Treefolks’
NeighborWoods Program
A Spatial Assessment

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Executive Summary
As much of the planet continues to experience record high annual temperatures, city governments are increasingly recognizing the economic and social costs associated with the urban heat island effect (NOAA, 2012; Tallis, et al., 2011). One method identified to mitigate the effects of the urban heat island is to reduce the sunlight exposure of paved surfaces with tree shade, and city governments and local charities are increasingly implementing or expanding programs which aim to both protect and strengthen the size of the urban tree canopy (Gartland, 2012).

Sponsored by the City of Austin’s Climate Protection Program, Austin-based TreeFolks began delivering free street trees through the NeighborWoods program in 2003. By targeting the street tree canopy the NeighborWoods program aims to mitigate the urban heat island effect, thereby lowering summer temperatures reducing overall energy consumption. To date, over 30,000 NeighborWoods trees have been distributed to more than 17,000 unique addresses. However, TreeFolks does not have a systematic approach for targeting neighborhoods for tree plantings. Further, TreeFolks has few metrics on which to evaluate the success of their program.

I have partnered with TreeFolks to provide a spatial assessment of the NeighborWoods program, with the goal of making the program as efficient as possible and to maximize the impact of the NeighborWoods program on the urban environment. Analysis reveals that while TreeFolks has thus far been successful in selecting areas for planting, business parks and apartment complexes represent an untapped real-estate market in terms of tree-planting opportunities. Further analysis showed that NeighborWoods data collection and organization methods could be improved to facilitate deeper analysis, and that setting a street-tree canopy ‘goal’ might serve to better track the contribution NeighborWoods is making to the urban forest.
Introduction

As much of the planet continues to experience record high annual temperatures, city governments are increasingly recognizing the economic and social costs associated with the urban heat island effect (NOAA, 2012; Tallis, et al., 2011). The urban heat island refers to the phenomenon that cities often experience warmer temperatures than the areas around them. This effect occurs as a result of cities’ high density of impervious surfaces (asphalt, steel, and concrete, for example) which can be heated by the sun to temperatures much hotter than the air itself. Such surfaces in turn increase air temperatures around them and continue to exude residual heat long after the sun has set (EPA, 2012). The result is that cities experience average annual temperatures that range from 2 to 5 degrees warmer than surrounding rural areas (EPA 2012). As such, the heat island effect in US cities has been estimated to account for a 5% to 10% increase in electric demand to due air conditioning use (Akbari, 2001).

One method identified to mitigate the effects of the urban heat island is to reduce the sunlight exposure of paved surfaces with tree shade, and city governments and local charities are increasingly implementing or expanding programs which aim to both protect and strengthen the size of the urban tree canopy (Gartland, 2012). Investing in urban trees is particularly appealing due to the many benefits that trees provide to cities in addition to reducing the urban heat island affect (Zheng, 2011). Trees improve local air quality, sequester greenhouse gases, reduce noise pollution, provide wildlife habitat, mitigate storm water runoff, and also enhance the beauty of the urban landscape (Lewis, 1997; Mackey, Lee, and Smith, 2012). Trees also provide economic benefits to residents by increasing property values and reducing home energy costs by providing shade.

As a rapidly growing urban area with high annual average temperatures, the City of Austin Urban Forestry Administration actively supports programs to mitigate the urban heat island effect, and to generally improve the size and quality of the Austin’s urban forest (Urban Forestry, n.d.). In 2007, the City of Austin, Texas, contracted a private arborist, ArborPro, Inc., to conduct an inventory of Austin’s trees along sixteen thoroughfares and in 24 parks across the city. Completed in 2008, the goal of the inventory was to provide guidance to Austin’s Urban Forestry Administration for future care and planting of trees in the city. While the final report makes recommendations on specific large shade canopy species that the city should continue to plant, as well as urges a need for greater attention to the pruning and structural well-being of the city’s trees, the report does not evaluate the street tree canopy in residential areas, or make recommendations for a city-wide approach to protecting and growing the tree canopy.
The Austin, Texas-based TreeFolks has been working to promote and protect the city’s urban tree canopy since 1989 (TreeFolks, 2012). TreeFolks operates a number of programs and partnerships which aim to raise awareness about the importance of protecting the urban forest as well as educate the public in urban forestry practices such as selecting, planting, and pruning trees. In addition to educational activities, TreeFolks plants a whole lot of trees—250,000 since 1989.

