Portland State University

SoMa EcoDistrict

Tree Inventory Report

Spring 2016

TREE INVENTORY REPOR
SoMa EcoDistrict

Spring Term 2016

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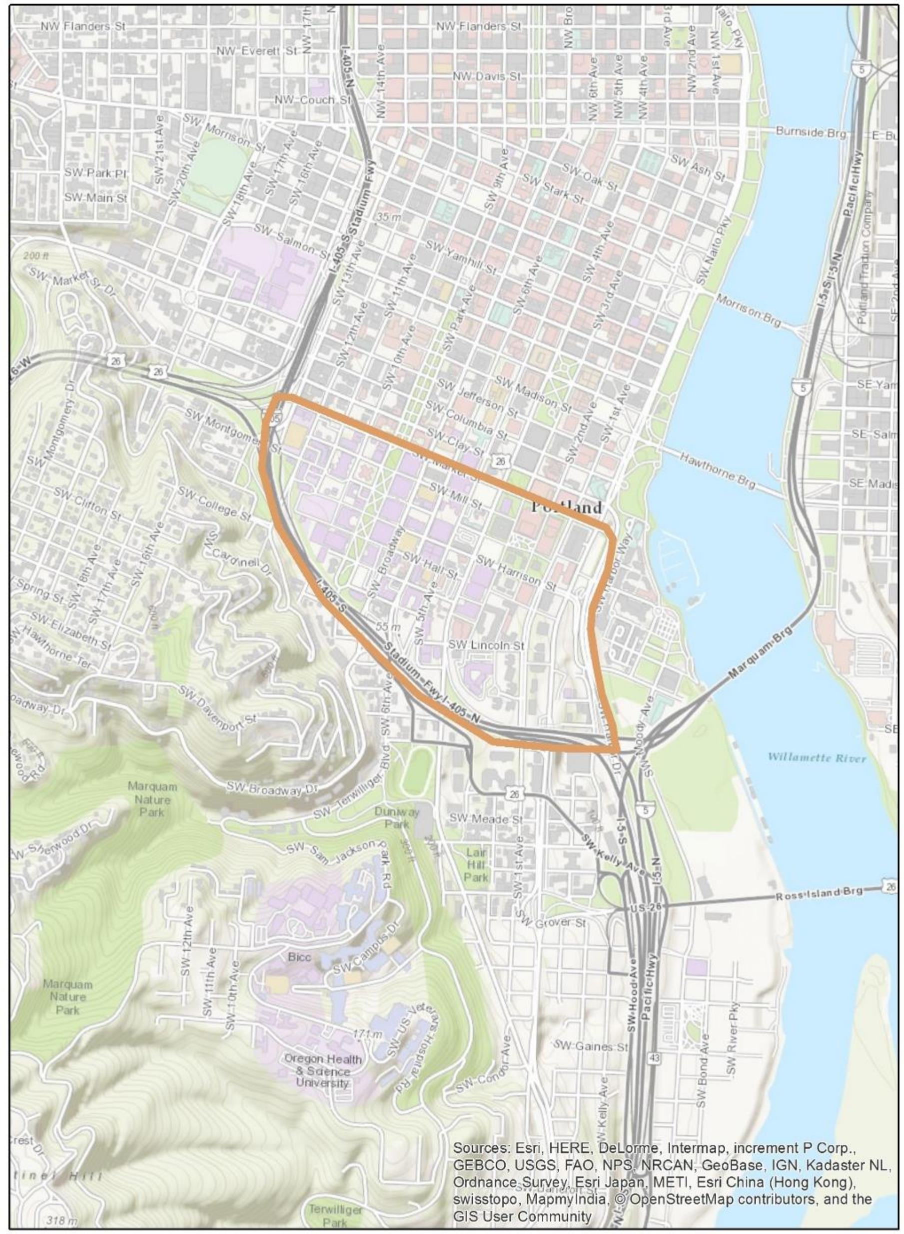

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INTRODUCTION

During the 2015-2016 academic year, two groups of students at Portland State University (PSU) came together from diverse backgrounds and majors, into a singular Senior Capstone course to develop a tree inventory and plan for the South of Market (SoMa) EcoDistrict in downtown Portland. A Senior Capstone class is required for all graduating students. They are designed by the University's faculty to culminate a student's education while working on a community impact project, with community partners and other students of varying backgrounds and majors with the guidance and supervision of a professor. A majority of the students involved in this project had GIS experience, and the remaining students were grateful for their skills when it came to the data crunching aspect of this project. Everyone worked on the data collection together and had a part to play in the creation of the final report.

This project was begun in the Fall of 2015 by a class of students who laid the groundwork for the Spring 2016 term. The first class had it rough, with problematic software and data loss. The goal for the Spring term students was to take that foundation and build upon it, completing the data collection, analysis, and production of a tree inventory report and plan for the SoMa EcoDistrict. The students were aided in their work by Mark Armstrong and Katelynn Bisso, directed and supervised by Dr. Meg Merrick. The project was made possible by several key partners; PSU Campus Sustainability Office (CSO), the Institute for Sustainable Solutions at PSU (ISS), and the PSU Campus Planning Office (CPO). The CSO is designed to help foster partnerships across departments and disciplines, facilitating collaboration between the ISS and those who receive funding from them. The CSO's interest in this project specifically is to help aid the goal of a zero carbon footprint campus while encouraging student sustainability education and research. The ISS administers a 10 year, $25 million grant designed to provide catalytic funding to integrate sustainability

across campus, with focal research areas being urban sustainability: building smart cities, ecosystem services, understanding nature's benefits, and social determinants of health—connecting wellness, place and equity. The ISS and CSO provided funding for the project. This funding covered ISS fellowships and the cost of the diameter tapes utilized to measure the trees, as well as the cost of utilizing Fulcrum—the smartphone data collection program. The CPO's primary goal from this project was to receive a completed report that can aide them in current and future campus maintenance and development.

The reason for focusing this project on the SoMa EcoDistrict was simply because that is the location of PSU. The street trees were already inventoried by the City of Portland, but much of this EcoDistrict's canopy coverage is not represented by street trees. The purpose of the inventory was not just to plot and identify the trees but to get a clear picture of tree diversity, health and distribution across the district, allowing planning and attention to troubled areas or tree species. By utilizing the software, iTree (an analysis tool developed by the US Forest Service), the data was analyzed and the trees' impacts on their environment was calculated. The class also identified any high VOC (volatile organic compounds) areas related to urban heat islands (using the Health and Trees tool data, www.treesandhealth.org, and data from Jackson Voelkel and Vivek Shandas at PSU) so that concerns can be addressed.

The Capstone's report is intended for use when future PSU campus and EcoDistrict developments are considered. A clear, concise, and detailed report will assist in the maintenance of current trees and the planning of future tree placement. It is hoped that the report will be utilized when considering the impact of future development on existing trees and canopy coverage allowing for the responsible expansion of the university and the SoMa EcoDistrict where smart utilization and planning is key.

HISTORY OF TREES IN PORTLAND

Portland, which was once nicknamed Stumptown due to the massive deforestation that made way for development in the 1800s, has rebounded in recent years to a city known for environmental activism and progressive legislation. Restoration of urban trees has occurred over the years, beginning in 1871 with the creation of the elm-lined Park Blocks and development of Washington Park (Friends of Trees, 2009). In the 1970s, thousands of trees were planted throughout the city, but a lack of public funds slowed these efforts in the 80s. The nonprofit organization Friends of Trees was founded in 1989, and has organized volunteers to plant trees in neighborhoods with a low presence of street trees.

Portland has recently made efforts to regulate the removal of trees. The Heritage Tree Code was created in 1993, which has designated over 300 heritage trees, recognized for their size, age, and historical significance (Hedberg, 2014). These trees are specially protected and must have city approval before being removed. A new tree code, Title 11 Trees, was created in 2005. This code mandates that any tree over 12 inches in diameter, if removed, must be replaced with a tree of equal diameter (or multiple trees that sum to an equal DBH- breast height diameter), or pay the city the replacement cost of a tree of equal size (Portland Tree Permit Series, 2014).

The Portland metropolitan area now contains over half of Oregon's population, and continues to grow (Population Research Center, 2011). Between 2010 and 2014, the metro area's population rose by 5.2 percent, the 20th fastest growth among major cities within the United States (Christensen, 2015). With increased population comes higher-density development, and trees are at risk for removal throughout the SoMa district and the rest of Portland. It will be important to consider the many benefits provided by urban trees as development continues to boom.

BENEFITS OF URBAN TREES

Urban trees provide many tangible benefits to communities. They deliver ecological services such as flood prevention, cooling through shade and transpiration, and removal of atmospheric CO_2 and other air pollutants (Nowak et. Al, 2014; Chen, 2015, Page et. Al, 2015; Sheng et. Al, 2015). These services have a tremendous monetary value, reducing the cost of stormwater treatment by preventing spikes in runoff during storms (Page et. al, 2015) and lowering cooling costs through shade in the summer and heating costs through wind protection in the winter (Chen, 2015). The value of pollution removal by trees across the U.S. has been calculated at $86 billion per year (Novak et. al, 2015). The presence of trees also has a positive economic impact on individual property owners, increasing the value of property anywhere from 1.9% to 7% (Mansfield et. al, 2005), as well as the decrease costs in heating and cooling.

Finally, research has shown that the presence of trees can enhance psychological wellbeing. Trees can reduce stress (Cimprich & Ronis, 2003), increase ability to concentrate (Kuo & Taylor, 2004), and can even reduce rates of violent crime and property damage (Kuo, & Sullivan, 2001). Though less measureable, and not quantifiable in a monetary benefit analysis, these benefits are important to the wellbeing of communities.

