LINCOLN PARK TREE HEALTH STUDY

Lincoln Park Tree Group

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Project Summary

In this study, tree health in the Lincoln Park neighborhood of Chicago, Illinois was explored in relation to land use type. Roughly 200 trees were evaluated using ArcGIS and statistical analysis to determine whether or not land use has a significant effect on tree health. The project was first initiated by the environmental science department at De Paul University. The final analysis indicated a correlation between tree health and land use

1. Introduction

This project is a continuation of the Lincoln Park Tree Study that began in the DePaul Environmental Sciences department under the supervision of Professor Liam Henegan. The main purpose of the study was to determine the correlation between land use affects and tree health. The database we used was created by students of DePaul. Our goal was to improve the quality of that data, produce maps, and graphs which would examine the relationship between trees and land use. The original survey covered an 80 block area of Lincoln Park. In this study the global positioning coordinates for 800 trees were taken using the Garmin eTrex Legend cX GPS receiver. Unfortunately out of those 800 trees only 294 of the surveyed points were usable, this was the result of human error.

Each group member has their own reasons for choosing this project. I believe some of the reasons we have in common are: we are city-dwelling tree huggers who care about our environment, we like to breath, and trees are quite useful in that realm when it comes to the carbon cycle. Trees remove ton s of pollutants from our air every year. And as a geographer I ***know*** I chose this because of location. This is a study being done in our own backyard! In regards to the complexities of our modern day society, and the environmental challenges our planet faces, trees are part of the future saving grace.

What we did in this study was to take a section in the northwest corner of the 80 block area of the original Lincoln Park Survey. We used a Garmin to get the waypoints for the trees and attched the database to the waypoint table. The using the U.S. Census tracts we, palced these points on the map. Unfortunately, we did not meet our goal because of err.

This error can be reconciled and the data created via “gpsing” trees will still be able to be used in the future.

In this project we were our own clients. This study will be expanded and overtime will be completed in the future. People who are involved in the study of urban trees are arborists, city planners, hydrologists, and other environmentalists.

2. Needs Assessment

2.1 Background

The mission of the Tree project is to determine what effects the land use (residential and non-residential) has on tree health in the Lincoln Park neighborhood community. Urban forestry in Chicago, IL has received increasing attention as a major component in city policy and environmental management. Ecological research has placed Chicago’s urban forest in an economical context that recognized the role of urban trees in air pollutants removal, carbon sequestering, savings in annual heating and cooling costs, and reduced neighborhood wind speeds (McPherson, E. G., et al., 1997). Much of the estimated value of the urban trees depends on tree maturation, which in turn depends on tree health. Exploring patterns of urban tree health could inform forest management policy and ultimately better inform urban foresters in order to decrease tree death and city costs of tree replacement.

Stakeholders from this research include the community members living within the Lincoln Park neighborhood, members of the scientific and geographic community at De Paul University as well as city and regional organizations such as the City of Chicago, United States Department of Forestry, and the Chicago area Environmental Protection Area.

The community of Lincoln Park would receive substantial benefit from this research by being aware of the land use effects on local tree health in addition to possible personal health effects. Also, the resultant data may be able to show ways to improve tree conditions as well as preventative measures to ensure tree health for existing or future tree species in the area. The Environmental Sciences department at DePaul University has initiated on-going research to survey the urban forest within the parkways of the Lincoln Park neighborhood. Tree species, diameter at breast height, and qualitative health condition (good, fair, poor, dead) have been identified and recorded and is currently mapped as separate shapefiles each containing only a portion of the available data.

Our proposed project aims to increase the quality and value of the data, create intelligent maps that coordinate all available data, and use the new data visualizations to perform geostatistical analyses to identify potential relationships between tree health variables (qualitative measurement "Condition" and quantitative measurement "DBH" or Diameter at Breast Height) and basic types of land use (residential and non-residential). Currently, there is a great deal of data available that requires substantial improvement through the capabilities of a GIS system such as clear, precise mapping through GPS technology, more detailed information considering tree health and attributes and analyzing varying tree health in certain regions along with statistical information of the area.

2.1.1 Literature Review

Whereas the importance of urban forests has been identified in the context of environmental, economical (McPherson, E. G., et al., 1997; Akbari, et al., 1992), and social sciences (Sullivan and Kuo, 1996), municipal budgets for tree maintenance have declined (TreeLink, 2007). Current tree maintenance methods are dominated by dead tree removal and replacement during which replacement tree species are chosen for environmental stress resistance. The choice of suitable tree species is severely limited due to stressors such as severe weather (Sissini, et al., 1995), disease, pestilence, pollutants, and soil compaction (McPherson, et al., 1994). Both the aesthetic and ecological roles of urban forests will require management that is grounded in an ecosystem-based approach that target the variables having the most influence on tree and forest health through research that identifies indirect effects of human activity (Dwyer, et al., 2002). An ecosystem-based management could prevent tree loss, lower urban forestry budget needs due to decreased demand for tree replacement, and further increase ecosystem quality to broaden the range of suitable tree species and increasing urban forest biodiversity.

Ecosystem tolerance and resilience to environmental stressors has been shown to increase when soil quality increases (Seybold, et al., 1999). Soil quality, defined as soil function, includes decreases soil compaction in order to improve nutrient cycling, microbial populations, and water infiltration (Karlen, et al., 2003). Soil compaction largely results from soil management practices that do not prioritize soil quality sustainability and such management methods directly result from the type of land use occurring on a given soils (Karlen, et al., 2003). In an urban forest, land use is diverse and can contain several types of use within a small area (Dwyer et al, 2002). The Lincoln Park neighborhood in Chicago, Illinois is an example of an urban forest that must be managed on a continuous gradient of land use type including residential, commercial, recreational, industrial parks.

Current literature identifies technology as a critical component of future urban forest management policies in order to efficiently manage ecosystem and city development change and in order to more easily transfer knowledge from the researcher to the land manager. Specifically addressed are needs for initial forest inventory and the identification of "forces for change in the urban forest and their influence on the extent, use, and management of urban forest resources" (Dwyer, et al., 2002). Our project intends to use ArcGIS to clearly display previous inventory work of Lincoln Park's urban forest. Currently the existing urban forest data consists of individual trees spatially identified by the local spatial reference system of Chicago postal addresses on which each tree is located or near. Due to the outmoded nature of locally based references systems (Chrisman, 2002) and the inaccuracies present in the current data, we will initiate work that spatially locates each tree on a universal reference system that is geodetic and based on GPS outputs gained from our own re-surveying of Lincoln Park trees. We will also combine representations of tree GPS locations with existing tree attribute data including individual tree health condition and tree diameter at breast height (DBH). Once visually represented, we intend to use the geospatial applications in ArcGIS to assess the probability of land use as a key factor driving urban forest health within Lincoln. Previous use of GIS in urban forest research has identified a spatial pattern of urban forest closely related to general land use zonings in Munich, Germany (Pauleit & Duhme, 2000). Our project hopes to further the application of GIS to the local urban forest by not only visually identifying spatial forest patterns correlating with land use, but also exploring the potential causal relationship between land use and urban forest health.

Points of contact for this project include the group members who are Kim Frye, Mandy Nyerges, Liz Baer, Amy Wagenblast, Carla Podrasky and Andy Metz, as well as Liam Heneghan who is a DePaul University Environmental Science faculty member and oversees DePaul's Urban Forestry program research. Meetings to discuss progress, problems or issues that arise and to perform the necessary tasks to complete the database will be scheduled to coincide with deadlines to coincide with the groups schedule and progress.

Deadlines will be as follows:

Needs Assessment	January 30, 2007
System Requirements	February 13, 2007
Data Acquisition	February 20, 2007
Data Analysis	February 27, 2007
Presentation	March 20, 2007
Final Report	March 20, 2007

Each of the components listed above will enable the group to be able to follow a strict working schedule to ensure the greatest accuracy and work integrity goes into the final product. Progress will be communicated primarily through group meetings and e-mail as the project continues. Although group meetings are essential to creating the ideal and best working final project, the group dynamic requires communication via e-mail. Points of contact have been established within the group if any immediate or urgent questions or issues should arise.

2.2 Project Goal

Trees are vital to the health of an urban environment, its residents, and the aesthetic of a neighborhood. They remove carbon dioxide from the air and can make a city a beautiful place to live. However, cities can pose hazards for tree health if the effects of an urban environment on the growth and survival of trees are not researched and available to urban planners. Our group will examine the topic of tree health in three different urban settings: residential, commercial, recreational, and industrial. These four urban land uses offer different environmental conditions for trees to live. Our project will use the data obtained by DePaul students and faculty. This data contains a survey of all the trees within an 80-block area of Lincoln Park, Chicago. The surveys show the size (DBH), tree species, tree health at the time of the survey, and the location of the tree by Chicago address (see Appendix B). For the purpose of our study, we will be using the tree health and location data to determine the, if any, correlation between tree health and the location of the tree. The information obtained from this study will be helpful to urban planners and to the residents of Chicago and other cities. Our environment is also a stakeholder in this group, including animals and air quality.

