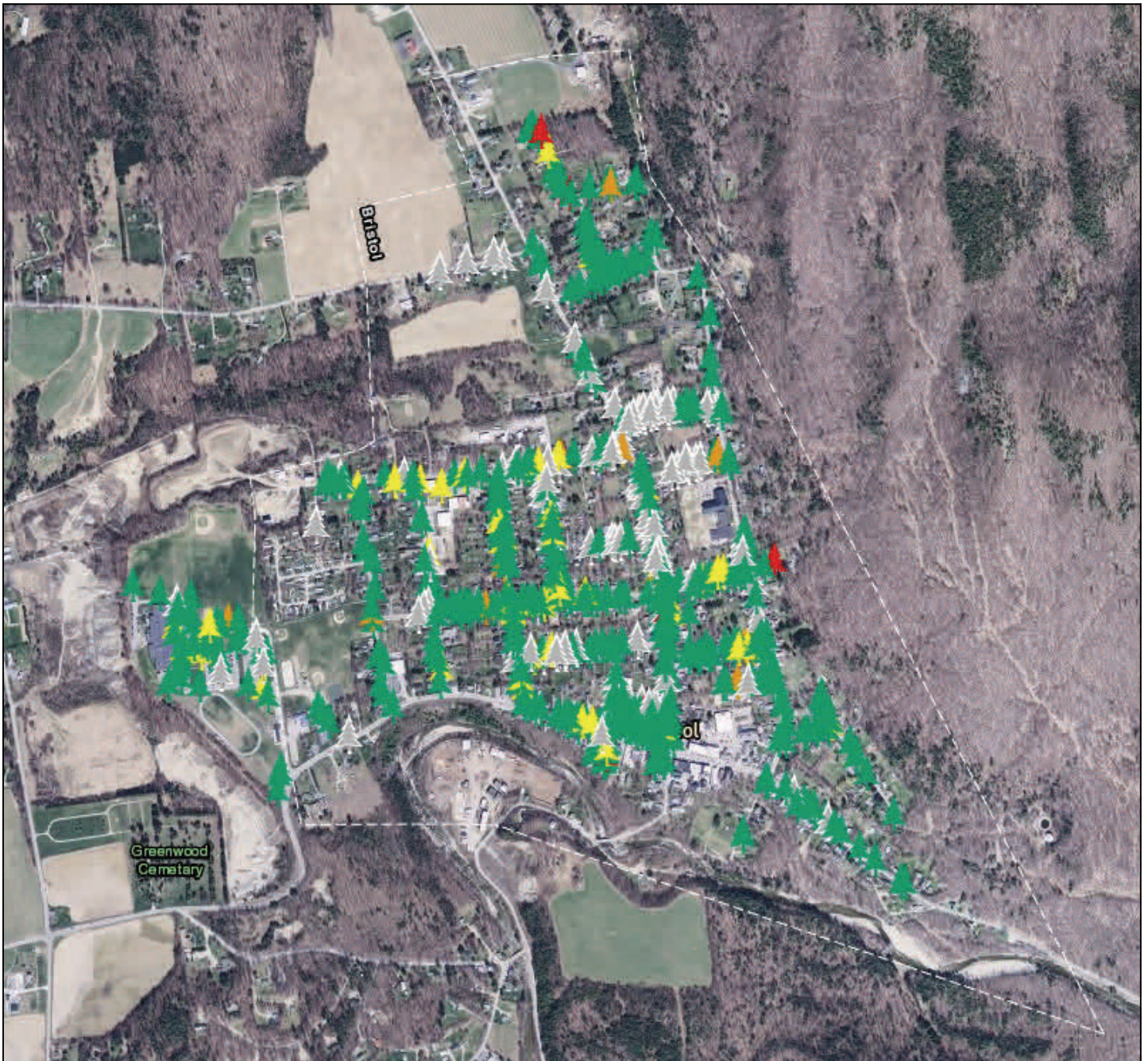


Bristol Public Tree Inventory Report



*Prepared for the Town of Bristol by the Vermont Urban & Community Forestry Program and the University of Vermont Land Stewardship Program
January 2015*



Acknowledgements

This report was developed by four students from the Land Stewardship (LANDS) Field Semester program and subsequently edited and supplemented by Vermont Urban & Community Forestry Program (VT UCF) staff based on field work conducted for the Town of Bristol, Vermont during the fall of 2014. We would like to thank the members of the Bristol Conservation Commission for providing direction and context, particularly Randy Durand and Dave Rosen, the main contacts for the project. We would also like to thank the Bristol Historical Society for hosting the inventory team for lunch, Darla Senecal for her hospitality and support, and Therese Kirby for sharing key information about the Town of Bristol's engagement with its trees. Finally, we would like to thank the Town of Bristol for allowing the LANDS Field Semester students to camp at Eagle Park for the duration of the inventory data collection component of this project.

About the Vermont Urban & Community Forestry Program

The field of forestry management is not confined to the natural areas and forests of Vermont, but extends to the urban and rural spaces where trees play important roles. The trees in public parks, along roadsides, on town greens, and in municipal forests compose our urban and community forests and merit careful stewardship. The Vermont Urban & Community Forestry Program (VT UCF) is a collaborative effort between the Vermont Department of Forests, Parks, & Recreation, the University of Vermont (UVM) Extension, and the USDA Forest Service. The program provides technical and financial assistance as well as educational programs and resources for the management of trees and forests in and around Vermont communities. The mission of VT UCF is *to lead citizens, businesses, and governments in understanding the value of urban and community forests and promote civic responsibility for and participation in the stewardship of these resources for this and future generations*. Since 1991, the program has been guided by a small staff and a twenty-member advisory council. The council meets quarterly to share information and advise the program; its members come from various professional associations, non-profits, educational institutions, tree boards, regional officials, and state agencies.

The trees in our communities offer a wide variety of environmental, social, and economic benefits to the surrounding community, including, but not limited to stormwater control, carbon dioxide (CO₂) sequestration, and aesthetic value. VT UCF seeks to maximize these benefits by working with state and municipal officials and dedicated volunteers to steward the urban forest's ecological integrity and diversity. VT UCF's programming and support reaches 100 Vermont communities annually. More information about VT UCF and its programming can be found at www.vtcommunityforestry.org.

About LANDS

LANDS is an innovative college conservation corps established in 2007 through a partnership between the University of Vermont's Rubenstein School of Environment and Natural Resources (RSENR) and the Student Conservation Association (SCA). Through a summer internship program and a fall field semester, LANDS students work as a crew to provide valuable field and planning support to land management agencies throughout Vermont. At the same time, they learn how to solve complex environmental problems, strengthen their understanding of ecology and conservation, and develop professional skills that prepare them for successful careers.

LANDS students enter the program with college-level educational backgrounds in environmental fields, enabling them to tackle advanced projects not usually associated with conservation corps. Students further prepare for their work through intensive training provided by natural resources professionals and University faculty. Projects focus on natural resource inventory and assessment, monitoring, management planning, GIS mapping, hands-on conservation activities, public presentations, and community engagement.

LANDS provides affordable services and high-quality products for municipalities, land trusts, state agencies, national forests and parks, and volunteer-managed conservation organizations. The program also benefits Vermonters by collaborating with the University and local

communities, and enabling partnering organizations to share their missions and increase their visibility among the next generation of conservation leaders. Since its inception in 2007, 84 LANDS students have conducted 102 projects and service activities for 33 conservation partners. LANDS provides much-needed support to conservation organizations in Vermont while creating a knowledgeable, highly skilled cohort of professionals poised to become the future stewards of our land and resources.



Students in the fall 2014 LANDS Field Semester inventoried public trees in Bristol, Middlebury, and Vergennes. From the far left, Shannon Scarbrough, James Pospishil, Grant Troester, and Julienna Brooks made up the Bristol inventory team.

Table of Contents

Acknowledgements	i
About the Vermont Urban & Community Forestry Program	i
About LANDS.....	ii
Executive Summary	1
Summary of findings	2
Summary of recommendations.....	3
Introduction	5
Project Description.....	5
Methodology	6
Inventory Results	9
Urban Forest Diversity.....	9
Urban Forest Structure	11
Urban Forest Health	13
Monetary Value and Ecosystem Services.....	14
Bristol Full Canopy Assessment.....	18
Discussion and Recommendations	20
Urban Forest Diversity and Structure	20
Maintenance.....	22
Urban Forest Health	23
Assessment Tools	24
Conclusion.....	25
Literature Cited	27
Appendix A: Full Street and Site List for the Bristol Inventory.....	28
Appendix B: Full Species List for Bristol’s Public Trees	29
Appendix C: Instructions for Accessing Public Tree Data in ANR Atlas.....	31
Appendix D: Maps	32

Executive Summary

The goal of the public tree inventory was to *document the location, size, species composition, and condition of trees planted within the public right-of-way (ROW) and on town-owned land within the downtown and most populated neighborhoods of the Town of Bristol*. This information provides residents and decisions-makers with a better understanding of the composition, health, and benefits of Bristol's urban forest and will allow the Bristol Conservation Commission (BCC) to plan for future tree planting and maintenance using a map-based tree inventory system.

This project was initiated in the spring of 2014, was coordinated with the members of the BCC, and was approved by the Bristol Selectboard. LANDS students completed an inventory of **562 trees** located within the public ROW of **26 streets** and on **3 town-owned properties**, and identified **106 potential tree planting locations**. Staff from VT UCF provided technical assistance in data collection, tree species identification, and data analysis. This report was prepared in the fall of 2014 by LANDS interns and was subsequently edited and supplemented by VT UCF program staff. It presents the results of an inventory and provides a basic assessment of the trees and urban canopy cover in Bristol.

Local government, conservation agencies, and private landowners all play an important role in monitoring and maintaining urban forests. Urban trees provide a number of benefits to a community, including reducing storm water runoff, reducing air pollution, providing shade, sequestering carbon dioxide, enhancing property values, and improving the aesthetics of the community. The 562 public trees that were inventoried provide an estimated **\$65,365 in benefits annually** to the residents of Bristol. In addition to the public trees inventoried, an aerial tree canopy assessment was completed for the specific area inventoried, which indicated an existing canopy cover of 24.5% and an estimated long-term **stored CO₂ value of over \$174,000**.

Summary of findings

Forest Diversity

- Of the 562 public trees, there were 46 different species in 25 different genera identified.
- The top five most common tree genera represented are *Acer* (maple) at 48%, *Fraxinus* (ash) at 6%, and *Picea* (spruce), *Malus* (crabapple), and *Gleditsia* (honeylocust) at 5% each.
- *Acer* and *Fraxinus* species represent 54% percent of Bristol's public trees. Invasive tree pests currently threaten both of these genera: the Asian longhorned beetle (ALB) and the emerald ash borer (EAB), respectively.
- The top five most common species represented are *Acer saccharum* (sugar maple) at 21%, *Acer platanoides* (Norway maple) at 10%, *Acer rubrum* (red maple) at 6%, *Malus* sp. (crabapple) at 5%, and *Gleditsia triacanthos* (honeylocust) at 5%.

Forest structure

- The majority of inventoried public trees (61%) have diameter at breast height (DBH) measurements of 6-18". 32% of inventoried public trees have a DBH within the 6-12" size class and 29% of the inventoried trees have DBH measurements in the 12-18" size class.
- The remaining 39% of inventoried trees were represented in the following size categories: 0-3" (8%), 3-6" (9%), 18-24" (11%), 24-30" (7%), 30-36" (2%), 36-42" (1%), and 42"+ (1%).

Forest Cover

- There is estimated existing urban tree canopy (UTC) cover of 24.5% in the 0.58mi² inventory area. This includes public and private trees.
- Trees could potentially cover an additional 65.4% of the Bristol's land surface; these "possible UTC" areas include low-lying vegetation (47%) and impervious surfaces (18%) (e.g. parking lots, paved playgrounds, and the ROW).

- The remaining 10.1% of the Town’s area is comprised of buildings, streets, and other permanent features that are generally unsuited for UTC improvement.

Forest health

- An overwhelming majority (88% or 493) of Bristol’s inventoried public trees was assessed as being in “Good” condition. Of the remaining trees, 9% (51) were considered to be in “Fair” condition, 2% (12) were considered to be in “Poor” condition, and 1% (6) were found to be “Dead”.
- 44 public trees were flagged as in need of a future consultation by an arborist, town employee, or representative from the Bristol Conservation Commission.

