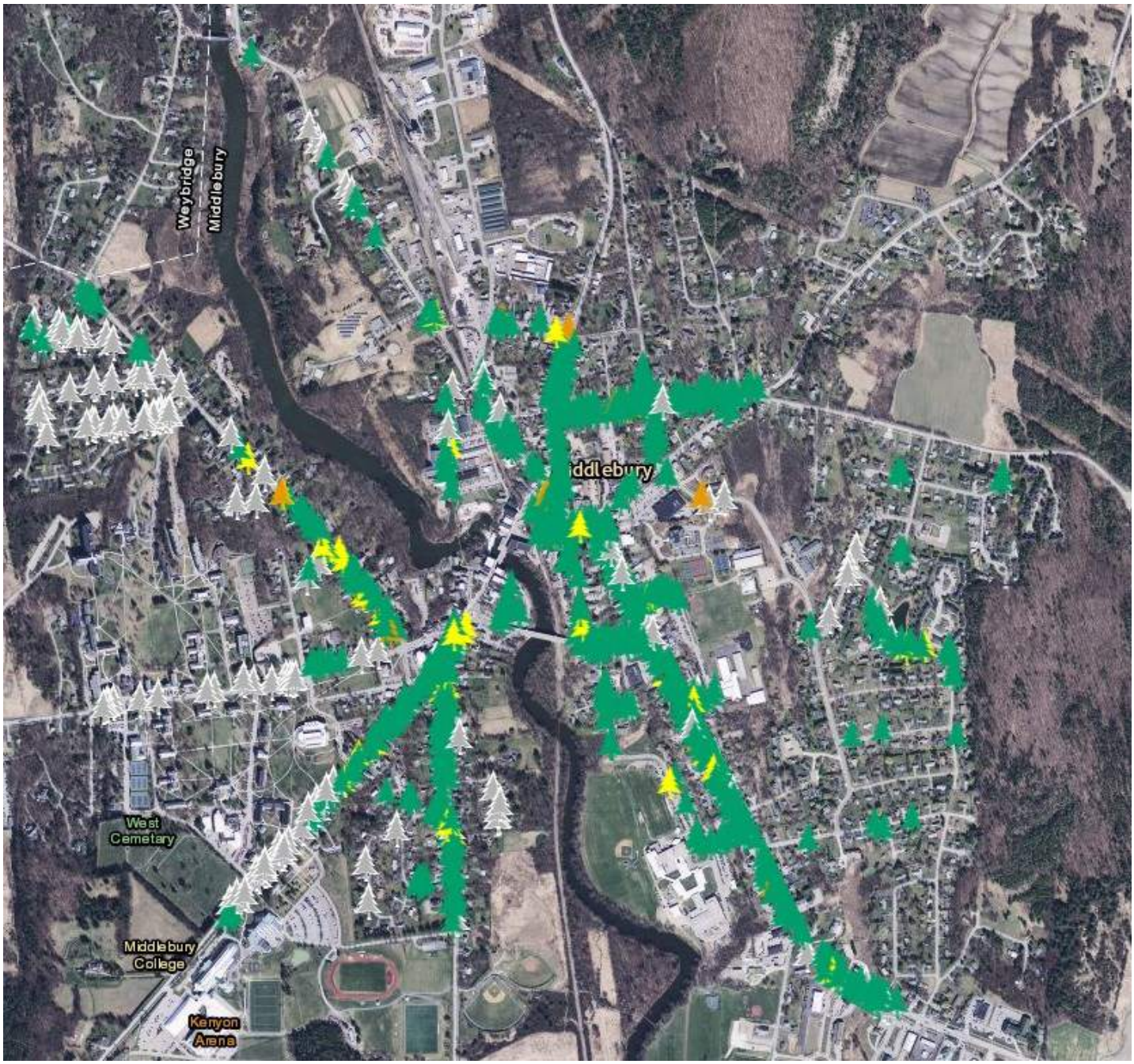
Middlebury Public Tree Inventory Report



Prepared for the Town of Middlebury by the Vermont Urban & Community Forestry Program and the University of Vermont Land Stewardship Program
February 2015

VERMONT FORESTS, PARKS & RECREATION
UNIVERSITY OF VERMONT EXTENSION
CULTIVATING HEALTHY COMMUNITIES
VERMONT
AGENCY OF NATURAL RESOURCES
PLANT LIVE GROW
VERMONT URBAN & COMMUNITY FORESTRY PROGRAM
FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE
VT ANR
GIS
LANDS
The Land Stewardship Program