FIELDWORK METHODOLOGY

Tree data for the SoMa district were collected from three sources: City of Portland Street Tree Inventory, a PSU Senior Capstone survey in Fall 2015, and the Senior Capstone students' survey in the Spring 2016. Data for the Spring 2016 Capstone class was collected from April 18th to May 17th, 2016.

Students were trained in tree identification techniques and data collection methods. In the field, groups of two students worked together to identify and measure trees, using a diameter measuring tape, field identification guides, and the Fulcrum smartphone and tablet app. Fulcrum allows data points to be plotted by location, using GPS and manual pinpointing. Each data point included the following information: Tree Genus/Species; Diameter; Multistem (Yes/No); Condition; Overhead Wires (Yes/No); and Date Inventoried.

Tree Genus/Species: Trees were identified to the Genus level at a minimum, and where possible, identified to the species level. Quercas trees (Oaks) were identified as either deciduous or coniferous.

Diameter and Multistem: Diameter at Breast Height (DBH: roughly 4.5' above ground) was measured with a diameter tape. Trees that did not have a single trunk at 4.5' were marked 'Multistem' to indicate a non-normal growth pattern.

Tree Condition: Trees were rated as very poor, poor, fair, good, very good, and excellent. The default setting was good, and poor and very poor were used to indicate trees in poor health and dying/dead trees, respectively.

Overhead Wires: Marked 'Yes' If power lines were present above or within the tree canopy.

DATA PROCESSING METHODOLOGY

Background

iTree is a free software program created for urban forestry programs. The program was created by the USDA Forest Service in 2006 to help promote, manage, and advocate for urban forest through a benefit and analysis report. This report incorporates data from individual trees and quantifies a monetary value to encourage groups, from small communities to states, to support urban forests. More information on iTree can be found at http://www.itreetools.org.

Data processing

Data was combined from three sources: The present study, collected with the Fulcrum mobile app; a survey in Fall 2015 collected with ESRI Collector; and the downtown street tree inventory conducted by the City of Portland. The tree data (genus, species, DBH, date recorded, tree condition) was exported as a Microsoft Excel spreadsheet file (.xlsx). In Excel, the data was refined and formatted to fit requirements for an iTree analysis. This included labelling species codes (provided by i-Tree) and formatting the columns to i-Tree requirements. Through Excel, the new file was saved as an .xlsx file to load into Microsoft Access. The data from Excel was processed into a Microsoft Access table (.mdb file) for importing a streets-formatted inventory, compatible with the iTree software. The .mdb file was loaded into the iTree software, and tree codes were defined for our inventory to ensure proper classification. A full analysis was then run within i-Tree.

iTree Results

The iTree inventory provides two outputs: annual monetary benefits of public trees by species, and replacement value of all trees. The benefit analysis provides a monetary value for each tree species based on the Urban Forest Effects (UFORE) model, which considers five major components: anatomy of the urban forest, biogenic volatile organic compound (VOC) emissions, carbon storage and sequestration, dry deposition of air pollution, and energy conservation. A series of equations are used in these calculations which are detailed in the UFORE methods (https://www.itreetools.org/eco/resources/UFORE%20Methods.pdf).

INVENTORY FINDINGS

Tree type composition

Trees inventoried within the SoMa EcoDistrict were identified to the genus and/or species level. Trees such as Maples were identified to the species level (e.g. Bigleaf, Japanese, Norway, Paperbark, Red, and Silver). Other trees, such as Oaks and Elms, were identified to the genus level followed by “spp.” (which is a general term used for species). A full list of trees inventoried can be found in Appendix A.

The population inventoried by the 2016 Spring Term class included 2,255 trees. The data set used also contains Fall term data from 2015, and street tree data provided by the City of Portland, giving a total of 3,689 within the SoMa EcoDistrict. The most abundant tree species are Norway Maples, representing 9.4% of all urban trees inventoried. Oak, Elm, and Prunus are also common, representing 8.6%, 6.1%, and 5.8% of all trees, respectively. The Top 10 most common tree species inventoried within the population can be seen in (Table 1) below.

Common Name	Scientific Name	Number of Trees	% of Total Trees
Norway Maple	Acer platanoides	345	9.4
Oak	Quercus	318	8.6
Elm	Ulmas	224	6.1
Prunus	Prunus	213	5.8
Pine	Pinus	171	4.6
Arborvitae	Thuja	142	3.8
Maple Spp.	Acer	141	3.8
Japanese Maple	Acer palmatum	127	3.4
Western Red Cedar	Thuja pilcata	127	3.4
Vine Maple	Acer circinatum	123	3.3
All other tree types		624	47.5

Table 1.

Size class distribution

Due to the difficulty in obtaining accurate tree age information DBH is used as a proxy for calculating tree age. However, it must be noted that some species mature at different rates and/or never grow larger then 3-12 inches in diameter. Regardless, measuring the trees diameters at breast height (DBH) is a sufficient way to identify the approximate age of the SoMa EcoDistrict urban forest. Within the SoMa EcoDistrict, the results suggest that the urban forest is relatively young. This is shown by the skewed distribution shown in (Figure 1). Roughly 65% of all trees inventoried fall between 0-12 inches in diameter. The largest class size is 6-12 inches in diameter, making up roughly 23% of all trees.

The prominence of small trees suggests that many of the older trees (i.e. trees that are over 24 inches in diameter) were removed during the cities development, and new trees were planted around developing areas. However a wide distribution in size is actually desirable for managing tree maintenance costs. Age diversity can help reduce the chance that canopy cover is destroyed with mortality, the same way species diversity does.

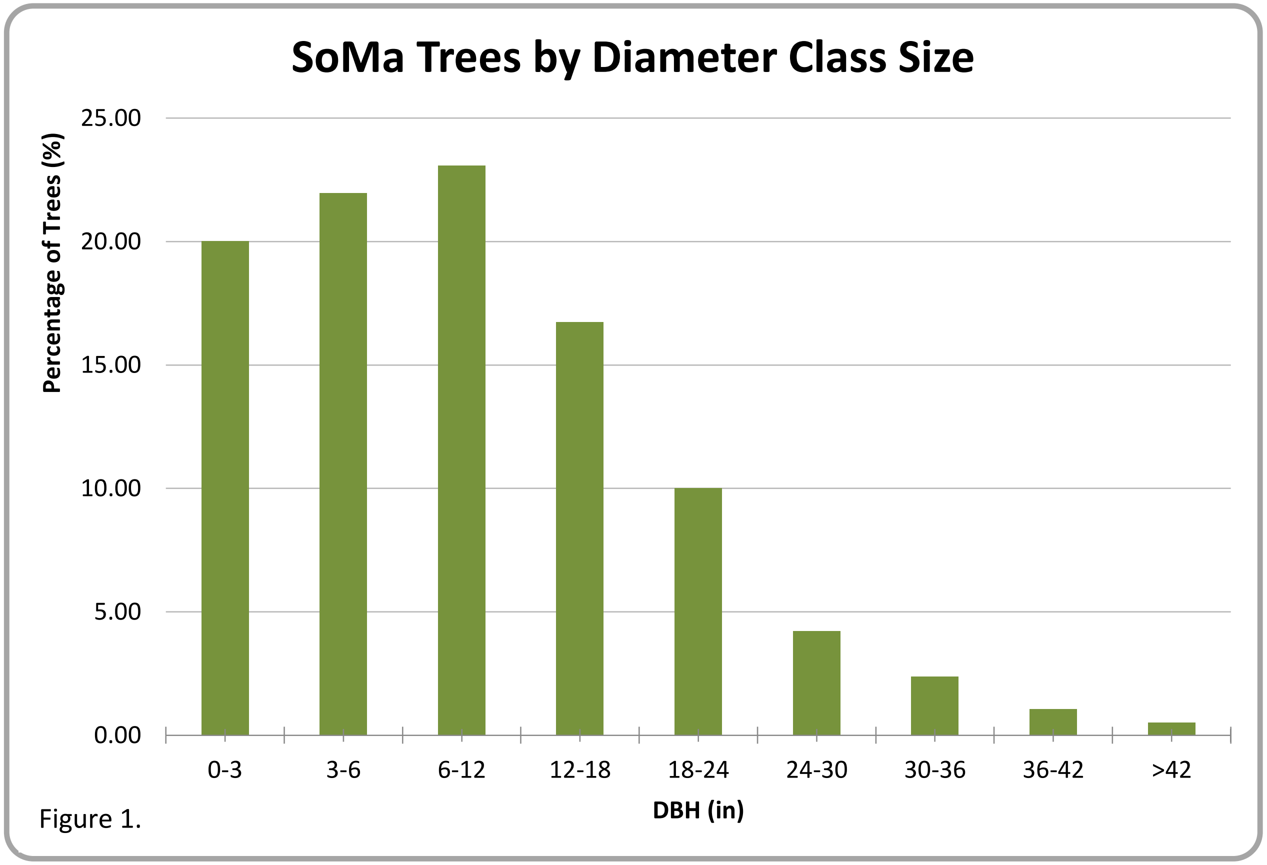


Figure 1.

Annual benefits

The annual benefits calculation helps to illustrate which urban trees are providing the greatest value. The annual benefits measure is used to quantify the dollar value of annual environmental services and aesthetic benefits provided by urban trees: Aesthetic/property value increase, air quality improvement, carbon dioxide reduction, energy savings, and storm water processing. The calculations are made using iTree software. The iTree software relies on species data gathered from inventory, as well as Portland's current energy costs (gas and electric), regional benefit prices for air quality, regional storm water interception costs, and median housing resale values provided by Zillow. In (Figure 2) below are the top ten tree species in the Soma EcoDistrict with the greatest annual benefits.