2.3 Objectives:

-To decide how many trees to include in our study, so that we have enough time to complete the study, but still have a sufficient amount of trees to constitute a useful sample size.

-To decide from where within the 80 block area of Lincoln Park, Chicago to focus the study.

-To transfer the address location of each tree in the study into specific GPS coordinates.

-To determine if different urban land uses (residential/non-residential) have an adverse effect on tree health, and consequently, to determine to what extent it does.

2.4 Information category

In order to meet the needs of the Lincoln Park Urban Forestry Tree Health Group we will identify the following attributes of the trees: species, diameter at breast height (DBH), tree health (measured as a gradient), and their exact and relative location. The four categories of land use will be defined as residential and non-residential. The data will be input in our database and mapped to identify spatial patterns of how or if tree health (DBH and Condition) is affected by land use. The study will include a small defined area of the original one which included 3,911 trees of 32 varying species.

2.5 Information Structure

The information structures that we wish to create from our information products (DBH, tree species, location, and tree health) will be the following:

- GIS map including information from the original database and GPS
- Spatial analyses of trees with updated and precise GPS identified locations

Along with the visual representations of our data, text definitions will be made of DBH, gradients of the tree health, and land use classification. We will also be concluding our initial hypothesis on the relationship between tree health and land use.

3. Systems Requirements

3.1. Introduction:
The Systems Requirement sections contains information on entity relationships, data requirements, brief overview of qualified systems that were considered for the project, relationship modeling, brief description of the layers used in our project, systems function matrix, and institutional requirements.

3.2. Data Requirements as a Conceptual Database Design
3.2.1 Matrix of need to know questions cross-referenced with entity classes:

		Need to Know Questions		
		Feasible amount of trees for final product given project constraints? **(t)**	Placement of study area within the 80 block area of original data? **(b)**	Do different urban settings (land use) have an effect on tree health? **(l)**
Entity Classes		LP trees	Census Blocks, LP blocks	Land use

3.2.2 Entity Relationship Modeling

		Need to Know Questions		
Entity Classes		Feasible amount of trees for final product given project constraints? **(t)**	Placement of study area within the 80 block area of original data? **(b)**	What effect do different urban settings (land use) have on tree health? **(l)**
LPtrees		X	X	X
LPblocks		X		X
Census Blocks			X	
Land Use				X

Name of Entity Class: LP trees
Entity Definition: surveyed trees
Spatial Type: point
Temporal Character: 2005
Relationship: Bound to LP blocks, On Land Use
Attribute Field Name List & Description:

TREE	Identification number for tree
SPECIES	Species of tree
STREET	Street name on which tree is located
BLDG NO	Building number tree is located on or nearest.
LOCATION	Longitude & latitude of tree acquired by GPS receiver
CONDITION	Qualitative health condition of tree
DBH	Diameter-at-breast height of tree
PROP TYPE	Land use category on which tree is located

Name of Entity (Object) Class: Census Blocks
Entity Definition: US Census Bureau digital database for Cook County
Spatial Type: vector
Temporal Character: 2006
Relationship: Shares Land Use
Attribute Field Name & Description List[1]:

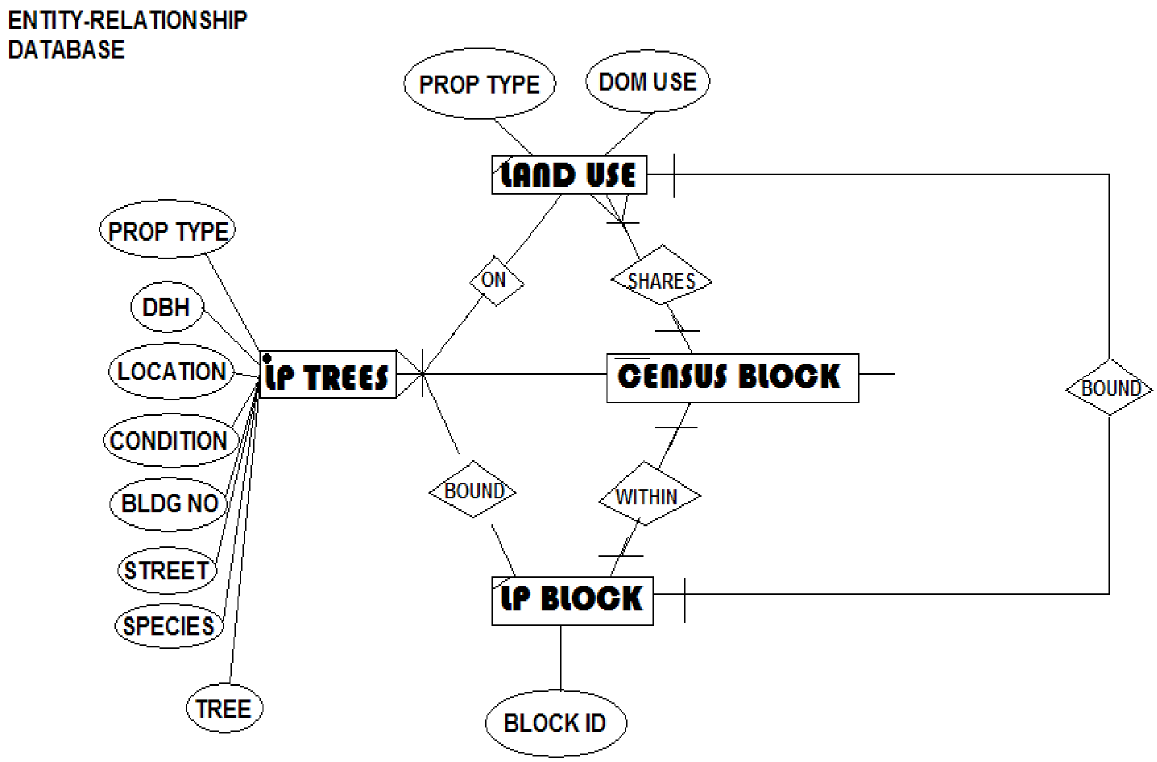
BG17_D00	US Bureau of the Census 2000 Illinois Block Group number.
STATE	FIPS State Numeric Code
COUNTY	FIPS County Code
TRACT	Census 2000 Tract Code
BLKGROUP	Name of Block Group file
NAME	County Name
LSAD	The legal/statistical area description
LSAD_TRANS	The legal/statistical area description translation

Name of Entity (Object) Class: LP blocks
Entity Definition: Lincoln Park division by city block
Spatial Type: polygon
Temporal Character: 2005
Relationship: Within Census Blocks
Attribute Field Name & Description List:

BLOCK ID	Identification number for block

[1] **Please note:** The first four fields - Area, Perimeter, xxnn_d00_, xxnn_d00_I (where ""xx"" is Tr for Tract, Bg for Block Group, etc., and "nn" is the 2-digit state FIPS code) - are produced as a by-product of the cartographic boundary file creation process, and have no meaning for public data users, therefore, these fields have been ignored or deleted . U.S Census Bureau. February 13, 2007. Cartographic Boundary Files. <http://www.census.gov/geo/www/cob/shape_info.html >Last revised April 19,2005.

3.2.3 Entity Relationship Diagram



3.3 Software Requirements

3.3.1 Matrix of need to know questions cross-referenced with software functions

SYSTEMS FUNCTION MATRIX

		Need to Know Questions		
		Feasible amount of trees for final product given project constraints? **(t)**	Placement of study area within the 80 block area of original data? **(b)**	What effect do different urban settings (land use) have on tree health? **(l)**
Function				
Select by Attribute		X		
Address Matching			X	
Data Overlay		X	X	X
Data Management		X	X	X
View Metadata		X	X	X
Statistical Analysis Tools		X		X
Georeferencing		X	X	X
Table & Shapefile Joins		X	X	X
Symbology		X		X
Spatial Inquiry			X	X

3.3.2 Software Systems

ESRI

ESRI, Environmental Systems Research Institute, Inc., was created in 1969 and the key focus of the group was to build a core set of applications to expand the growing field of GIS. (esri.com). ARC/INFO, the first commercial GIS software bundle was introduced in 1982. ArcGIS, completed in April 2001, is a "scalable system for geographic data creation, management, integration, analysis, and dissemination for every organization from an individual to a globally distributed network of people."

The ArcGIS desktop is the central application for all map-based tasks including cartography, map analysis, and editing. Included is ArcMap, ArcCatalog, and ArcToolbox (which is embedded in ArcMap and ArcCatalog). ArcMap is a comprehensive map-authoring application offering two types of views (geographic data view and layout view) where layers are symbolized, analyzed, and compiled into GIS datasets and other map elements such as scale bars, legends, north arrows, and reference maps are added. ArcCatalog is a shared ArcGIS application that allows you to organize and access all GIS information such as maps, globes, datasets, models, metadata, and services. ArcToolbox is a user interface in ArcGIS used for accessing, organizing, and managing a collection of geoprocessing tools, models, and scripts.

Despite the cost for an edition of the ESRI ArcGIS application running at about $1500.00, there will be no additional cost because De Paul University offers students access to the program at no additional charge.

