South Campus Neighborhood Project

Urban Forest

REPORT

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California State University, Chico | Spring 2016

Resilient Cities Initiative
Institute for Sustainable Development
California State University, Chico

The South Campus Neighborhood Project

The South Campus Neighborhood Project is an award-winning neighborhood improvement planning effort coordinated by the Resilient Cities Initiative at California State University, Chico and the Public Works-Engineering Division at the City of Chico, CA. The project is focused on the public rights-of-way in Chico, California's South Campus Neighborhood, a six by seven square-block area bound by 2nd Street to the North, 9th Street to the South, Orange Street to the West and Salem Street to the East. Immediately adjacent to both downtown Chico and the University, it is Chico's oldest residential neighborhood and was laid out by the town's founder, John Bidwell, in the 1860's.

The neighborhood today is densely populated with university students and is also home to a number of small businesses, restaurants, bars, churches, community organizations, a school, a fire station, a police station, a railway station and transit center. Given its location, population and mixed uses, the neighborhood faces a unique set of circumstances and challenges. This three-year project aims to assess existing conditions and to develop and refine neighborhood improvement concepts to address a range of identified issues. The neighborhood improvement planning process is focused on concepts for complete streets and public works that will enhance public health and safety, quality of life, sense of place and environmental sustainability.

☛ *More information can be found online at http://scnpchico.com/*

City of Chico Public Works-Engineering

The overall Mission, Vision and Goal of the City of Chico Public Works Department is to provide the best possible Quality of Life through our abilities to protect, plan, construct and maintain the physical assets of the City. This is achieved through teamwork, integrity, professionalism, innovation, respectful customer service, value to the citizens of Chico, accountability and stewardship of the City's infrastructure and public resources. We serve the public in a manner that supports the rich heritage of Chico, as well as progressing into future improvements desired by the community in a sustainable manner. We continue to look for new technology that assists in meeting these goals so that we can operate at the most efficient level and continue to be at the leading edge of modern standards.

Our Mission, Vision and Goals include ensuring public safety through detail oriented and strategic improvements to mitigate unsafe operation and use of our Public property; Providing safe, sustainable, integrated and efficient transportation systems to enhance the City of Chico's economy and livability for all modes of transportation; Efficiently and effectively providing a reliable, sustainable and cost effective sanitary sewer and storm water collection system for our residents and businesses in-line with our overall Mission and Vision. We are stewards of the natural environment and through responsible practices, we construct and maintain our natural environment to the highest of standards. We will continue to make the City of Chico a leader in sustainable and clean practices so that our residents can experience the quality of life that is desired for an infinite length of time.

The Resilient Cities Initiative

The Resilient Cities Initiative (RCI) is an interdisciplinary university-community partnership program established by the Institute for Sustainable Development at California State University, Chico in 2016. The RCI connects real-world community sustainability projects – identified and funded by partner agencies – with faculty expertise and student innovation from departments and disciplines across the University's academic colleges. The RCI recruits partner agencies through a competitive selection process and matches projects with existing courses across the university's curricula. Partner agencies are able to harness incredible momentum for their projects in large part because the partnership is realized on a bigger scale than more typical one-off university-community projects. Faculty are able to opt-in and augment their existing curriculum with real-world projects that have been identified, funded and supported by the leadership and staff of the partner agency – ultimately delivering their students' work for consideration and implementation.

The RCI is a member of the Educational Partnerships for Innovation in Communities (EPIC) Network, a nationwide network of over 25 universities that have replicated the highly successful Sustainable City Year Model that was established at the University of Oregon in 2009. The model is based on university-community partnerships with a defined geographic and temporal scope, focused on advancing sustainability and the social good, leveraging the multidisciplinary knowledge and capacity of the university to 'move the needle' on pressing community issues. The RCI directly engages hundreds of CSU, Chico students each academic year, providing impactful opportunities for them to put theory to practice in their own community and region, connecting them with decision-makers in practitioners in their fields of study, and helping develop the next generation of workforce professionals and leaders.

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Abstract

The Resilient Cities Initiative's partnership with the Public Works-Engineering Department at the City of Chico of 2016-2017 outlines a plan to appraise Chico's urban forest which includes an area called the South Campus Neighborhood (SCN or Neighborhood). The Neighborhood, home to a large number of CSU Chico students, is also one of the oldest neighborhoods in the city. This report assesses the current status and condition of the trees in SCN including the frequency, size, and tree health as well as safety issues such as powerline interference and sidewalk uplift. Three classes in the College of Natural Sciences developed and implemented the sampling protocols for collecting and analyzing the tree data. The classes did the initial field sampling in mid-March through mid-April of 2016. Data collection included tree location, species, diameter at breast height (DBH, see Appendix A), and vigor (see Appendix A), as well as sidewalk uplift and powerline interference. One student from each class formed a team to field check the data for accuracy, collect missing data, create the GIS database, and compare this database with the 2009 City of Chico urban tree database for the study area and write the final report.

The long history of the study area is reflected in the diversity, number, and size of trees. Collectively, 904 trees that represent 85 species and subspecies were sampled in the SCN. Maple species and subspecies were the most common trees sampled in the area, and make up 22% of the urban forestry within the SCN. The diversity and number of trees is relatively evenly distributed throughout the area with the exception of the southern portion where trees are less common.

As noted, the study area is one of the oldest neighborhoods in Chico. This is reflected in the size of trees. For this report, we used diameter at breast height (DBH) to reflect size. A majority (65%) of the trees are less than 50 centimeters DBH (20 inch diameter) reflecting the ever changing nature of the urban forest. There are a number of large trees though, with 140 trees (14%) recorded as having 75 centimeters DBH (30 inch diameter) or greater. The majority of the larger trees (100 centimeters or 39 inches DBH) are located

north of West 4th Street between Cherry Street and Hazel Street. The smaller trees (DBHs smaller than 25 centimeters or 10 inches) are more common in the southeastern portion of the study area.

Collectively, the trees appear to be in relatively good health throughout the study area. Over 40% of the trees are classified as 'good' vigor condition and 38% are classified as 'fair' vigor. Approximately 9% of the trees are classified as 'poor' or 'dead/dying'. There is a noticeable tendency for trees in the 'fair' and 'good' vigor condition to be clustered, often covering an entire side of a block. In contrast, the trees in poorer condition are widely distributed.

Sidewalk uplift and powerline interference represent safety hazards associated with urban forests. A total of 92 trees have caused sidewalk uplift and 429 trees are associated with powerline interference. A total of 95 trees (approximately 10%) display both of these attributes. Powerline interference is common and positively associated with tree size. Though not all large trees exhibit powerline interference, in the majority of the cases the trees are larger. It is important to note though that some of the smaller trees have also exhibited powerline interference, but at a much lower frequency. Also, powerlines do not always line both sides of a street block and thus the distribution patterns of powerline interference parallels the positioning of the power lines.

This report approximates the current status of the urban forest in the South Campus Neighborhood in the late spring of 2016. The dynamic nature of the urban forest in the study area, as well as the skill level of the students involved in the data collection, make it difficult to gain a completely accurate picture of the urban forest. Nonetheless, the information contained in this report provides valuable insights on the existing conditions of the Neighborhood's urban forest and the information herein will be used to inform the development of a neighborhood improvement plan.

Introduction

Urban ecology planning requires a complex knowledge of the South Campus Neighborhood and its surroundings. Many factors must be taken into account in order to be able to envision neighborhood designs that satisfy the needs of the area's occupants, as well as effectuate safety regulations and achieve environmental impartiality, if not enhancement. Fabricating such designs requires the collaboration of environmental, social, economic, and political dynamics in a mutual effort to augment the Neighborhood into a safe place of residence for its citizens. This is particularly challenging for a city like Chico that has a long history of settlement, dating back to the 1850s. This long history of settlement, in combination with a strong interest in different types of trees, originally initiated by John Bidwell, has resulted in Chico often being referred to as the "City of Trees." Artists such as Jake Early, with their remarkable pictures that capture the beautiful fall foliage in and around the city, serve to increase awareness and pride in the city's urban trees.

Management of the urban forestry is complex and continuous. Tree health must be monitored and safety concerns must be continuously addressed. In a city the size of Chico, it is a complex and ever-present challenge for the city managers to monitor the health and safety of the abundant tree cover that exists, and the South Campus Neighborhood is no exception. This 42-block area is one of the oldest sections of the city. It is also currently an area that houses a large number of the students who attend California State University, Chico.

The purpose of this document is to report on the status and condition of the urban forest in this 42-block area (Figure 1). This effort also serves as an update to the 2009 City of Chico report (Chico Draft UFMP 2009) which documented the status of the urban forest in Chico, including this 42-block neighborhood. The City of Chico and the Institute of Sustainability collaboratively worked to initiate the overall study. For the urban forest component, the faculty and students in the Department of Biological Sciences and the Department of Geological and Environmental Sciences in the College of Natural Sciences combined efforts to report on the status and condition of roughly 1000 trees located within the 42-square blocks of the South Campus Neighborhood.

***Figure 1:** The 42-block area that represents the South Campus Neighborhood*

Background

The South Campus Neighborhood lies on land with a relatively long history of human utilization. The Native American Mechoopda tribe originally populated and maintained the area, which gave way to Spanish possession, and, in turn, transitioned into the ownership of the government of the United States of America (Bidwell Mansion Association 2016). The SCN was originally a small piece of a 20,000 acre parcel purchased by a very successful profiteer named John Bidwell in the 1850s. This parcel of land contained rich soil which was agriculturally optimal, but the SCN, and the immediate surrounding areas, was chosen early in its development to be the very first residential area established by the City (Bidwell Mansion Park 2015). Within a few years of this land acquisition, street plans were made for this neighborhood and structures were built. For this reason, much the South Campus Neighborhood is also a part of the South Campus Historic District (CSUChico.edu 2016).

The City of Chico was officially incorporated in 1872, but the city's founder, John Bidwell, had come to the area almost two decades before with a vision of utilizing California soil for a plethora of agricultural diversity. He intended to bring crops from all over the world and experiment with them on Californian soil to see which crops thrived and which would be the most profitable. Orchards soon sprung up around the area, engulfing the land in a new life that it had never experienced before. Along with utilizing the land for an abundant diversity of crops, he also took a particular interest in planting trees in and around the city. His great interest in tree planting was well known, and friends would often send him trees from all over the world to plant on Chico soil (Bidwell Mansion Association 2016). Evidence of his legacy has since lived on throughout the years and can be seen when walking down numerous streets of Chico. Some trees that still stand in the older sections of Chico are a part of the original groups of trees planted along the first dirt streets of the town.

The City of Chico's urban forest is comprised of a diverse array of trees and vegetation, intermingling with a broader landscape of creeks, parks, homes, and daily infrastructure. Recognized as a key component of the community design, the tradition of planting trees was initiated by John Bidwell long before he founded the city in 1872 (City of Chico, 2009). With photographs dating back to 1861 illustrating trees lining the fronts of iconic buildings and historic dirt roads, it is evident that the city's urban forest provides foundational character to the city (City of Chico, 2009). Several creeks course through Chico, and remnants of the native riparian ecosystem are evident with large old-growth valley oaks, sycamores, and other riparian trees further contributing to the diverse nature of the urban forest. The urban forest continues to provide boundless aesthetic values, pride and community health, functional benefits, and ecosystem services for the people of Chico and the city as a whole.

While the forest of Chico has an indefinite urban character with anthropogenic influences like roads and sidewalks, or power lines, it sustains the amenities offered by a natural forest. Some of the ecosystem services provided by the forest include a reduction in urban heat gain and energy demand up to 25% annually, increased carbon sequestration, buffered sound and light pollution, and increased property values of 7-20% (Chico Draft UFMP, 2013; Arbor Day Foundation 2016). Urban trees also improve air quality by capturing significant amounts of pollutants, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), and particulate matter (<10μm) (Chico Draft UFMP, 2013). The Arbor Day Foundation highlights that a healthy and sustainable urban forest also provides storm water management and erosion control, as well builds ties amongst neighborhoods and communities. Undoubtedly, natural forest processes such as nutrient cycling are impeded by manmade lawns and sidewalks, resulting in the need for particular tending of the forest for trees and vegetation to continue to flourish in the urban community (Chico Draft UFMP, 2013). As a consequence, a sustainably healthy and robust urban forest necessitates perpetual attention and conservation.

