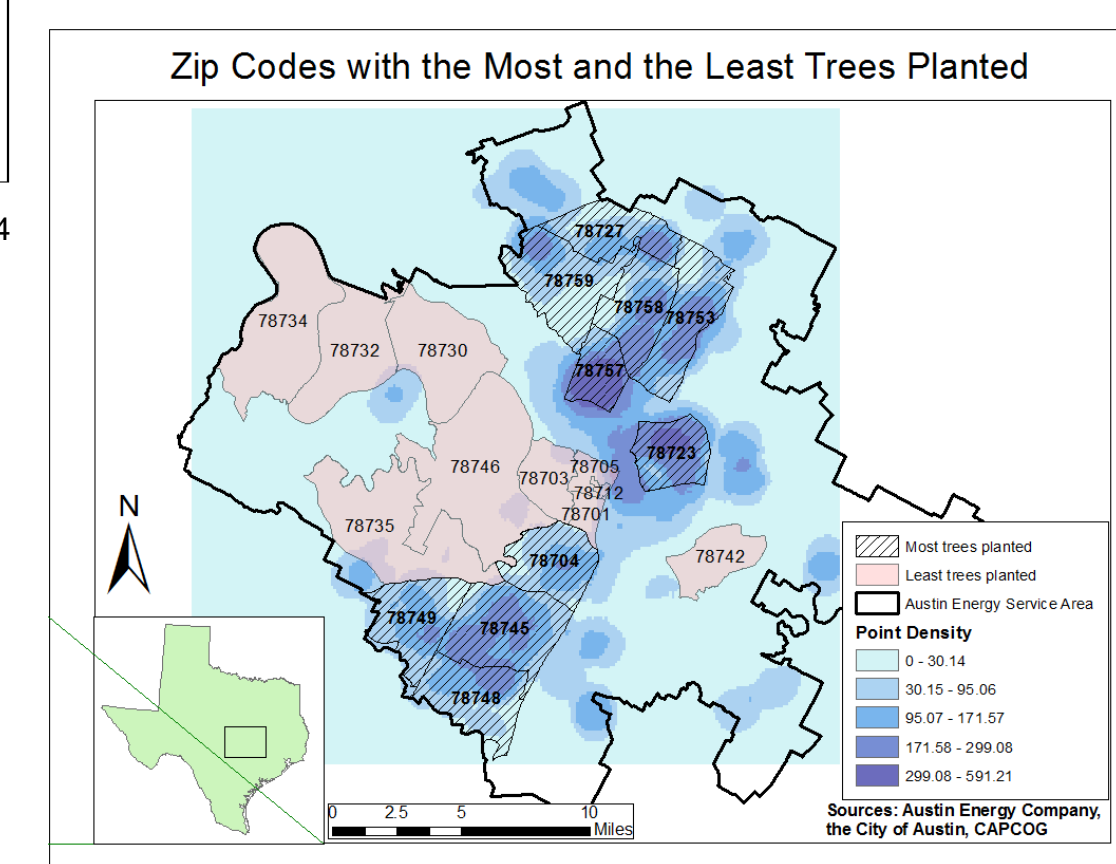

Figure 4- Surface Change 2002-2014

Figure 5- Zip Codes with the Most and the Least Trees Planted

Results

Statistical Analysis Results-

The analysis for 2002 through 2014 showed a significant temperature difference (Shown in Figure 6).The zip codes with the most NeighborWoods tree plantings had cooler temperatures than those that did not. The analysis for 2002 through 2009 did not show a significant temperature difference. While could be due to the age of the trees or weather conditions for the time period. The analysis for 2009 through 2014 showed a significant temperature difference between the two groups of zip codes.

