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:

ROW distance from curb = (ROW extent for specific road - 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	• *Good:* full canopy (75-100%), no dieback of branches over 2" in diameter, no significant defects, minimal mechanical damage • *Fair:* thinning canopy (50-75%), medium to low new growth, significant mechanical damage, obvious defects/insects/disease, foliage off-color and/or sparse • *Poor:* declining (25-50%), visible dead branches over 2" in diameter, significant dieback, severe mechanical damage or decay (over 40% of stem affected) • *Dead:* no signs of life, bark peeling; scratch test on twigs for signs of life (green) • *Vacant:* potential spot for a tree within the public ROW. Add "small", "medium", or "large" in the comments box - 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	• *Yes:* 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, blonding, epicormic branching/water sprouts, and/or suspicious exit holes • *No:* 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.

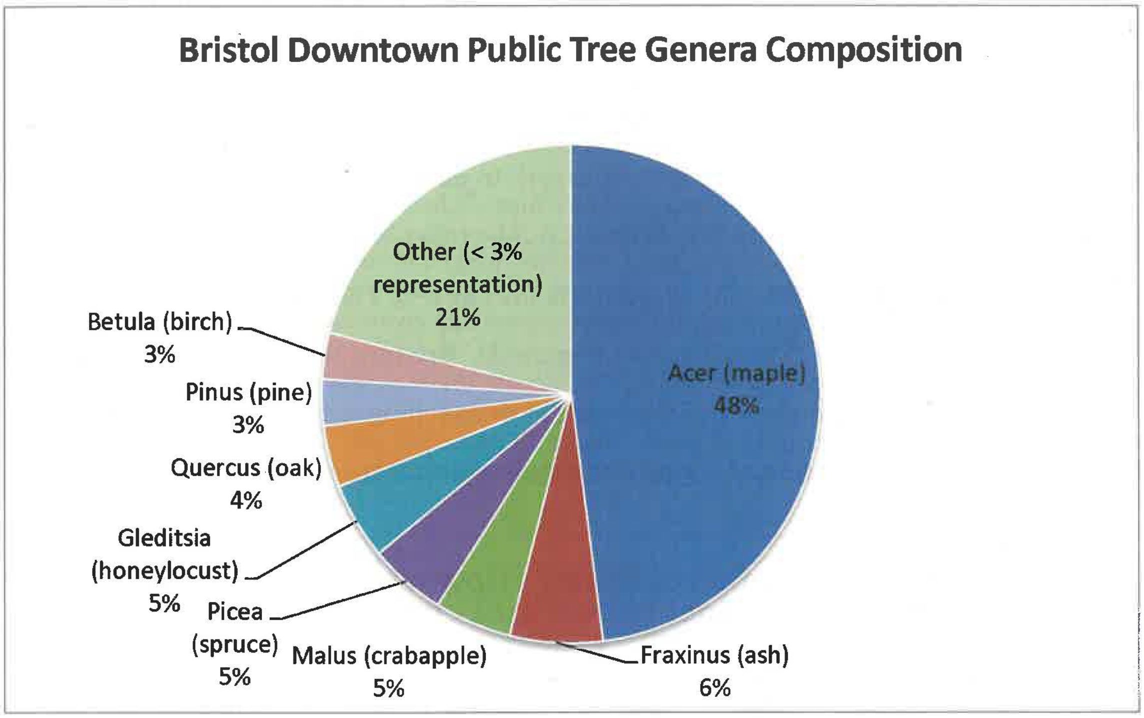


Figure 1: Most common tree genera by percent within the public ROW in Bristol.