Sponsored by the City of Austin’s Climate Protection Program, TreeFolks’ largest program dedicated to increasing the urban tree canopy is the NeighborWoods program. Through the NeighborWoods program, TreeFolks distributes free ‘street trees’ to qualifying Austin residents, with the goal of increasing street tree canopy coverage and mitigating the urban heat island effect. Trees are distributed on the condition that they be planted near streets and sidewalks, and the resident must further agree to water the tree for at least 2 years. Since 2003, the NeighborWoods program has distributed over 33,000 trees to more than 17,000 unique addresses in the Austin metropolitan area.
A NeighborWoods tree being distributed to a resident. Source: TreeFolks
Problem, Hypothesis, and Research Questions
As the only charity in the region dedicated to promoting “comprehensive urban forestry practices,” TreeFolks’ small staff shoulders a heavy burden on a tight budget (TreeFolks, 2012). Although TreeFolks strives to ensure that planting programs operate efficiently while having the biggest possible impact on the health of the city’s tree canopy, staff and budget limitations mean they do not necessarily have the resources to critically evaluate their efforts. For example, TreeFolks does not have a systematic approach for targeting neighborhoods for tree plantings. Further, TreeFolks has few metrics on which to evaluate the success of their program.

In the fall of 2012, I approached TreeFolks about the possibility of using GIS technologies to assess and visualize their tree planting efforts. I have partnered with TreeFolks to provide a spatial assessment of the NeighborWoods program, with the goal of making the program as efficient as possible and to maximize the impact of the NeighborWoods program on the urban environment.

In all, I have identified four primary research questions which will be addressed in the findings and analysis that follow:

1. Where in Austin are NeighborWoods trees being distributed?
2. Which tree species are most likely to survive, and where?
3. What is the value of TreeFolks trees in terms of heat island mitigation and other environmental improvements in Austin?
4. What areas should be the focus of future TreeFolks plantings?
Methodology

Required data.

To carry out my analysis of the NeighborWoods program and its contribution to the urban tree canopy, two pieces of data were crucial. First, I needed the historical NeighborWoods tree planting location data from TreeFolks. The tree planting locations were essential to the entire mapping process; without knowing where trees have been distributed, there would be no means to assess how such plantings were distributed across Austin’s urban landscape.

Secondly, I needed data about the existing city-wide tree canopy of Austin in order to compare it to the NeighborWoods tree plantings. This data needed to be not just in raw numbers (for example, the estimated total canopy coverage in the city), but rather I required the specific shape and location of tree canopy data. With location based canopy data, I was able to further assess where street trees in the city are most prevalent, and where they are lacking.

For reference purposes, I would also need spatial information about the city of Austin itself, such as its boundaries, major bodies of water, and aerial photography. I also required data about the location and size of Austin’s streets, so that I could extract information about trees proximity to city streets, as well as to create reference maps of Austin that included the names of major streets. Lastly, I would need a means to subdivide the city into logical groupings of neighborhoods so as to distinguish the differences in tree canopy distribution across the city.

Obtaining the data.

I interfaced directly with TreeFolks to obtain the complete tree delivery records of the NeighborWoods program since 2003 in the form of a Microsoft Excel workbook computer file. All additional data I obtained from three sources. From the City of Austin website I downloaded ArcGIS-compatible data sets of the Austin tree canopy from 2006, as well as spatial data information on the bodies of water and streets of Austin. I downloaded data of the city limits of Austin and aerial photography of Austin from the Capital Area Council of Governments (CAPCOG). Finally, I downloaded census tract data and population data from the US Census Bureau website.

The TreeFolks delivery workbook contains a total of 9 individual spreadsheets, one for each year of NeighborWoods tree deliveries. Each worksheet lists the address of the tree recipient, as well as the species types and quantity of trees delivered to that address. Worksheets for years 2003, 2005, and 2007-2011 also included retroactive ‘survivability’ data which indicated if the trees had been planted properly in the front yard, or if any of the trees at a given location had died within 12 months of delivery.
Street data from the city of Austin attributes related to the size of the street (minor, major, or interstate highway), as well as the names of each stretch of road. Census tract data included the census tracts of the entire state of Texas, and included the ID number of the tract, as well as a code for the county and state in which the tract was located.