Summary of recommendations

We recommend that the Town of Bristol work on continuing to *increase the diversity* of tree species to ensure the long-term health of individual trees and Bristol’s complete urban forest. Plant a variety of species instead of high-density stands of the same species whose close proximity may be conducive to the spreading of disease and pests. Plant native trees with high survivability rates, pollution tolerance, salt tolerance, and long life spans.

Monitor tree health, specifically for signs and symptoms of EAB, ALB, and other forest pests and diseases. Encourage citizens to learn to identify and report invasive pests.

Maintain tree health by ensuring that those who are caring for Bristol’s public trees are trained in best tree care practices.

Plan for the arrival of EAB by developing a community invasive pest preparedness and response plan.

Establish a routine systematic trimming cycle (multi-year) for all public trees to reduce future tree failures due to poor structure, minimize conflicts with people and infrastructure, improve lines of sight, reduce storm damage, and protect public safety.

Develop a comprehensive management and urban forest master plan based on this inventory report and build off the management plan created in conjunction with this document.

Fill vacant spots with native trees. Be sure to take into consideration obstructions such as proximity to power lines, impervious surface, pollution, and salt exposure when choosing species and planting space.

Communicate about the benefits of Bristol’s public trees at local events, and encourage participation in VT UCF educational programming such as the *Stewardship of the Urban Landscape* course and the *Forest Pest First Detectors* trainings.

Encourage residents to plant trees on their private property to increase overall UTC cover.

Consult trees in need of consult and *remove* dead trees, which could endanger property and/or residents.



Introduction

Project Description

VT UCF currently has a grant from the USDA Forest Service to assist twenty priority communities in Vermont in moving their forestry programs forward. The project, *Care of the Urban Forest*, is a multi-year effort that aims to support these communities in three specific ways: (1) conducting a public tree inventory to assess urban forest structure, diversity, and health; (2) helping the community in the development of an urban forest management plan (or master plan) using information from the inventory; and (3) providing technical training for volunteers and town employees to promote the proper care and management of public trees.

The Bristol Conservation Commission requested an urban tree inventory because the town has never had one. While Bristol has a volunteer tree warden, there is no paid arborist or professional group who maintains and plants trees. The intent of this inventory is to enable Bristol to better understand, steward, and manage public trees more efficiently and cost effectively. Benefits of urban forests, such as the improvement of air and water quality, and increased property value and aesthetics will be more profound when the town is able to manage and support healthy public trees. The mission statement of the Bristol Conservation Commission states that they aim “*to conserve Bristol’s natural and cultural heritage for present and future generations; raise public awareness of these resources; and provide opportunities for greater involvement by the community*”. A comprehensive tree inventory and subsequent management plan are crucial foundations to support this mission.

The goal of the public tree inventory was to document the location, size, species composition, and condition of trees planted within the public right-of-way (ROW) and on town-owned land within the downtown area of Bristol. Students from the LANDS Field Semester Program conducted a comprehensive public tree inventory over the course of three field days. This inventory establishes a baseline for future inventories, management decisions, and improvements to Bristol’s urban forest.

Town Profile

Bristol is a town in Addison County, Vermont with a population of 3,900 (in 2010) and an area of 42.2 square miles. At one point Bristol was home to the largest coffin factory in the country; the coffins were made from timber harvested around the area. Bristol's history is a product of how its citizens were able to make a living off of the natural resources of the area. Now, most businesses are located along Main Street with a beautiful mountainous backdrop.

Methodology

Prior to the public tree inventory, VT UCF staff met numerous times with the Bristol Conservation Commission to plan for the inventory. Originally, 26 streets in Bristol were chosen to be included in the inventory, as well as a number of priority town-owned properties. In total, the land area of the inventory was about 0.58 square miles, representing less than 1.3% of the total land area of Bristol, but including the most densely populated section of town. The ROW boundaries for all streets were provided by the Bristol Conservation Committee in consultation with town administration. The list of streets and sites with ROW boundaries is found in Appendix A and

Importance of Inventory and Urban Forestry in Vermont

An inventory of urban trees provides a record of the trees present in a community. An inventory can provide information about the species, size, health, and location of each tree and future management needs. This detailed information allows town planners to estimate the monetary contributions of their community's green infrastructure. In the event of a disease outbreak or insect infestation, data from an inventory may assist in monitoring and preventing the spread of a forest health epidemic. An inventory can also help build public support for expanding community forests and to guide future urban planning.

Urban trees improve the quality of life for Vermont communities in a variety of ways. The most readily apparent benefit is the aesthetic value that trees provide a street, home, or public space. Along with this beauty is the functional benefit of providing shade along the streets in the summertime and blocking wind to reduce heating costs in the wintertime. The presence of trees has been shown to positively affect property values (Morales 1973; 1983) and boosts foot traffic in commercial areas. Parks and tree-lined sidewalks promote physical activity by creating shaded, comfortable outdoor spaces. Many types of urban wildlife depend on trees as sources of food and shelter. Unseen environmental benefits of urban trees include improvements in air quality and temperature regulation through reduction of the heat island effect. Trees can mitigate noise pollution common in an urban environment and can clean and conserve water by controlling run-off. Additionally, urban forests create opportunities for environmental education, community engagement and in some instances can be related to crime reduction. Trees are an integral part of the green infrastructure of a community and contribute to keeping our families healthier and our everyday lives more fulfilling.

GIS maps of the inventoried trees are in Appendix D.

VT UCF has developed an inventory system in collaboration with the VT Agency of Natural Resources' (ANR) GIS team. The map-based inventory system uses the free application "Collector" by ArcGIS for data collection and is linked to the ANR Atlas online mapping tool. All inventory data collected on public trees in Bristol is available for viewing on the ANR Atlas tool and instructions are included in Appendix C.

On September 16-18, 2014, four LANDS semester students walked along predetermined streets and on town-owned sites in downtown Bristol, inventorying the public trees and identifying appropriate potential planting locations or green strips (recorded as "Vacant"). To ensure that only public trees were inventoried (as opposed to trees on private property) each team of students had a list of the ROW boundaries for each street. Their first step upon reaching a new street was to determine the extent of the ROW from the curb; the team measured the road width, subtracted that number from the full ROW boundary, and then divided the number in half to determine the ROW extent back the curb on each side of the street. The following equation demonstrates this process:

$$\text{ROW distance from curb} = (\text{ROW extent for specific road} - \text{road width})/2$$

Each public tree identified was recorded into the "Collector" application using an iPad, provided by VT UCF. "Collector" is map-based and uses GPS and a base layer map to allow the user to input information about a tree, linking it to a particular geographic location. Data recorded for each tree included condition, tree number, street name, species, diameter class (using a diameter at breast height, or DBH, measurement), consultation recommendation, comments, and nearest house or building number. In most cases, a picture was also taken of each tree or vacant (potential) tree location. A full list and description of the parameters used in data collection can be found in Table 1.

The data were compiled and subsequently analyzed and summarized using Microsoft Excel and ArcGIS. Data were also uploaded to i-Tree Streets in order to determine the monetary and ecological benefits of Bristol’s inventoried public trees. The LANDS students additionally performed a baseline full canopy cover assessment of Bristol, encompassing both private and public property, using i-Tree Canopy. i-Tree is a free software suite developed by the USDA Forest Service and is available at www.itreetools.org.

Table 1: Data collection parameters for the Bristol public tree inventory

Data Parameters	Description
Site ID	Street name or property name.
Tree Number	Count starts at 1 for each street/site. Unique to tree.
Species	Common name. Include in comments box if not listed.
Tree Condition	<ul style="list-style-type: none"> ● <i>Good</i>: full canopy (75-100%), no dieback of branches over 2” in diameter, no significant defects, minimal mechanical damage ● <i>Fair</i>: thinning canopy (50-75%), medium to low new growth, significant mechanical damage, obvious defects/insects/disease, foliage off-color and/or sparse ● <i>Poor</i>: declining (25-50%), visible dead branches over 2” in diameter, significant dieback, severe mechanical damage or decay (over 40% of stem affected) ● <i>Dead</i>: no signs of life, bark peeling; scratch test on twigs for signs of life (green) ● <i>Vacant</i>: potential spot for a tree within the public ROW. Add “small”, “medium”, or “large” in the comments box <ul style="list-style-type: none"> - Small= max 30’ at maturity, presence of overhead wires, minimum planting space 4’ x 4’ - Medium= 30-50’ at maturity, green belts over 6’ wide, no overhead wires - Large= 50’+ at maturity, parks and open space
Diameter (DBH)	Diameter taken at 4.5’ above ground in classes of 0-3”, 3-6”, 6-12”, 12-18”, 18-24”, 24-36”, 36-42”, 42”+. If on slope, uphill side measured. If abnormal growth, measured above or below growth. If multi-stemmed, each stem’s DBH is squared, all squares summed, and the square root taken; indicate “multi-stemmed” in comments box.
Consult	<ul style="list-style-type: none"> ● <i>Yes</i>: any one defect is affecting >40% of the tree, posing a hazard to people/infrastructure/cars, growing into utility wires, dead or poor condition, ash tree showing evidence of woodpecker flecking, blanding, epicormic branching/water sprouts, and/or suspicious exit holes ● <i>No</i>: no major defects, tree in good or fair condition
Comments	Notes, elaborate on any existing conditions; max 255 characters.
House Number	Corresponding house address, numerical field. If a corner lot house is on a different street, enter house number and write “House located on X Street; corner tree” in comments box.
Collection Date/Time	Date and time.
Photo	Photo of full tree. Additional photos of any significant defects.



Left: An example of a photograph of an individual tree that is attached to its record in “Collector”.



Right: Each morning and afternoon the LANDS students met to discuss and plan the most effective routes for data collection using a large parcel map.

Inventory Results

Urban Forest Diversity

Of the 562 trees inventoried within the public ROW or on town-owned land, there were a total of 46 different species in 25 different genera. The most common tree genera, *Acer* (maple), *Fraxinus* (ash), *Malus* (crabapple), *Picea* (spruce), *Gleditsia* (honeylocust) comprise 69% of the urban forest (Figure 1). Sugar maple (*Acer saccharum*) was the most common species at 21% of the total distribution, followed by Norway maple (*Acer platanoides*) at 10%, red maple (*Acer rubrum*) at 6%, and crabapple (*Malus* sp.) and honeylocust (*Gleditsia triacanthos*) at 5% each (Figure 2). Complete species and genera lists can be found in Appendix B.

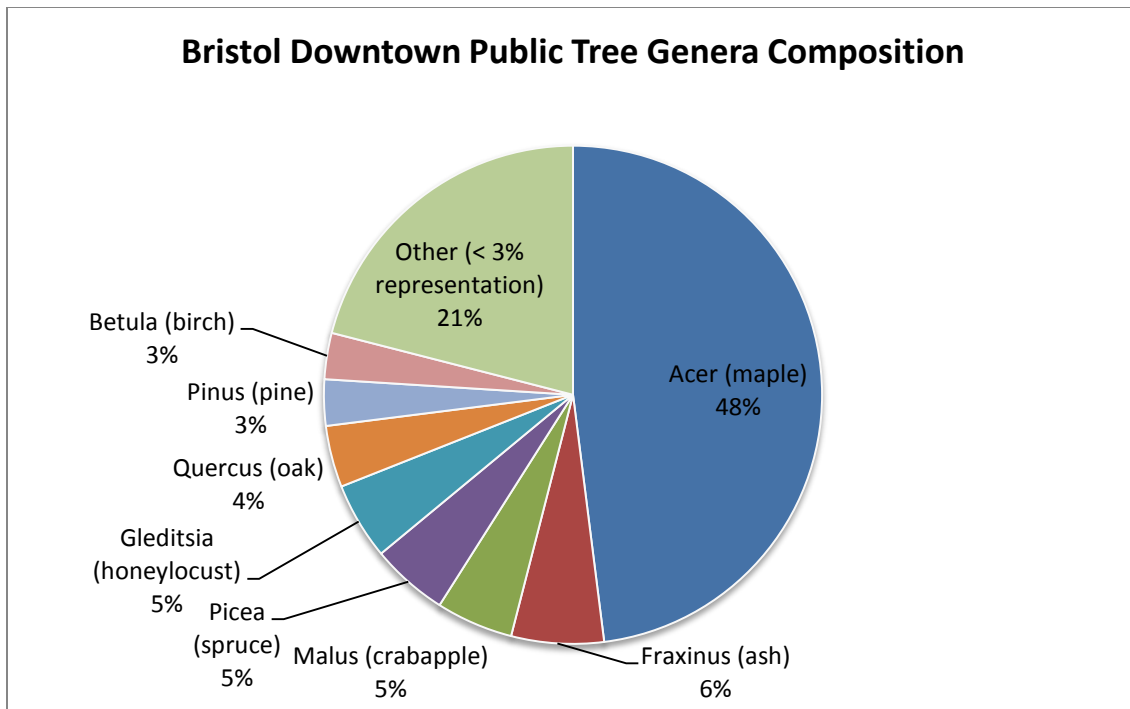


Figure 1: Most common tree genera by percent within the public ROW in Bristol.