MapViewer 6

Produced by Golden Software, Inc., MapViewer is an affordable mapping and spatial analysis tool that allows you to produce publication-quality thematic maps. MapViewer creates thematic maps by linking worksheet data to areas or points on the map. MapViewer offers many types of mapping possibilites such as: base, contour, vector, non-contiguous cartograms, pin, hatch, density, gradient, dorling cartograms, symbol, territory, pie, bar, line, prism and flow maps. MapViewer can also import boundary information from several formats including BIP, TIF, georeferenced maps and ESRI shape files.

The price for MapViewer is an initial payment of $249.00 and each installment of system upgrades runs about $79.00.

CRIMESTAT

A free program distributed in class to run spatial analyses. Program was developed by Ned Levine & Associates and is Windows-based and capable of interfacing with ArcGIS.[2]

CEDRA:

CEDRA AVland, AVwater, AVsand, and AVparcel are produced in 1895 by CERDA Corporation which is located in Rochester, New York. The program works with ESRI and ArcGIS to meet the needs of the client and community. At an affordable price CERDA software provides a quick way for hard copy maps along with attribute data to be converted to a digital format through scanning and digitizing. Below is a list of just a few functions that the software provides:

CEDRA AVland - surveying, COGO, contouring, traverse adjustments, stakeout, road design, profiling, cross-sections, earthwork, tax mapping, site modeling applications

[2] http://www.icpsr.umich.edu/CRIMESTAT/about.html

CEDRA AVwater - establish the materials inventory of a water distribution network, introduce supply and demand loads, perform analyses, display pertinent results in graphic and/or tabular format

CEDRA AVsand - create the spatial geometric model of a storm water, wastewater or combined system, impose storm water and/or wastewater loads, and apply custom peaking factors to average daily contributions

CEDRA AVparcel - provide tax (cadastral) mapping, parcel maintenance and general Polygon Editing, includes all the functions of AVcad
The CEDRA Corporation provides its clients, at up to 40% below competitive rates.

3.4 Institutional Requirements

Our project will use the data obtained by DePaul students and faculty through the Environmental Science Department's Urban Forestry research program.

DePaul University

• Liam Heneghan, Professor Environmental Sciences, Co-Director of DePaul University Institute for Nature and Culture – provided end-use needs and access to past data.

Data Providers

• Students through DePaul University's Urban Forestry Tree Survey project

• Illinois Natural Resources Geospatial Data Clearinghouse

• U.S. Census Bureau On-Line

4. Data Acquisition

4.1 Introduction

In the Lincoln Park Tree Survey project, four data sets (Lincoln Park Trees, Census Blocks, Lincoln Park Blocks, and Land Use) have been used in our data acquisition, and were provided for by the DePaul University Department of Environmental Sciences and from the US Census. The original data was inaccurate or insufficient in some areas (tree species, exact addresses), and we have used our own group members to acquire specific GPS coordinates of trees in the Lincoln Park area. More specific Land Use data would have been welcome for this project. That, as well as a general lack of time, was the greatest constraint in our data acquisitioning.

4.2 Data Dictionary

Data Set Name: Lincoln Park Trees

File Name: LP trees

Description: Data on surveyed trees in the Lincoln Park area containing information of tree identification number, species, street name and building number on which each tree is located, location with latitude/longitude values, condition of tree, diameter-at-breast height, and land use category on which tree is located.

Spatial Type: point

Source of the Data: De Paul University Department of Environmental Sciences, Professor Liam Heneghan.

Data Set Name: Census Blocks

File Name: Census Blocks

Description: Census data obtained from US Census Bureau digital database for Cook County including information of FIPS State and County Codes, Census 2000 Tract Code, legal and statistical area description and translation and County Name's.

Spatial Type: Vector

Source of the Data: US Census Bureau

Data Set Name: Lincoln Park Blocks

Filename: LP Blocks

Description: Identification information for the Lincoln Park division by city block.

Spatial Type: polygon

Source of the Data: De Paul University Department of Environmental Sciences, Professor Liam Henegan.

4.3 Data Source Steps

The majority of the data for this project and the original Lincoln Park Trees database were compiled via a field survey conducted by the DePaul University's Environmental Science department. The survey recorded attributes of trees within the parkways of the Lincoln Park neighborhood provided the data for the LP trees file that we are utilizing and enhancing in this project. The recorded data contains information on individual tree species, tree location (building number and street name), qualitative health condition of each tree, diameter-at breast-height measurement, and property type (commercial, residential, industrial or recreational). There are numerous errors in the original database, including non-unique tree identifiers and inaccurately identified building numbers. One significant improvement in this project is the transfer of the original data to Global Positioning System (GPS) coordinates of trees in our study area using a Garmin eTrex Legend cX GPS receiver. We have also enhanced the original tree data by giving each tree a unique identifier. To date we have spent 6 hours surveying the coordinates of 639 trees located within 15 of the initial 80 block area of the Lincoln Park study.

The **Census Block** data is from the Bureau of the United States Census Tiger/Line files. These are digitized vector files from the Census Bureau's Cook County area. Federal information processing standards (FIPS) state and county codes are standardized alphanumeric codes originated by the National Institute of Standards and Technology. These are used to guarantee uniformity in the identification of geographic entities (such as state and county) in all government agencies.

The **Lincoln Park Blocks** contain polygons that identify the LP Blocks file. These files are also from the first survey by the DePaul Environmental Sciences department. The block numbering system was set up by the students and faculty who were involved in the original survey.

The **Land Use** data was defined by the current project group and are based on the dominant land use on each block (commercial, residential, industrial or recreational), determined by individual property types recorded in the original survey.

4.4 Fitness For Use

The data sets used for the purposes of the project are fairly appropriate and accurate. The Lincoln Park Trees data was taken by a group of students using the same measurement systems and processes. However, human error is a factor; therefore the original data collected is not completely accurate. For the accuracy of this project, these trees were rerecorded with longitude and latitude coordinates to digitize the addresses given to each tree location. The spatial type of this data is appropriate because we are using points to represent absolute entities.

The Census Blocks data is credible because it come from the US Census Bureau database, which is reliable as a source. The vector spatial type incorporates our point data with the Lincoln Park Trees.

The Lincoln Park Blocks and Land Use data sets are both from our DePaul University Department of Environmental Science client, Liam Heneghan, and are both in polygon spatial type. This is reliable data due to our source's expertise and experience with the subject and data collection.

The accuracy is what we and our client had hoped for, but like all data sets there are some limitations. Situational circumstances could have altered the collection of longitude and latitude coordinates, and human error is possible.

4.5. Data Acquisition Constraints

Additional non-essential data that may have been useful for this project would have been to elaborate more on the types of land use. Each land use category could have been elaborated on even more to create a better understanding of the usage. For example, under the land use category recreation, sub-categories could have been created to provide more detail such as: is the recreational site a playground, baseball field, a park, etc… This data would provide us with even more understanding of land usage. The land use data for this project was all pre-collected information and would have ideally been completely checked over for accuracy, but due to the considerable size of the data that was not possible at this time. Time did allow us to check the exact location (longitude and latitude) vs. having only a street address of each tree by using GPS.

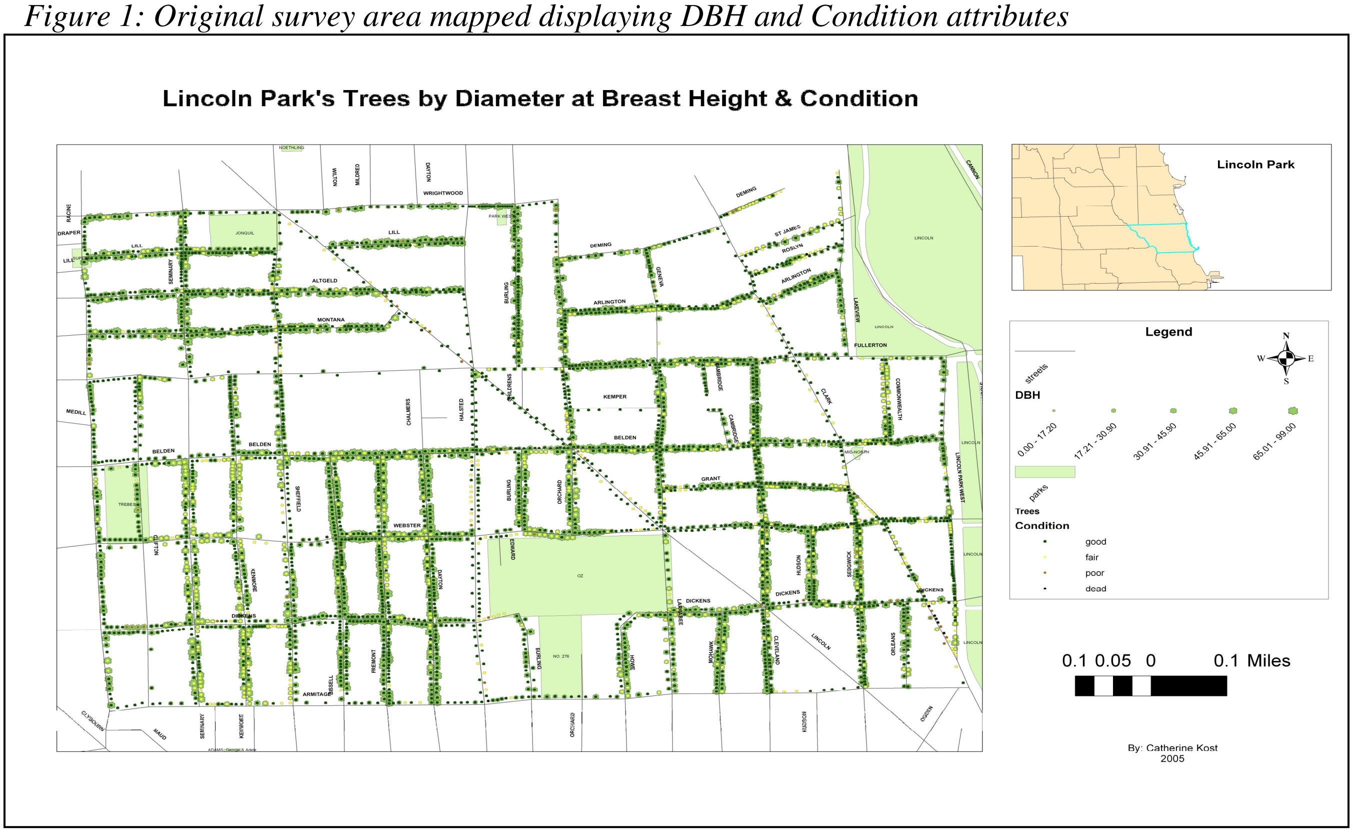
A constraint that we faced was a shortage of time; if we had more it would have allowed us to create more maps and visual aids. With more time we could have included more detail to our data as described above. It is important to note that data acquisition constraints did not change the outcome and goal of our project. Our goal, to determine the correlation between tree health and land use, is still met. However, without these constraints the project would be more detailed.