**Analyzing the data.**

A. City of Austin basemap
   - Import relevant data
     - City of Austin Boundaries
     - Census Tracts
     - Streets
     - Water features
   - Remove unwanted features and symbolize layers

1. Map 1: Distribution of Planted Trees - Points
   - Prepare NeighborWoods tree delivery data and import to Austin basemap
   - Build ‘address locator’ from Austin streets data
   - Spot-check results
   - Symbolize points

2. Map 2: Distribution of Planted Trees – Census tract
   - Import Austin basemap and geocoded NeighborWoods tree planting locations
   - Use geoprocessing features to assign census tract to each planting location
   - Use Microsoft Excel to calculate number of trees planted per census tract, and join with census tract basemap.
   - Symbolize census tracts

3. Map 3: Austin Tree Canopy, 2006
   - Import city of Austin tree canopy data to basemap
   - Remove canopy outside of city boundaries and symbolize

   - Add Austin tree canopy to basemap
   - Measure area of trees within 50 feet of street centerlines, divide by total street area
   - Geoprocess street tree areas to incorporate with census tracts
   - Symbolize

5. Map 5: 10-Year Projected Street Canopy Contribution
• Group trees into categories of large, medium, and small
• Estimate 10-year average canopy size of large, medium, small trees
• Multiply averages by total number per trees per census tract to get projected total street tree area per census tract
• Symbolize

6. Map 6: Population density of Austin
• Import US census population data to Austin basemap
• Join US census population data to related census tracts
• Divide census tract population by census tract area
• Symbolize

7. Map 7: Potential Future Planting Sites
• Develop criteria for ideal planting sites
  o Med-high to med-low population density
  o Low number of previous NeighborWoods tree plantings
  o Low street tree canopy density
• Add maps 1, 4, and 6 to Austin basemap
• Remove all census tracts that do not fit criteria
• Symbolize

8. Map 8: Tree Failures
• Re-symbolize Map 1 for failed trees only
• Symbolize
• Use ArcMap to perform Ripley’s K Analysis and save chart graphic (see appendix A)

9. Map 9: Tree Failure Rate
• Import Map 8, correlate number of tree failures to total number of trees planted per census track
• Symbolize

10. Map 10: LISA Analysis (see Appendix A)
• Import Map 9 to GeoDa software package
• Run weighted LISA analysis processor, export results

List of Maps
Pg. 11: Distribution of Planted Trees – Points
Pg. 12: Distribution of Planted Trees – Census tract
Pg. 13: Austin Tree Canopy, 2006
Pg. 14: Street Tree Canopy Density, 2006
Pg. 15: 10-Year Projected Street Canopy Contribution
Pg. 16: Population density of Austin
Pg. 17: Potential Future Planting Sites
Pg. 18: Tree Failures
Pg. 19: Tree Failure Rate
Tree Canopy, 2006

Texas Central State Plane Projection: NAD83
Created by: John Clary; University of Texas at Austin; 10 Dec 2012
Source: CAPCOG; City of Austin

Legend:
- Green: Tree Canopy
- Blue: Water
- Yellow: Census Tract

Scale: 0 1 2 4 Miles
Analysis

Tree locations.
Reviewing the maps of NeighborWoods planting locations compared to the existing street tree canopy, we can see that to date TreeFolks has done a relatively good job of targeting areas for planting. I would suggest that this reflects the hard work and expertise of TreeFolks staff, who have dedicated much time exploring Austin neighborhoods by car and foot to verify areas that are in need of street trees. However, the sustainability of this method may become increasingly questionable as TreeFolks exhausts the most obvious planting locations in the city of Austin.

Calculating the benefits of NeighborWoods.
The approach of calculating street tree canopy density may not be the most effective method of presenting NeighborWoods planting contributions, as the projected impact on overall street canopy density remains quite low. This method may be improved by narrowing the study area. Perhaps calculating street tree canopy contributions in specific neighborhood areas, rather than across the entire city, would result in a larger perceived impact. As I will discuss in my recommendations I do believe it is important to establish metrics of success for the NeighborWoods program.