In 1897, the responsibility for maintenance of street trees and other applicable street vegetation was designated to the corresponding property owner. This street tree ordinance was marked as the first of many street tree ordinances to come. In 1918, the Bidwell Park and Playground Commission (BPPC) became a leading authority over the city's urban forest, as dictated by the Chico City Charter Section 1006.1.B, Municipal Code (CMC) 14.40 (Urban Forest Management Plan Draft 2016). The BPPC continues to uphold the regulation and specifications governing the planting, removal and maintenance of trees and shrubs within the public right-of-way (ROW City of Chico, 2009). In the case of infrastructure built after 1960, the ROW typically extends 5.5 feet behind the contiguous curb, gutter, or sidewalk along the city streets; trees further back from the walkway are privately owned (City of Chico, 2016). North-South streets in the older sections of urban Chico commonly have 80-foot ROWs, while East-West streets usually have a 60-foot ROW (City of Chico, 2009). BPPC works in concert with the city's Street Trees Division within the General Services Department to collectively manage Chico's urban forest. The BPPC endeavors to preserve and enhance the natural resources of Bidwell Park and the community parks, the Street Tree Division strives to enhance the standing and significance of trees throughout the City, and both the Public Works General Services Department are responsible for safety and infrastructure maintenance (Chico Draft UFMP, 2013). Collectively these entities work together to manage and protect our native and urban forests. Some general policies upheld by these governing commissions are as follows. Permits for pruning, planting, or removal require that only contractors with the International Society of Arboriculture (ISA) can provide maintenance of city trees. Quarterly analyses determine which trees are to be removed due to rotting, disease, being dead, being structurally unsound or causing significant root damage to infrastructure. These trees are then removed by certified contractors and replaced by new trees in accordance with the city's Approved Street Tree List (City of Chico, 2009). Tree pruning has been historically performed by city tree maintenance staff, although the program is currently suspended and the service is now being provided by an outsourced contractor.

According to the Chico Draft Urban Forest Management Plan of 2013, the most recent inventory was completed in 2010, concluding a total of approximately 30,631 street trees, as well as 3,546 locations identified as future tree planting sites, which are all maintained by the Street Tree Division staff. In the 2010 report, the assessed tree health was generally fair to good, with 55% of trees being in fair condition and 22% ranked as good condition; only 10% of the trees are rated as having excellent vigor (Chico Draft UFMP, 2013).

The urban forest serves as a reminder of the rich history that the City of Chico and the surrounding areas enjoy. The urban forest serves as a source of shade for Chico's inhabitants, and contributes an aesthetically pleasing atmosphere to the city's streets and avenues. This landscape represents the unique balance between nature and civilization, where the city maintains the health of the forestry and the forestry serves to provide Chico's citizens many benefits. Shade is the most obvious service that the forest provides, but the trees also are able to utilize gaseous carbon with the process of carbon fixation. Since 1984, the City of Chico has been recognized annually by the Arbor Day Foundation as a 'Tree City USA', acknowledging a flourishing urban forest and sound management program. Chico's long-lived historical enthusiasm as the City of Trees has aided in providing what has become an oasis to those traveling into the city from the east.

Methods

To document and update the 2013 report (Chico Draft UFMP, 2013) on the status and condition of the trees in the South Campus Neighborhood, three courses within the College of Natural Sciences (BIOL 484: Field Ecology, BIOL 350: Ecology, and GEOS 365: Applications of Environmental Science) developed and implemented the protocol for collecting the urban tree data. Collectively, 78 students and five faculty across these three classes were involved in this phase of the overall project. The protocol was developed in early spring of 2016 by the Field Ecology class (BIOL 484). The students in this class reviewed previous sampling protocols implemented by the city as well as protocols published in the literature as a foundation for developing the protocols the students in the following two classes would implement (Figure 2). Three separate teams worked independently to develop protocols, and the faculty and city selected the most appropriate protocol to implement (see Appendix A).

Figure 2: *Dan Efseaff, Parks and Natural Resources Manager from the City talking with the Field Ecology class (BIOL484) who developed the sampling protocol*

The two other classes (BIOL 350, which was divided into three lab sections of 20 students each, and GEOS 365, which was a class of 23 students) received one day of training on the protocol before spreading out into the study area to collect data. Students were provided with maps of the study area, field sampling equipment (meter and DBH tapes, Garmin eTrex GPS units, clinometers) and data sheets (see Appendix B) and an abbreviated tree ID booklet (see Appendix C). The GEOS 365 class was assigned the north-eastern portion of the SCN and the BIOL 350 students the south-western portion. Faculty worked together to ensure that all areas were covered during the sampling effort. Students worked in teams of two or three to collect the data in mid-March through early-April of 2016. Teams recorded the tree species, height, diameter at breast height (DBH), vigor, and GPS location (UTM) of each data point within the public ROW (from the sidewalk to the street) managed by the City of Chico (Figure 3) and identified locations where future trees could be planted. (Although height data was collected, it was not included in this report).

In determining the species and varieties, we reverted to the city's database for trees that were either old enough to be included in the 2009 tree inventory or were subsequently updated. We chose this option because there are many different horticultural varieties of urban tree species and using the city data was the best choice. As a case in point, there are 14 different species/varieties of maple in the study area, so if an individual tree looked to be older than six years (i.e. sampled in 2009) then we used the City's species and/or variety identification. In instances when identity could not be determined to species, the genus was recorded.

Tree fitness was also measured, using an index that was established and approved by the City of Chico for previous surveys. Vigor, which reflects tree health, was surveyed on a 1-5 scale, using one's own judgement (Figure 4). The vigor scales were: 1 - Excellent: A very healthy tree with lots of green foliage, a sturdy trunk and minimal damage - few or very small dead branches (this rating should be rarely used, it is not often that a tree is in near perfect condition). 2 - Good: tree is growing well and appears to be free of significant health factors, but may have some dying foliage with dead branches. 3 - Fair: Tree has an average vigor, but may

Figure 3: *Field data collection by students.*

Left - Student using a DBH tape to measure the Diameter at Breast Height.

Right – Students collecting data in mid-March have only a few leaves with multiple dead branches. 4 - Poor: The tree is weak, possibly under stress and is growing slowly, with a lot of evidence of dead branches and trunk, and may be questionably sturdy. 5 - Dead or Dying: major branches of the tree are dead, few foliage and dead bark patches are common.

In addition to documenting the current condition of the urban trees, potential hazards presented by the trees were also recorded. As trees mature, tree roots can cause damage to sidewalks including cracking and uplift (Francis, 1996). These damages can lead to costly repercussions including safety issues, injury compensation, and pavement maintenance (Mullaney, 2015). Dr. Kim Coder (1998) suggests that many of these issues may be easily prevented with proper planning and monitoring of long-term tree growth. Thus sidewalk damage as well as powerline interference were also part of the data collected.

After students collected the data for their assigned section, each team entered their data in an MS Excel spreadsheet and different members of each team rechecked the data for accuracy.

Figure 4:

Left – Students marking a potential planting site.

Right – Example of a tree that would be classified as Vigor 4: Poor.

Data was compiled across teams for each class and again checked for accuracy by a faculty member. The data was then imported into ArcGIS 10.2 (ESRI) and again checked for positional accuracy. Revisions were made with team input for clarification. Once the two classes had their data in good shape, the two class datasets were merged to create one data-layer in GIS. Further refinement and revision to the location data continued throughout the analysis process. For example, because the sampling occurred early in the season, often when leaves were not yet out, some factors such as species identity and vigor had to be field-verified later in the semester. Three students were identified to serve as interns on the project, one from each class, to continue to work with the data and write the final report. Interns were responsible for filling in the missing data. When species could not be identified, the city's species identity was used.

Ideally, the data the students collected would be spatially compared with the city's urban forest database of 2009 and on-going tree inventory data managed by the Public Works and supported by the City of Chico GIS Web Administrator. However, this data was not available in the ESRI ArcGIS format used for this document in the early stages of the spatial analysis. To expedite the process within the confines of a semester project, initially the students accessed the city's website where there was current information for each individual tree (species identity, vigor, height, etc.). Tree by tree, interns worked to rectify the two datasets (the city's and the students), and had covered approximately one-third of the study area before the GIS level information became available. Interns then rectified the student-collected tree data to the City's, snapping to the City tree location thus relying on the City's spatial accuracy compared to the inexperienced students using GPS units with less spatial accuracy. The exception to this process was for trees along West 8th and West 9th Streets where there appeared to be some inaccuracies with the city data layer. For these trees, we relied on student data combined with random field verification. In instances where the tree species identity could not be determined and it was clear that it was not a newly planted tree, we defaulted to the city's identification. The interns continued their accuracy assessment through spot checking randomly selected trees in the neighborhood and comparing their locational data with the city's 2009 data. Once completed, trends and patterns of the South Campus Neighborhood urban forest could be represented.

Inconsistent data collection by students warranted the merging of the class data and the city data for identifying potential planting sites. The approach used to identify potential planting sites was: if a site identified in the city data had been updated with a tree identification in the student data indicating that a tree had been planted, the student data was used. If in cases where the city data indicated a planting site and there was no student data to indicate otherwise, the city data was used. To the extent possible, planting sites were verified by the interns.

Results

There were 1097 data points which represent existing trees and potential planting sites in the city's ROW. Of the 1097 data points, 904 represent existing trees and 193 points represent planting sites identified using the students and the city data (Figure 5). As evidenced by Figure 6, there is a relatively high density of data points spread throughout the South Campus Neighborhood with the exception of the very south and south-eastern portion of the study area between West 8th and West 9th Streets where trees become less common. Planting sites identified by both the students and the city data (see Methods) are also widely distributed, but, as with the overall tree data, become more sparse towards the southern and southeastern area (Figure 7).