5. DATA ANALYSIS

5.1 Introduction

Our initial client goals included identifying the effects of different types of land uses on tree condition within the Lincoln Park urban forest. After spending time with the original data as we collected GPS positions, hypothesis development revealed the need for a more directly defined relationship for a feasible analysis for the 10 week timeline. Based on observing the map of original data (Figure 1) the original data, land use appeared to have an effect on tree condition. At the core of this potential relationship between land use and tree health seemed to be an inherent soil quality that could be observed in association with the different land uses in the study area; the four basic categories of land use (residential, recreational, commercial, and industrial) seemed to have a generally decreasing soil quality, with residential trees displaying a greater number of healthy indicators compared to the other land use types. As the project progresses, data acquisition processes limited our data collection to an area that did not include industrial

Figure 1: Original survey area mapped displaying DBH and Condition attributes



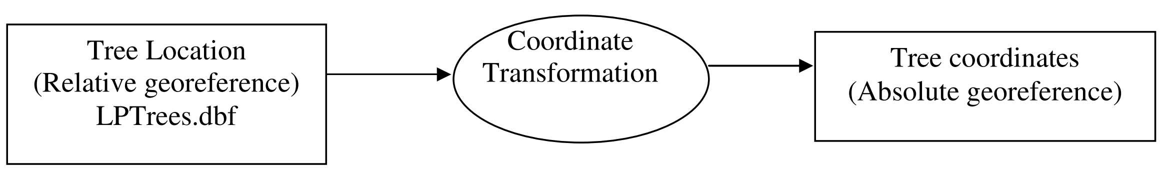
land use, so that category was eliminated form the initially designed land use categories. Once most of the data acquisition phase was completed, observations were made that the data points on residential land use outnumbered both recreationally and commercially located data points. Therefore our analysis was redesigned to specifically question if there were spatial differences between DBH values and tree condition values and to explore the question of potential difference between tree health (DBH and Condition) on residential and non-residential (= recreational + commercial) land uses.

5.2 Analysis Plan

What is a feasible amount of trees for final product given project constraints?

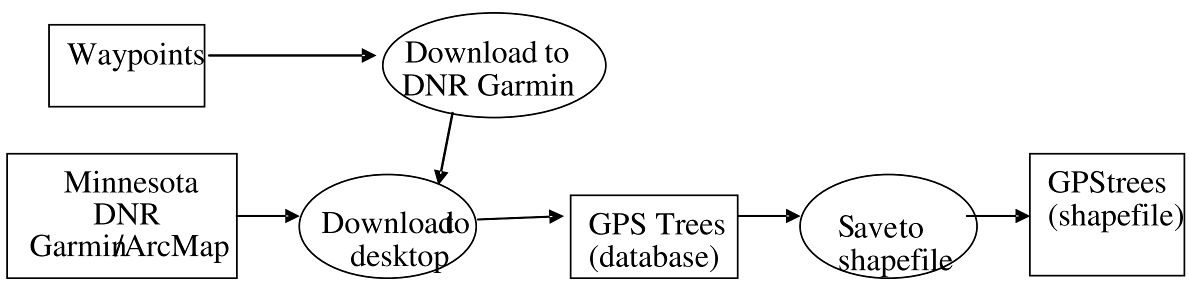
The originally surveyed data was recorded in the postal code relative georeference system and will be transformed into the Universal Transverse Mercator (UTM) projected coordinate system. Acquired tree coordinates will employ Global Positioning System (GPS) technology through the use of Garmin eTrex Legend cX GPS receivers, which record tree location as waypoints. To date we have spent 9.5 hours surveying the coordinates of 800 trees located within 20 of the initial 80 block area of the Lincoln Park study.

Figure 2: Field survey using GPS to locate geodetic tree coordinates



Where is the placement of our study area within the 80 block area of original data?
Figure 3 shows the process of data acquisition of exact and absolute tree coordinates from the original tree locations based on postal address. The Garmin eTrex Legend receiver waypoints are downloaded through a USB connection that requires previous download of DNR Garmin Extension for ArcView[3] and the eTrex Legend cx USB driver[4]. Waypoints are saved from the garmin application as a shapefile (ArcView), dbf database files (ArcView), and xls worksheets (Excel). The shapefile layer will be joined to the LPtrees

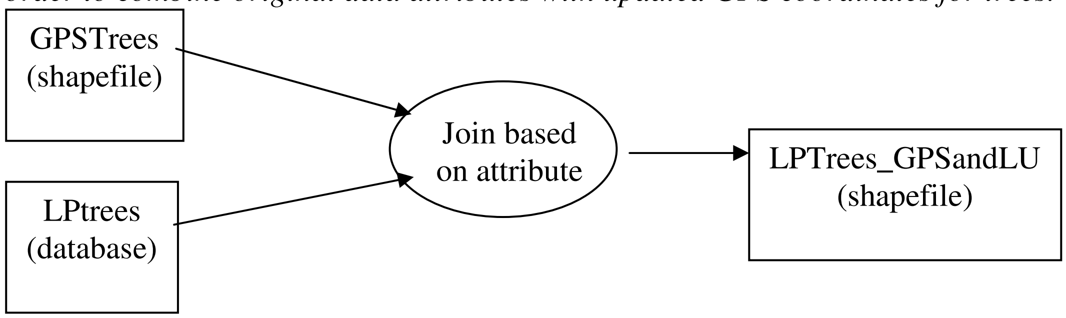
Figure 3: Process diagram for transforming waypoints into shapefiles



layer that contains the tree attribute database based on the Waypoint assigned identification number that serves as the feature key IDENT in the garmin database and IDENTCODE in the LPtrees database. Joined layer is renamed LPTrees_GPSandLU to represent that the attribute table now contains both the updated absolute positions of trees and all of the original LPtrees data, including land use type.

[3] http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html
[4] http://www.garmin.com/support/collection.jsp?product=010-00440-00

Figure 4: Process diagram for table join of LPTrees database to GPStrees shapefile in order to combine original data attributes with updated GPS coordinates for trees.



Do different urban settings (land use) have an effect on tree health?

All layers were set to the NAD 1983 datum and projected in UTM zone 16N. The street layer representing the roads within Lincoln Park were downloaded from the 2000 US Census Tiger data, and even after projecting the streets layer there was some spatial discrepancy between this layer and the roads as they appear in aerial photos of the same area downloaded from the Illinois Natural Resources Geospatial Clearinghouse[5]. This spatial inconsistency appeared to affect the representation of the GPS tree data points, with some roads being displaced slightly for an entire polyline length.

Figure5: IL Natural Resources Geospaial Data Clearinghouse Ortho photos compared to US census 2000 tiger street file. An example of the spatial anomalies present between files is emphasized.