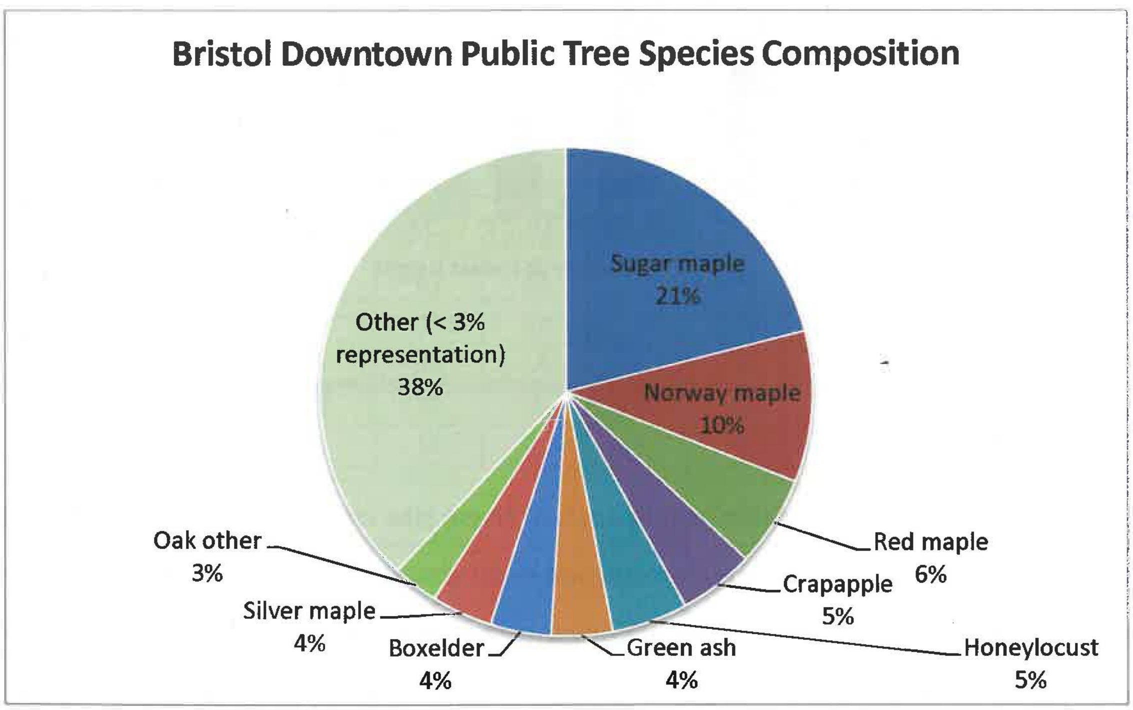


Figure 2: Most common species by percent within the public ROW of downtown Bristol.

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.