Acknowledgements

This report was developed by 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 Middlebury, Vermont during the fall of 2014. We would like to thank Eric Blair, Middlebury's Town Planner, for providing a wonderful tour of Middlebury, support, and information while we worked on 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, town greens, and municipal forests compose our urban and community forests and merit careful stewardship. The Vermont Urban & Community Forestry program is a collaborative effort between the Department of Forests, Parks, & Recreation and the University of Vermont (UVM) Extension. The program provides technical and financial assistance as well as educational programs and products 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 to promote *civic responsibility for and participation in the stewardship of these resources for this and future generations*. Since 1991, a small staff and a twenty-member advisory council have guided the program. 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, CO_2 sequestration, and aesthetic value. VT UCF seeks to maximize these benefits by stewarding the urban forest's ecological integrity and diversity. The program assists communities with planning, planting, and caring for their community forests. With more than $1,000,000 in

competitive grants, VT UCF has provided assistance to over 150 Vermont communities. The program also provides local training and workshops, educational brochures, and newsletters for the public. All of the material and assistance provided by the program is designed to further its mission of enhancing local communities across Vermont.

About the Land Stewardship Program (LANDS)

LANDS is an innovative college conservation corps established in 2007 through a partnership between UVM'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. While doing so, LANDS students 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 building collaboration between UVM 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.

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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 Town of Middlebury. This information will provide residents and decisions-makers with a better understanding of the health and benefits of Middlebury's urban forest and will allow the municipal leaders to plan for future tree planting and maintenance using a map-based tree inventory system.

Two community forest inventories have been conduced: one in Middlebury, Vermont and one in East Middlebury, Vermont. Both were coordinated with the Middlebury Town Planner, Eric Blair. LANDS students completed the first inventory of **726 trees** located within the public ROW of 40 streets and on town-owned land, and identified 127 specific locations or strips of public (i.e. vacant) land appropriate for future tree plantings in Middlebury. Staff from VT UCF provided technical assistance for this inventory and conducted the second inventory in East Middlebury. **126 public trees** were inventoried in East Middlebury, with 44 "vacant" locations identified as suitable for future plantings. The following report focuses specifically on Middlebury's inventory. ***Please see Appendix E for East Middlebury's inventory results***. This report was drafted in the fall of 2014 by the LANDS interns and subsequently edited and supplemented by VT UCF program staff and graduate intern. It presents the results of the inventories and a basic assessment of the trees and canopy cover in Middlebury**.**

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 stormwater runoff, reducing air pollution, providing shade, sequestering carbon dioxide, enhancing property values, and improving the aesthetics of the community. The 726 public trees that were inventoried in Middlebury provide an estimated **$59,922** in benefits annually to Middlebury residents. In addition to the public trees inventoried, a tree canopy assessment was completed for the full inventory area (public and private land), which indicated existing canopy cover of 45% and a stored value carbon dioxide of over $800,000.

Summary of Findings

Forest Diversity

- Of the 726 inventoried public trees in Middlebury, there are 42 different species in 25 different genera.
- The top five most common tree genera: *Acer* (maple) (26.58%)*, Malus* (crabapple) (16.53), *Fraxinus* (ash) (9.37%)*, Gleditsia* (honeylocust) (5.65%), and *Ulmus* (elm) (4.96%) comprise 63.09% of the urban forest.
- *Fraxinus* (ash) and *Acer* (maple) genera comprise 30.67% of the inventoried public trees. Both of these genera are currently threatened by invasive tree pests: the emerald ash borer (EAB) and Asian long-horned beetle (ALB), respectively.
- The top five most common species: *Malus* species (crabapples) (16.53%), *Acer platanoides* (Norway maple) (12.26%), *Fraxinus* (ash species) (8.54%), *Acer saccharum* (sugar maple) (5.65%), and *Gleditsia triacanthos* (honeylocust) (5.65%), comprise 48.62% of Middlebury's stock.

Forest structure

- The majority of trees (200 or 28%) have diameter measurements falling within the 6-12" size class.
- 23% (or 170) of the inventoried trees fall into the 0-3" size class, 19% (or 137) of the trees are in the 3-6" size class, 16% (or 117) are in the 12-18" size class, 7% (or 48) of the trees fall into the 18-24" class, 4% (or 26) of trees are in the 24-30" size class, 2% (or 12) trees are within the 30-36" diameter class, and only 0.5% of the inventoried trees fall within the 36-42" diameter size class.
- No inventoried public trees have a diameter of 42" or greater.