Figure 5: *Examples of a planting site in the ROW.*

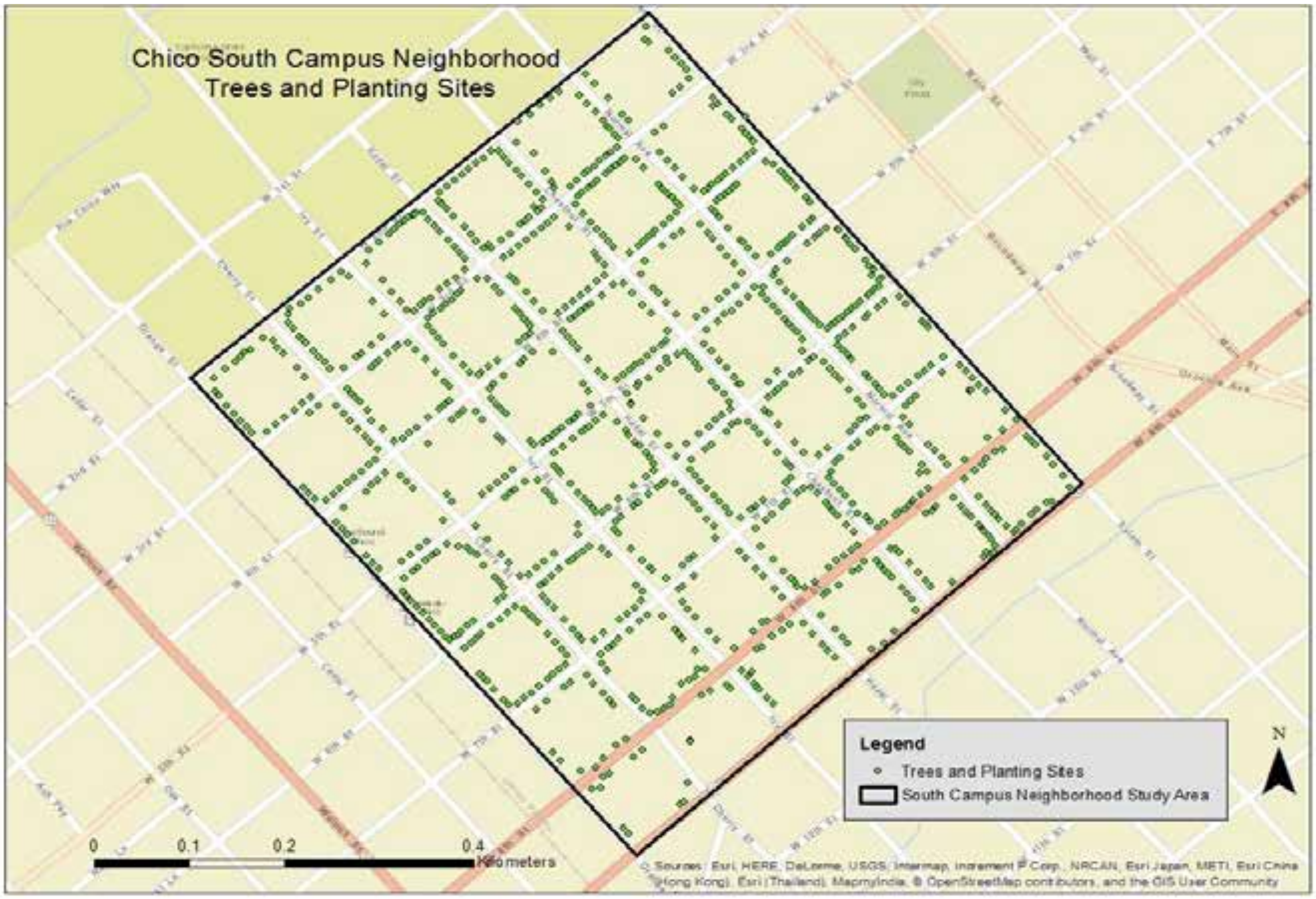

__Figure 6:__ Trees and planting sites identified within the South Campus Neighborhood

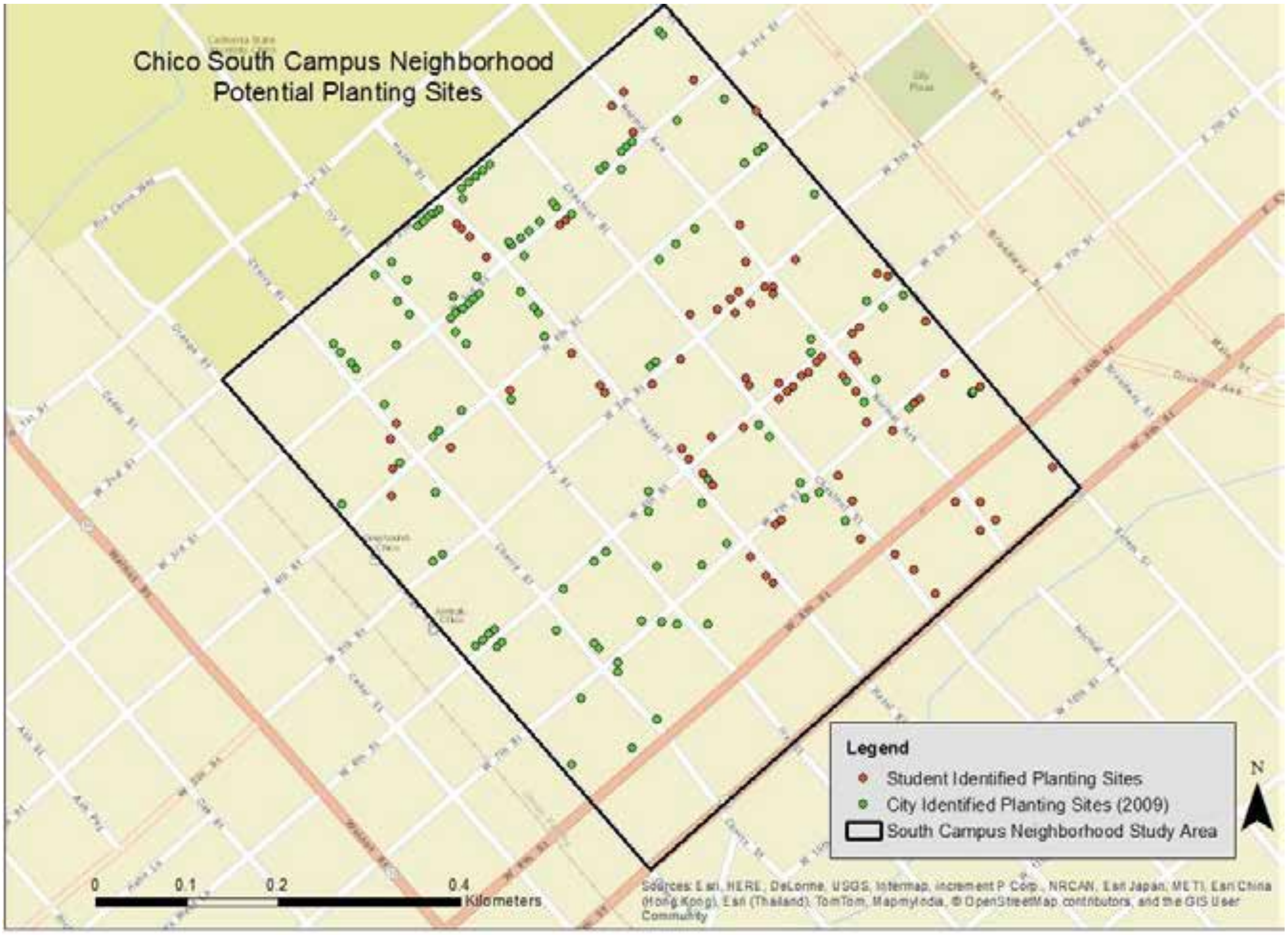

__Figure__ 7: Location of potential planting sites identified by students and the City data

Species Diversity

There were over 85 species, including different varieties, represented in the South Campus Neighborhood (Table 1). Over a third of these were represented by only one or two individuals.

Genus	Species/Variety	Count
Almond	Sp.	1
Ash	Arizona	2
Ash	Green	9
Ash	Modesto	1
Birch	European	1
Camphor	Sp.	19
Cedar	Port	1
Cedar	Sp.	1
Cherry	Sp.	3
Chestnut	American	5
Chinese	Lantern	2
Chinese	Tallow	1
Citrus	Sp.	59
Crape	Myrtle	30
Cypress	Italian	1
Cypress	Sp.	1
Elm	American	1
Elm	Chinese	2
Eucalyptus	Sp.	1
Fir	Douglas	2
Ginkgo	Fairmont	1
Ginkgo	Princeton	3
Ginkgo	Saratoga	1
Ginkgo	Sp.	12
Goldenrain	Tree	3
Hackberry	Chinese	45
Hackberry	Eastern	1
Hackberry	European	19
Hackberry	Sp.	1
Hornbeam	Eastern	1
Incense	Cedar	1
Jujube	Sp.	6
Linden		6
Loquat	Sp.	2
Magnolia	Saucer	1
Magnolia	Southern	17
Maple	Boxelder	6
Maple	Japanese	1
Maple	Norway	104
Maple	Norwegian	6
Maple	Pacific	6
Maple	Red	9
Maple	Rocky	15
Maple	Silver	11
Maple	Sugar	5
Maple	Trident	4
Maple	Sp.	22
Mulberry	Red	5
Oak	Bur	1
Oak	Cork	3
Oak	Holly	12
Oak	Northern	8
Oak	Pin	12
Oak	Sawtooth	10
Oak	Scarlet	4
Oak	Shingle	2
Oak	Shumard	5
Oak	Valley	4
Olive	Common	1
Other	Species	7
Palm	California	30
Peach	Sp.	1
Pear	Callery	5
Pecan	Sp.	9
Persimmon	Common	2
Pine	Sp.	1
Pistache	Chinese	70
Planting	site	86
Plum	Other	1
Plum	Purple	3
Plum	Purpleleaf	7
Privet	Species	2
Redbud	Sp.	1
Redwood	Coast	5
Redwood	Giant	1
Royal	Paulownia	2
Shrub	Sp.	1
Sweetgum	Sp.	20
Sycamore	Bloodgood	1
Sycamore	Eastern	16
Sycamore	London	66
Sycamore	Yarwood	3
Tulip	Tree	20
Unknown	Sp.	16
Walnut	Bastone	5
Walnut	Black	35
Walnut	English	6
Zelkova	Japanese	51
Zelkova	Village	2

Table 1: *Species and varieties of species identified in the South Campus Neighborhood.*

Commonalities of Tree Species

We identified the most common trees in the SCN (Table 2). As evidenced in Figure 8, these common trees are distributed throughout the South Campus Neighborhood and collectively, these species account for 73% of the diversity in the study area. Maple trees, with 196 individuals, were by far the most common species distributed throughout the study area. There were a variety of species and subspecies such as the Silver Maple, Norway Maple and several varieties of this particular species. The sycamore, with 85 individuals, is the second most common variety followed by Chinese Pistache and Hackberry. It is also not uncommon for many of the same tree types to line an entire side of the street.

Not surprisingly, with the high diversity in this urban forest, there are also a number of tree species that are represented by only a few individuals (Figure __). Figure 9 shows the distribution of tree varieties that are represented by 15 or fewer individuals. The majority of these species tend to be located in the neighborhood north of Hazel Street. Many of these less common trees tend to be clustered together, for example, the cluster of plum trees on Salem Street between West 5th and West 6th Streets.

Species	Number of Individuals
Maple	189
Sycamore	86
Pistache	70
Hackberry	66
Oak	61

Species	Number of Individuals
Citrus	59
Zelkova	53
Walnut	46
Crepe Myrtle	30
Palm	30

Table 2: *The top 10 most common tree species in the study area.*

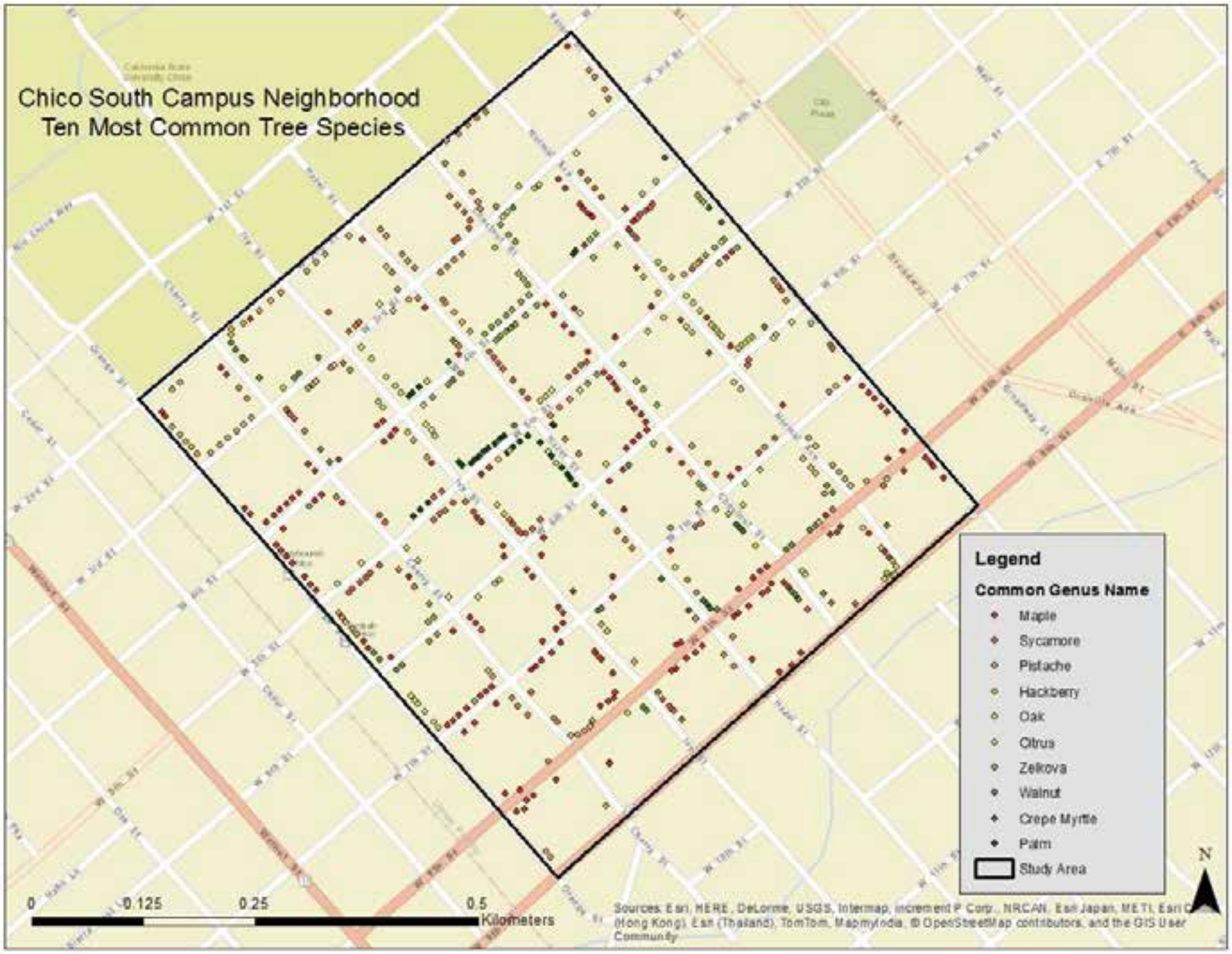

Figure 8: *Locations of the most common tree species in the Study Area organized by color.*