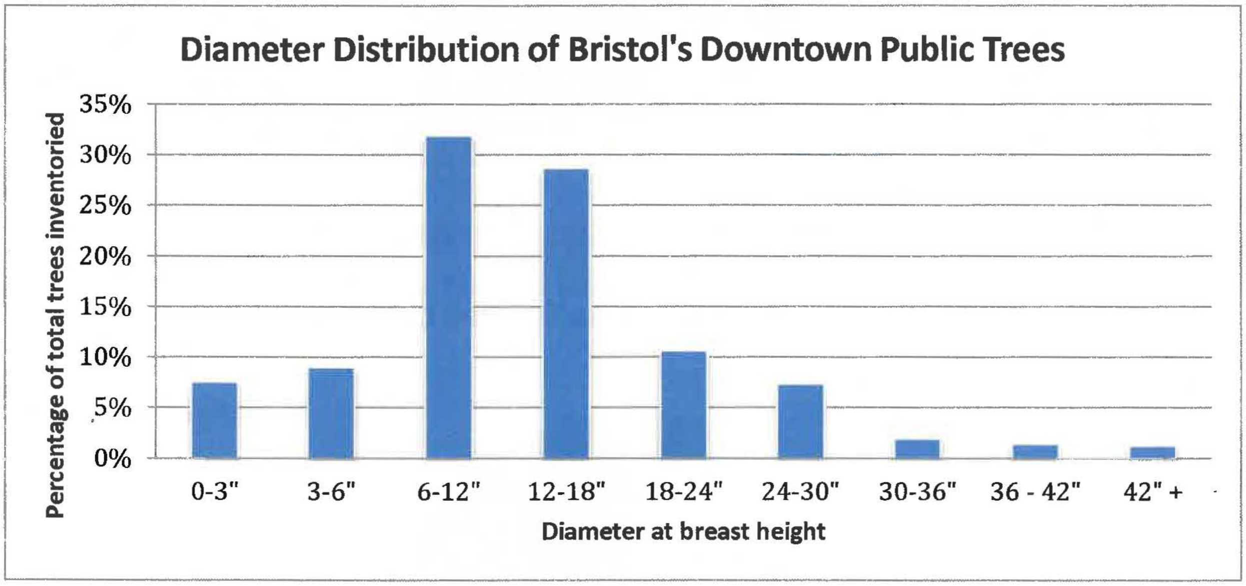
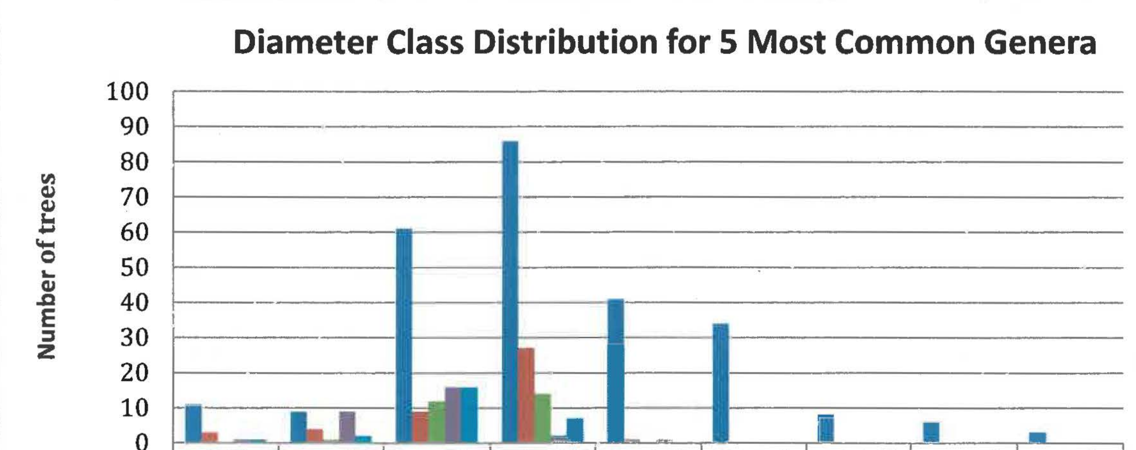


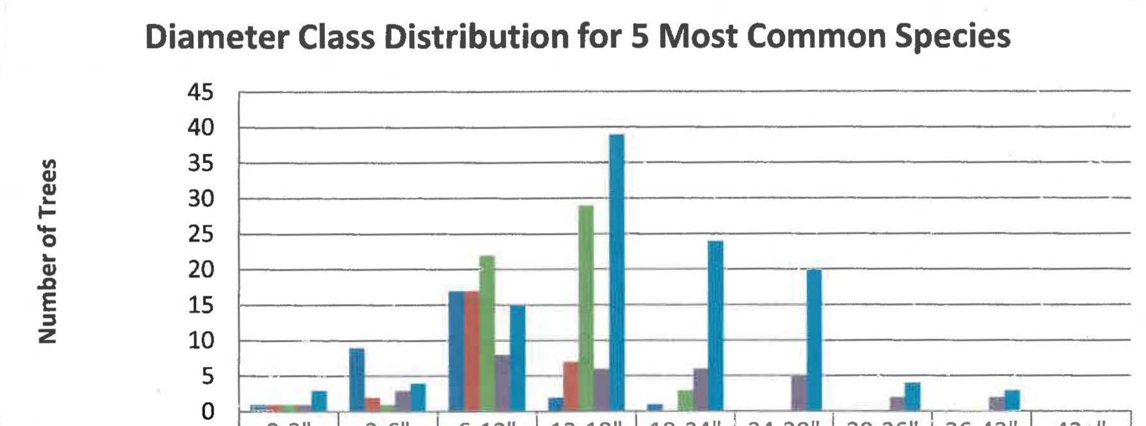
Figure 3: Diameter (inches) distribution of Bristol's inventoried public trees, by percent representation.