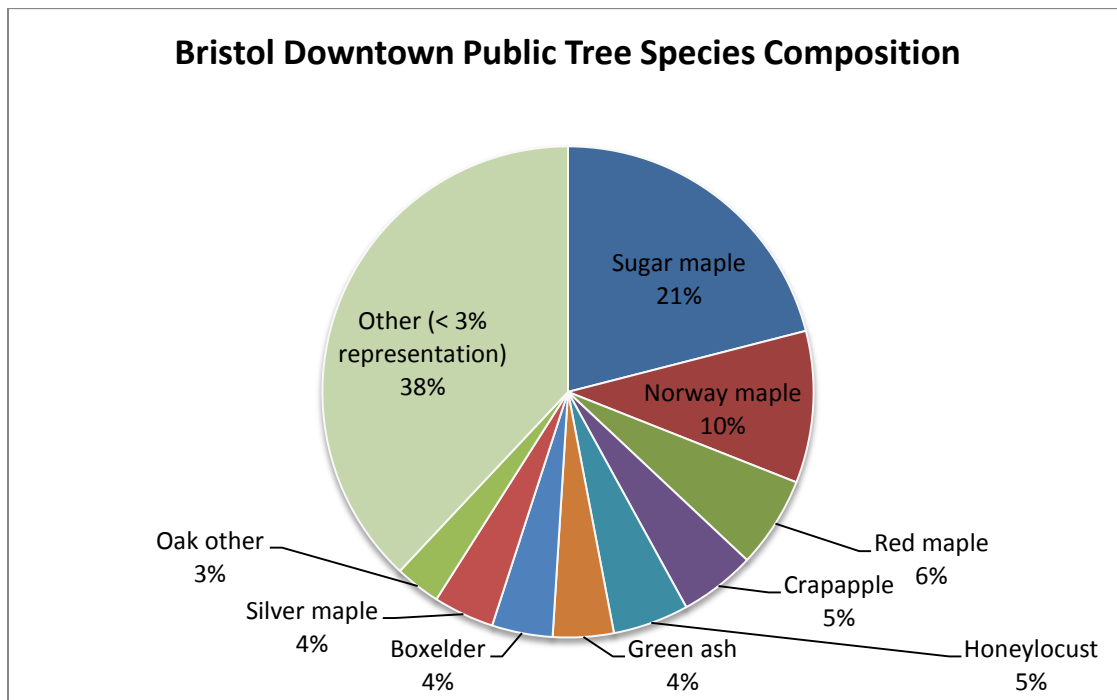


Figure 2: Most common species by percent within the public ROW of downtown Bristol.

Urban Forest Structure

Of the 562 inventoried trees, 554 had DBH measurements taken (8 trees did not have a recorded DBH measurement, likely due to user error). In descending order by percent size class, the diameter distribution represented by Bristol's public trees is: 32% (177) at 6-12", 29% (159) at 12-18", 11% (59) at 18-24", 9% (50) at 3-6", 8% (42) at 0-3", 7% (41) at 24-30", 2% (8) at 30-36" 1% (8) at 36-42", and 1% (7) at 42"+ (1%) (Figure 3). Bristol's diameter distribution follows normal distribution, with the majority of the trees at or reaching maturity, a small population of aging trees and a small population of young and newly-planted trees.

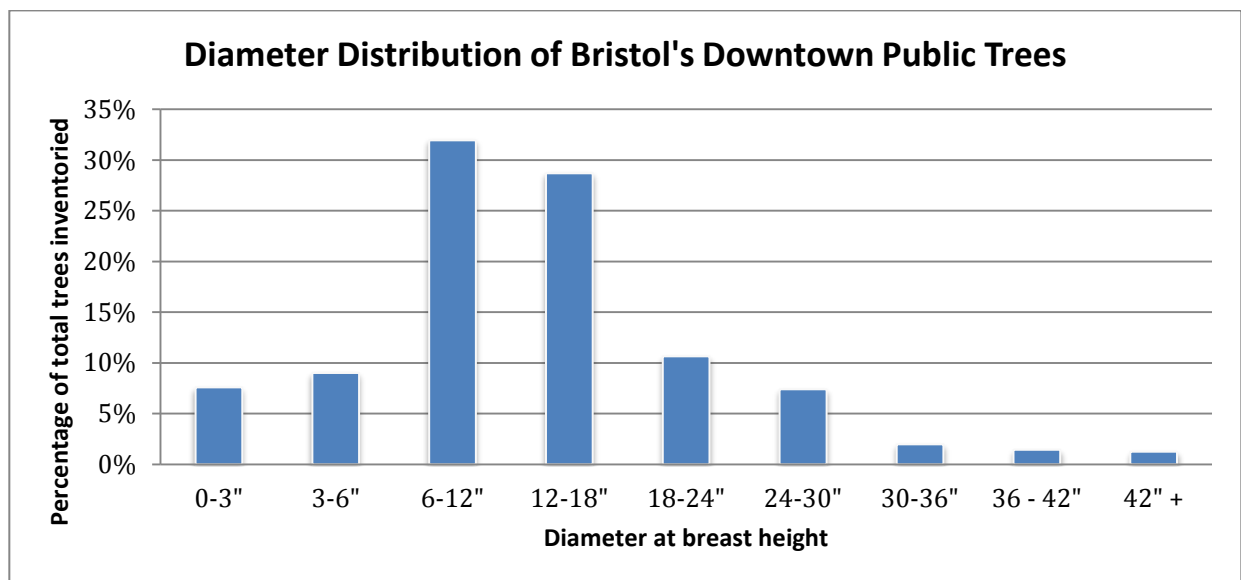


Figure 3: Diameter (inches) distribution of Bristol's inventoried public trees, by percent representation.

The genera and species composition within each of these size classes (Figures 4 and 5) indicate that Acer (maple) is most commonly represented in all size classes, which is likely because the genus comprises nearly half of all Bristol's inventoried public trees. The majority of larger-diameter (18"+) trees are silver or sugar maple, while most trees 6-12" in diameter are Norway maples. It is therefore evident that Norway maples were a popular street tree planting choice in the recent past since for the most part they fall into the same size class. Interestingly, it appears that Norway maples are no longer being planted in Bristol and that, which may be an

intentional choice or be based upon availability at nearby tree nurseries. The low percentage of *Fraxinus* (ash) trees within the two smallest DBH class categories may indicate that Bristol has ceased choosing ash species as a street tree because of the threat of EAB. The three largest size classes represented, 30-36", 36-42", and >42" contain a total of 28 trees. These trees are growing within the public ROW, on town-owned land, and at Bristol High School, and were probably not planted as street trees but were instead left as remnants as the town developed. The largest tree inventoried was a silver maple on Spring Street with a DBH of 72 inches. Since the inventory was conducted this tree has been removed at the request of the property owner due to hazard concerns.

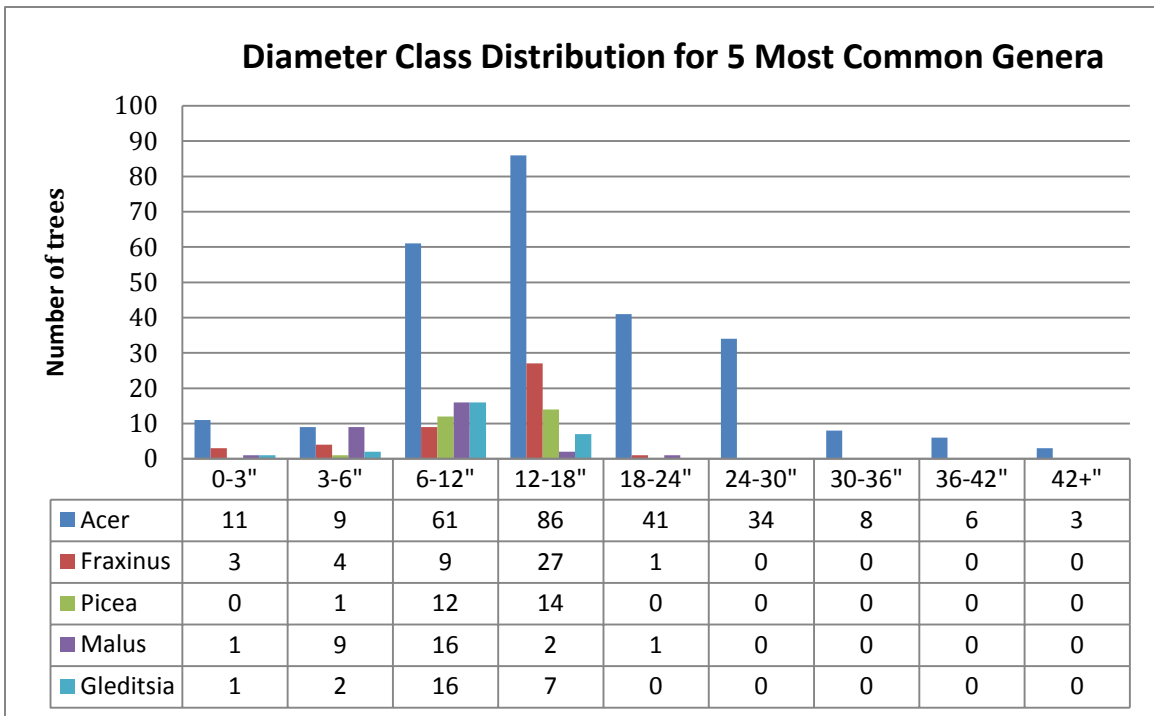


Figure 4: Diameter (inches) distribution for the five most common genera in Bristol’s downtown urban forest.

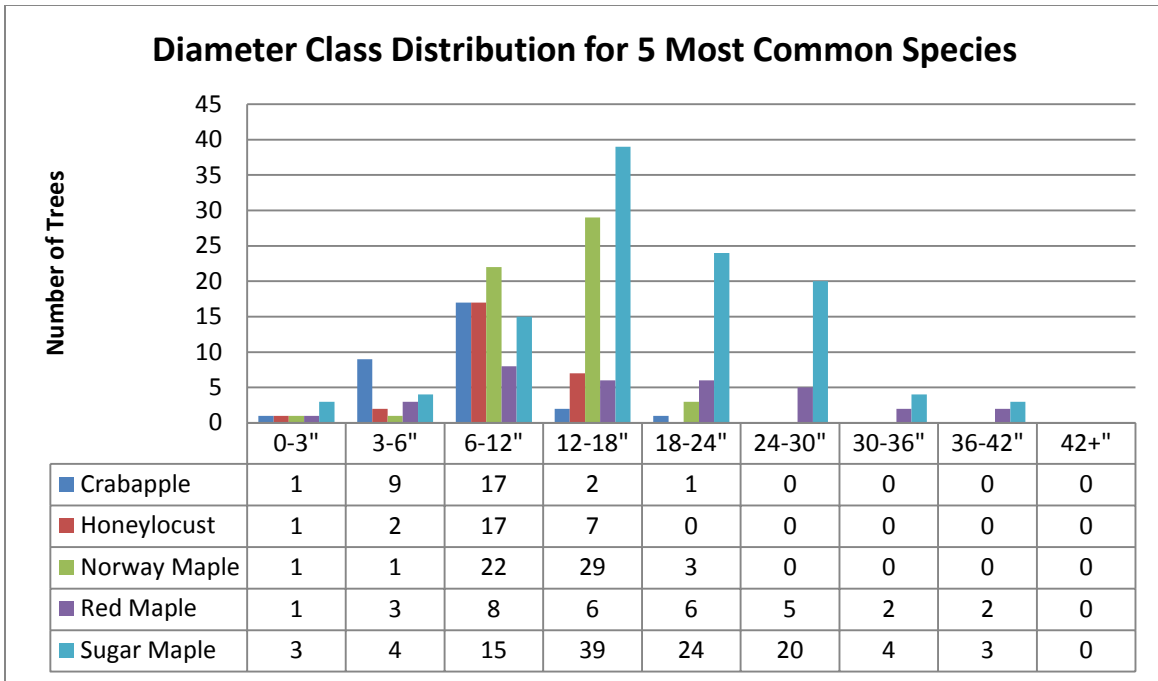


Figure 5: Diameter (inches) distribution for the five most common species in Bristol’s downtown urban forest.