From (Figure 2) we can see that Oaks, Norway Maples, and Elms have relatively large annual benefits providing roughly $210,000 in annual benefits a year. This is almost half of the entire annual benefits provided by all species of trees within the SoMa EcoDistrict. In the SoMa EcoDistrict all species together provide an annual benefit of $450,000. Of that, SoMa trees increase aesthetic/property value by $342,750, improve air quality with a value of $6,168, reduce carbon dioxide levels at a value of $2,824, save $12,133 of Portland's energy costs (gas and electric), and naturally process stormwater which is valued at $85,254.

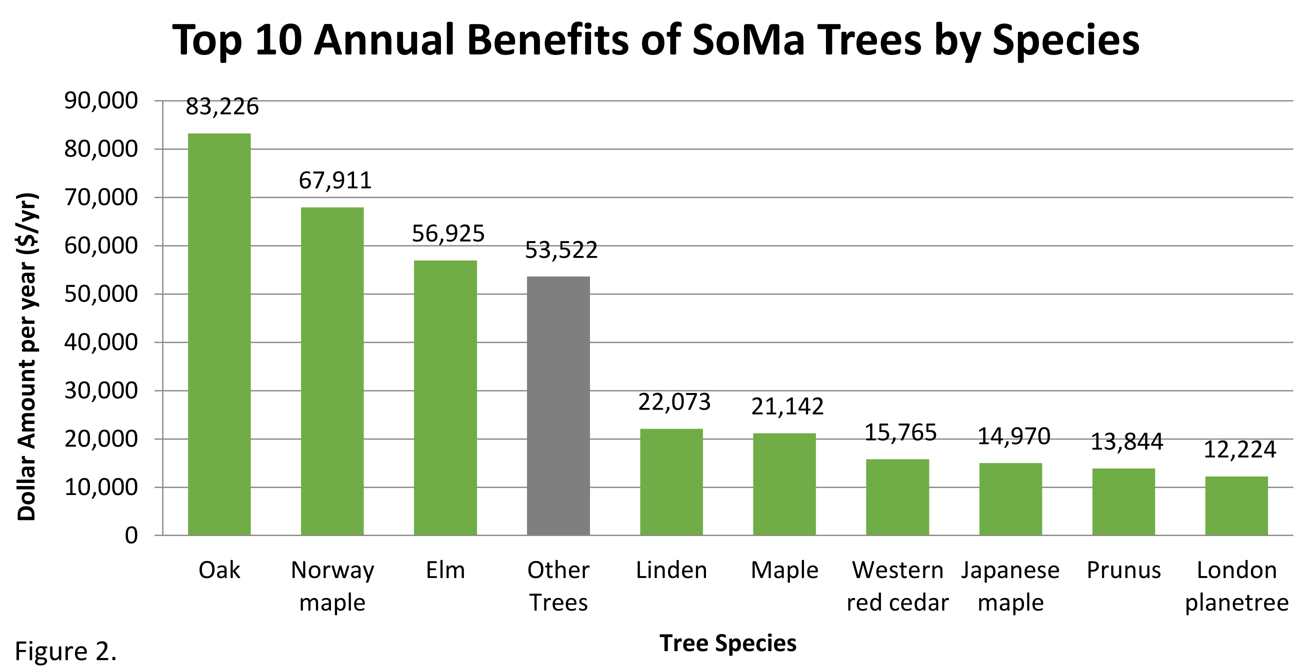


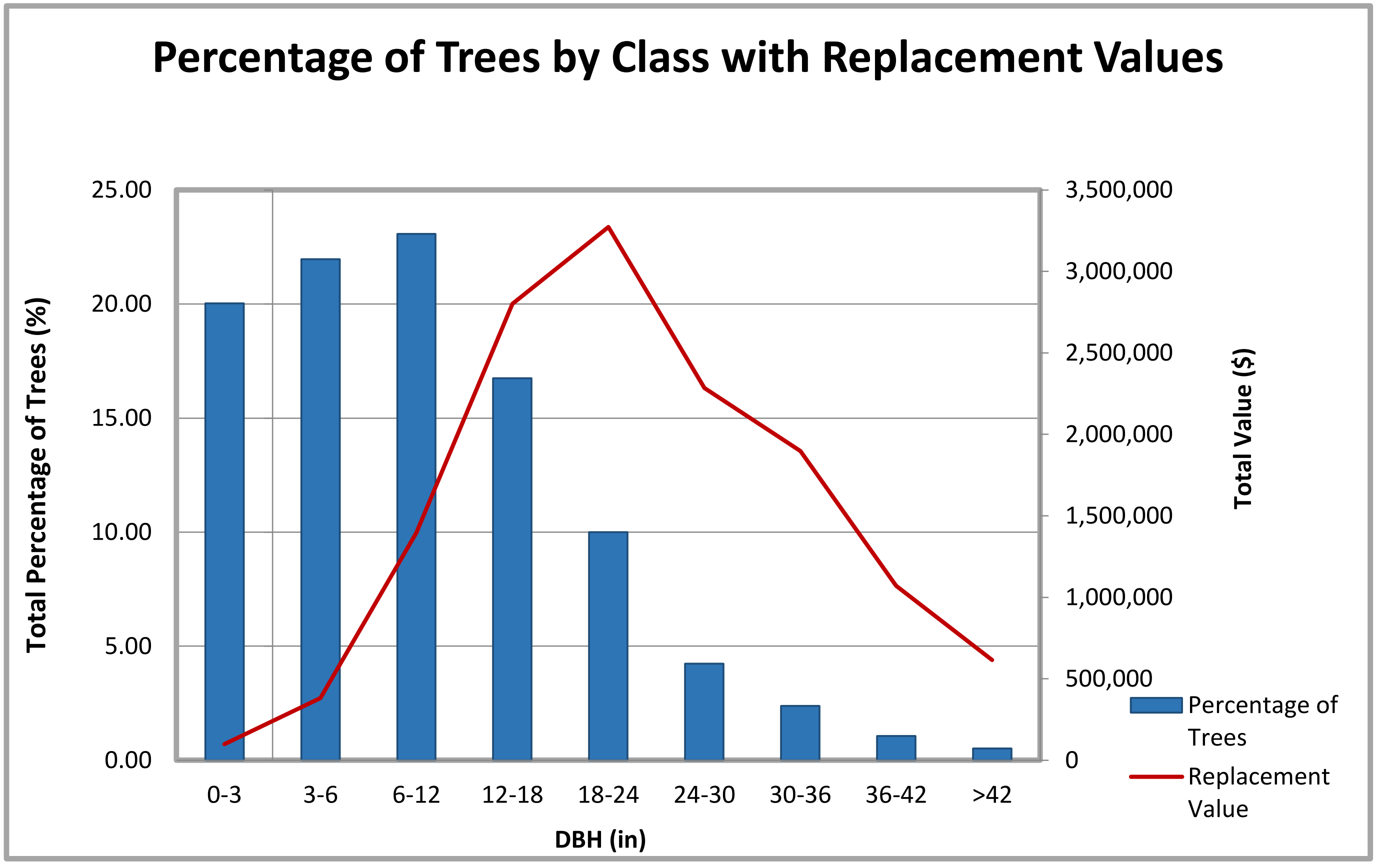
Figure 2.

Replacement values

A replacement value is an estimate of the full cost of replacing a tree at its current size and condition, should it be removed. Replacement Value is a basic replacement price from the state of Oregon *Council of Tree and Landscape Appraisers Guide for Plant Appraisal*. The value is calculated by multiplying the trunk area and species factor (0-1) to determine a tree's basic value. The minimum basic value for a tree prior to species adjustment was set at $150. Within the SoMa EcoDistrict a summary of replacement value can seen on the red line.

While it appears that trees over 24 inches in diameter decrease in value, that assumption would be incorrect. If we look at the same graph while also considering the percentage of SoMa trees by class size we see the real story below.

Here we can see that the reason the replacement value of trees appears to decrease for larger trees is because there are fewer trees over 24 inches in diameter then under. Therefore, although the value per tree is greater for larger trees, the significant number of small trees creates a gross value that is larger than that of larger class sizes containing few trees.



VOCs

Several of the trees genreas identified in this inventory are emitters of Volatile Organic Compounds (VOC's). Of all the tree genera the highest emitting species include: sweetgum (Liquidambar spp.), black gum (Nyssa spp.), sycamore (Platanus spp.), poplar (Populus spp.), oak (Quercus spp.), black locust (Robinia spp.), and willow (Salix spp.)(D.N., 2012)

VOC compounds have been noted by the EPA as having damaging effects to human health as well as contributing to an overall "heat island" effect in and around their location. Further, these emissions are always in higher concentrations indoors in some instances these compounds can reach concentrations 10 times that of what is found outdoors (EPA, 2016), meaning the effects of these compounds are felt by those living within a close proximity to large stands of these trees.

These species emit isoprene (among other) compounds which aid in the creation of ozone (O_3) as well as carbon monoxide (CO). These two gases in large quantities are known to have an adverse or damaging effect to their ground level surroundings. CO in addition to being a greenhouse gas also has a poisonous effect in elevated concentrations. Though, these levels need to be somewhat high (at least 667 ppm) one has to remember that these emissions are always higher in concentration when comparing indoor levels to outdoor levels. Ozone (O_3) is another of the emitted compounds which has detrimental effects to surrounding animals but also detrimental effects on plant life. In animals elevated O_3 concentrations damages respiratory tissue and acts as an even more aggressive oxidizer than atmospheric oxygen (O_2). The effects on plants is leaf tissue damage known as stipples. Stipples are black or purplish spots which appear on the leaf surface (Davis, 2007). These spots effectively reduce overall plant vigor by reducing photosynthetic capacity. In addition, elevated O_3 concentrations increases production of CO and CH_4 each of which act as a greenhouse gas. CH_4 more so than CO or even CO_2 (D.N., 2012).