This analysis showed that there are significant temperature differences in areas with NeighborWoods tree plantings than those without the trees. Overall, two of the analyses proved significant with 95% confidence retaining that the alternate hypothesis is the truest.
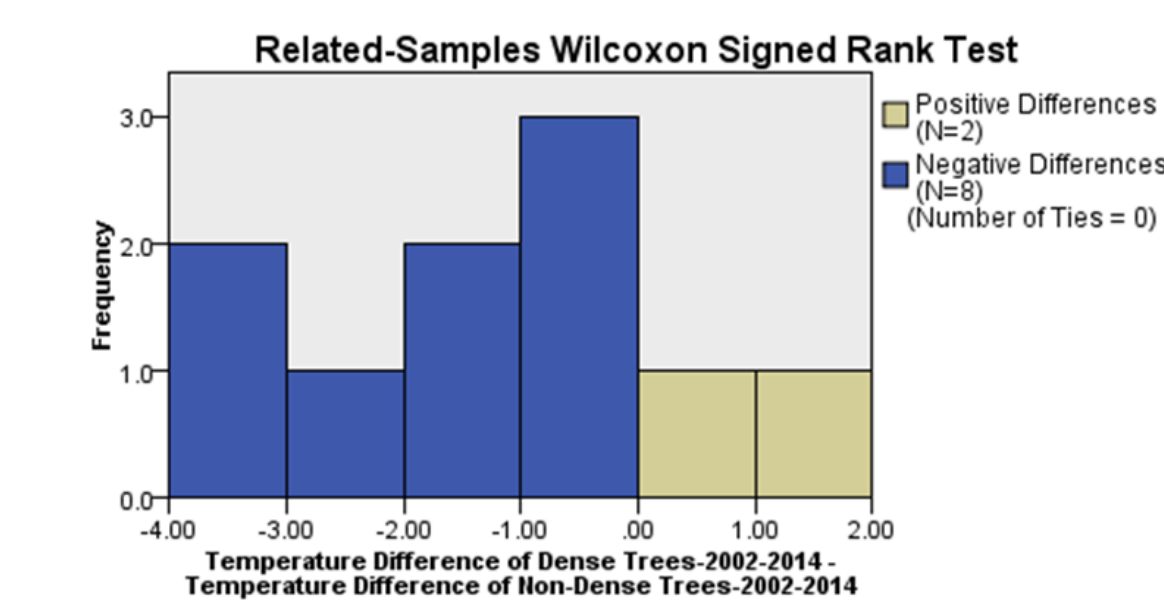

Figure 6- 2002-20014 Wilcoxon Signed Rank Test results

- **Null Hypothesis (H0):** The median of differences between the temperature differences of the non-dense tree zip codes and the temperature differences of the dense zip codes is not statistically significant.
- **Alternative Hypothesis (H1):** The median of differences between the temperature differences of the non-dense tree zip codes and the temperature differences of the dense zip codes is statistically significant.

National Tree Benefit Calculator Results
- The NeighborWoods Tree Program provided the city of Austin with a total of 43,563 trees.
- The total energy savings is 5,798,479 kW/h.
- Estimated 27,396,863 pounds of CO_2 reduced from our atmosphere.

Tree Planting Years	Total Trees	Savings in kWh	CO2 Reduction (pounds)
2002	2,885	N/A	N/A
2003	2,967	1,329,737	6,446,146
2004	4,044	1,237,907	6,087,872
2005	3,950	1,099,412	5,272,047
2006	2,059	392,359	1,836,520
2007	4,085	659,818	3,002,413
2008	1,458	201,133	886,347
2009	5,391	463,087	2,097,706
2010	3,994	219,868	928,568
2011	3,204	104,827	473,334
2012	3,023	54,616	234,498
2013	3,767	30,546	112,454
2014	2,736	5,169	18,958
Total	43,563	5,798,479	27,396,863

Figure 7- National Tree Benefit Calculator Results

Conclusion

Overall, the NeighborWoods program is having a positive impact in the City of Austin. It is helping mitigate the UHI effect by lowering temperatures in areas with the tree plantings. These trees are also helping to save energy in individual's homes (saving money and reducing energy demand), as well as taking carbon dioxide out of the atmosphere. In further research it would be helpful to have data about the status of the tree and whether or not it is in good health. This program should look for ways to continue and hopefully expand to positively impact more of the city. Future studies like this could be utilized in other cities with residential tree planting programs.

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