It is further noted that the long-term benefits of these tree plantings will largely depend on care from residents. At 10 years of age, trees are only beginning to impart the many environmental benefits they offer urban cities. To ensure robust contributions from NeighborWoods trees, residents will need to be educated in care methods for mature and maturing trees to ensure the longest—and largest—lifespan as possible.

Making sense of survival rates.
While my statistical analysis of tree failures across the city suggests some clustering of failed trees, there is much room for error in these studies. A number of the census tracts that showed high tree failure rates contained a very low number of trees. Furthermore, the survival data is only available for seven of the eleven years of NeighborWoods data, and much of it contains visible errors. In the next section, I will make recommendations on how the survival study can be improved.

High-density housing and business parks need trees
A particularly interesting finding is that many of the potential future planting sites identified in my analysis are census tracts with large amounts of commercial business parks and multifamily housing. Today, these locations are ineligible for NeighborWoods plantings because the program focuses only on single-family residences with yard space to plant trees. These locations represent an untapped real-estate market in terms of tree-planting opportunities.
Recommendations

Record keeping can be improved
A large effort at the outset of this projected was dedicated to organizing and formatting TreeFolks’ NeighborWoods data. The data is spread across multiple worksheets, and each worksheet has a unique column order, address format, and species name abbreviations. A small amount of consistency in naming and formatting would go a long way in making additional analysis much easier. Furthermore, the survival study data collection would be vastly improved by indicating which species of tree failed. Today, the data only includes if a tree failed—but often times there have been more than one tree species distributed at a given location, so it is impossible to tell which species of tree has died.

Improve canopy contribution calculations, set a canopy goal
I believe that my technique of calculating street tree canopy can be improved. This might be done by targeting specific Neighborhood areas that have received trees, versus a compilation of all street tree canopy in the entire city. More time could also be spent on determining the street-tree buffer zone. I elected to use a 50’ buffer for all Austin streets, while clearly streets vary in size. More time could thus be invested in developing a more accurate measure of the street tree canopy.

I also suggest that TreeFolks staff considers giving themselves a street tree percentage canopy goal. The goal would act as a benchmark to track the progress of NeighborWoods plantings, and would serve a target that could be shared publicly to raise awareness of the importance of the urban forest.

Reach out to recipients every 5 years
While it would require additional valuable resources, TreeFolks should consider reaching out to residents approximately every five years after trees have been distributed. As we have seen, the benefits of trees increase greatly as the trees age. Ensuring tree longevity means educating owners about caring for maturing and mature trees. Such skills would include identifying structural issues, and knowing when to call an arborist.

Partner with apartment complexes and business parks
Finally, TreeFolks should attempt to expand the NeighborWoods program to partner with apartment complexes and business parks. These locations represent an untapped real-estate market in terms of tree-planting opportunities. It should not be difficult to find property managers and commercial organizations interested in improving their open green spaces with trees.
APPENDIX
Appendix A: Selected GIS and Excel Methodology

1. Geocoding Results
   - Matched: 1667 (98.1%); Duplicates 66 (.04%); Unmatched: 323 (1.9%)

2. Integrating Planting Location Points to Census Tracts
   - Import Texas census tracts shapefile and Austin city limits data
   - Clip Texas census tracts to Austin city limits
   - Import geocoded tree planting points
   - Intersect planting points with census tracts – the resulting file will be a point shapefile with with census tract ID numbers assigned to each point.
   - Export attribute table to Excel for analysis

3. Combining individual point totals to census tract-wide data
   - In Excel, open attribute file of planting locations with intersected census ID numbers.
   - Use the ‘combine’ function to group all point totals by census tract.
   - This function can be used to summarize the number of plantings per year, by species, or any other column in the Excel file
   - Import the new table of census tract-point information into ArcMap
   - Use the ‘join’ function to merge the census tract-point information to the original census tract shape file.
   - Export the joined shapefile to make the join permanent, and import the new shapefile.