It should be noted that VOC emission becomes more pronounced when these trees are subjected to greater heat stresses. Planting more trees in localized areas increases rates of evapotranspiration thereby decreasing heat effects

If removal of targeted VOC emitters is not feasible it would be recommended to plant tree species which help mitigate some of these compounds. For example species such as Mulberry (Morus spp.), Cherry (Prunus spp.), Linden (Tilia spp.) and honey locust (Gleditsia sp.) actively reduce VOC concentrations, by degrading, O_3 within the local environment. Since O_3 is linked to the formation of CO we can effectively reduce the concentration of both of these compounds in the atmosphere by limiting the concentration of O_3. In areas where these trees are in higher abundance concentrations of these compounds dramatically increase.

Heat Islands

Heat islands are areas within cities which absorb and retain excessive amounts of solar radiation, this heat is then slowly dissipated to the surrounding environment. These areas artificially prolong and exacerbate the effects of disseminating heat throughout the course of the day. These areas are made more pronounced with the presence of certain compounds which are known to alter the radiative properties of the surrounding atmosphere. These compounds, such as CO, CO_2, and CH_4, all act to retain heat in a given area. The absence of foliage further exacerbates these heat "island" effects by not absorbing solar radiation or other organic compounds. In addition to not absorbing these compounds (namely CO_2), the absence of foliage necessarily decreases evapotranspiration which is a key part of this equation because of the added cooling effect of H_2O. H_2O has an incredibly large heat capacity making it an essential component in reducing or maintaining temperatures on a large scale.

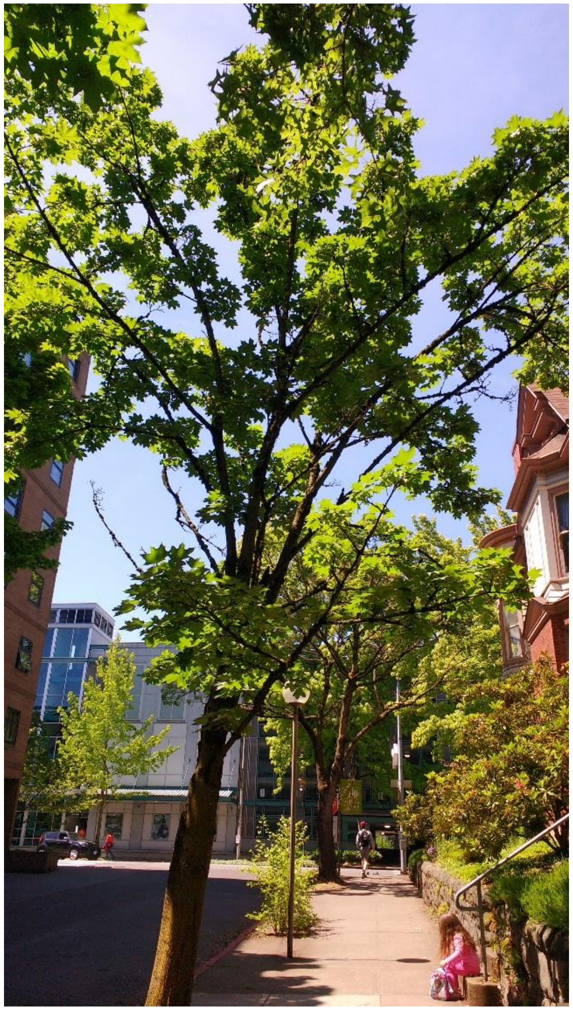
Increasing the population of tree species that reduce O_3 concentrations not only adds foliage (which will increase evapotranspiration) but also increases the amount of O_3 degraded locally, thereby decreasing the production of CO and reduces the available CO_2 retained in the atmosphere.

It quickly becomes evident that VOCs intensify heat islands and that heat islands increases the VOC production in trees. This situation is a positive feedback cycle where in every turn of the cycle each component piece becomes more pronounced. Consideration of these concepts is integral to future planning in the SoMa EcoDistrict.

TREE PLAN

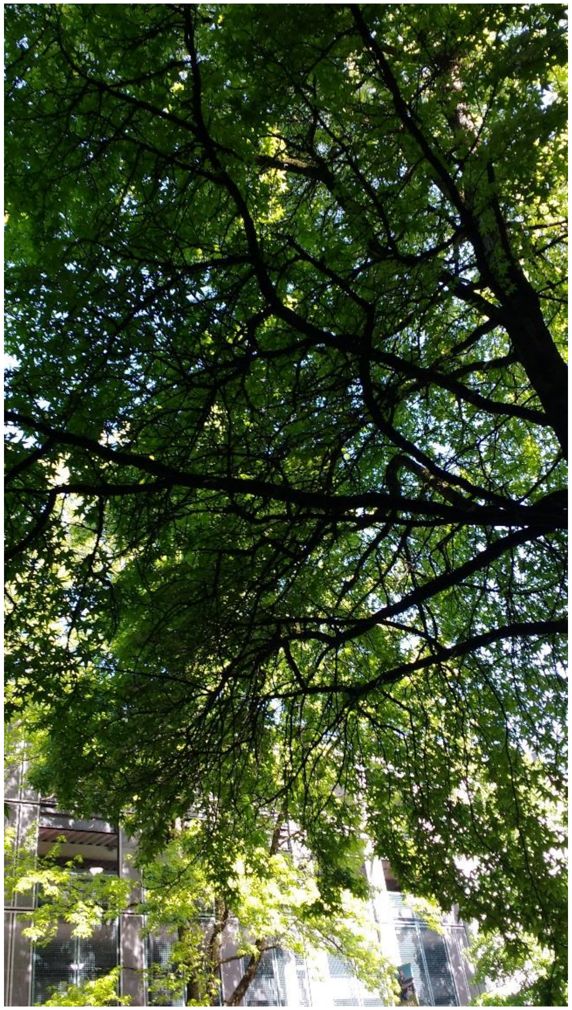
Overall Goals

- Focus on increased species diversity in and around SoMa Ecodistrict
  - Prioritize native species in an effort to restore historic habitat and biodiversity
- Preserve the integrity of existing trees
- Identify potential 'New natives'
  - drought tolerant species which are resistant to the effects of climate change
  - increasing diversity
  - focus on what works here
- Prioritize building and expanding canopy cover
  - Significant in size
  - Zero loss in canopy
- Continuation of research and outreach
- Future Capstone courses
  - Further education and interest in tree communities
  - Use class as a tool for future research, inventories, recommendations
  - Organize community event(s) focused on maintenance, identification, urban canopy tour, etc.
  - Seasonal projects
- Active experimentation
  - i.e. Identify suitable species for highway corridor noise and pollution barriers



Short Term Goals

- Identify areas within the district whose current use is less than optimal (i.e. grassy areas, surface parking lots)
    - Encourage the incorporation of trees into new development sites
- Establish high priority areas where tree abundance or quality is lacking
    - Promote use of large trees
    - Identify trees in poor condition to organize their replacement
    - High VOC emitting trees that are small can either be relocated or removed completely
- Freeway/heat island criteria
    - Determine species that are useful as a sound/VOC barrier
        - Conifers
        - Species with robust growth patterns
        - Low VOC producers
        - Species that mitigate VOCs
        - Resilience
        - Less 'native' focus
    - Multiple species and heights
    - Active experimentation on what works best in these corridors
- Education
- Identify trees suitable for heritage status, encourage landowners to apply