106 potential tree planting locations or strips were identified within Bristol’s public ROW (recorded as “Vacant”). Appendix A breaks down these locations by street; with 37 potential spots, North Street and Crescent Street have the most potential for tree planting within Bristol’s public ROW.

Urban Forest Health

An overwhelming majority (88%) of Bristol’s inventoried public trees was assessed as being in “Good” condition. Of the remaining trees, 51 (9%) were considered in “Fair” condition, 12 (2%) were in “Poor” condition, and 6 (1%) were “Dead” (Figure 6). The trees in the genus *Acer* had the most trees in fair or poor condition; however, this genus also comprises the highest percentage of overall trees inventoried. The six dead trees are comprised of two boxelders, a birch, an ash, a sugar maple, and one unidentifiable species. Appendix D includes a map detailing the location of the inventoried trees by condition.

44 trees were flagged by the inventory team as in need of a consult and should be prioritized to be reassessed by a member of the BCC or a professional arborist in a timely matter. Trees that were flagged for a consult expressed one or more of the following conditions:

- The tree had a defect affecting >40% of the tree,
- The tree posed a hazard to people, infrastructure, and/or cars,
- The tree was growing into utility wires,
- The tree was dead or in poor condition, or
- The tree was an ash (*Fraxinus*) and was showing evidence of possible infestation by the emerald ash borer (extensive woodpecker flecking, bark blanding, epicormic branching/water sprouts, and/or suspicious exit holes).

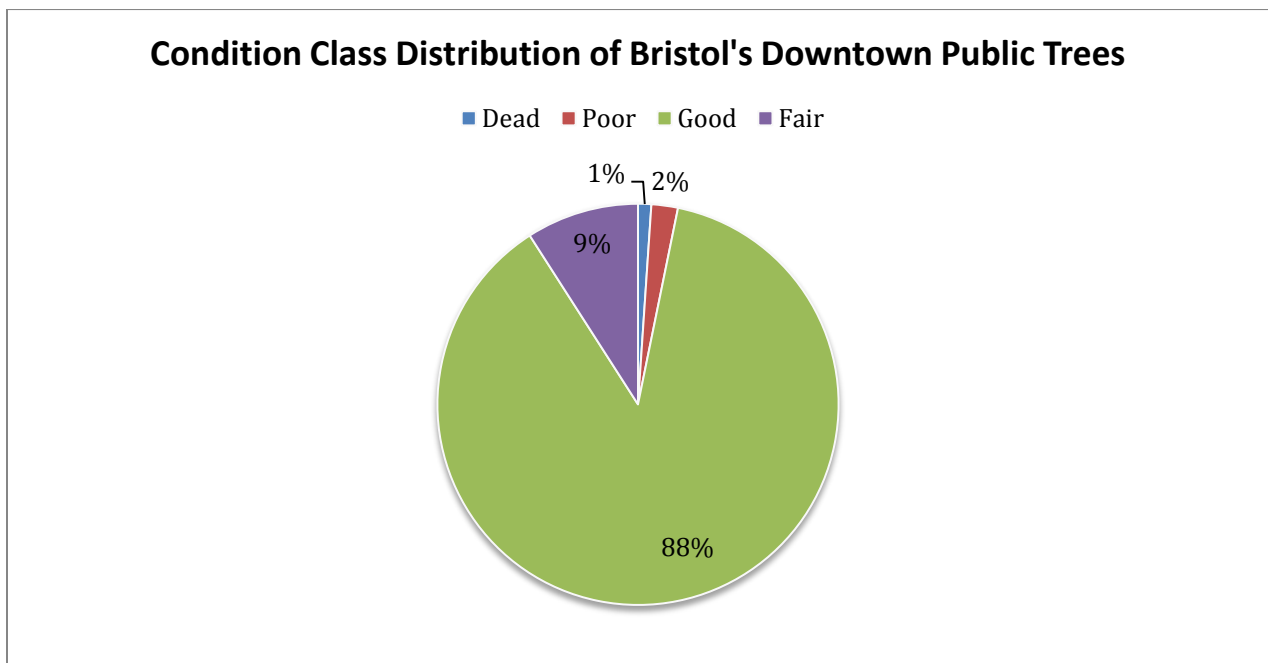


Figure 6: Percentage of Bristol public trees inventoried in each condition class.

Monetary Value and Ecosystem Services

Bristol's urban forestry inventory data was analyzed using i-Tree Streets software to determine the monetary value of the ecosystem services provided by the Town's trees. Annually, the 562

trees provide a total of \$62,613 in benefits by filtering air pollutants, mitigating stormwater runoff, sequestering CO₂, conserving energy, and increasing property values. On average, each public tree offers \$111.61 annually in savings or services.

Figure 7 and Table 2 provide an overview of each ecosystem service provided by Bristol's downtown public trees. In terms of their monetary value, energy conservation (\$29,507) and property value increase (\$20, 631) are the most significant annual services provided by these trees. The full reports produced through the i-Tree Streets program for Bristol are available upon request through VT UCF.

It is important to recognize that the trees inventoried through this project are located on approximately 0.58 square miles of Bristol's 42.2 square miles of total land area. Expanding the inventory to all Bristol roads would increase these findings dramatically. It is also noteworthy that larger and long-lived trees provide substantially more benefits than small, young trees. Regular maintenance and care are needed to provide for urban tree health, longevity, and maximized urban forest benefits.

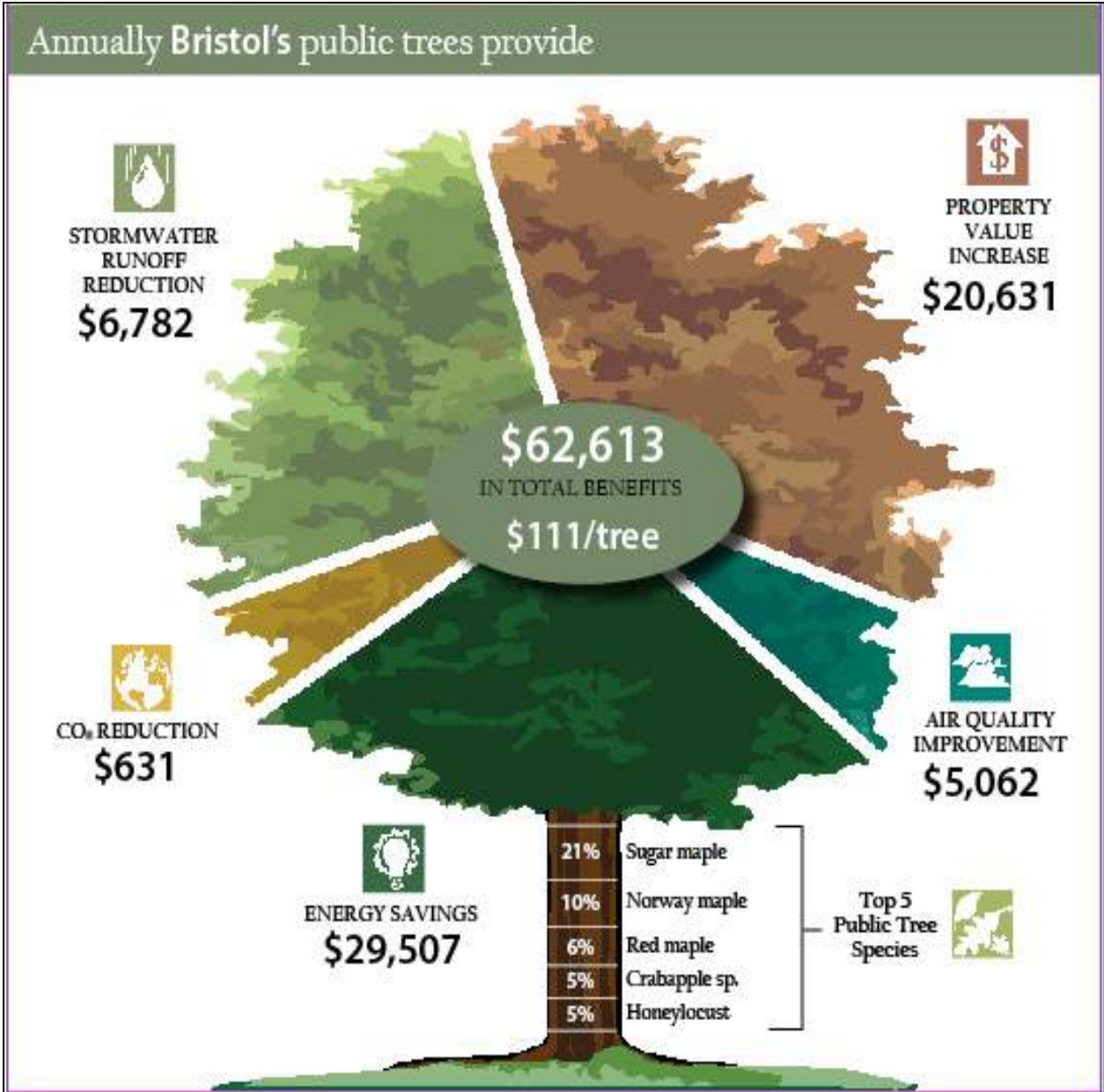


Figure 7: Summary of annual benefits provided by Bristol's downtown public trees inventoried through this project, according to the i-Tree Streets assessment. Tree graphic concept courtesy of City of New York Department of Parks & Recreation.

Table 2: Annual environmental and monetary benefits provided by Bristol's public trees.

Benefit Type	Benefit Description	Total Value of Trees Inventoried	Average value/tree
Energy conservation	Reduced natural gas use in winter and reduced electricity use for air conditioning in summer	\$29,507.30	\$52.60
Carbon dioxide	Annual reductions in atmospheric CO2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use. The model accounts for CO2 released as trees die and decompose and CO2 released during the care and maintenance of trees.	\$631.03	\$12.81
Air quality	Quantifies the air pollutants (O3, NO2, SO2, PM10) deposited on tree surfaces and reduced emissions from power plants (NO2, PM10, VOCs, SO2) due to reduced electricity use. Also reported are the potential negative effects of trees on air quality due to BVOC emissions.	\$5,062	\$1.12
Stormwater	Reductions in annual stormwater run-off due to rainfall interception by trees.	\$6,781.99	\$12.09
Aesthetic/other	Tangible and intangible benefits of trees reflected in increases in property values.	\$20,630.78	\$36.78
Stored carbon dioxide	Tallies all of the carbon dioxide stored in the urban forest over the life of the trees as a result of sequestration; *not an annual benefit but a cumulative benefit.	\$7,184.47	\$1.12 *
Cumulative Totals		\$65,365.85	\$111.61

Bristol Full Canopy Assessment

Complementary to the public tree inventory, the LANDS semester students completed an i-Tree Canopy assessment for the inventoried area in Bristol, Vermont. i-Tree Canopy is a free, easy-to-use online application that allows users to assess total tree cover over an area based on randomly-generated map points and user-defined land cover types. The tool also assigns monetary values to the benefits associated with the overall tree canopy cover. The aim of this assessment is to help citizens and decision-makers better understand the existing and potential tree canopy – encompassing public and private land – in their community.

Figure 8 compliments the i-Tree Streets analysis of the benefits provided by Bristol’s public trees by estimating the air quality benefits and corresponding monetary value for the full urban forest canopy. Of note is an estimated \$6,906 in annual CO₂ sequestration and \$174,132 in cumulative CO₂ storage.