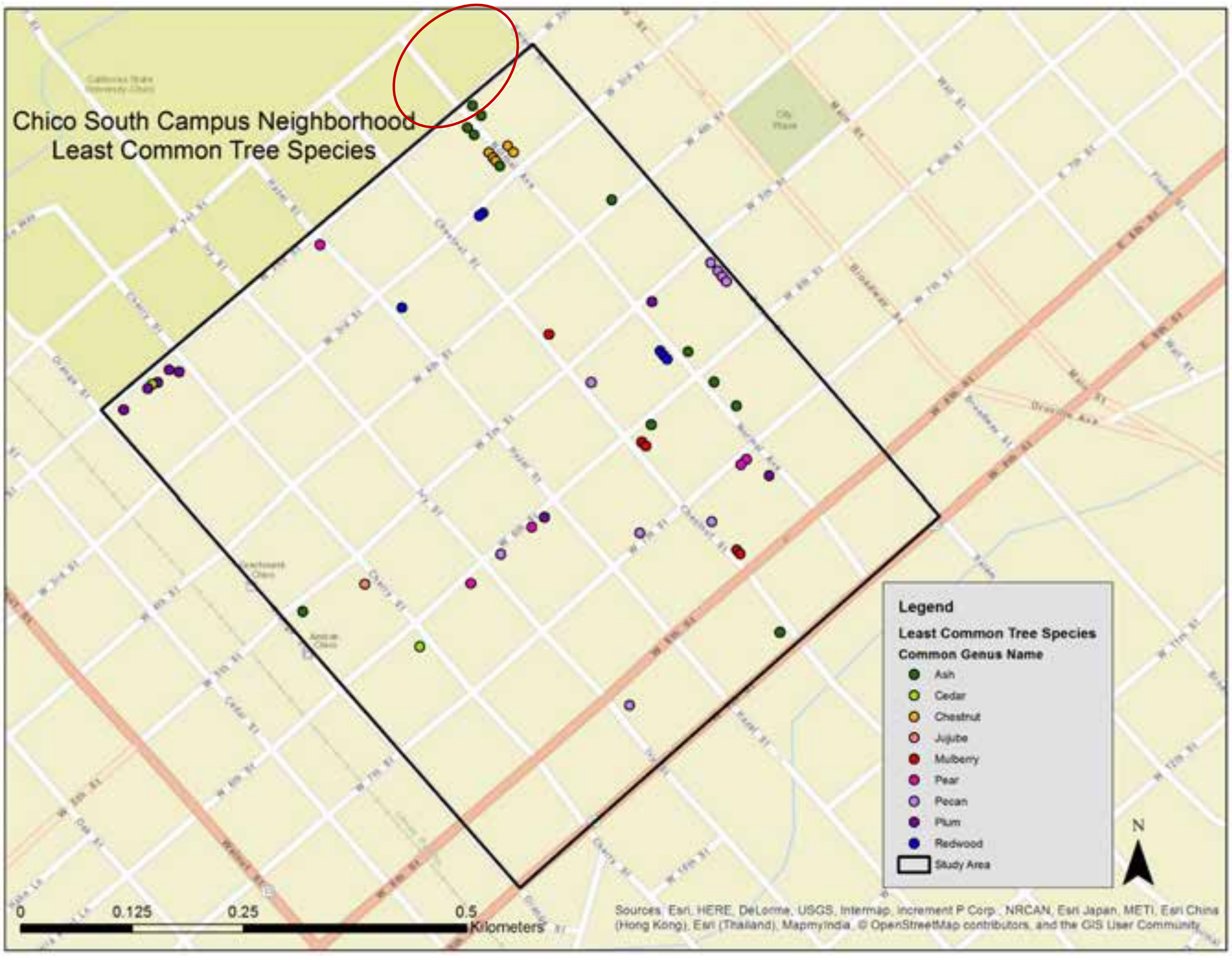

Figure 9: *Locations of less common tree species organized by color.*

Some of these species tend to be clustered (i.e. the red circle)

Species	Number of Individuals	Species	Number of Individuals
Ash	15	Redwood	6
Pecan	12	Pear	5
Plum	9	American Chestnut	5
Cedar	6	Mulberry	5
Jujube	6		

Table 3: *Less common species and varieties with between 5 and 15 individuals which contribute to the species diversity in the study area*

Tree Size

The variation in tree ages and sizes based on the collected data can best be shown in the size of the trunk which was recorded in diameter at breast height (DBH). We made the assumption that as a tree progresses in age, DBH increases. To better visualize sizes, trees were placed into size categories and the frequency of trees in each category was summarized as shown in Table 4 and the spatial distribution of the trees based on DBH is shown in Figure 10. Although there are a number of relatively large trees, the majority (>65%) of the trees are in the 0-50 centimeters (0-19.5 inches) size category. Of this group, the smaller trees (less than 25 centimeters or 10 inches diameter) comprise over 35% of the trees and are widely distributed throughout the study area, but tend to increase in the eastern portion of the study area (Figure 11). The youngest trees (<10 centimeters) are distributed throughout the study area. There are some areas, such as along West 6th Street between Normal Avenue and Chestnut Street, which have very young trees. Clusters of similar sized trees are relatively common throughout the study area (e.g. West 5th Street between Hazel and Ivy Streets). However, in general, there is diversity in tree sizes interspersed throughout the study area.

Tree dbh size category	Frequency	Percentage
0 - 10.0	175	17.7
10.1-25.0	199	20.2
25.1 – 50.0	276	28.0
50.1 – 75.0	195	19.8
75.1 – 100.0	104	10.5
>100.0	37	3.8
Total	986	100.0

Table 4: *The frequency of trees in the South Campus Neighborhood classified according to DBH size class categories.*

In total, there are 37 trees with DBHs larger than 100 centimeters (>39 inches) in the South Campus Neighborhood (Figure 12). The majority of these mature trees are located in the northwestern portion of the study area with fewer trees of this size as one progresses south. Approximately 67% of the trees in this DBH category reside north of West 4th Street between Cherry Street and Hazel Street. The most commonly occurring species in this large size category, over 100 centimeters, is the sycamore tree, with 12 individuals, followed by oak (7 individuals) and redwood (6 individuals).

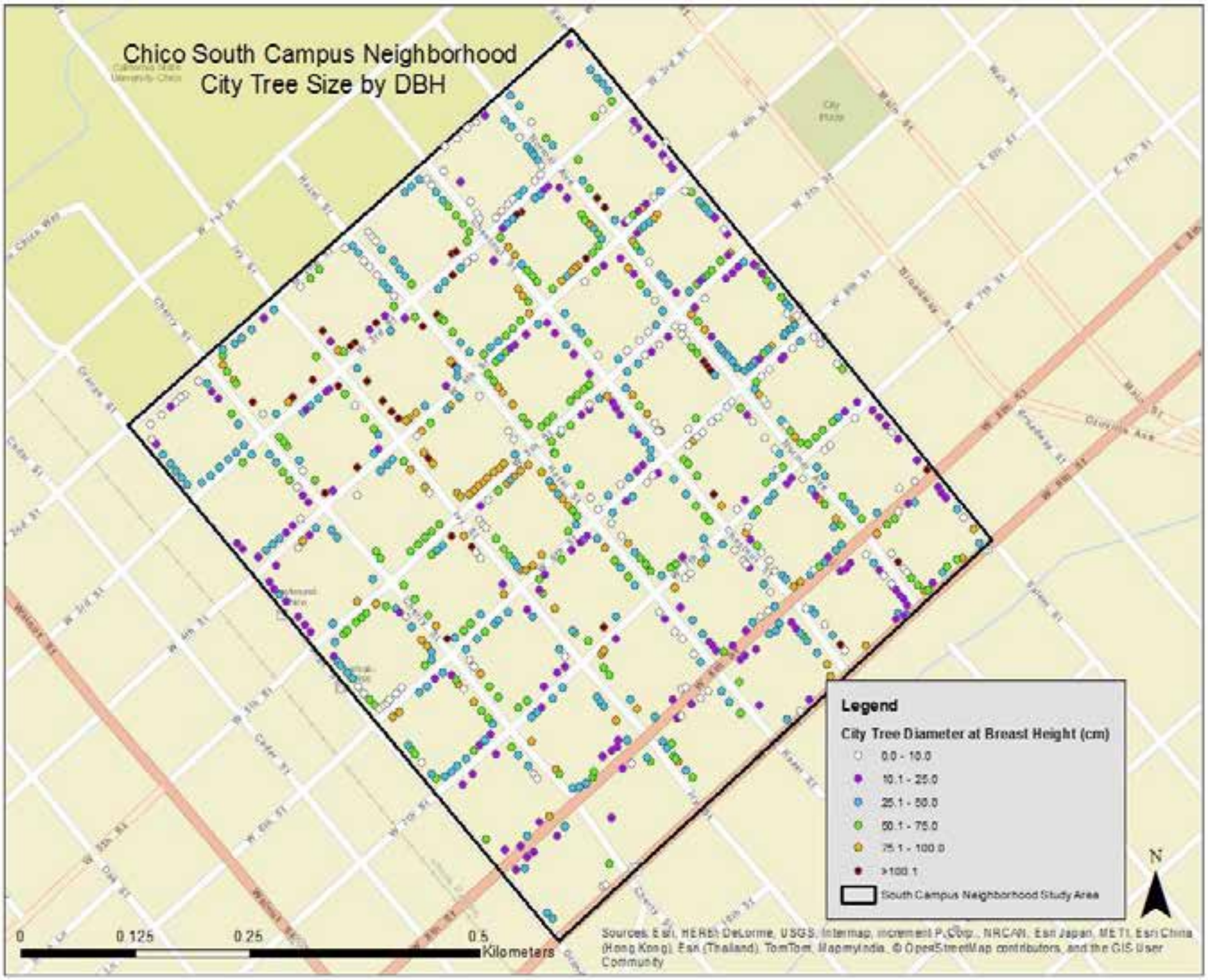

Figure 10: *Distribution of trees classified by size (diameter at breast height (DBH)) in the Study Area.*