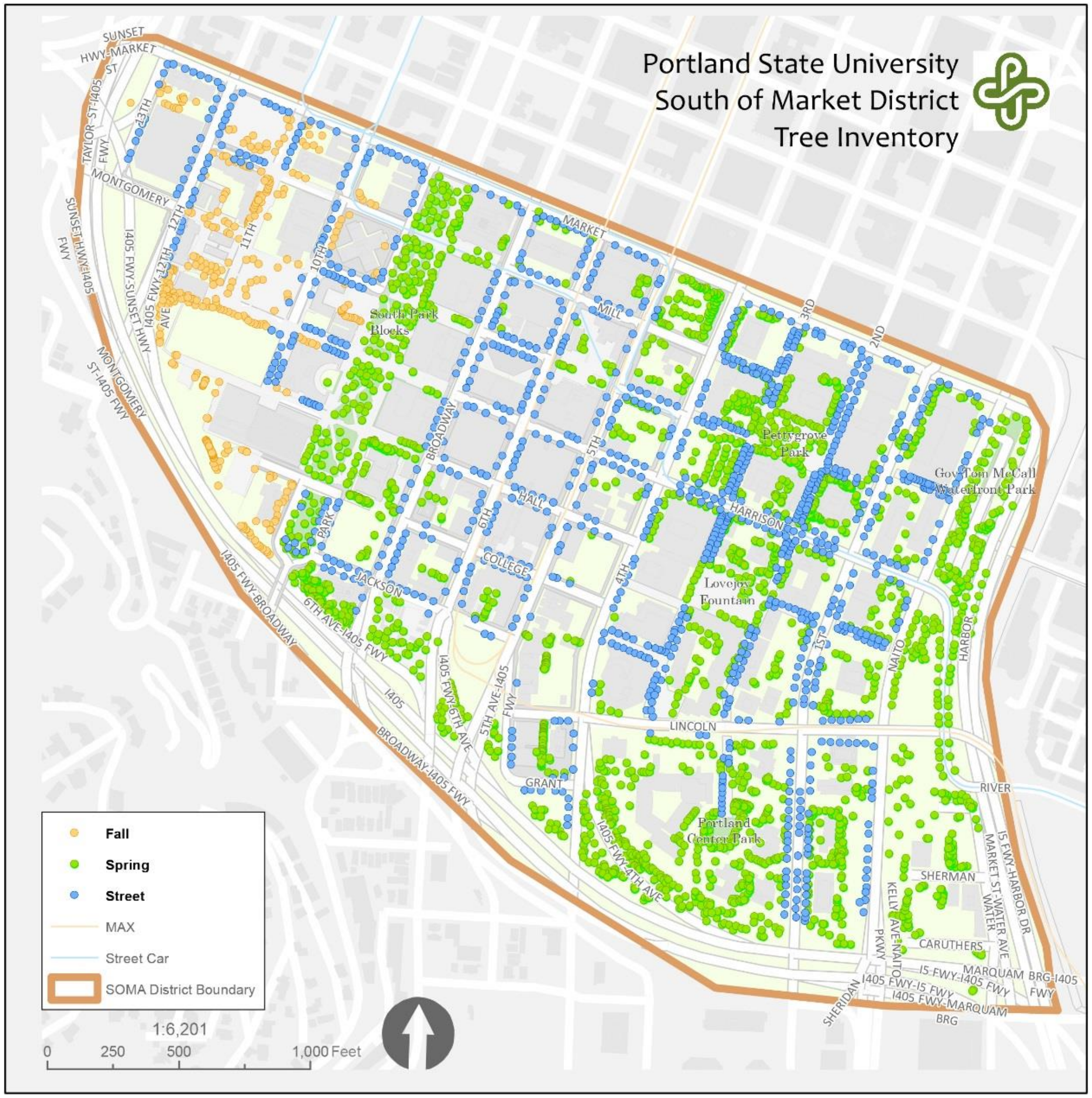
Long Term Goals

- Habitat connectivity: increase and connect wildlife corridors in an effort to foster more diverse fauna to pass through these areas
  - Island biogeography principles
  - Connectivity to forest park
  - Future plans should consider these principles
- Double amount of trees above 36 inches
  - Currently 53; goal of 106
  - Heat island analysis/pollution corridor
- Lobbying for inner city environmental laws
  - Improve tree code
  - Local focus
  - Educate PSU community
  - Capstone to support canopy cover
  - Identify potential corporate sponsors for future projects

APPENDIX

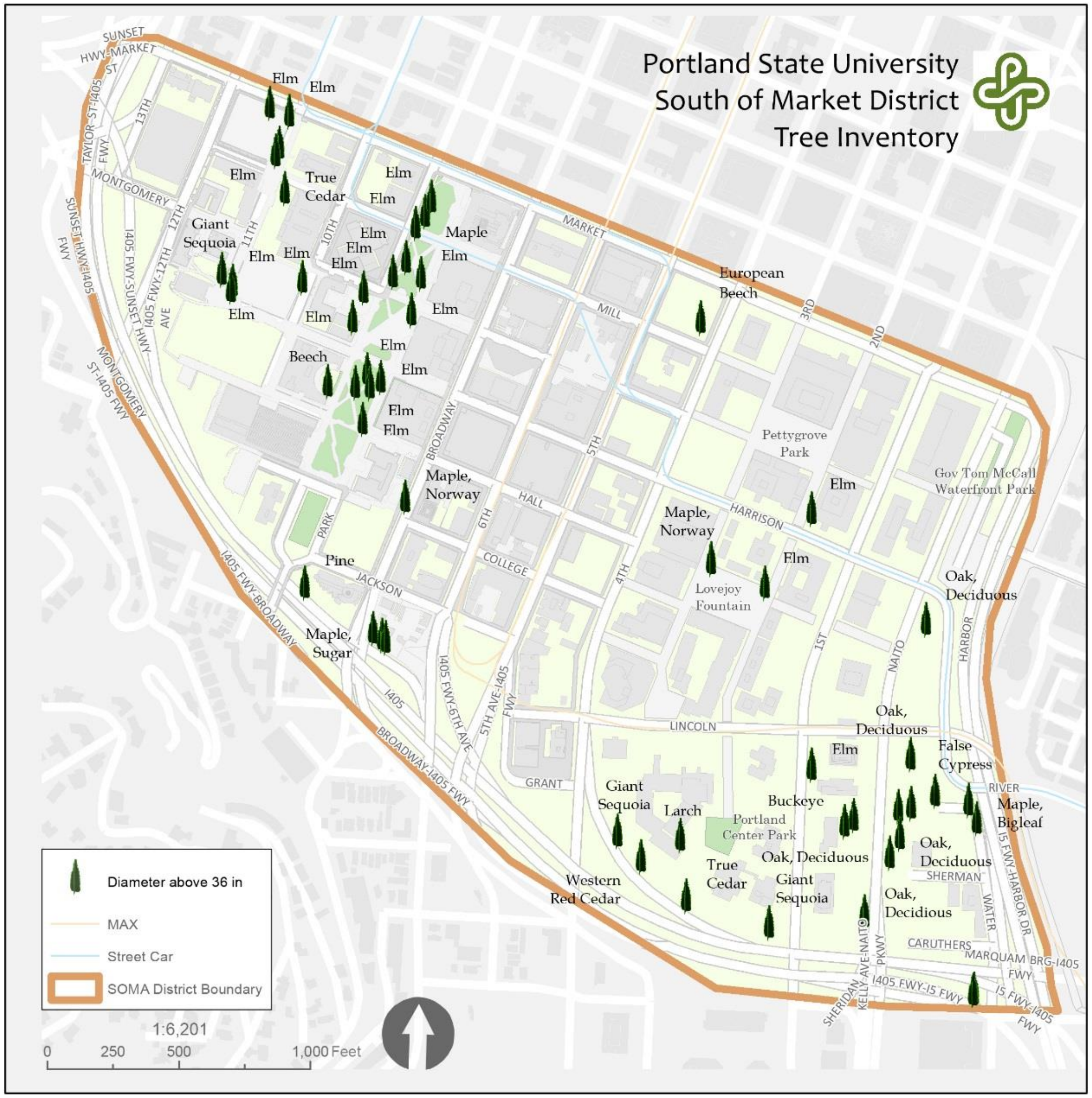
Total Tree Inventory

This is a map of all 3,689 trees inventoried within the SoMa EcoDistrict. The colors represent who was responsible for inventorying which trees. The blue dots represent The Portland Street Tree Inventory that was done by volunteers in 2013. The orange dots represents the efforts of Portland State University students during the Fall term of 2015. The green dots represent the efforts of PSU students during the Spring term of 2016.



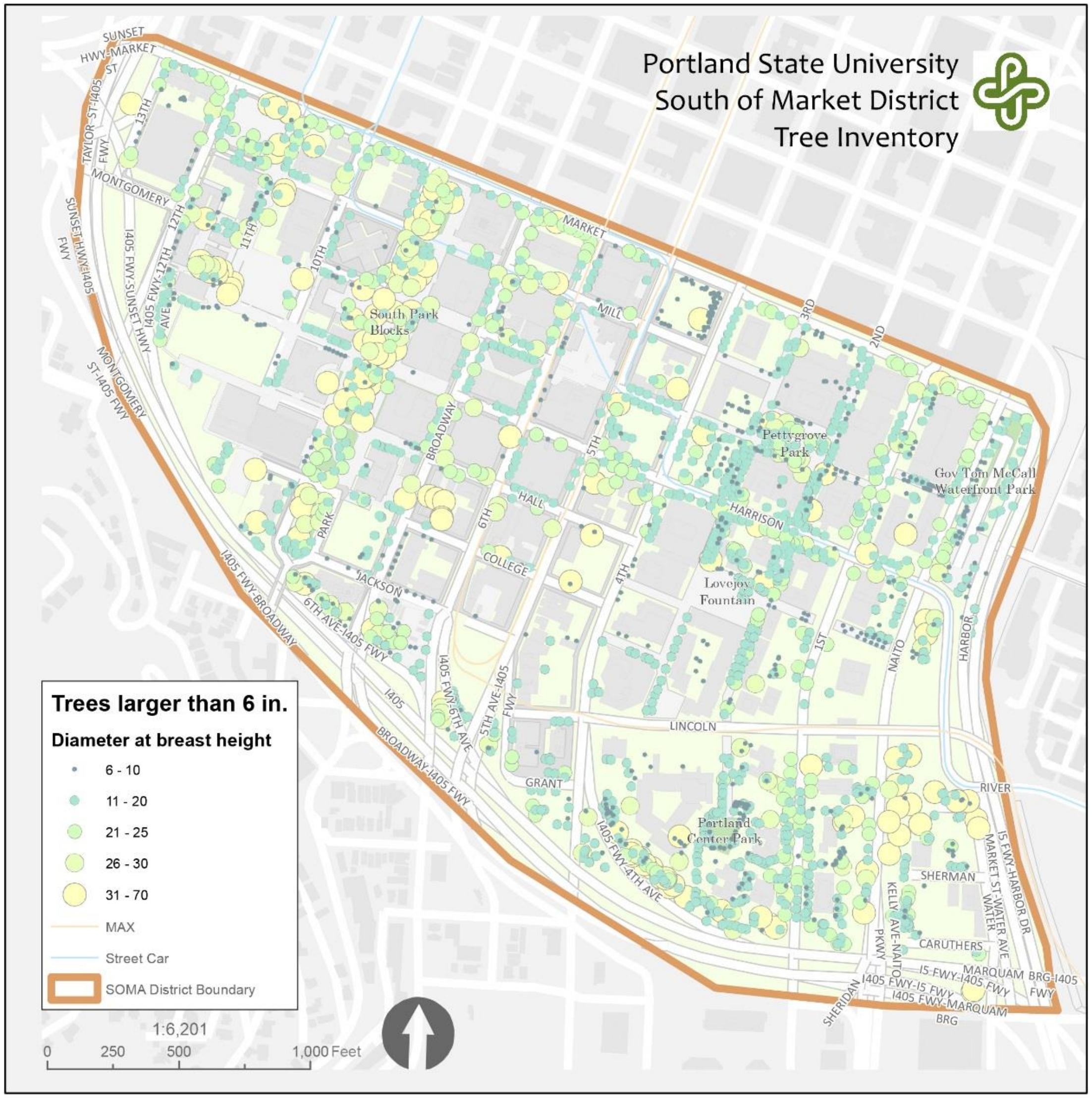
Trees with a DBH above 36 inches

Out of the 3,689 trees inventoried, this map shows the locations of the largest tree: those that have a diameter at breast height (DBH) of 36 inches or greater. Each tree is also identified by genus and species, where available. These are considered to be highly significant trees. There are 53 trees in the SoMa EcoDistrict with a DBH of 36 inches or greater. These may qualify as heritage trees.