* Tree Benefit Estimates					
Abbr.	Benefit Description	Value	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	\$2.73	±0.69	64.51 lb	±16.18
NO2	Nitrogen Dioxide removed annually	\$4.71	±1.18	351.76 lb	±88.24
O3	Ozone removed annually	\$245.18	±61.50	1.75 T	±0.44
PM2.5	Particulate Matter less than 2.5 microns removed annually	\$506.84	±127.14	170.24 lb	±42.70
SO2	Sulfur Dioxide removed annually	\$0.82	±0.21	221.67 lb	±55.61
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	\$178.00	±44.65	1,173.50 lb	±294.37
CO2seq	Carbon Dioxide sequestered annually in trees	\$6,906.42	±1,732.47	356.68 T	±89.47
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	\$174,132.47	±43,680.94	8,992.90 T	±2,255.86

Figure 8: i-Tree Canopy assessment estimates for air quality benefits of Bristol’s full canopy.

Based on the Bristol i-Tree Canopy assessment, approximately 24.5% of Bristol’s inventoried area is currently occupied by tree canopy (Figure 9). In consideration of the other land cover types present, Bristol could potentially increase its total tree canopy cover by an additional

46.9% on agricultural and open lands of low-lying vegetation and, with strategic planning, 18.4% on impervious surfaces (parking lots, playgrounds, along the ROW) (Figure 9); In total, there is currently potential to increase overall tree canopy cover in Bristol by 65.3%. Currently 10.2% of the area is occupied by buildings, not suitable for tree planting (Figure 10).

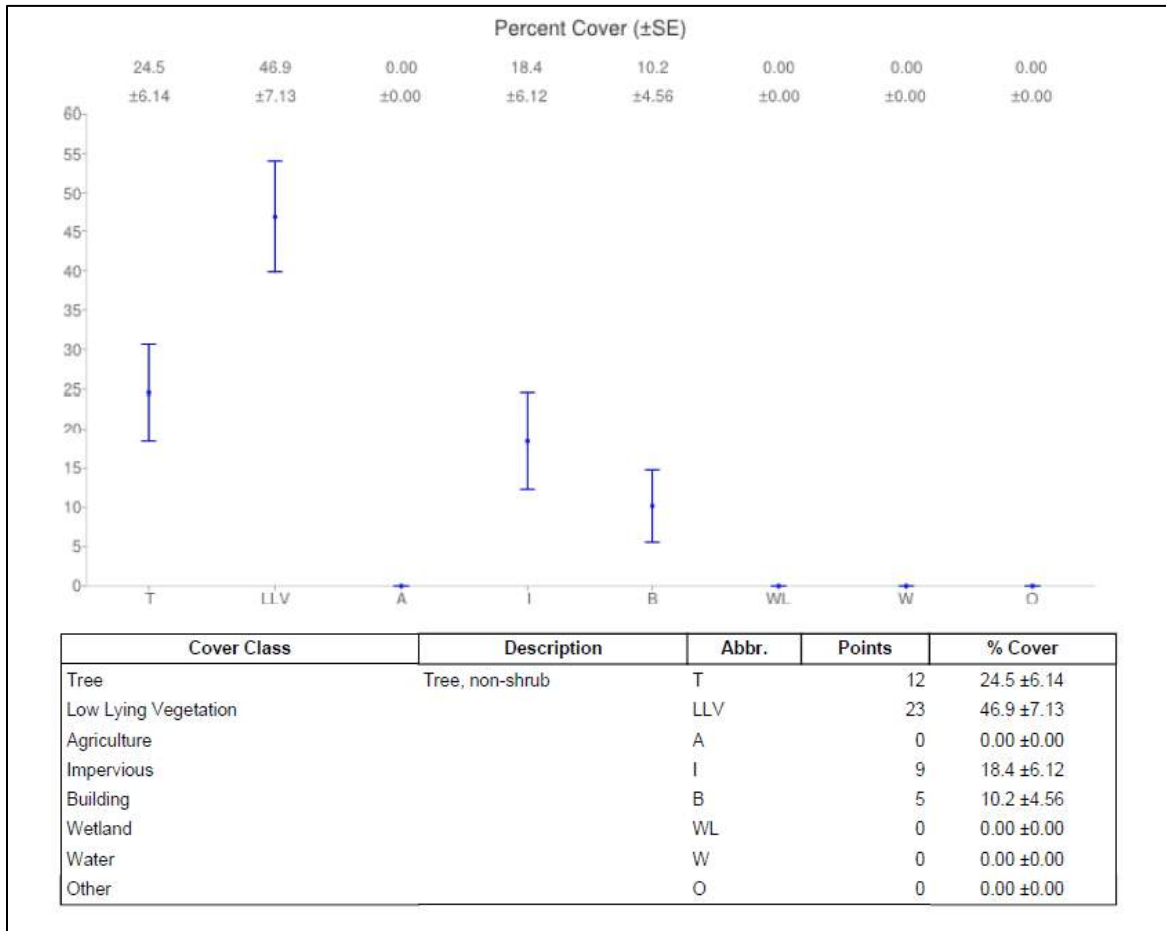


Figure 9: i-Tree Canopy assessment for the area covered in the public tree inventory for Bristol, Vermont, including both public and private land. The above image shows the ground cover composition distribution of total area inventoried.

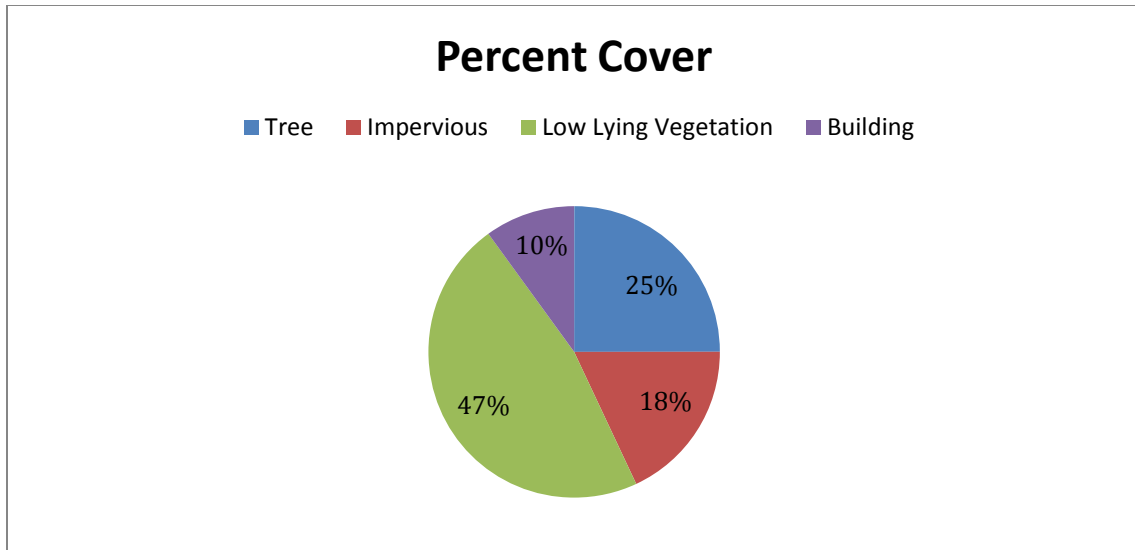


Figure 10: Downtown Bristol ground cover analysis, by percentage, using i-Tree Canopy.

Discussion and Recommendations

Urban Forest Diversity and Structure

An important best management practice in urban forestry is to maintain a diverse range of species. It is recommended that communities work towards a goal of no more than 20% representation of a single genus (for example: *Quercus*) in a tree population and no more than 10% of one species (for example: *Quercus rubra*). Resistance to disease and insect infestation is one of the many reasons why diversity within the urban forest is of paramount concern. A more diverse forest will be more resistant to environmental stressors, and is therefore more likely to remain healthy and resilient in the face of change. Furthermore, by maintaining higher genera and species diversity, a community can prevent a rapid loss of canopy (and its benefits) due to insect and disease issues.

In downtown Bristol, 48% of inventoried public trees were in the maple (*Acer*) genus, which is more than double the recommended representation within the community's urban forest. Specifically, sugar maple, Norway maple, red maple, boxelder, and silver maple – all members of the *Acer* genus – represent 21%, 10%, 6%, 4%, and 4% of the species diversity respectively. Sugar maple is the most prevalent species in Bristol. Norway maple is the second most

prevalent species and is considered to be a non-native invasive species. Although an aesthetically pleasing and hearty tree, Norway maple can spread into nearby forests and out-compete native species such as sugar maple. In fact, Vermont's Plant Quarantine Rule prohibits the movement, distribution, and sale of Norway maple, as well as other invasive plant species. Ash trees (genus *Fraxinus*) make up 6% of the public tree canopy of Bristol. Invasive tree pests currently threaten both ash and maple trees; the emerald ash borer (EAB) threatens the former and Asian longhorned beetle (ALB) is a threat to the latter. While neither of these pests have been discovered in Vermont, the largest ALB infestation in North America is a little over 50 miles to Vermont's south, in Worcester, MA and with the discovery of EAB in New Hampshire in 2013, Vermont is now surrounded on all sides by states or provinces with isolated infestations of EAB.

Recommendation: Develop species, structural, and age diversity by planting new species and increasing the number of lesser represented species using best management practices in order to promote long-term health and resilience of individual trees and Bristol's urban forest.

Recommended action practices:

- We advise against planting high-density stands of the same species (monocultures) whose close proximity may be conducive to the spreading of disease.
- Due to the high number of existing maple (*Acer*) trees in Bristol, we suggest selecting non-maple trees for future plantings.
- We suggest planting tree species that have grown successfully in the area that do not show any signs of diseases and deformity, and that are not non-native invasive species (specifically Norway maple). For more information on site assessment and species selection, refer to VT UCF's Tree Selection Guide at <http://www.vtcommunityforestry.org/resources/tree-care/tree-selection>.
- Existing ash (*Fraxinus*) trees should be consulted and regularly monitored for signs of EAB, and additional ash trees should not be planted.
- Plan for the arrival of EAB by using the Community Preparedness Toolbox, available at <http://www.vtinvasives.org/tree-pests/community-preparedness>.

- Encourage citizens to participate in the Vermont Forest Pest First Detector Training to expand local capacity to identify and monitor for invasive forest pests.
- In order to diversify both species composition and age structure, refer to the 106 identified vacant planting locations within the public ROW and develop a strategic planting plan.
- In planning for future tree plantings, make sure the right tree is being planting in the right place. Consider obstructions above ground (power lines) and below ground, minimize grey infrastructure conflicts (sidewalks, streets, buildings, etc.), and understand available soil volume, mature size (height and spread), branching patterns, environmental tolerances (exposure, salt, and drought), and desired function when choosing species.
- Encourage residents to plant trees on their properties that increase species diversity, age structure, and overall tree canopy benefits to the community.

Maintenance

Proper tree maintenance, especially pruning, can extend the life and health of trees, as well as reduce public safety issues. There are four main pruning practices of note:

- Crown cleaning: removes dead, diseased, and damaged limbs
- Crown thinning: selective removal of stems and branches to increase light penetration and air movement throughout the crown of a tree
- Crown raising: the removal of lower branches over 2 inches in diameter to provide clearance for pedestrians and vehicles
- Crown reduction: removing individual limbs from structures or utility wires

In addition to pruning, proper mulching for soil health, moisture retention, and protection from mechanical damage is encouraged. Finally, for newly planted trees, an irrigation regime should be in place to ensure proper establishment and tree root regeneration.

Recommendation: Establish a routine maintenance cycle, implemented by trained professionals and overseen by the Bristol Conservation Commission for all public trees to promote tree health and reduce any threat to public safety.

Recommended action practices:

- Complete a full inventory of all public trees in Bristol in order to lay the foundation for establishing a routine maintenance regime for all town-managed trees.
- Work with VT UCF to ensure municipal tree maintenance staff is trained in best management practices.
- Establish a systematic pruning cycle to reduce branch and tree failures due to poor structure, minimize conflicts with people and infrastructure, improve line of sight, and reduce storm damage. When trees are located near electrical utility lines, it is important to work directly with the local utility company.
- Encourage Bristol citizens to participate in VT UCF’s Stewardship of the Urban Landscape (SOUL) training course to continue to build local capacity to care for and promote Bristol’s canopy.