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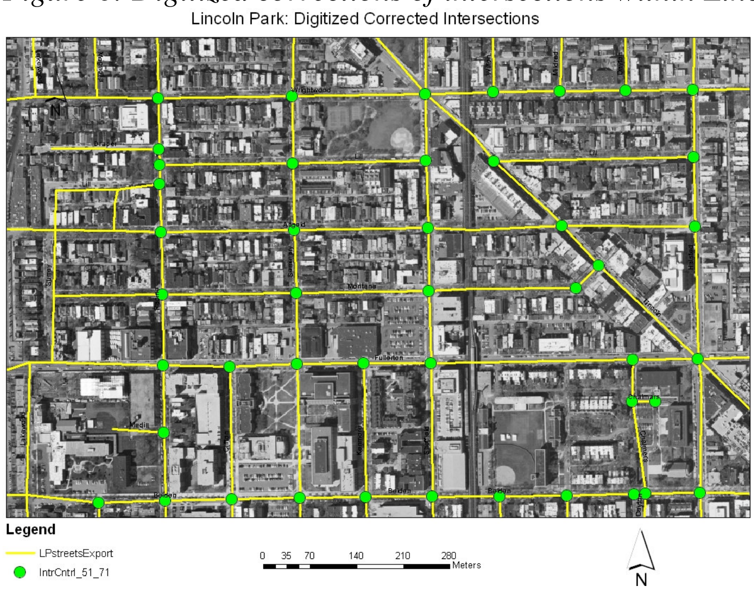
[5] http://www.isgs.uiuc.edu/nsdihome/

In order to adjust the census street layer, rubbersheeting spatial adjustment was performed by using the aerial photos of Lincoln Park to create a point shapefile with the center of each intersection as a data point. The intersections of the census streets file were then rubbersheeted to align more precisely with the aerial photo (see Figure 6).

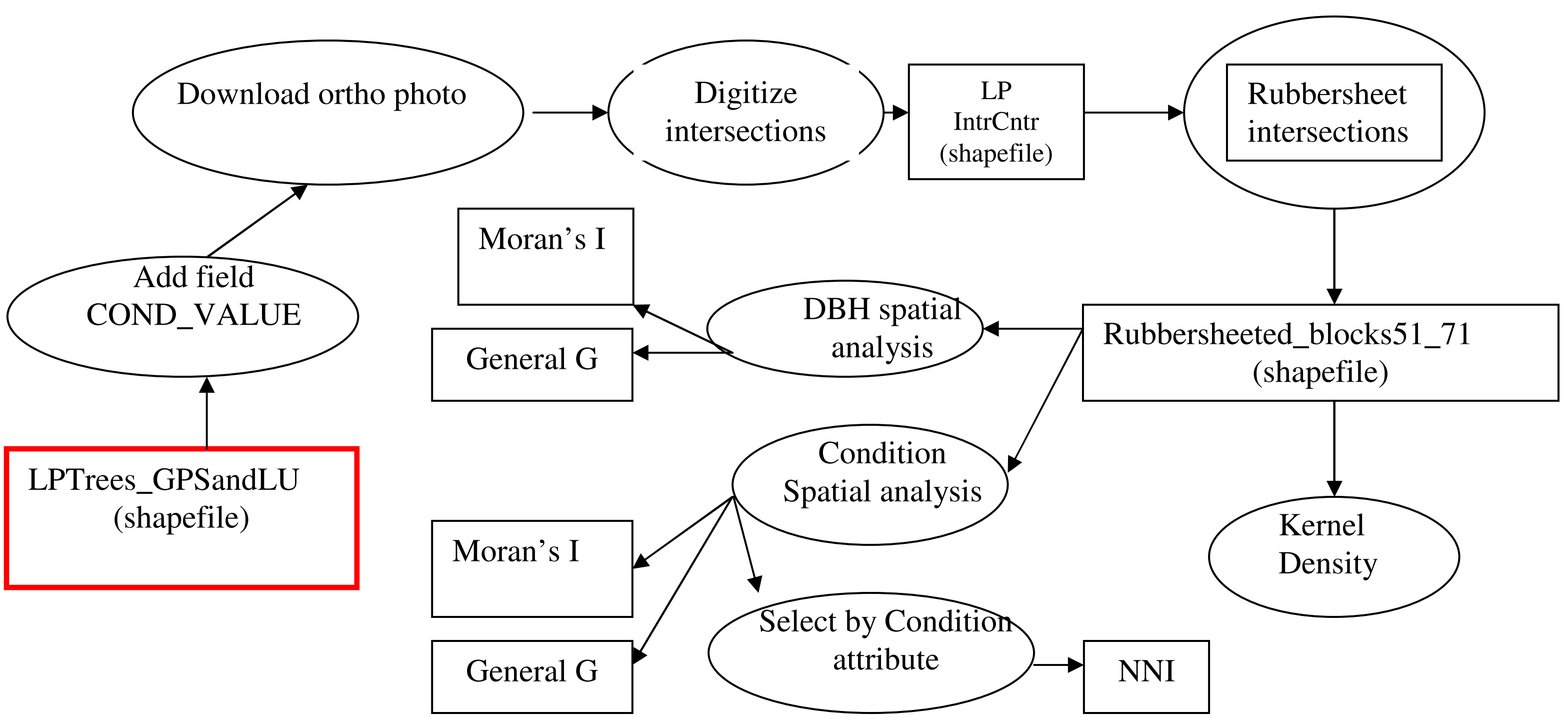
Figure 6: Digitized corrections of intersections within Lincoln Park



Spatial autocorrelation was tested using Moran's I statistic to assess whether the attributes of DBH and Condition follow clustered or dispersed spatial patterns. General G was then calculated to determine whether hot-spots existed consisting of either low values or high values for DBH and Condition. Condition was coded into an ordinal scale ranking 4-1 for Good, Fair, Poor, and Dead values respectively; no dead values remained in our data after normalization processes so the value scale resulted as Good = 4, Fair = 3, Poor = 2. A Nearest Neighbor Index (NNI) was generated to evaluate the mean distances between same values of Condition; the data for condition was mapped by selecting for the separate attribute values and exporting data into an image file (.jpg). Figure 7 displays the process diagram for analysis of joined data.

A Kernel density map was also constructed to visualize the spatial distribution of DBH, a graduated color scheme of increasing green hue saturation was used to convey the interval data with an intuitive color scheme associated with health vegetation. Natural breaks were used to classify the data is skewed to the left. A map displaying tree condition according to land use (residential/non-residential) was used to visually display the common spatial distributions between the attribute fields Condition and Land_Use. Residential and non-residential land use types are visually represented by symbols of different building shapes (home and commercial) and follow an identical color scheme to symbolize Condition. As ordinal data, Condition color is represented by non-graduated scheme yet still uses colors intuitively associated with vegetation health states (Good = green, Fair = greenish-yellow, Poor = brown). The results are depicted in the following section.

Figure7: Process diagram for analysis of joined LPtrees database file and LPTrees_GPSandLU shapefile.



6. RESULTS

6.1 INTRODUCTION

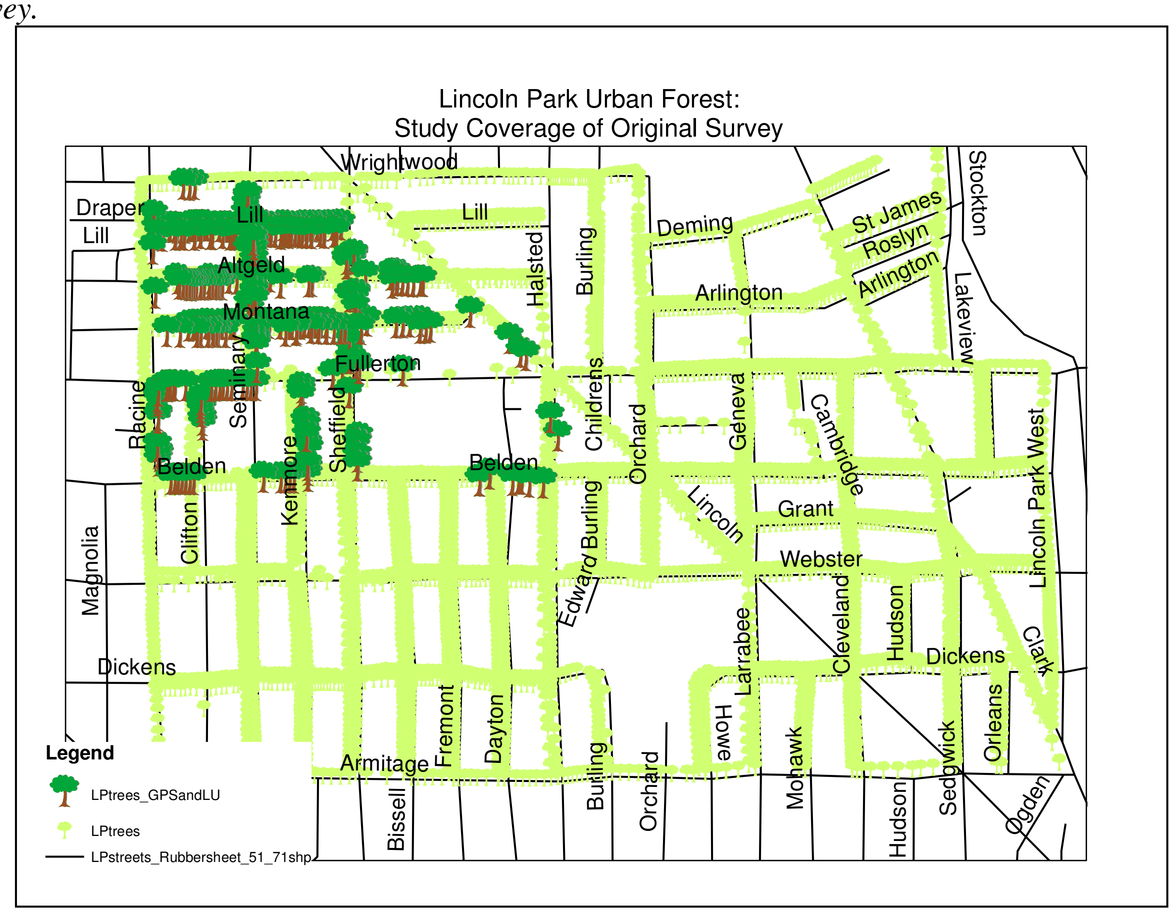
The results of our exploratory analysis of Lincoln Park's urban forest tree health are divided by need-to-know questions listed in section five of this report. Our overall results support the idea that land use can contribute to tree health in Lincoln Park. For instance, we have found that both DBH and condition display clustering, however DBH reveals more significant finding compared to condition values and therefore may serve as a better health indicator for suture statistical analysis. Our results are explained in further detail in the following sub-section.