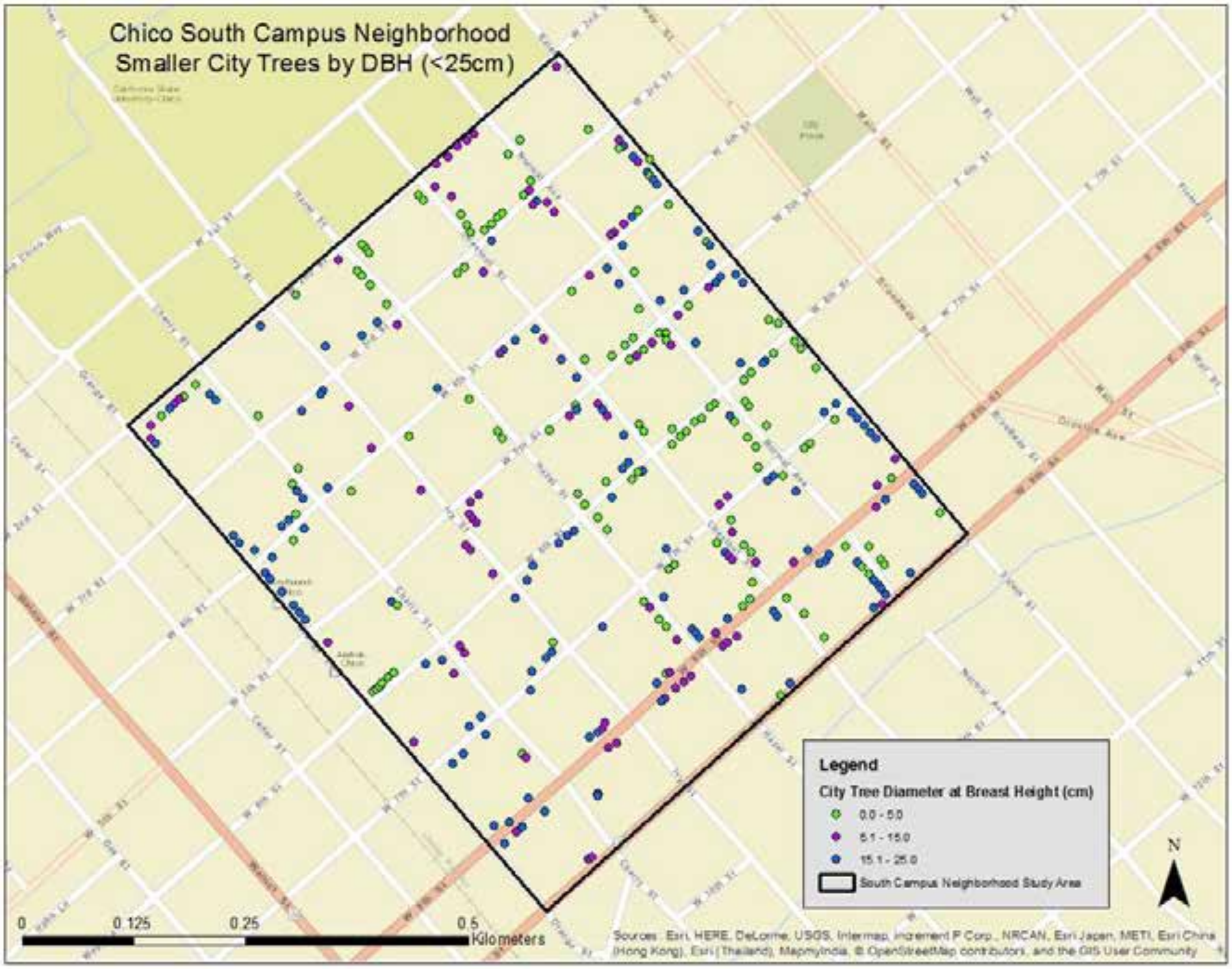

Figure 11: *Distribution of smaller trees (< 25cm dbh) in the study area.*

Areas described in the text are highlighted in red.

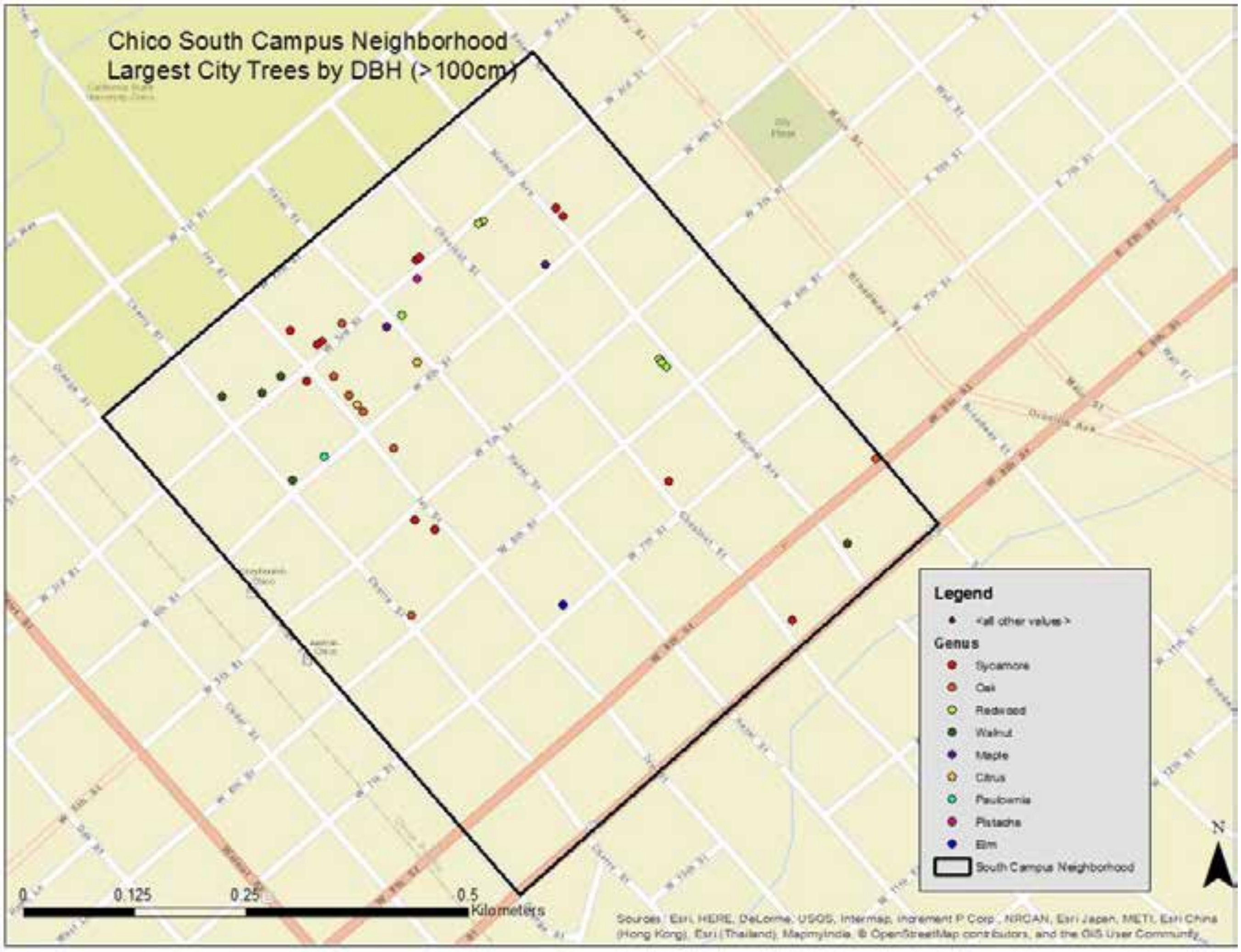

Figure 12: *Largest trees (>100 cm or 39 inches in trunk diameter) in the South Campus Neighborhood listed by the most common to least common.*

Vigor

One of the most important qualities that determines the status of a tree, or an overall indicator of its health, is vigor. Tree vigor was categorized into five different categories (see Methods). An important factor to keep in mind is that assigning vigor is a relatively subjective process since it is based on the observer's best judgement. Considering there were a number of teams collecting the data, it is likely that there are inherent biases in the vigor classifications to keep in mind. Figure 13 shows the frequency distribution of trees in each of the vigor categories. The largest percentage of individuals were ranked as being in "Good" health (44%), with "Fair" (39%) health following as a close second. A small percentage of trees were ranked as being in "Poor" health (8%), and the trees ranked as "Dead/Dying" (1%) constituted the smallest percentage. Distribution-wise, there tends to be clusters of trees along streets with the same vigor status (see Figure 14). For example, there is a large line of trees classified as "Fair" along the north side of West 5th Street and Hazel Street. In contrast, there is a continuous line of trees classified as "Good" to "Excellent" vigor in the area of West 4th Street and Normal Avenue. Trees of "Excellent" health make up approximately 8% of the arboreal population.