Urban Forest Health

Overall, Bristol’s downtown public trees are in good health. Only 2% (12) of the inventoried trees were considered to be in “Poor” condition, and 1% (6) was found to be “Dead”. The eastern section of Garfield Street had a particularly large number of trees in relatively poor condition. There were 44 trees flagged to be revisited by a professional arborist or a member of the BCC. Many of these trees overlap those designated to be in “Poor” condition or “Dead”, but others were likely noted because of conflict with utility wires or other infrastructure. See Appendix D for a map detailing the locations of the “Fair”, “Poor”, and “Dead” trees in Bristol and a map indicating the location of the trees requiring a consult.

Low soil volume and fertility, exposure to salt spray, root damage, mechanical damage to the stem, poor pruning, and improper planting are some of the contributing factors that may lead to decreased tree health in an urban setting.

Recommendation: Continue to monitor trees in “Good” and “Fair” condition, plan to lose trees in “Poor” condition, remove “Dead” trees to increase overall urban forest health, and involve the community, especially youth, in tree plantings, stewardship, and maintenance.

Recommended action practices:

- Visit and assess the 44 trees flagged for consultation in a systematic and timely fashion.
- Remove the 6 dead public trees identified.
- Continue to monitor the health of the trees in “Good” and “Fair” condition and record any changes in tree health.
- Focus efforts on the east section of Garfield Street, an area of high use and high value to the public that contains a large number of trees in poor condition.

Assessment Tools

i-Tree software developed by the USDA Forest Service, assesses the value and potential expansion of Bristol’s urban tree canopy. i-Tree Streets determined the economic value of the ecosystem services provided by the 562 inventoried public trees in Bristol. Bristol’s urban forest generates about \$62,613 annually through the benefits of air quality improvement, CO₂ sequestration, electricity and natural gas, aesthetics, and stormwater control. On average, each tree offers \$111.61 in service or savings every year. The trees of Bristol provide services to the town in the following ways:

- **Aesthetics:** Urban trees can make an urban or suburban environment a more pleasant and satisfying place to live, work, and spend leisure time (Dwyer et al. 1991). In monetary terms, presence of shade trees can significantly increase property value. Trees also provide numerous health benefits. For example, hospital patients with window

views of trees have been shown to recover faster than patients without such views (Ulrich 1984).

- **Air quality:** Trees improve air quality by removing air pollutants through their leaves, altering emissions from building energy use, and by lowering air temperature.
- **Energy use:** Trees influence thermal comfort and energy use by providing shade, transpiring moisture, and reducing wind speeds. Over 100 million trees have been established around residences in the U.S., saving \$2 billion annually in reduced energy costs (Akbari et al. 1988).
- **Stored Carbon Dioxide:** Urban trees can affect climate change by storing carbon in their tissues and reducing emissions through lowered building energy use. Urban trees in the contiguous United States store 770 million tons of carbon, which is valued at \$14.4 billion (Nowak and Crane 2002).
- **Storm water run-off:** Trees and soil improve water quality and reduce costs associated with storm water treatment by retaining or slowing precipitation flow.

Using a random sample method and based on assessing land cover types, i-Tree Canopy measured the overall tree canopy cover within the boundaries of Bristol's inventoried area, capturing both private and public tree canopy.

Recommendation: Use the information generated through the i-Tree Streets and i-Tree Canopy programs to promote local stewardship and investment in urban forest management. Explore the other free assessment tools in the i-Tree tools suite (www.itreetools.org).

Conclusion

Trees in our urban landscapes contribute to environmental integrity, social cohesiveness, economic activity, cultural heritage, and overall well-being. This report is one component of a long-term effort by the Town of Bristol to understand, manage, and steward its urban forest. The recommendations outlined in this report are based on the LANDS students' observations and data analysis combined with the experience and evaluation of VT UCF staff. The Bristol

Conservation Commission should consider these provided recommendations based on their long-term vision and current capacity.

Literature Cited

- Akbari, H.; Davis, S.; Dorsano, S.; Huang, J.; Winnett, S. 1992. *Cooling our communities: a guidebook on tree planting and light-colored surfacing*. Washington, DC: U.S. Environmental Protection Agency. 217 p.
- Bristol Downtown Community Partnership. 2014. "About Bristol." *Discover Bristol Vermont*. Retrieved September 23, 2014 from <http://discoverbristolvt.com/bristol/about/>
- Dwyer, J.F., H. W. Schroeder, and P. H. Gobster. 1991. *The significance of urban trees and forests: toward a deeper understanding of values*. *Journal of Arboriculture* 17: 276-284.
- Morales, D., B. N. Boyce, et al. (1976). *The contribution of trees to residential property value*. *ASA Valuation* (23): 26-43.
- Morales, D.J., F.R. Micha, et al. (1983). *Two methods of valuating trees on residential sites*. *Journal of Arboriculture* 9(1): 21-24.
- Nowak, D.J.; D. E. Crane. 2002. *Carbon storage and sequestration by urban trees in the USA*. *Environmental Pollution* 116(3): 381-389.
- Ulrich, R.S. 1984. *View through a window may influence recovery from surgery*. *Science* 224: 420-421

Appendix A: Full Street and Site List for the Bristol Inventory

Street/site name	ROW Extent (feet)	Number of Trees	Number of Vacant Spots or Strips
Airport Drive	50	8	4
Basin Street	50	5	1
Church Street	50	12	1
Crescent Street	50	5	14
Devino Lane	50	13	5
East Street	50	12	1
Elm Street	50	3	0
Fitch Avenue	50	2	0
Garfield Street	50	18	2
Bristol High School	n/a	44	7
Lawrence Lane	50	4	0
Liberty Street	50	18	0
Lower Meadow Lane	50	23	0
Maple Street	50	45	2
Meadow Lane	50	19	6
Mountain Street	50	40	15
Mountain Terrace	50	23	0
Munsill Avenue	50	20	5
North Street	50	43	12
Park Place	50	0	2
Pine Street	50	30	0
Plank Road	50	0	1
Pleasant Street	50	37	8
School Street	50	6	1
Spring Street	50	18	7
Taylor Avenue	50	33	7
Town Green	n/a	40	3
Town Offices (including Historic Society property)	n/a	24	2
West Street	50	17	0
TOTAL		562	106

Appendix B: Full Species List for Bristol's Public Trees

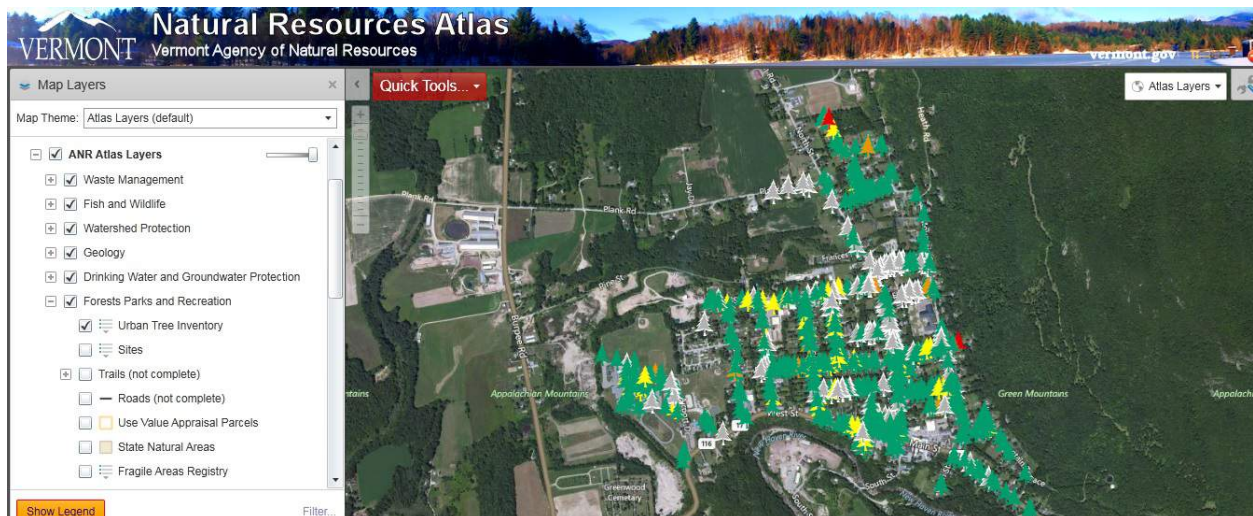
Common Name	Scientific Name	Number of Trees	Percent of Total Population
Sugar maple	<i>Acer saccharum</i>	118	21.00%
Norway maple	<i>Acer platanoides</i>	57	10.14%
Red maple	<i>Acer rubrum</i>	33	5.87%
Crabapple	<i>Malus sp.</i>	30	5.34%
Honeylocust	<i>Gleditsia triacanthos</i>	27	4.80%
Green ash	<i>Fraxinus pennsylvanica</i>	25	4.45%
Boxelder	<i>Acer negundo</i>	22	3.91%
Silver maple	<i>Acer saccharinum</i>	20	3.56%
Oak other	<i>Quercus sp.</i>	18	3.20%
Broadleaf deciduous other	n/a	14	2.49%
Maple other	<i>Acer sp.</i>	13	2.31%
Eastern red cedar	<i>Juniperus virginiana</i>	12	2.14%
American elm	<i>Ulmus americana</i>	11	1.96%
Scotch pine	<i>Pinus sylvestris</i>	11	1.96%
Birch	<i>Betula sp.</i>	10	1.78%
Blue spruce	<i>Picea pungens</i>	10	1.78%
Eastern Cottonwood	<i>Populus deltoides</i>	10	1.78%
Japanese tree lilac	<i>Syringa reticulata</i>	10	1.78%
Nowary spruce	<i>Picea abies</i>	9	1.60%
White ash	<i>Fraxinus americana</i>	9	1.60%
Hawthorn	<i>Crataegus sp.</i>	7	1.25%
Pine other	<i>Pinus sp.</i>	7	1.25%
Plum	<i>Prunus sp.</i>	7	1.25%
Amur maple	<i>Acer ginnala</i>	6	1.07%
Black locust	<i>Robinia pseudoacacia</i>	6	1.07%
Spruce other	<i>Picea sp.</i>	6	1.07%
Gingko	<i>Gingko biloba</i>	5	0.89%
Northern red oak	<i>Quercus rubra</i>	5	0.89%
Balsam fir	<i>Abies balsamea</i>	4	0.71%
Coniferous evergreen other	n/a	4	0.71%
Paper birch	<i>Betula papyrifera</i>	4	0.71%
Pear	<i>Pyrus sp.</i>	4	0.71%
Cherry plum	<i>Prunus sp.</i>	3	0.53%
Chokecherry	<i>Prunus virginiana</i>	3	0.53%
Mountain ash	<i>Sorbus americana</i>	3	0.53%
Red spruce	<i>Picea rubens</i>	3	0.53%

American basswood	<i>Tilia americana</i>	2	0.36%
Beech	<i>Fagus sp.</i>	2	0.36%
Northern catalpa	<i>Catalpa speciosa</i>	2	0.36%
Horsechestnut	<i>Aesculus hippocastanum</i>	2	0.36%
Black walnut	<i>Juglans nigra</i>	1	0.18%
Bur oak	<i>Quercus macrocarpa</i>	1	0.18%
Eastern white pine	<i>Pinus strobus</i>	1	0.18%
Quaking aspen	<i>Populus tremuloides</i>	1	0.18%
River birch	<i>Betula nigra</i>	1	0.18%
Magnolia	<i>Magnolia sp.</i>	1	0.18%
Swamp white oak	<i>Quercus bicolor</i>	1	0.18%
White spruce	<i>Picea glauca</i>	1	0.18%

Appendix C: Instructions for Accessing Public Tree Data in ANR Atlas

Anyone with internet access can view all of the inventoried Bristol public trees by using the Vermont Agency of Natural Resources' (ANR) Atlas mapping tool. Follow these simple steps:

1. Set your web browser to <http://anrmaps.vermont.gov/websites/anra/> (or search "VT ANR Atlas")
2. Zoom in to Bristol using the +/- scale navigation tool in the upper left portion of the map (the tree data layer won't show up unless you are zoomed in to the town-level so that you can see the street names on the map).
3. In the information pane on the left of the screen switch over to the "map layers" tab at the bottom.
4. Expand the "Forests, Parks, & Recreation" heading,
5. Click on the box to the left of "Urban Tree Inventory" to load public tree data (it might take a moment for the layer to load).
6. Once you see all the trees on the map, you can zoom in and right-click on any individual tree and click on "What's here"; when you do this, the left information pane will change to give you the basic details for that specific tree.
 - o To access all of the information collected on that specific tree, click on the grey text title of the tree in the left pane and a new window will open with all of the inventory data.
 - o In this new window there are three tabs: "Details" and "Attributes" display the same information in different formats and if a photo was taken of the tree, it will show up in the "Attachments" tab.