6.2 FINDINGS

What is a feasible amount of trees for final product given project constraints?

Our projects results indicate that several factors act as limitations on the amount of data points that could be used for analysis and final products resulted in 277 tree data points included from the original 3, 912 trees surveyed (7.1 %) (Figure 8). Data acquisition and normalization restricted the number of trees we were able to include in the study because of the time consumption each project stage required. Our 10 week study occurred during the winter season, and additionally Chicago happened to experience unseasonably record low temperatures and increased snowfall. Consequently, due the field basis of the data acquisition process the Chicago winter weather will expectedly present a disproportionate number of limiting factors in terms of both the time required for collecting GPS waypoints (waiting for clear days with reasonable temperature) and the frequency of signal reception errors (temperature and cloudiness induced errors).

Figure 8: The study coverage of the original survey area. Blocks 51-71 are represented with the GPS tree data points and are displayed as a northwestern subsection of the original area included in the original tree survey.



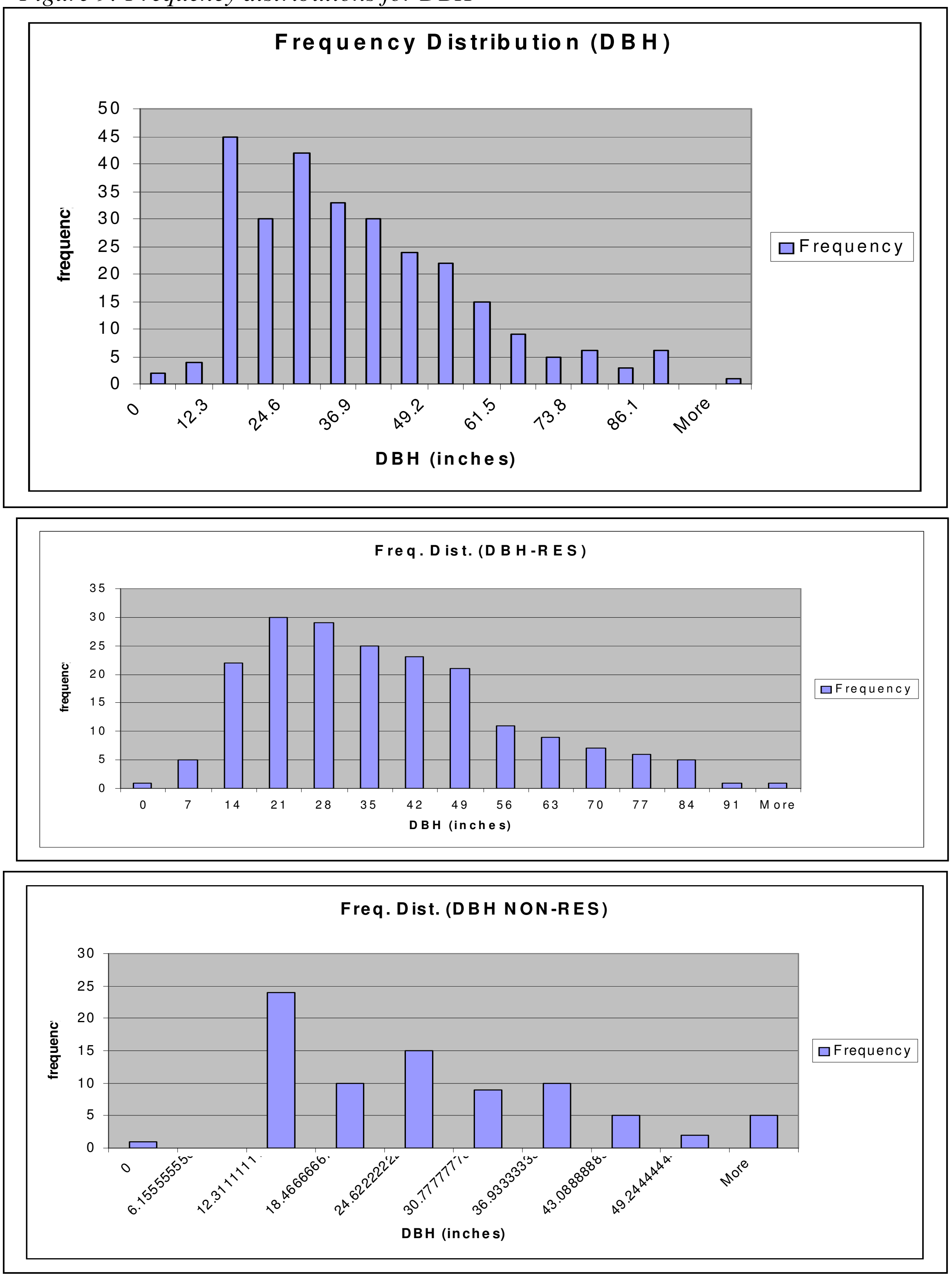
Where is the placement of our study area within the 80 block area of original data?

As shown in Figure ? the study covered a northwestern subsection of the originally surveyed area. Blocks are contained between the streets Wrightwood, Lincoln, Halstead, Belden, and Racine and include a large portion of DePaul University property and blocks directly to the north of the campus.

Do different urban settings (land use) have an effect on tree health?

Descriptive statistics were generated to summarize the data. Frequency distributions are shown in Figure 9 and show that overall tree DBH follows a normal curve with a slight skew to left or towards the lower end of the DBH range. When distributed separately according to residential and non-residential land uses, the residential tree DBH's display a much more normal distribution compared to the non-residential trees, although a slight skew towards the left still remains. The non-residential distribution is less normal and almost seems to be binomial, with a two peaks between the 12-18 in. and 24-30 in. ranges.

Figure 9: Frequency distributions for DBH



The mean of all DBH measurements is 30.94 in., the mean for just residential DBH is 34.26 in., and the non-residential mean is 22.92. The mode for Condition (nominal variable) was calculated at Good.

The calculated Moran's I and z-score for tree condition value both reported a value larger than zero indicating clustering. The reported p-value for the Moran's I value is 0.01 or a 99% chance that our results are significant and not due to chance. Additionally, the calculated General G statistic reported an observed value that is slightly smaller than the expected value and thus indicates that the low condition values are the clustered. The z-score for the General G of condition values is less than zero and is less than -1.96 and therefore reports a lower than 95% chance that our results are not due to chance. Due to this low z-score, the finding of clustered low condition values is not significant.

Figure 10: The reported calculated values for Moran's I and General G statistics on condition values

MORAN'S I and GENERAL G for condition value

```
MORAN'S I - CONDITION VALUE
Moran's "I" ......................:     0.029545
Spatially random (expected) "I" ...:    -0.003636
Standard deviation of "I" ..... ...:     0.013283
Normality significance (Z) ........:     2.498005
p-value (one tail) ................:      0.01
p-value (two tail) ................:      0.05
Randomization significance (Z) ....:     2.646529
p-value (one tail) ................:      0.01
p-value (two tail) ................:      0.01

GENERAL G - COND_VALUE
Observed General G = 0.0063014087213754599
Expected General G = 0.0063027252792625587
General G Variance = 5.9583548521252496e-010
Z Score = -0.053935756814426208 Standard Deviations
```

Figure 11: The reported calculated values for Moran's I and General G statistics on DBH

<u>MORAN'S I and GENERAL G for DBH</u>

```
MORAN's I:
  Moran's "I" .......................:     0.058661
  Spatially random (expected) "I" ...:    -0.003623
  Standard deviation of "I" ..... ...:     0.013251
  Normality significance (Z) ........:     4.700456
  p-value (one tail) ................:      0.0001
  p-value (two tail) ................:      0.0001
  Randomization significance (Z) ....:     4.704160
  p-value (one tail) ................:      0.0001
  p-value (two tail) ................:      0.0001
```