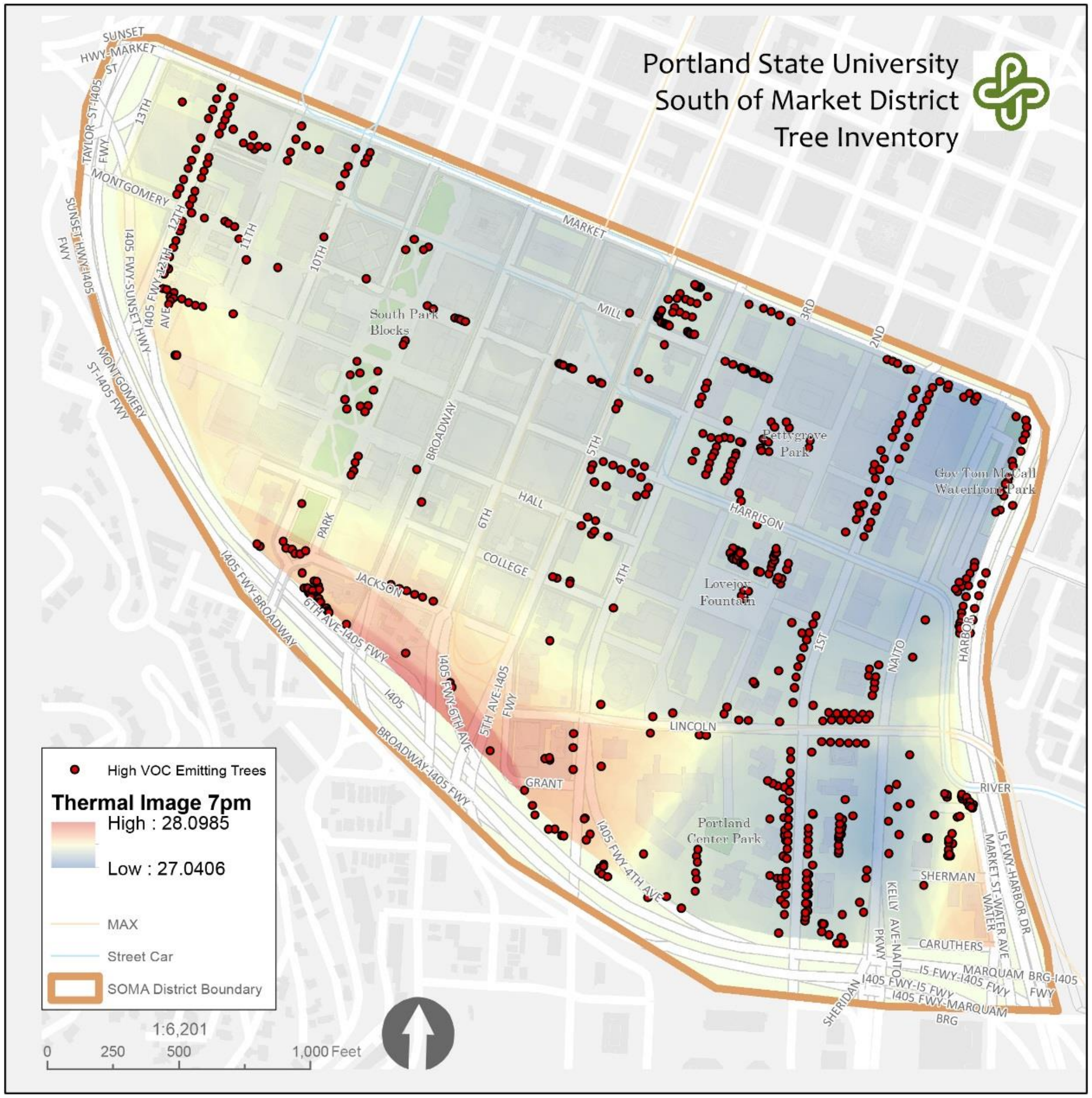
Trees with DBH 6 inches or Larger

This map shows the locations and representative size of all the trees that were inventoried with a diameter at breast height (DBH) of 6 inches and above. Instead of mapping all trees inventoried, a map was produced showing trees larger than 6 inches in DBH, which have a significant environmental impact. This distinction eliminates background noise and allows a more concise image of the tree canopy within the SoMa EcoDistrict.



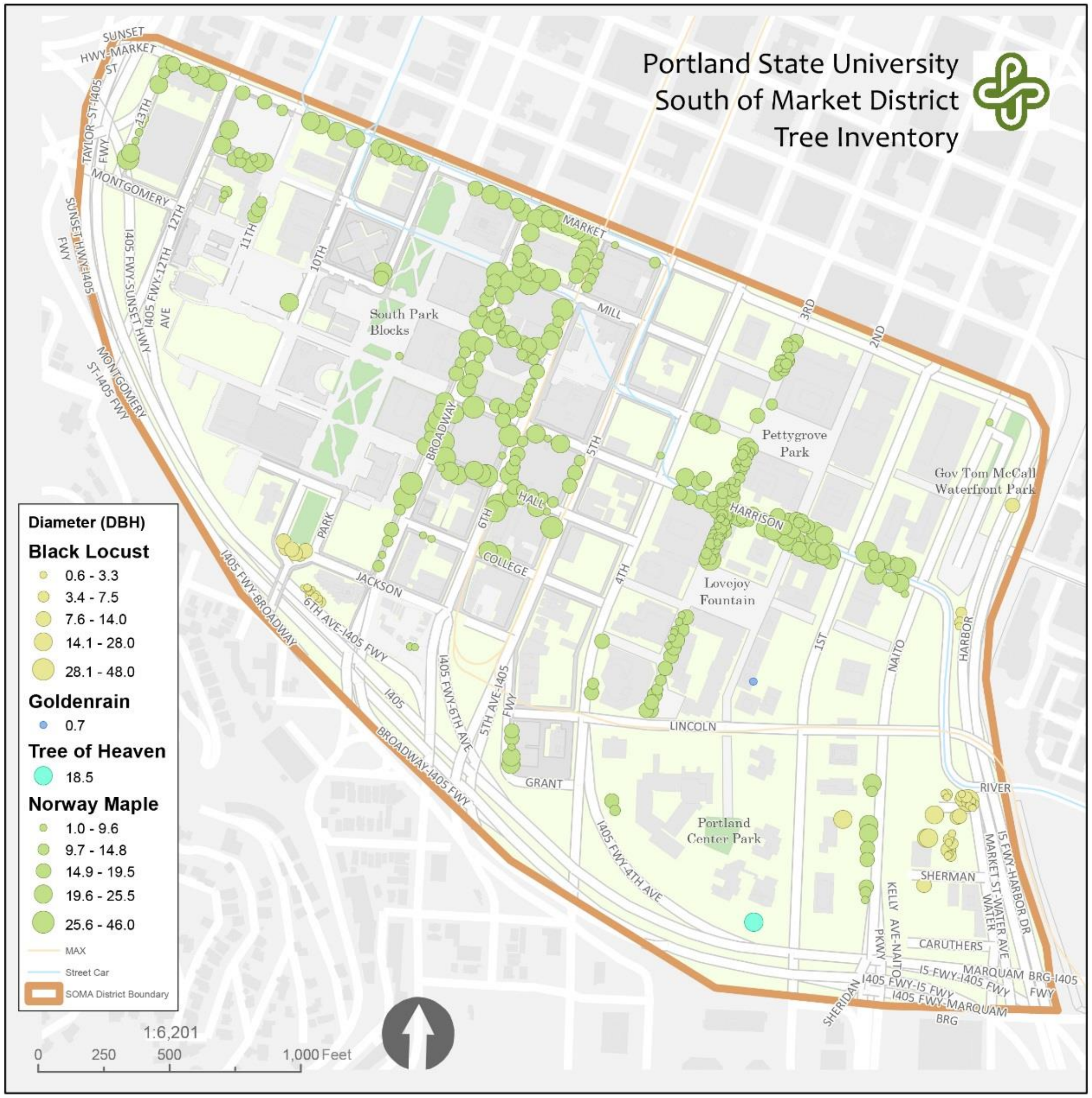
High VOC Emitting Trees and Heat Island Effect

This map is a thermal image of air temperature (° Celsius) at 7pm, with within the SoMa EcoDistrict. Overlaid is a map of high VOC emitting trees that were inventoried. This map shows the impact that high VOC trees upon the heat island created by the freeway, expanding it out away from the Freeway proper. High VOC producing trees cause greater health risks in areas of high heat. Though the temper variance appears small it is still quite significant. We utilized a list of 22 species that are high VOC producers, as defined by David J. Nowak. The heat island layer is courtesy of Jackson Voelkel and Dr. Vivek Shandas.