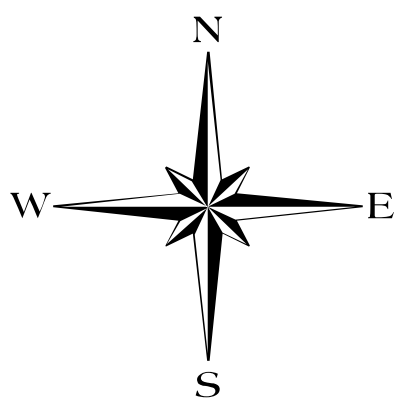
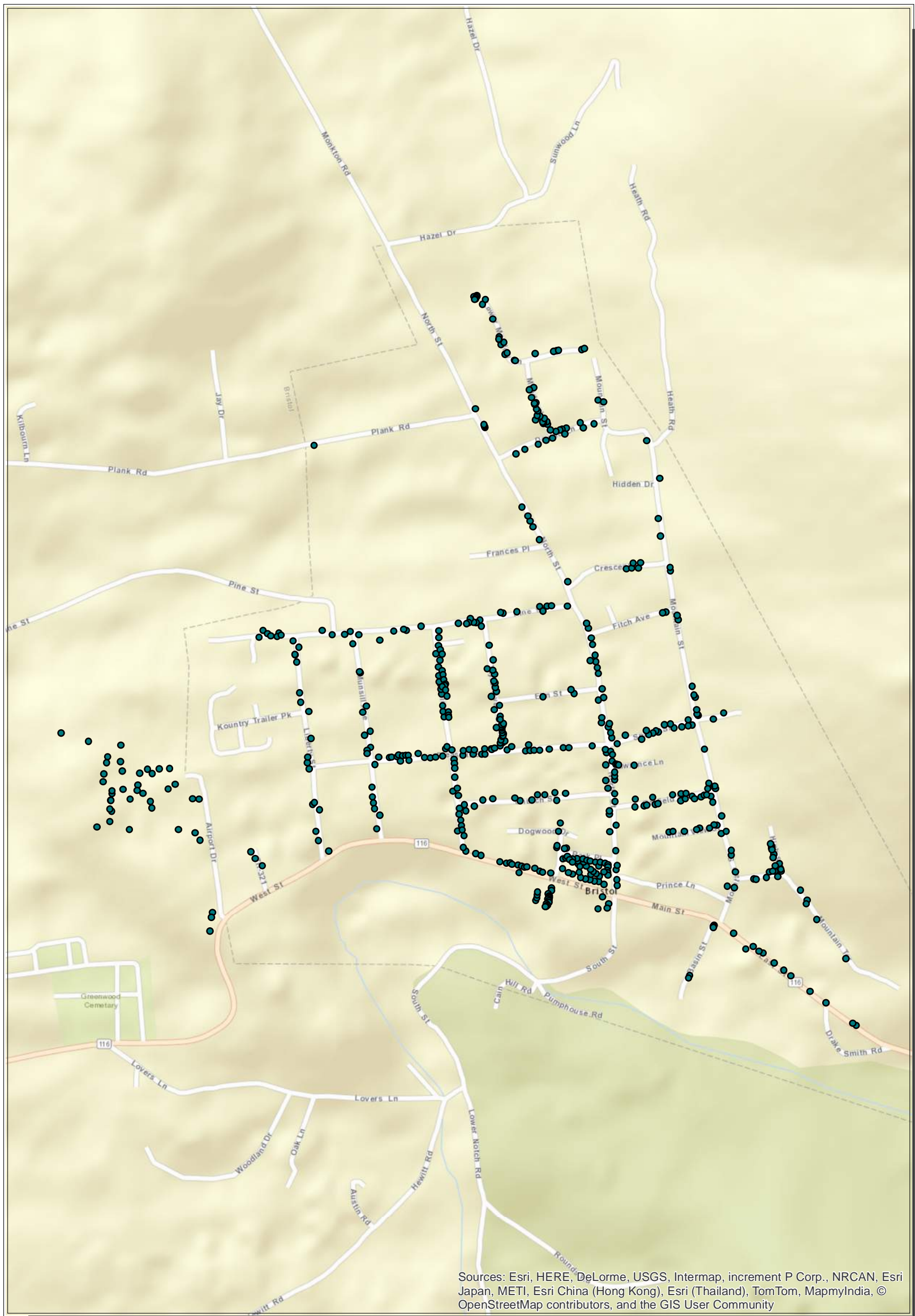


Screen shot of the Bristol public trees as seen through the ANR Atlas mapping tool.

Appendix D: Maps

1. All Public Trees Inventoried in Bristol
2. Public Trees Requiring a Consult in Bristol
3. All Public Trees Inventoried in Bristol by DBH Class
4. Public Trees in Bristol Designated as in “Fair”, “Poor”, or “Dead” Condition
5. Public Trees in Bristol Designated as in “Good” Condition
6. Potential Public Tree Planting Locations in Bristol

All Trees Inventoried in Bristol



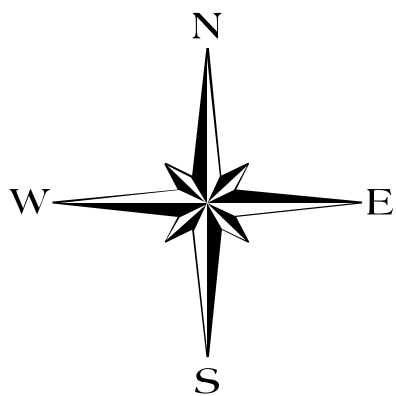
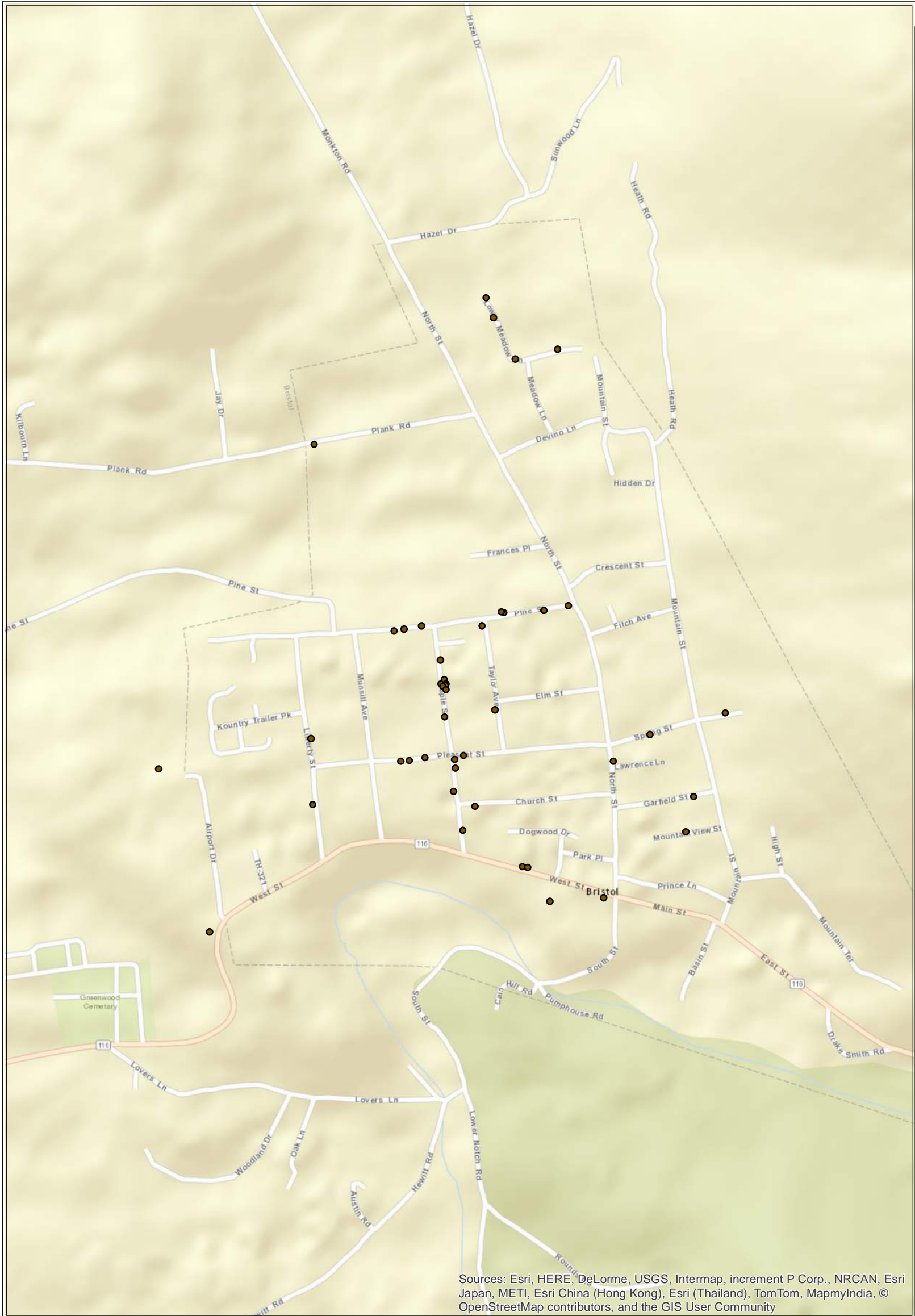
Created by LANDS Field Semester 2014