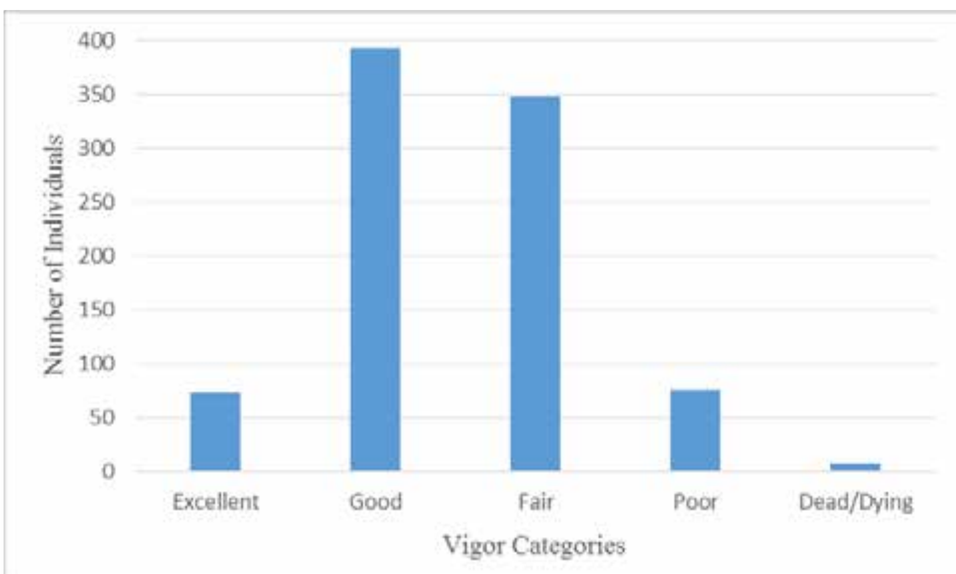

Figure 13: *Distribution of the number of trees in each Vigor category*

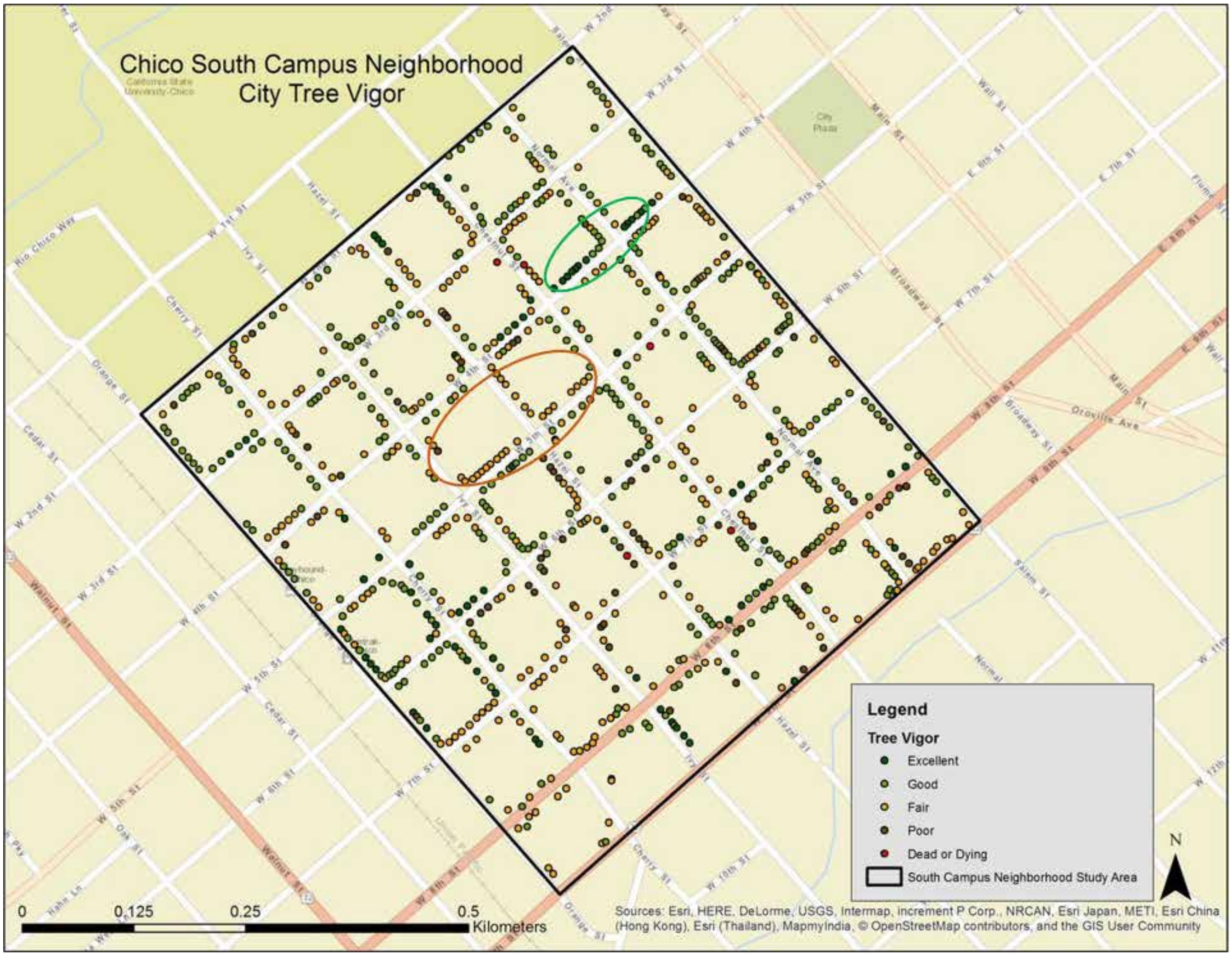

Figure 14: *Trees in the Study Area classified according to vigor.*

The ellipses highlight clusters with similar classifications

The 129 trees (or 9%) classified in the "Poor" and "Dead/Dying" categories (Figure 15) are widely distributed throughout the Neighborhood. There is a cluster of these trees located between West 5th and West 7th Streets and Cherry and Hazel Streets. In particular, there is one area on Hazel Street (circled in red on Figure 15) that contains six high-risk trees planted in the same vicinity.

Power Line Interference

There was a large number of trees observed in the Neighborhood which had power line interference (Figure 16). In general, power line interference appears in clusters and, only in a few instances, the trees with power line interference are interspersed between trees that do not interfere with the power lines (Figure 17). Some streets have areas where a majority of the trees exhibit this hazard (e.g. the southwest side of Chestnut Street). Another example is the block on Hazel Street between West 5th and West 6th Streets where a chain of individuals on both sides of the street display power line interference. The trees that are one block north between West 4th and West 5th streets, on the other hand, display the opposite.

We also looked at the relationship between tree size (measured as DBH) and power line interference (Figure 17 and 18). As is evident in the figures, there is a notable correlation between DBH size and power line interference. Large branches were frequently observed in the field crowding power lines, pushing electrical wires aside to accommodate for tree expansio

Figure 16: Example of power line interference within the South Campus Neighborhood

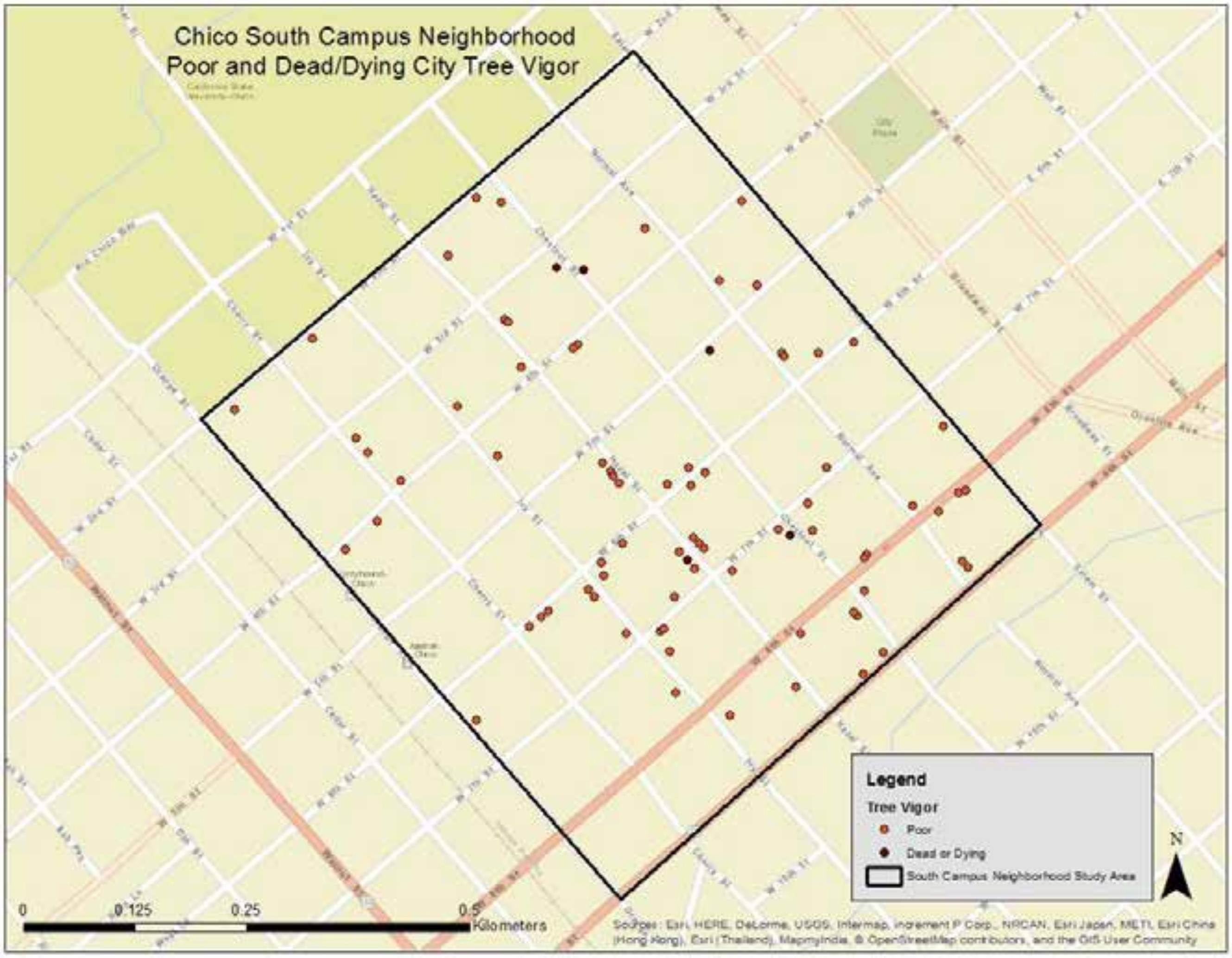

Figure 15: *Trees classified as 'Poor' or 'Dead/Dying' vigor in the South Campus Neighborhood.*

Sidewalk Uplift

Sidewalk uplift caused by tree roots is a very common and oftentimes problematic occurrence which confront cities. Sidewalk uplift is a safety hazard for pedestrians and could potentially cause infrastructure damage, so it is important to monitor trees that exhibit the potential for this hazard.

In the South Campus Neighborhood, 147 trees were recorded as having caused sidewalk uplift. These particular trees are generally spread throughout the study area (Figure 20). There is one area on Ivy Street that displays a large amount of sidewalk disturbance (circles in red in the figure). Figure 21 exhibits a typical example of sidewalk uplift.

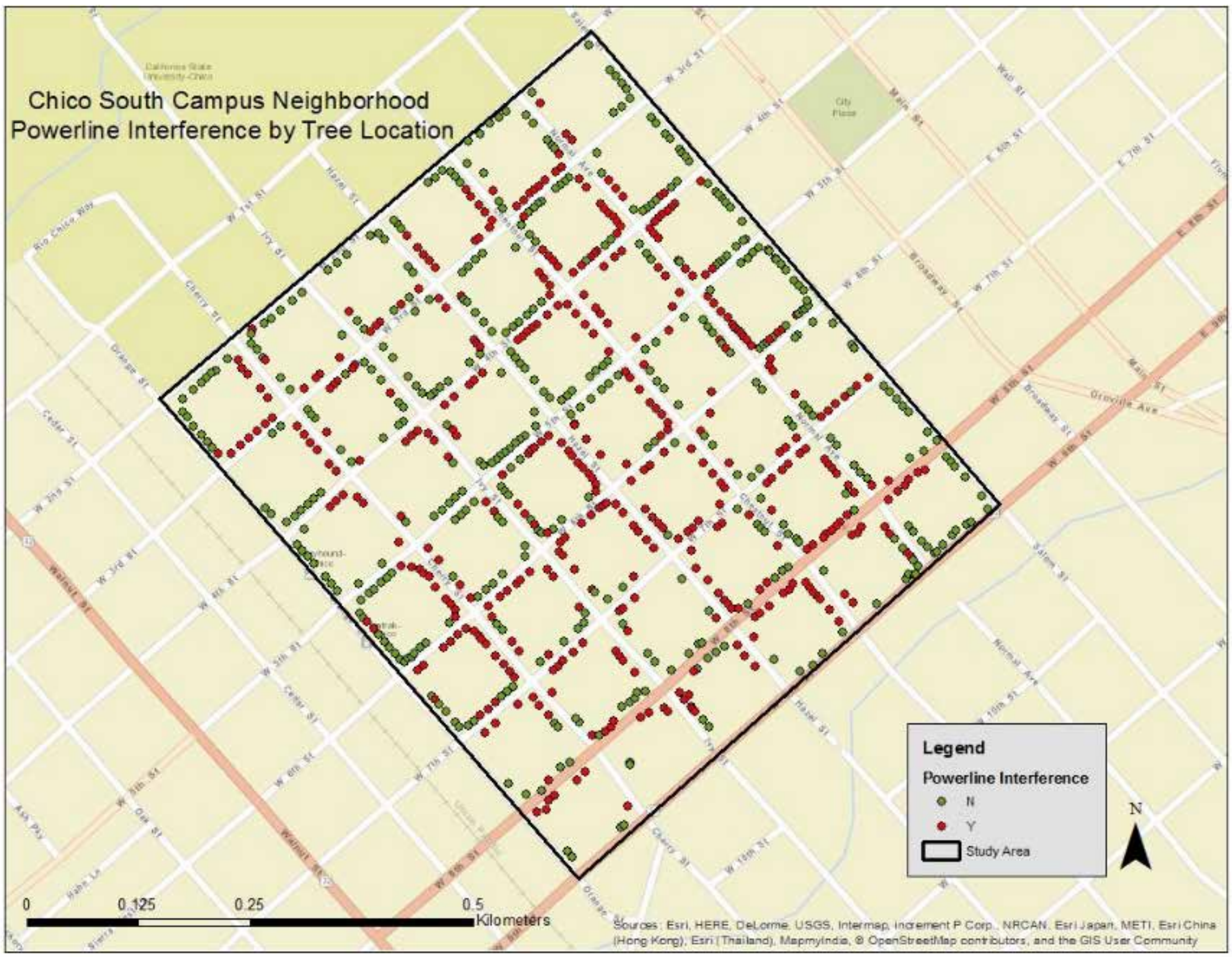

Figure 17: *South Campus Neighborhood trees with and without power line interference*