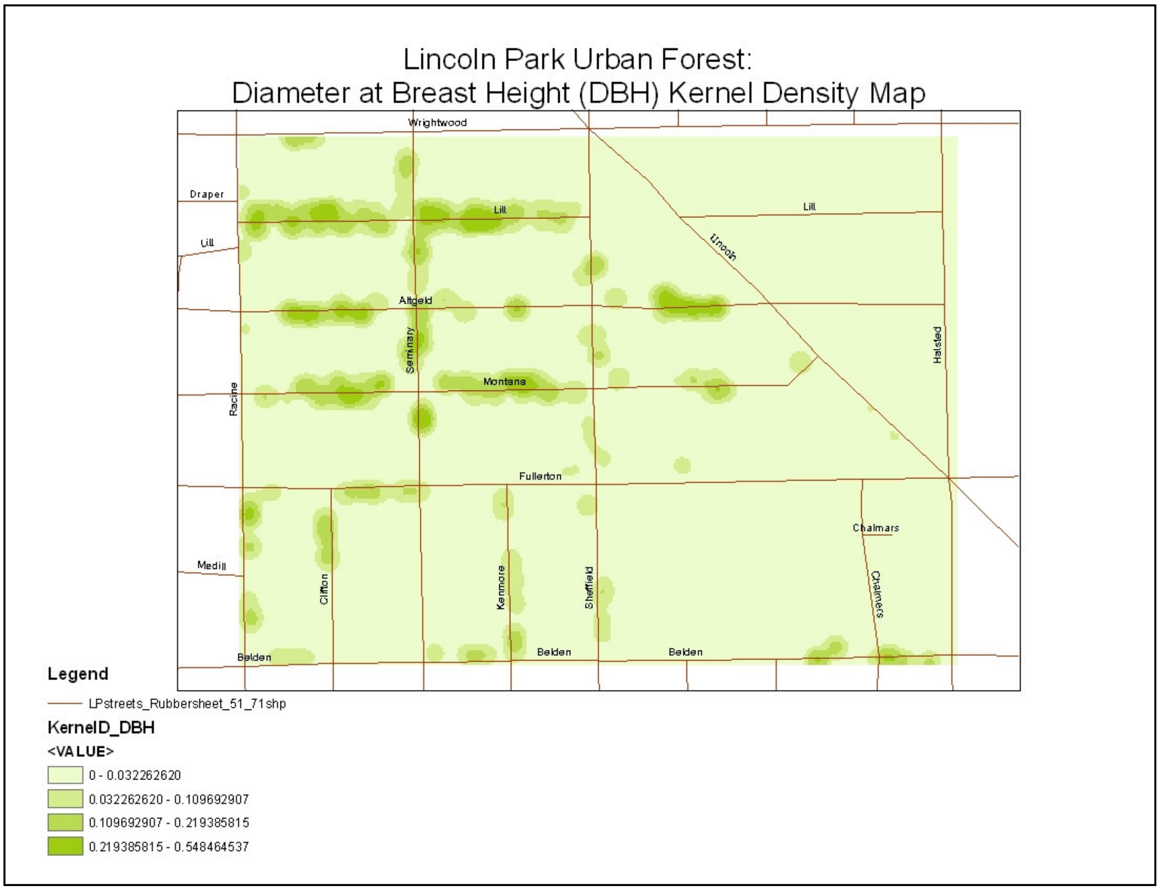
General G:

```
Observed General G = 0.0065642653679874405
Expected General G = 0.0063027252792625587
General G Variance = 1.6578555368307931e-008
Z Score = 2.0312572326183784 Standard Deviations
```

The calculated Moran's I and z-score for tree DBH both reported a value larger than zero indicating clustering with a reported p-value that is much smaller than 0.05, indicating that the clustering is significant. Additionally, the calculated General G statistic reported an observed value that is slightly larger than the expected value and thus indicates that the high DBH values are the clustered values. The z-score for the General G of DBH is positive (again indicating clustering of high values) and is larger than 1.96 and therefore reports a higher than 95% chance that our results are not due to chance and are significant.

A Kernel dot density map was also generated, and displayed in Figure 11, to visualize the spatial distribution of the DBH variable. The highest DBH values appear to be located most densely the more north the trees are of the streets that border the DePaul University campus. Sheffield appears to be an exception to this trend and reveals mostly middle to low values. Density of the highest values also occurs west of Lincoln Avenue and the polygon defined by Lincoln, Belden, and Sheffield, which is where DePaul's campus, Children's Hospital, and the majority of commercial buildings are located. The

Figure 12: Kernel Density Map Kernel density map (weighted by DBH values)



density trend presented here supports the notion that residential versus non-residential land uses may be a driving factor determining tree health. Figure 13 shows tree condition mapped by residential vs. non-residential land use.

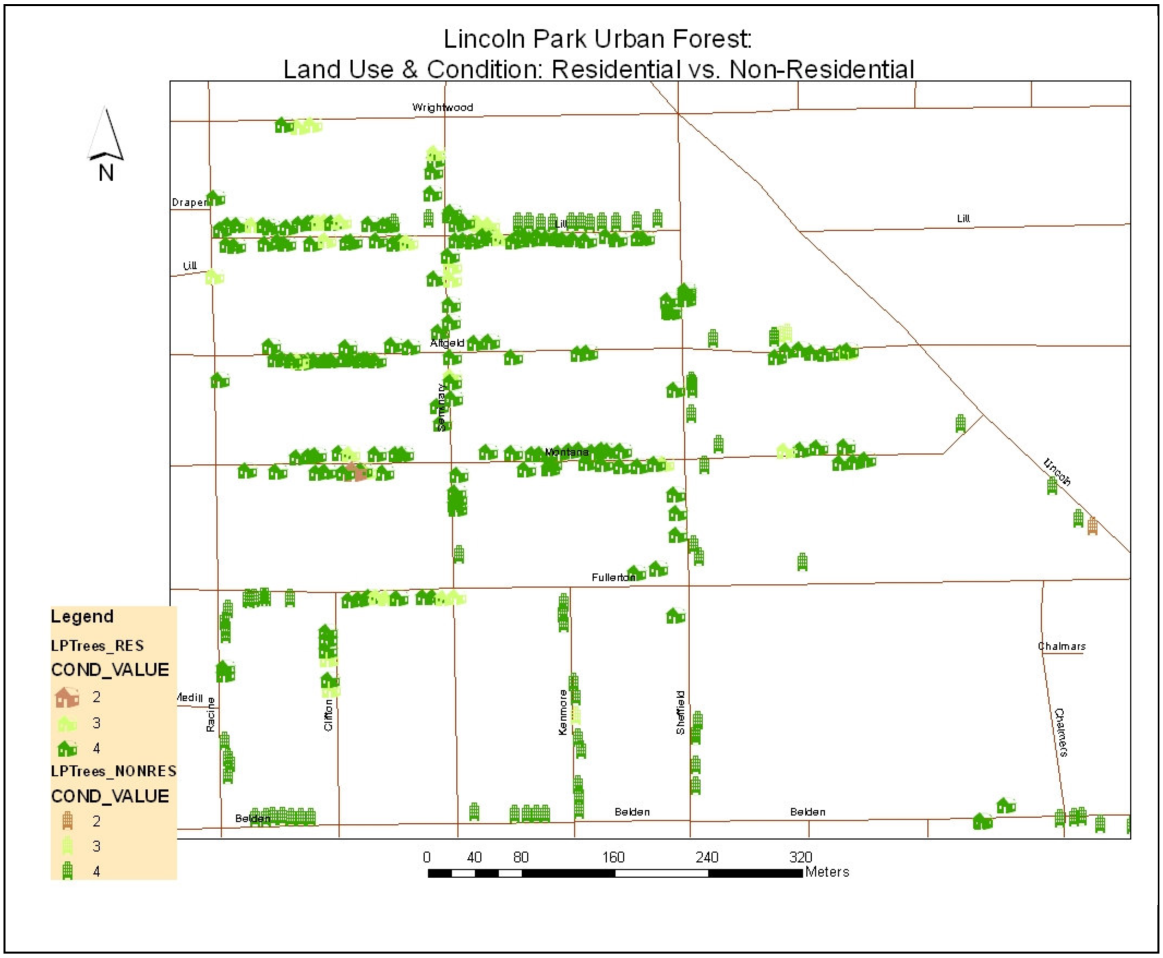


Figure 13: Tree Condition displayed according to land use

A Nearest Neighbor Index statistic was calculated separately for each represented value for the field CONDITION in order to see if expected mean distance between same value neighbors was larger or smaller than the observed mean distance. Figure 14 shows the trees by selection of the CONDITION attribute ratings “GOOD,” “FAIR,” and “POOR.” All values for each NNI test are listed in Figure 15. The Nearest neighbor observed mean distances calculated for GOOD and FAIR trees are lower than the expected mean distances and indicate that these points are both clustered (NNI < 1). The z-scores show that this clustering has less than a 1% chance that results are due to chance. The two trees with POOR condition values reported a dispersed NNI (> 1), with an observed mean distance that is much greater than the expected mean distance and a z-score that reports significance at less than 1% chance that results are due to chance.