0 250 500 1,000 Meters

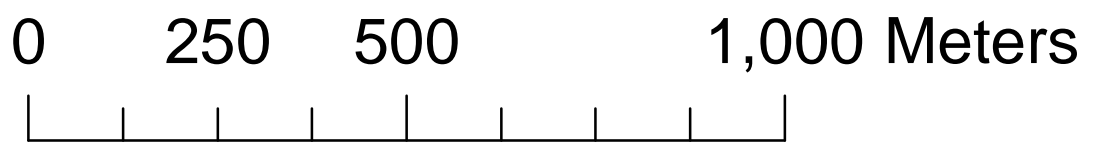


1:10,000

Trees Requiring a Consultation

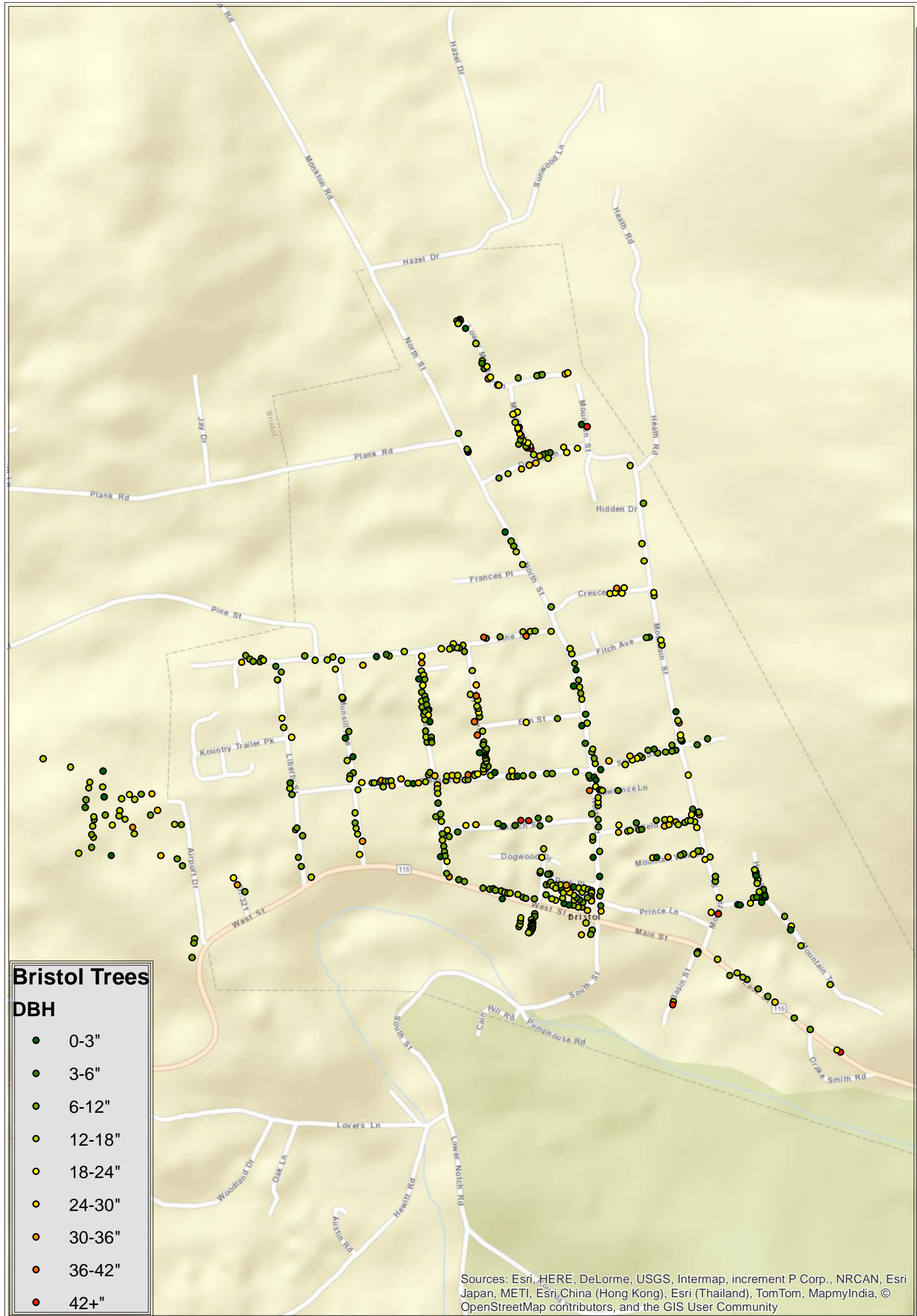


Created by LANDS Field Semester 2014

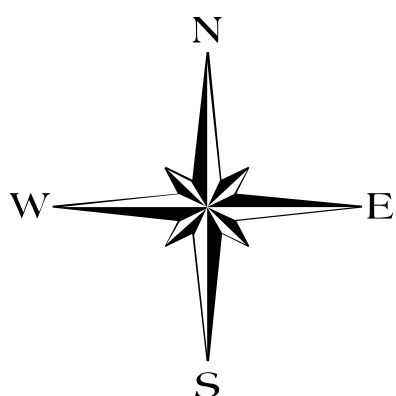


1:10,000

All Trees Inventoried by DBH Class



Created by LANDS Field Semester 2014

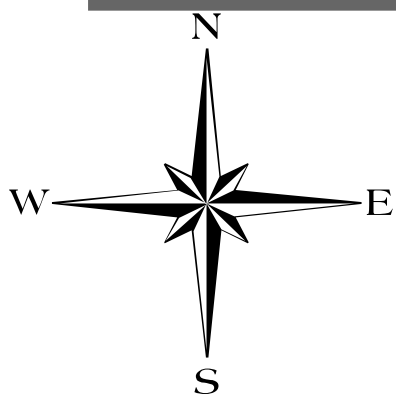
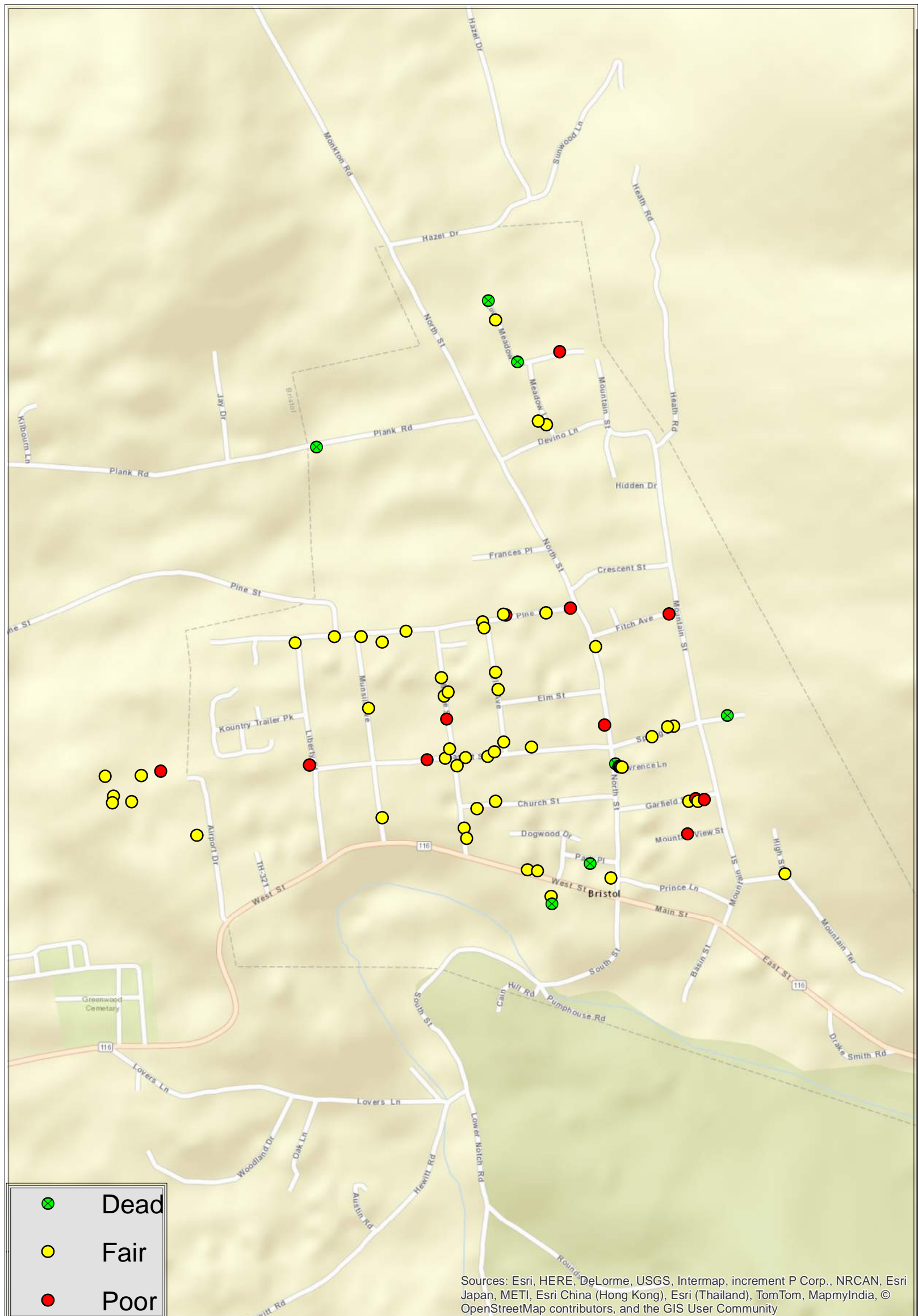


0 250 500 1,000 Meters



1:10,000

Trees Designated to be in "Fair," "Poor," or "Dead" Condition



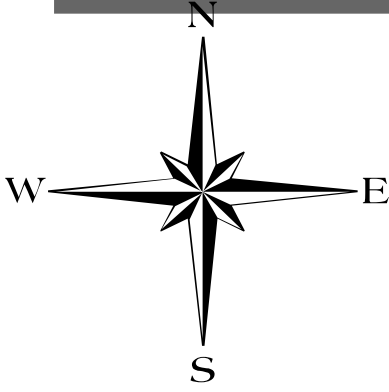
Created by LANDS Field Semester 2014

0 250 500 1,000 Meters



1:10,000

Trees Designated to be in "Good" Condition

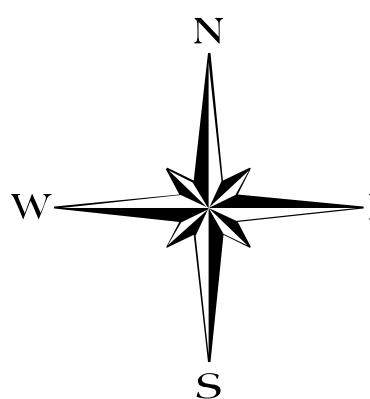
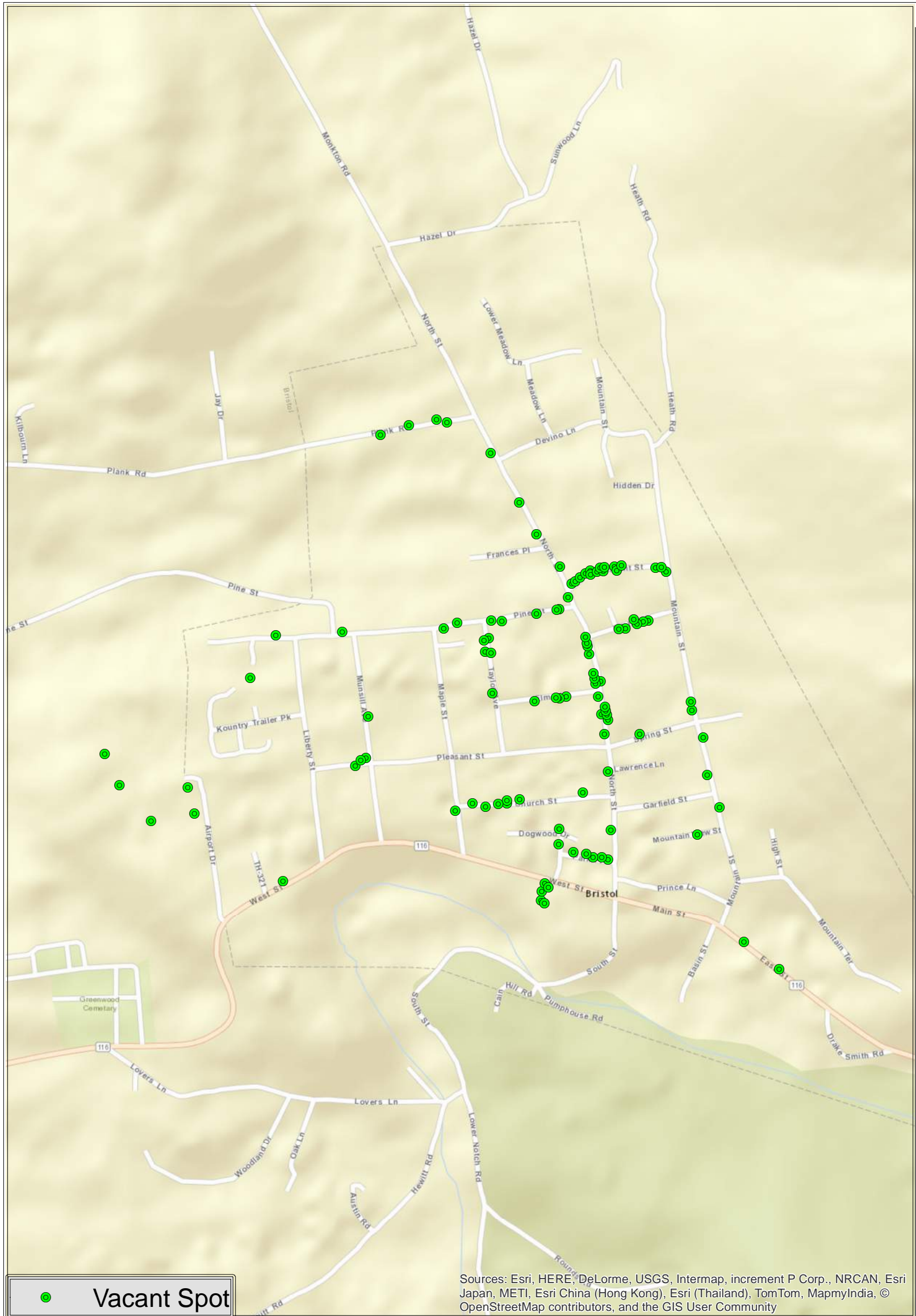


Created by LANDS Field Semester 2014

0 250 500 1,000 Meters

1:10,000

Potential Tree-Planting Locations within Right-of-Way or Town Property



Created by LANDS Field Semester 2014

0 250 500 1,000 Meters

1:10,000