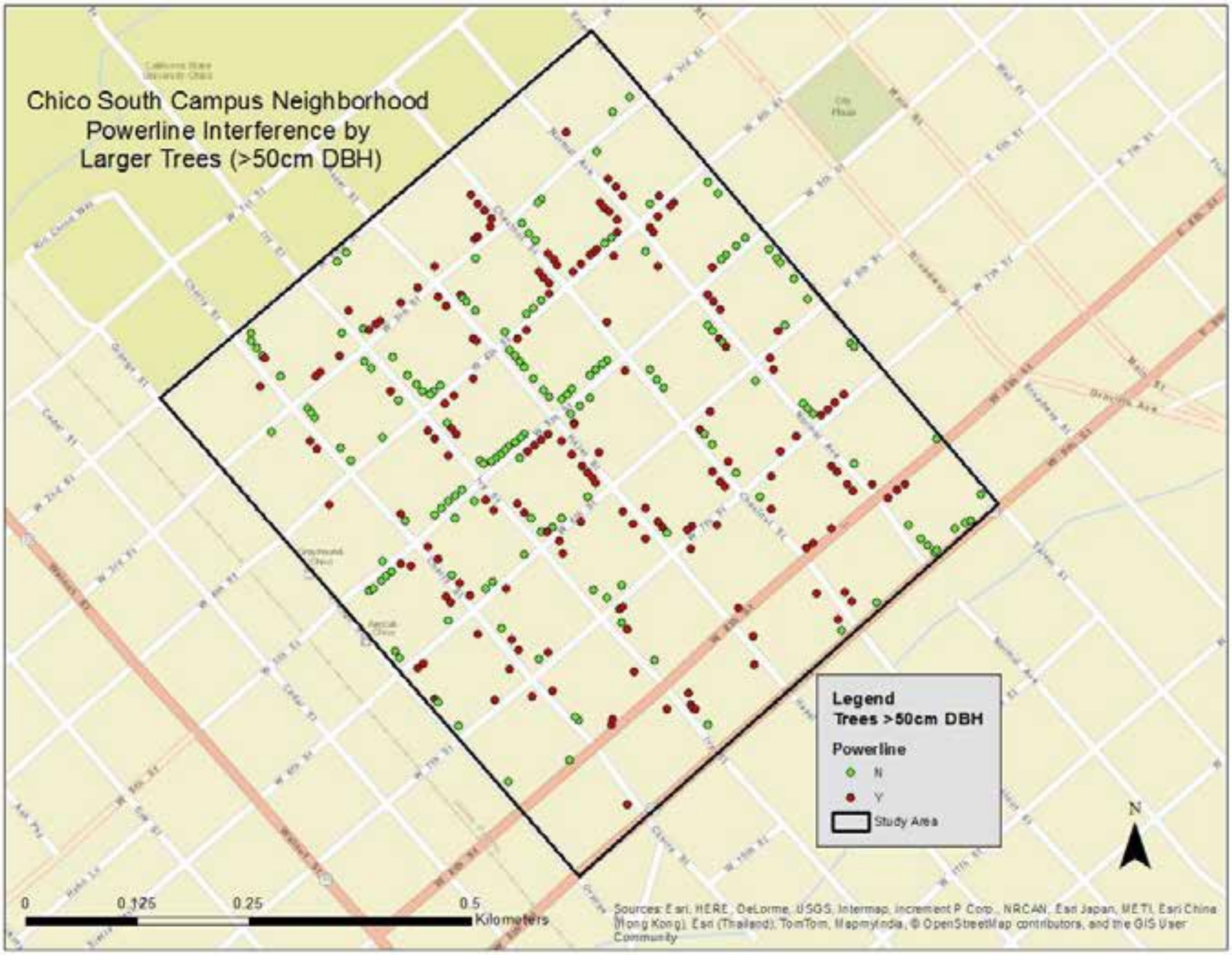

Figure 18: *All trees larger than 50 cm DBH highlighting those that exhibited powerline interference.*

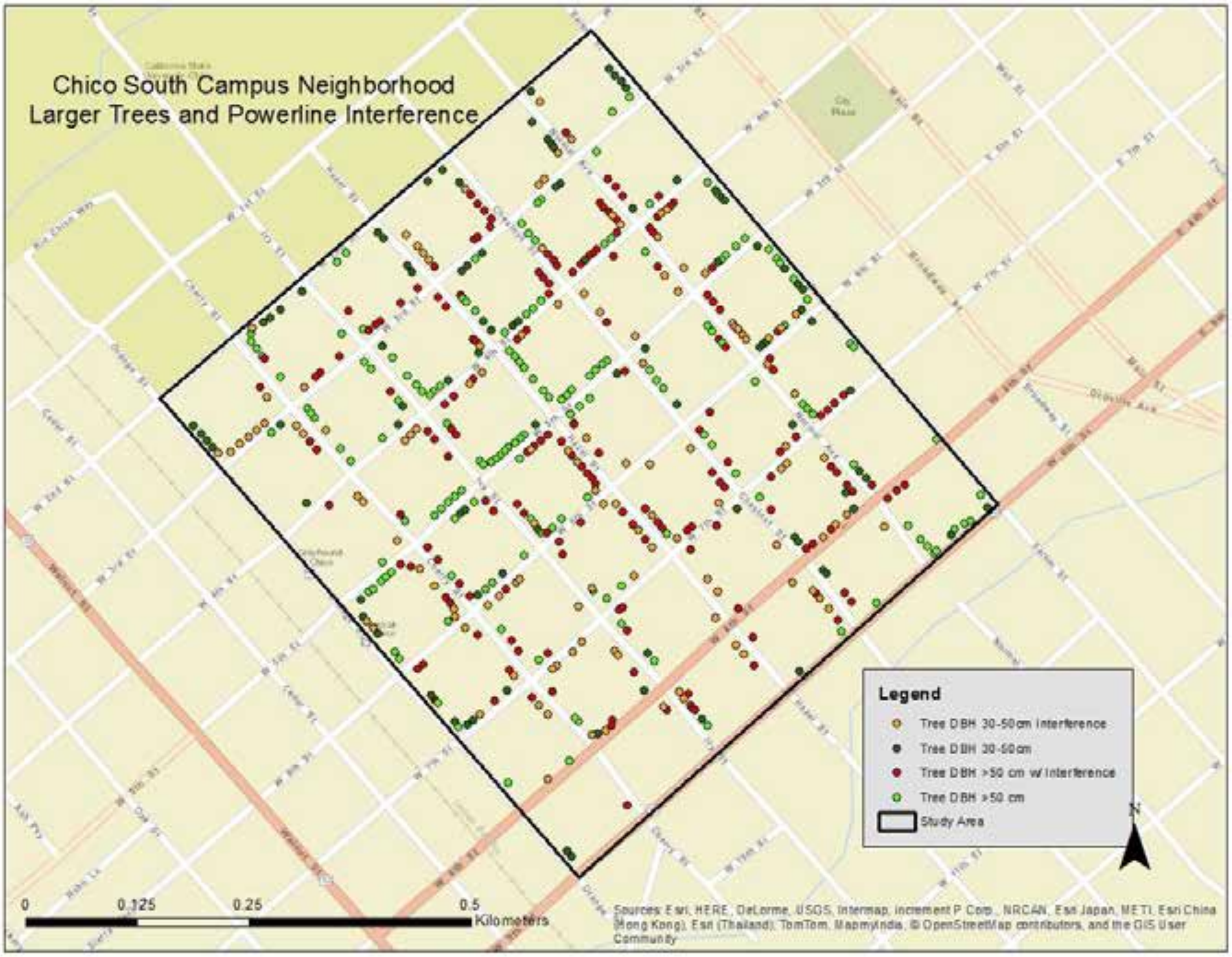

Figure 19: All trees larger than 30cm DBH including those that exhibited powerline interference.

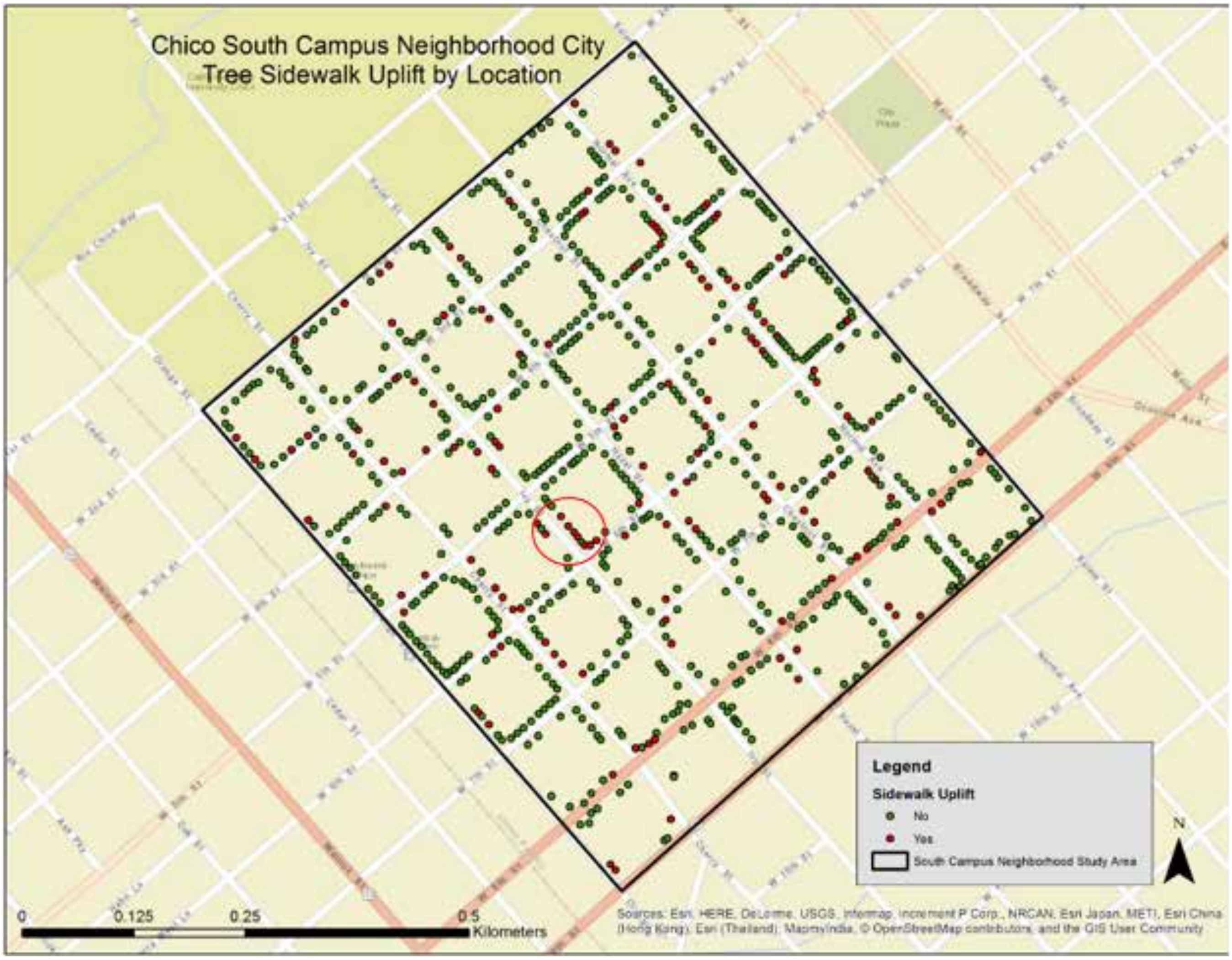

Figure 20: *Tree sidewalk uplift by location in the South Campus Neighborhood.*

Note the cluster on Ivy (red circle).

Figure 21: *Example of sidewalk uplift. (Photo by S. Roe)*

Finally, we looked at the relationship between sidewalk uplift and powerline interference (Figure 22). These trees tend to be widely dispersed throughout the study area and do not display the clustering we often see with some of the other patterns such as tree size or species.

Discussion and Conclusions

This neighborhood is the oldest within the "City of Trees," and thus has the longest history of tree planting and maintenance. Although it is a neighborhood that has various issues due to the diverse, and oftentimes long-lived individual trees, the studied area is an important monument to Chico's urban forest diversity. The 904 trees in this neighborhood represent a proud heritage and an important element that directly contributes to the Historic District classification for the South Campus Neighborhood.