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.



	0-3"	3-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42+"
Acer	11	9	61	86	41	34	8	6	3
Fraxinus	3	4	9	27	1	0	0	0	0
Picea	0	1	12	14	0	0	0	0	0
Malus	1	9	16	2	1	0	0	0	0
Gleditsia	1	2	16	7	0	0	0	0	0

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



	0-3"	3-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42+"
Crabapple	1	9	17	2	1	0	0	0	0
Honeylocust	1	2	17	7	0	0	0	0	0
Norway Maple	1	1	22	29	3	0	0	0	0
Red Maple	1	3	8	6	6	5	2	2	0
Sugar Maple	3	4	15	39	24	20	4	3	0

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 blonding, epicormic branching/water sprouts, and/or suspicious exit holes).

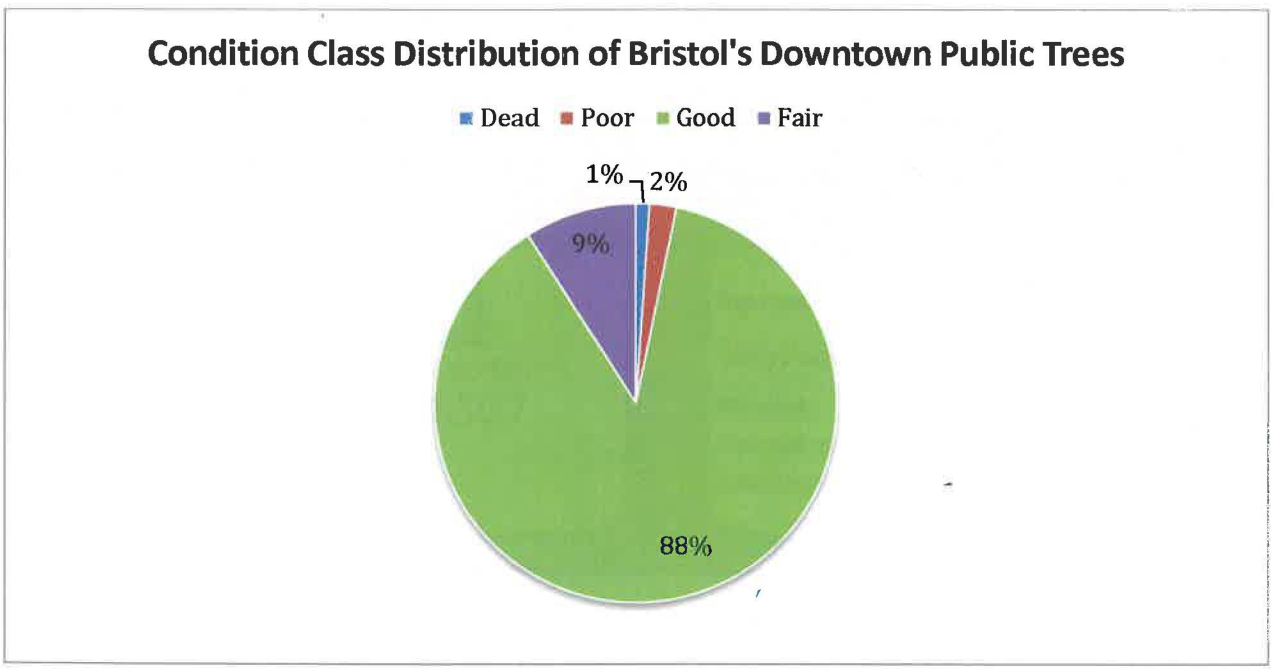


Figure 6: Percentage of Bristol public trees inventoried in each condition class.

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 CO_2, 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.