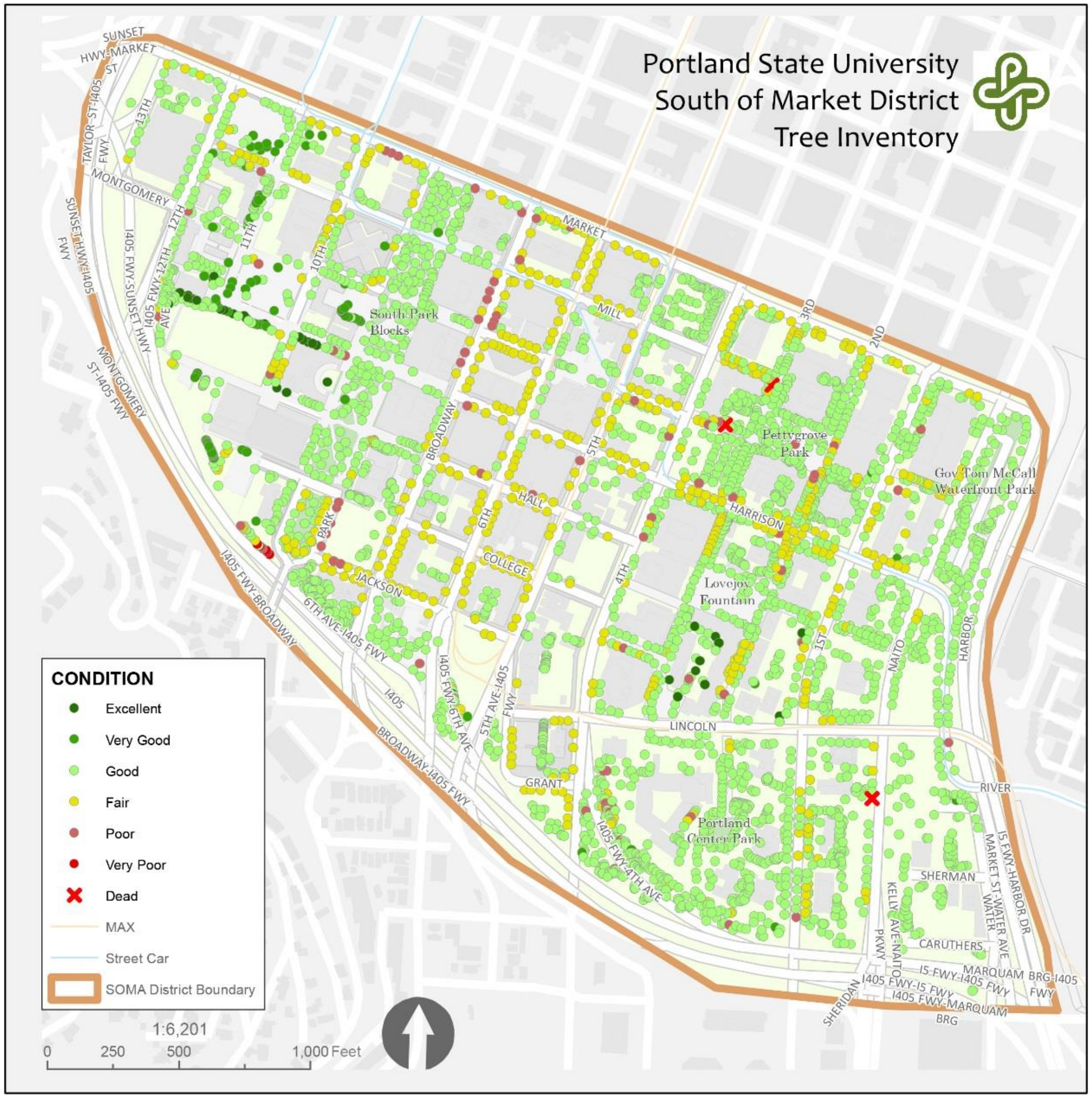
Invasive Trees with DBH

According to the City of Portland, invasive species are "Species that spread at such a rate that they cause harm to human health, the environment, and/or the economy." In natural areas, invasive plants are those species that displace native plants and become the dominant species in that vegetation layer. Invasive plants can halt successional processes by limiting the establishment and the growth patterns of native species. They can deprive native invertebrates of food sources, disrupting the food chain for native wildlife." For the purposes of this map the species considered invasive are *Acer platanoides, Ailanthus altissima, Koelreuteria paniculata,* and *Robinia pseudoacacia*.



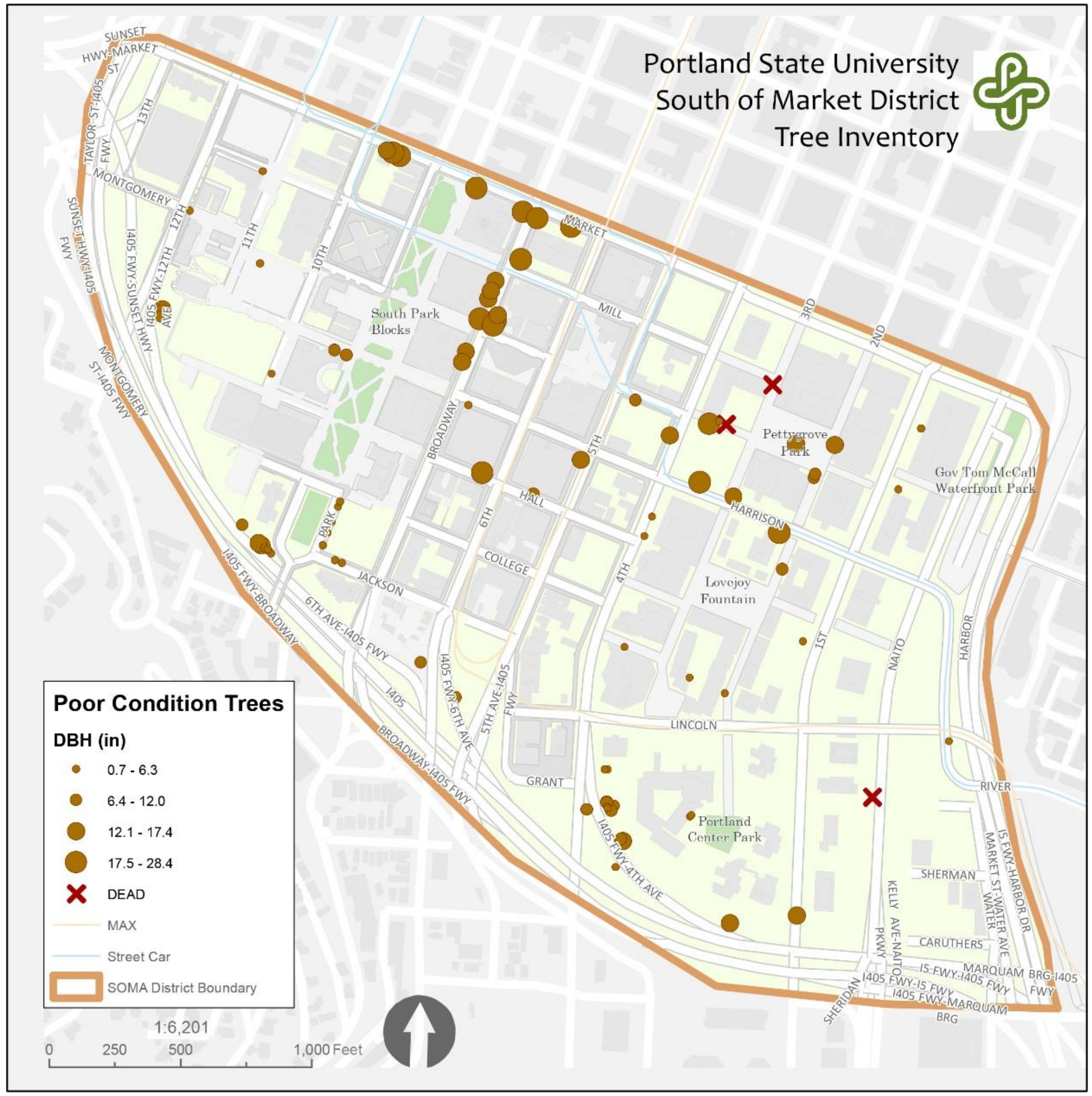
Total Tree Condition

This map utilizes color-coded dots to indicate the identified condition of each tree inventoried within the SoMa EcoDistrict. The Portland Street Tree inventory personnel and the Portland State University students defaulted to different conditions, with a majority of the PST trees tending towards ‘fair condition’ while the PSU students used ‘good condition’ as a baseline. Given that these designations are subjective the difference between good and fair trees can be considered minimal.



Trees in Poor Condition with DBH

This map shows the approximate size of all of the trees in the SoMa EcoDistrict that are considered to be in poor health as well as the location of inventoried dead trees. Of concern is the T-shaped area of trees along Market and Broadway that has a significant number of larger trees in poor condition clustered in a small area. Investigations should be considered to attempt to identify the cause, and rectify the situation, as the loss of these trees would represent a significant impact to the tree canopy in that area.