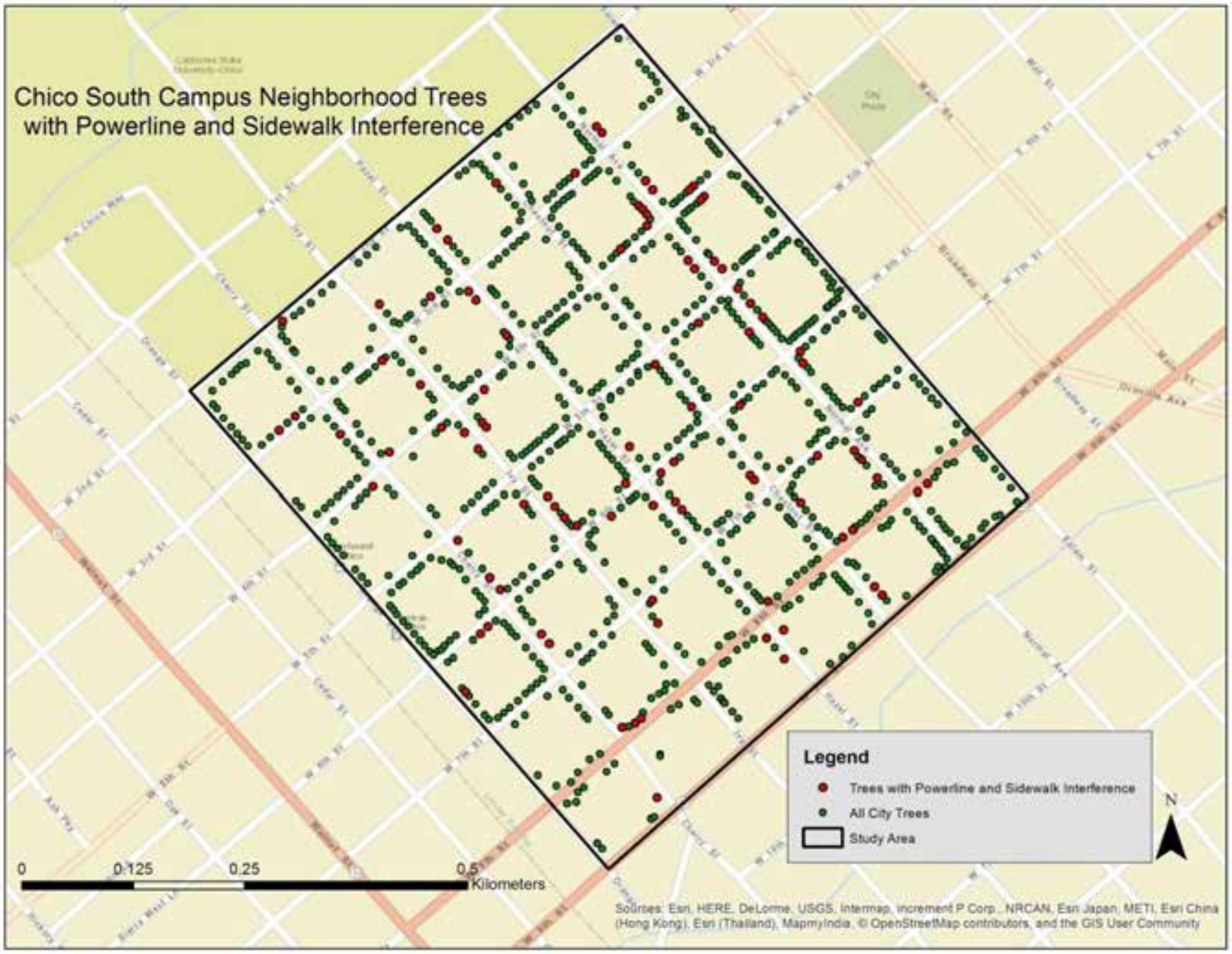

Figure 22: *Location of trees that exhibit both powerline interference and sidewalk uplift in the study area.*

There was a total of over 85 species including different varieties represented in the Neighborhood. The Maple varieties dominate as the most numerous of species subtypes, but no one species dominates block after block, the diversity is interspersed. As such, the tree diversity displays no particular geographic origins or geographical placing patterns. The trees in the area do exhibit some tree size patterns however. (As mentioned earlier, we used DBH as a proxy for tree size.) There is a clustering of the largest trees (>100 centimeters DBH) located north of West 4th Street and between Cherry Street and Hazel Street while smaller trees (<25 centimeters in diameter) are widely distributed throughout the area, though they do seem to be more common as one moves east through the Neighborhood.

The majority of the trees in the Neighborhood are classified as having good or fair vigor, with over 75% of the trees in these two categories. Vigor is a qualitative determination and some caution is warranted when interpreting the data, especially with respect to the trees that were classified as "excellent." This classification would imply a perfect tree and in reality few trees are perfect. We initially thought about comparing the tree vigor between the city's data and our data to see how things had changed over the intervening time. However, preliminary evaluation of vigor between the two datasets revealed that doing so would require additional time and resources in order to do the comparison accurately. This would be interesting to explore in the future.

There are 429 trees (48%) determined to have power line interference and 147 trees (16%) were recorded to have caused sidewalk uplift. While trees with sidewalk uplift seem to be more scattered and less numerous, trees with power line interference appear to be in loose clusters. Not surprisingly, it also was apparent that there was a close relationship between trees size (DBH) and power line interference.

Careful planning is necessary for continued success of the city's diverse and fruitful urban forest. The diversity of species and varieties require varied levels of on-going management. Considerations for spacing and height must be recognized and executed in a responsible manner. Future power line interference and sidewalk uplift must be accounted for when choosing and locating individuals, as well as consideration for lifespan, climate, community appeal, and frequency of maintenance that a species requires.

Dynamic Changing Landscape and Lessons Learned

The field data recorded for this project represents an ever-changing urban forest landscape. Subsequent to the final data collections and field checking for this project in May 2016, ongoing city maintenance has continued to change the urban forest landscape. Some of the trees within the Neighborhood that are included in in this report have been removed, while others have been newly planted. As a consequence, the information presented in this report is only a snapshot of a changing landscape.

An additional variable that is useful in managing an urban forest is tree height. Though students did record tree height in the study area, during the quality check of the data, it was apparent that the tree height data was not consistently reliable. Consequently, this information is not included in this report and should be updated when possible.

The landscape is also ever-changing due to the seasons. During the first data collection rounds in mid-March, it was generally difficult to identify the tree species as they had not leafed out (Figure 23). Without full foliage, it was also difficult to determine tree vigor. Both species identity and vigor were recorded later in the season by a smaller group of students as well as interns.

Collectively there were 95 students in three different classes collaborating on this urban forest project. To assess the impact the project had on students, a survey was conducted following the project. The comments were overwhelmingly positive with comments such as “I felt more connected with the community than I everhave during my five years as a CSU Chico student…” and “It was interesting to go downtown and be engaged with the trees that we walk by every day. I never really knew how much impact this data could have on the city and sidewalks, but now whenever I’m walking on the sidewalk I actually think about this project.” It was apparent that the project greatly increased the student’s awareness of the city and the challenges in managing an urban forest.

Figure 23: *Students collecting data in the rain before foliage had emerged on the trees.*

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Appendices

Appendix A: Urban Forest Survey Protocol

MATERIALS AND METHODS

Materials List

Clinometer	DBH Tape	Tree Guide	Site Map
GPS	Densiometer	Data Sheet	

Methods

Split up into groups. Each group will be assigned a separate location for tree surveying. Focus on the street trees, which are the trees that are located in between the sidewalk and the street (see diagram below). The dashed-and-dotted lines represent borders of private properties, such as yards and entrance ways. Do not record data for the trees located on private property. Record the species on the provided data sheet.

Tree Species Identification: Each tree needs to be properly identified. Use the provided tree identification guide to make an informed decision on the tree species.

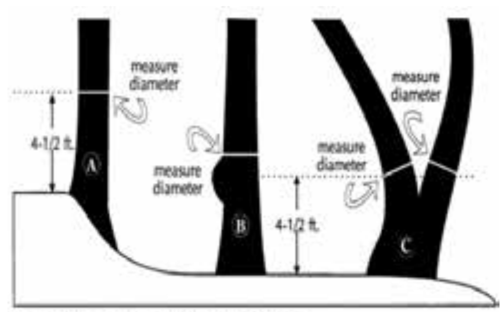
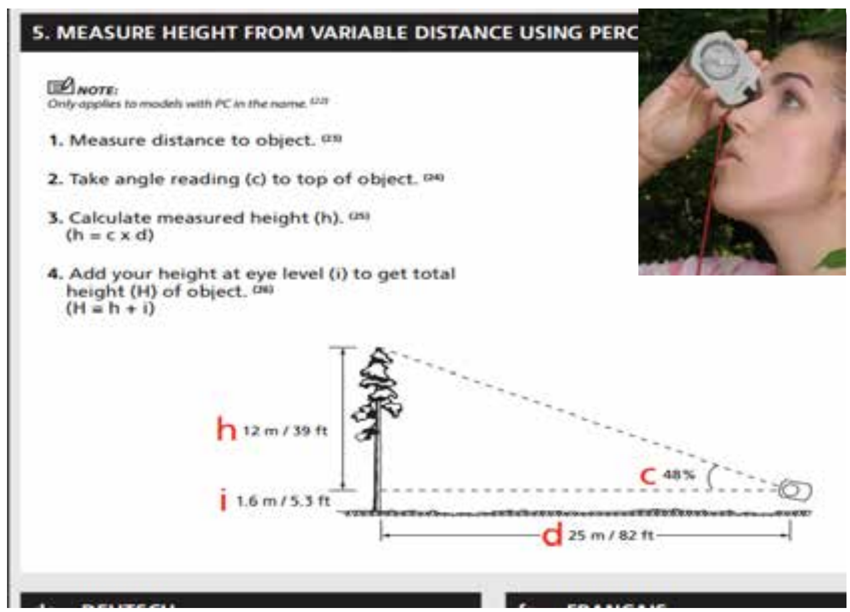


Figure 2-1. Measure stem diameter at breast height (DBH)

DBH Tape: Stand on the uphill side of the tree and measure 4.5 feet up from the ground at the base of the tree. At this point, wrap the DBH tape around the trunk of the tree completely and snugly. Keep the tape level. Record the total diameter in centimeters on the data sheet provided. This is your DBH, or diameter at breast height. This measurement gives insight on the approximate age of the tree.

GPS: Turn on provided unit with power button, next scroll down to the satellite image and click on it. Ensure good signal from satellites, watch accuracy (upper right). When get best accuracy, hit 'Back' button and scroll to 'Mark Waypoint'. Select 'Done'. Select "record coordinates" (ex. 10S 0603890m, 4400655m – note you are taking measurements in UTM). The front part of this measurement will be constant due to the location of Chico but the last 1-3 digits will change for each tree. Poor accuracy – do 'Average Waypoint'. Don't forget to record this number on your datasheet. Record each tree location facing north, which is indicated on the GPS. This will take longer but strive for best accuracy possible.

Clinometer:



These instruments are used to approximate the height of a tree. Follow the directions below.

1. *Adjust focus: Close one eye and look through optics. If held correctly a percentage scale will be visible.*
2. *Obtain Reading: Keep both eyes open and look through optics towards target object. An optical illusion makes the object and sighting line appear to overlap, allowing an accurate reading. Read value from sighting line.*
3. *Record the variables C, D, and I on data sheet*
4. *Calculate the height (H) in meters and transfer final values to data sheet 1 in following lab meeting.*

Vigor: You will be using your judgement to rate the health of each tree surveyed. Rate each tree on a scale of 1-5 according to the City of Chico's vigor scale as follows(for more detail refer to....) :

1= Excellent 2=Good 3=Fair 4=Poor 5=Dead or dying

Uplift: Look at the ground surrounding the tree being recorded. Does the surrounding sidewalk appear to be disturbed or previously shaven down to compensate for uplift? If yes, mark "Y" on the data sheet. If not, mark "N" on the data sheet. This is an important safety feature for all city pedestrians.

Power line Interference: Is there a power line running through the canopy of the tree? If yes, mark "Y" on the data sheet. If not, mark "N" on the data sheet.

Transfer data sheets 1 and 2 to excel documents to complete calculations and compile with classmates for further analysis.

Study Site

The survey will be conducted in the neighborhood adjacent to the southern section of CSU, Chico's campus, as shown below.

The red borders denote the boundaries of the study

Appendix B: Urban Forestry Datasheet

WP #	Tree Species	DBH (cm)	GPS Coord.		Data to determine height (m)				Sdwlk Uplift (Y/N)	Vigor (1-5)	Power line (Y/N)	Notes/
			UTMX Easting	UTMY Northing	angle C	dist (m) (street)	dist (m) (to sdwlk)	eye ht (m) (i)				

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