Figure 14: Maps showing trees selected by condition attribute.

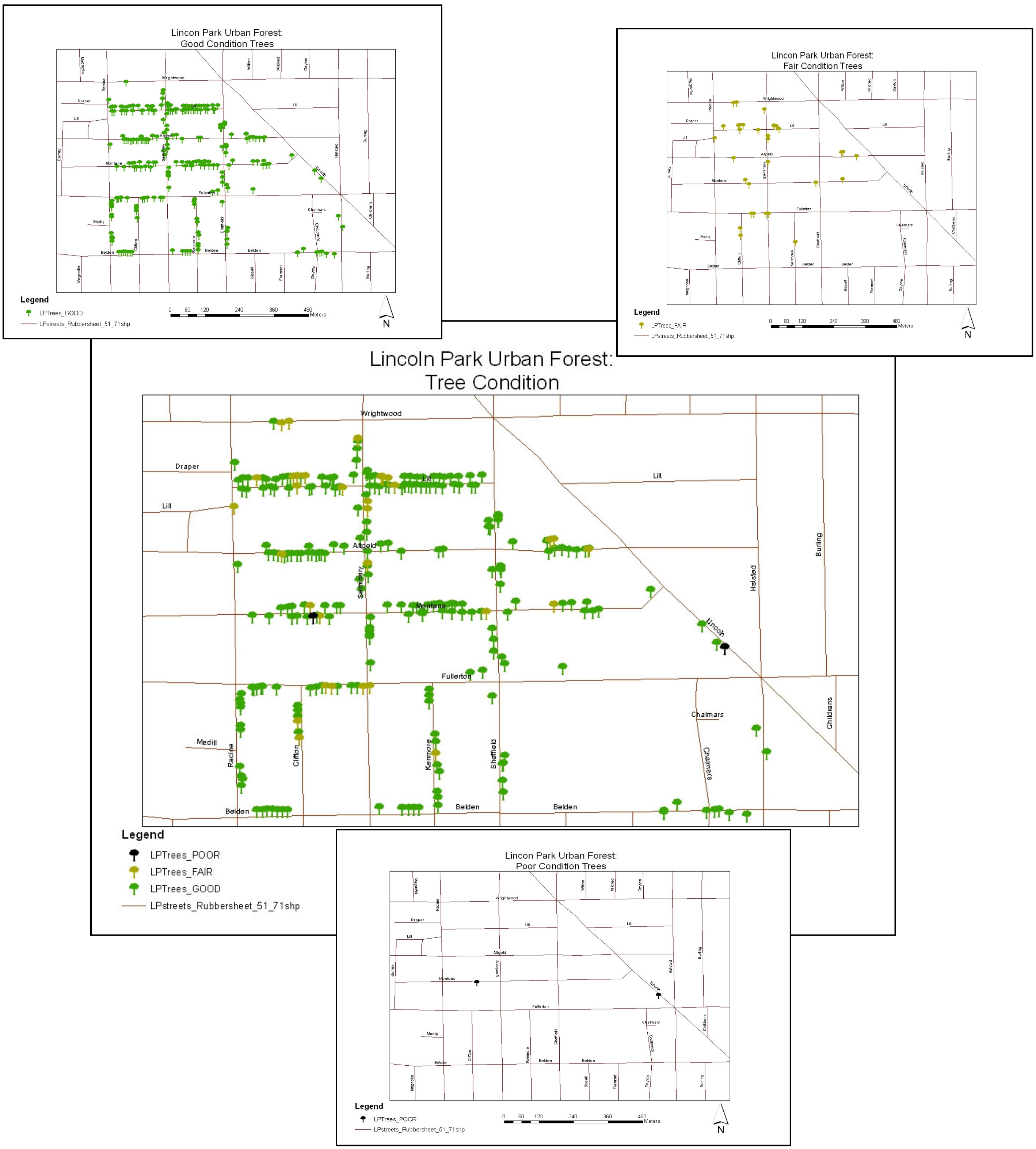


Figure 15: Reported values for NNI calculated separately on the different condition values found within the study area.

GOOD

```
Nearest Neighbor Observed Mean Distance = 11.666334
Expected Mean Distance = 22.425661
Nearest Neighbor Ratio = 0.520223
Z Score = -14.307834 Standard
```

FAIR

```
Nearest Neighbor Observed Mean Distance = 32.887828
Expected Mean Distance = 46.333877
Nearest Neighbor Ratio = 0.709801
Z Score = -3.140522 Standard Deviations
```

POOR

```
Nearest Neighbor Observed Mean Distance = 631.825925
Expected Mean Distance = 61.481705
Nearest Neighbor Ratio = 10.276649
Z Score = 25.097879 Standard Deviations
```

7. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Summary

277 trees were sampled for the final incarnation of our exploratory analysis of Lincoln Park's urban forest tree health, which took place over the course of the ten week term. Health assessment in residential and non-residential areas ranged from good to fair to poor, with the vast majority of the trees sampled categorized as being of either good or fair health.

Once the GPS data of each tree sample was joined to the original database, both Moran's I and General G statistics revealed that clustering of tree health values in the Lincoln Park area had occurred beyond the likelihood of chance, which led to the conclusion that residential urban land use has an significantly beneficial impact on tree health. As compared to non-residential land uses.

7.2 Conclusions

The overarching conclusion that can be made from our exploratory analysis of Lincoln Park's urban forest tree health is that there is support for a correlation between urban land use on tree health. Through the collection of a sufficient, if not ideal, amount of data points (277 trees), we have been able to conclude that residential land use often yields different results in tree health that non-residential land use.

Practical conclusions can also be drawn that hindered our ability to gather and interpret field data. As evidenced in the initial readings of data points, the reliability of the GPS locaters was compromised by the cold and inclement weather this winter, and by the existence of tall buildings on certain streets in Lincoln Park (i.e. Lincoln Avenue). This made the data points on the some of the early maps blatantly inaccurate, as trees were implied as existing on top of building, in the middle of the street and in parking lots, when they did not in reality.

Since it was winter when the GPS data was gathered, it was difficult to verify tree health data taken from warmer seasons, as it was near impossible to determine the health of trees in winter. Discrepancies between data collection also occurred in tree species, and in the case of one street, in tree size and location.

7.3 Recommendations

Because our exploratory analysis of Lincoln Park's urban forest tree health project faced numerous constraints, most of which were related to or a result of a very limited amount of time, if this were to be undertaken again, more time should be expected for completion.

Winter in Chicago is not an ideal season for fieldwork and data collection of this nature, so it is recommended that a project like this one be undertaken in a different season in which the weather is more hospitable.

The data collected for this project was taken by multiple groups, which led to inaccuracies that could likely have been fixed if the entirety of the data was collected by one group. Mistakes made in tree species categorization also leads to the recommendation that at least one or more members of the group be experts at identifying tree species – even in the winter season when one of the most useful identification tools is missing (leaves).

Though the project would have to expand beyond Lincoln Park to collect this data, an assessment of tree health in greater variations of urban land use (such as industrial) may yield more conclusive results.

8. Technical Appendices

Appendix A

Liam Heneghan, De Paul University Department of Environmental Sciences, Faculty Advisor

Appendix B: Sample data sheet from original field tree survey

Block Number: 51				Surveyed by: J.I, J.S			Date: 2005.07.28	
Tree No	**Species**	**Condt**	**Street**	**Bld. No.**	**Type of Property**	**DBH**	**Height**	**Age**
1	Red Maple	Good	Lill	1110	Church	28.3		
2	N.M	Good	Lill	1110	Church	28.7		
3	Choke Cherry	Good	Lill	1112	Residential	8		
4	Pine	Good	Lill	1114	Residential	n/a		
5	N.M	Good	Lill	1116	Residential	43.4		
6	Ash	Fair	Lill	1124	Residential	51.4		
7	Ash	Good	Lill	1126	Residential	35.8		
8	Ash	Fair	Lill	1128	Residential	43.5		
9	Ash	Fair	Lill	1132	Residential	35.9		
10	Linden	Good	Lill	1134	Residential	16.8		
11	Catalpa	Good	Lill	1134	Residential	16.1		
12	H.L	Good	Lill	1136	Residential	44.3		
13	Linden	Good	Lill	1138	Residential	30.9		
14	Plum	Good	Lill	1142	Residential	11.3		
15	S.M	Good	Lill	1146	Residential	47.5		
16	N.M	Fair	Lill	1150	Residential	26.7		
17	Cottonwood	Good	Lill	1150	Residential	77.2		
18	Ash	Good	Lill	1156	Residential	11.6		
19	Ash	Good	Lill	1156	Residential	15.2		
1	Red Maple	Good	Racine	n/a	Residential	12.2		
2	Birch	Good	Racine	n/a	Residential	24		
3	Ash	Good	Racine	2543	Residential	20		
4	Ash	Good	Racine	2543	Residential	16.2		
5	Ash	Good	Racine	2545	Residential	18.6		
6	Birch	Good	Racine	n/a	Residential	12.8		
7	Birch	Good	Racine	n/a	Residential	6.7		
8	Elm	Good	Racine	n/a	Residential	62.7		

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