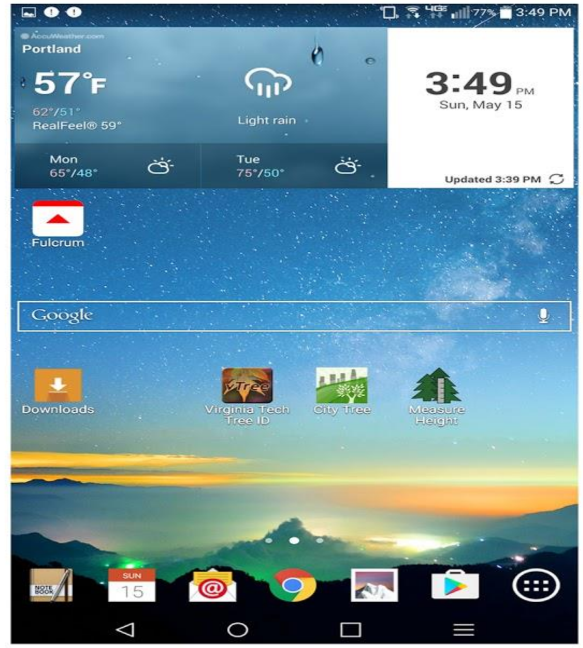


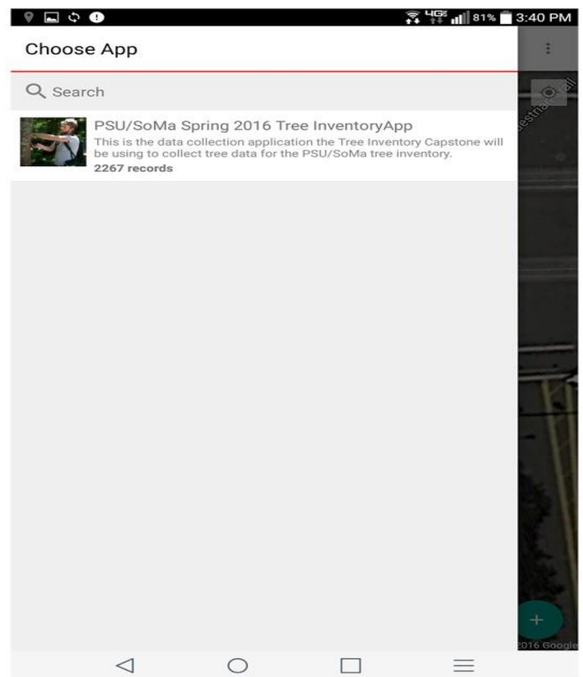
Fulcrum App

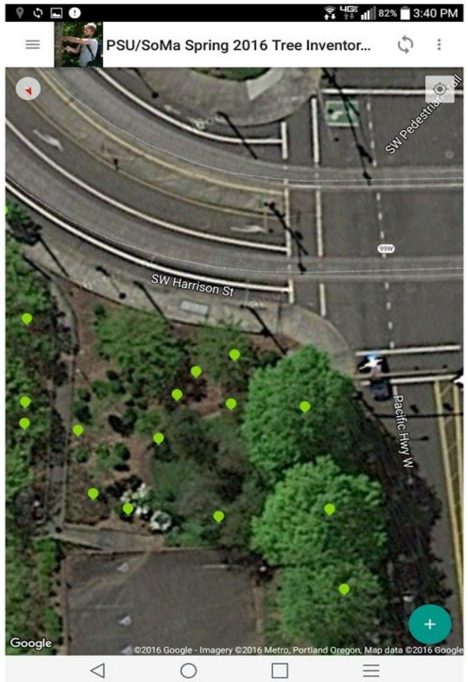
1. The fulcrum app as it appears on the tablet homescreen

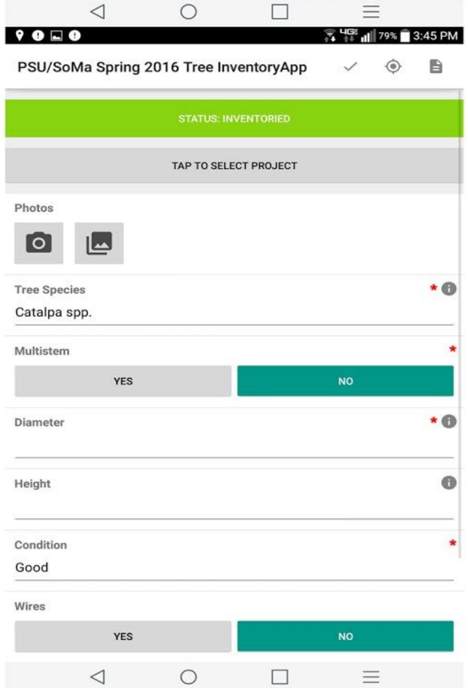
2. Upon opening the Fulcrum app the user is presented with a login screen

3. Once logged in the user selects their active project



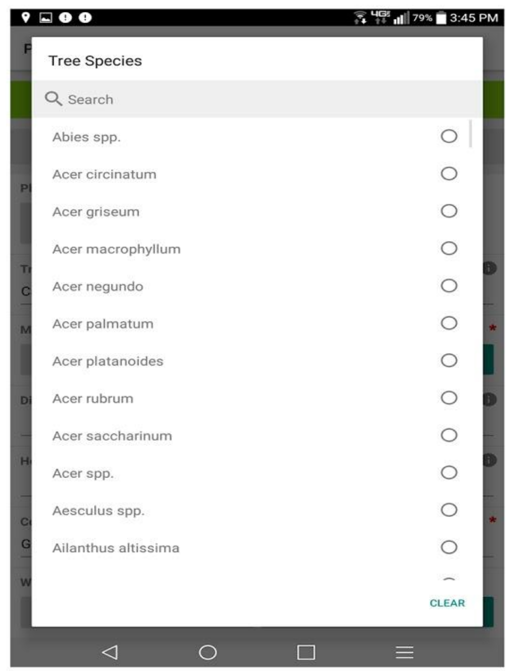


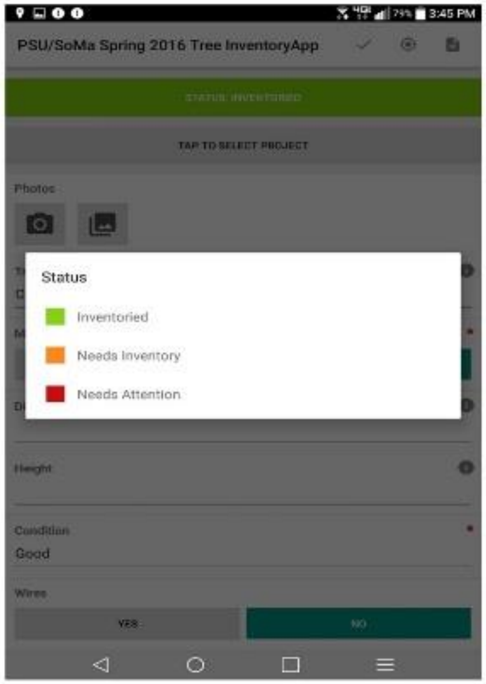


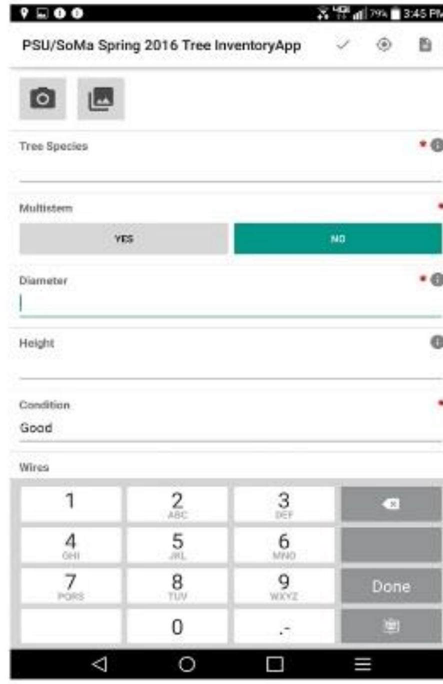


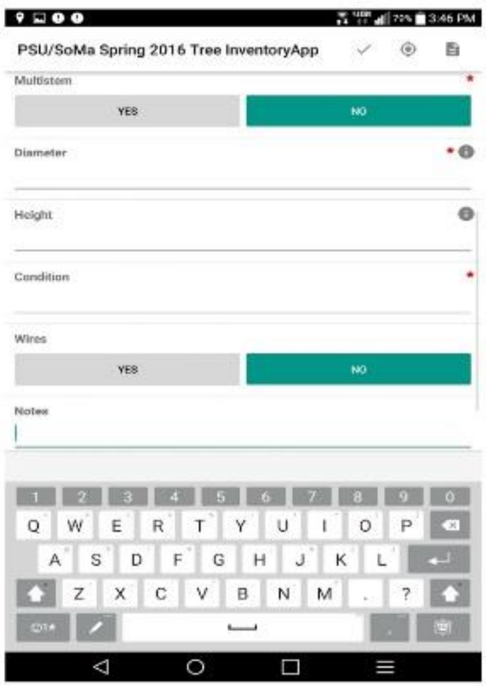
4. Once our team identified a tree which needs to be added to the inventory it is entered into fulcrum by pressing 

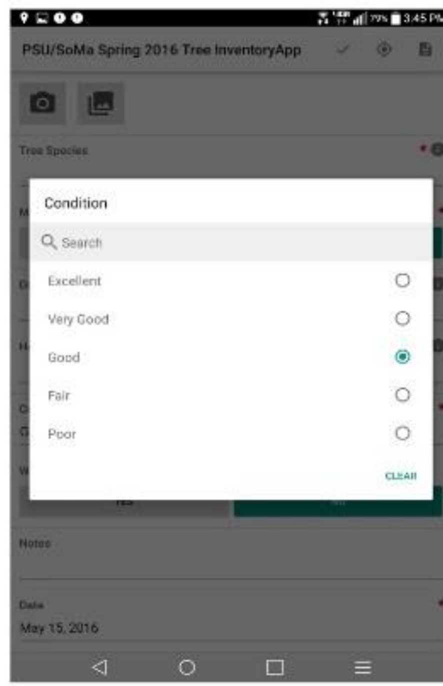
5. The tree species is selected and information pertaining to the tree recorded and saved within the app.











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