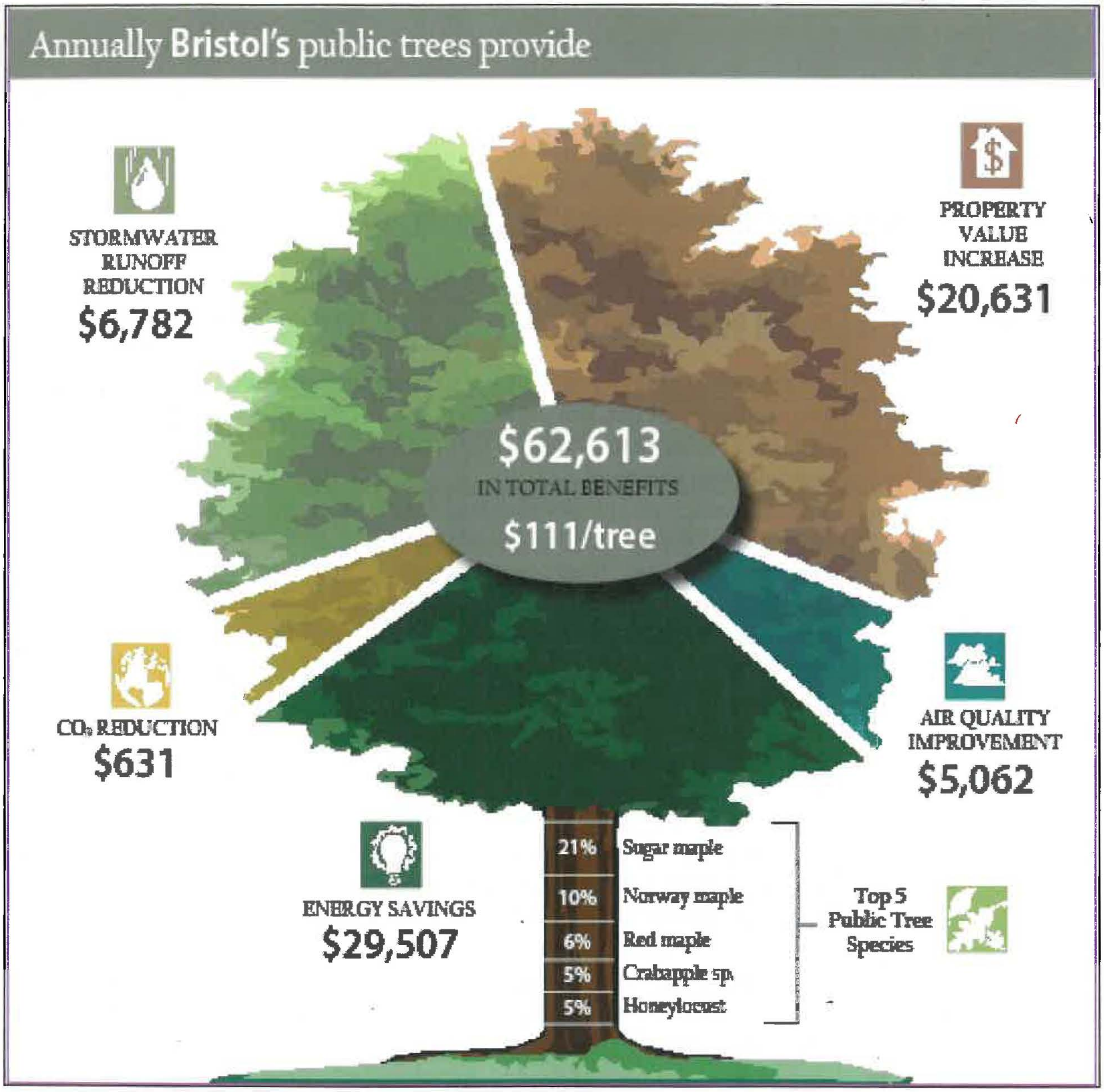


Figure 7: Summary of annual benefits provided by Bristol's downtown public trees inventoried through this project, according to the i-Tree Streets assessment. Tree graphic concept courtesy of City of New York Department of Parks & Recreation.

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