4. Calculating Street Tree Canopy
   - See illustrations in appendix B
   - Import Austin census tracts, city boundaries, and streets shapefile.
   - Clip Austin streets by Austin city boundaries.
   - Use buffer feature to create 50’ buffer around all city streets—make sure to check the ‘dissolve all’ box to remove polygon overlap
   - Import 2006 Austin street canopy shapefile
   - Use the clip feature to clip all tree canopy in buffer area (this will take aprox. 30 minutes on an Intel i7 processor.
   - Use the ‘intersect’ function to combine the buffered street canopy area with the census tracts shapefile—this will assign a census tract number to every street tree canopy polygon
   - Open attribute table and use the ‘calculate geometry’ function to calculate the total area of street tree canopy
Appendix B: Additional Maps, Charts, and Images

1. Tree Categorization Method

<table>
<thead>
<tr>
<th>Number of Trees Planted</th>
<th>Tree Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>~7000</td>
<td>BUR OAK</td>
</tr>
<tr>
<td>~6000</td>
<td>CEDAR ELM</td>
</tr>
<tr>
<td>~5000</td>
<td>LIVE OAK</td>
</tr>
<tr>
<td>~4000</td>
<td>CHIN PIST</td>
</tr>
<tr>
<td>~3000</td>
<td>CHINQ</td>
</tr>
<tr>
<td>~2000</td>
<td>LACEY OAK</td>
</tr>
<tr>
<td>~1000</td>
<td>MEX WHITE OAK</td>
</tr>
<tr>
<td>~6000</td>
<td>SO RED OAK</td>
</tr>
<tr>
<td>~5000</td>
<td>CREPE M</td>
</tr>
<tr>
<td>~4000</td>
<td>DEST WILLOW</td>
</tr>
<tr>
<td>~3000</td>
<td>MEX BUCKEYE</td>
</tr>
<tr>
<td>~2000</td>
<td>MEX PLUM</td>
</tr>
<tr>
<td>~1000</td>
<td>MT LAUREL</td>
</tr>
<tr>
<td>~7000</td>
<td>REDBUD</td>
</tr>
<tr>
<td>~6000</td>
<td>SMOKE TREE</td>
</tr>
<tr>
<td>~5000</td>
<td>SUMAC</td>
</tr>
<tr>
<td>~4000</td>
<td>TX PERSIMMON</td>
</tr>
<tr>
<td>~3000</td>
<td>YAUP</td>
</tr>
</tbody>
</table>

Large Trees
38%
~200 ft\textsuperscript{2} at Age 10

Medium Trees
41%
~150 ft\textsuperscript{2} at Age 10

Small Trees
21%
~100 ft\textsuperscript{2} at Age 10
2. Sample images of potential planting sites

Above: Northwest corner of East Riverside Dr and Burton Dr.

Above: Northwest corner of Metric Blvd and Rutland Dr.
3. Measuring the Street Tree Canopy
4. Ripley’s K Analysis of Failed Trees

Number of Distance Bands: 10
Confidence Envelope: 99 Permutations
Weight Field: Number of failed Trees per Point
Boundary Correlations: SIMULATE_OUTER_BOUNDARY_VALUES
Study Area: MINIMUM ENCLOSING RECTANGLE
5. LISA Analysis of tree failure rates per census tract

Legend Definitions:

*High-High* – tracts with high rates of failure clustered near tracts with high rates of failure.

*Low-Low*—tracts with low rates of failure clustered near tracts with low rates of failure

*Low-High*—tracts with low rates of failure clustered near tracts with high rates of failure

*High-Low*—tracts with high rates of failure clustered near tracts with low rates of failure.
Appendix C: Data Sources
2010 Census TIGER/Line Shapefiles for Travis County [machine-readable data files]/ prepared by the U.S. Census Bureau. (2011). San Antonio, TX:


References


Final Urban Forestry Management Plan and Inventory Summary. 2008. City of Austin, TX. ArborPro, Inc.


Mackey, C. W., Lee, X., & Smith, R. B. (2012). Remotely sensing the cooling effects of city scale efforts to reduce urban heat island. Building and Environment, 49(0), 348–358. doi:10.1016/j.buildenv.2011.08.004