Forest Cover

- There is an existing urban tree canopy (UTC) cover of 45% in the area of Middlebury that was inventoried (combined public and private land).

- Trees could potentially cover an additional 39% of the community's land surface. These "possible UTC" areas include grass, agricultural land, and impervious surfaces (e.g. parking lots, paved playgrounds, and the public ROW).
- The remaining 16% of Middlebury's area is occupied by buildings, wetlands, or water and is generally unsuited to UTC improvement.

Forest health

- An overwhelming majority (93% or 675) of the trees inventoried was assessed as being in "Good" condition. Of the remaining trees, 36 (5%) were considered to be in "Fair" condition, 12 (2%) were considered to "Poor" condition and 3 (0.4%) were "Dead".
- 21 trees were flagged as in need of a future consultation by a certified arborist, the Middlebury Tree Warden, or another qualified representative from the Town of Middlebury.

Summary of Recommendations

Based on the results of this inventory, we recommend that the Town of Middlebury:

- Build upon, and use the ***tree inventory*** to develop an urban forest management plan for Middlebury that emphasizes planning, planting, and maintaining current and future public trees along roadways to improve and build upon the health and sustainability of the urban forest.
- Continue to ***diversify*** urban forest structure, particularly species and age composition and distribution, to prepare for potential future threats and challenges, such as climate change, development, and various pests.
- Develop a comprehensive Middlebury ***Tree Policy*** to protect, promote, and enhance public health, safety, and general welfare by establishing provisions for planting, maintenance, protection, and removal of trees and shrubs on public lands, parks and town-owned properties.

- Develop a rich program of ***education and outreach*** to capture community-wide support of local urban forestry efforts in Middlebury through workshops and presentations. Encourage participation in VT UCF educational programming such as the *Stewardship of the Urban Landscape* course and the *Forest Pest First Detectors* trainings.
- ***Monitor*** tree health, specifically for signs and symptoms of Emerald Ash Borer (EAB), Asian Long-horned Beetle (ALB), and other forest pests and diseases.
- ***Plan*** for the arrival of EAB by developing a community preparedness and response plan.

The LANDS team who conducted Middlebury's public tree inventory. From left to right: Chris Chapman, Zoe Davis, Sarah Rosenblatt, Brian Borque, Rachel Wood, Olivia Arent, and Laura Yayac.

Introduction

Project Description

VT UCF is currently working on a project funded by 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) by conducting a public tree inventory to assess urban forest structure, diversity, and health; (2) by helping the community in the development of an urban forest management plan (or master plan) using information from the inventory; and (3) by providing technical training for volunteers and town employees to promote the proper care and management of public trees.

Prior to this project, Middlebury had no formal tree inventory. Middlebury's Town Planner, Eric Blair, has a background in urban forestry and is working towards developing a vibrant urban forestry program in Middlebury. This project is complimented by outreach efforts in Middlebury, funded through a 2014 Caring for Canopy grant from VT UCF. Maintaining Middlebury's existing trees will enhance the quality and health of its urban forest, and will augment the environmental, social, and economic benefits provided to Middlebury residents by its public trees.

The goal of the public tree inventory was to document the location, size, species composition, and condition of trees

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.

planted within the public right-of-way (ROW) and on town-owned land within approximately 4.87 square miles of the downtown and most densely populated areas of Middlebury. Students from the LANDS Field Semester program conducted a comprehensive public tree inventory over the course of three field days. East Middlebury was inventoried by VT UCF staff separately (results from East Middlebury's inventory included in Appendix E). These inventories establish a baseline for future inventories, management decisions, and improvements to Middlebury and East Middlebury's urban forest.

Middlebury Community Profile

The Town of Middlebury is located in central Addison County. Middlebury was chartered by Colonial Governor Benning Wentworth in 1761. The name "Middlebury" comes from the Town's nestled location between Salisbury and New Haven, Vermont. Middlebury's early industry revolved around power provided by Otter Creek. These industries included such businesses as a cotton factory, grist mill, iron foundry, and marble quarry. The total land area of Middlebury is 39.2 square miles. According to the 2010 U.S. Census, Middlebury's population is 8,496 people in 2,657 households. Middlebury plays host to the junction of several major roadways including U.S. Route 7, Vermont Route 23, Vermont Route 30 and, Vermont Route 116. Middlebury College is also located in the town of Middlebury and is one of the town's major attractions, along with the Henry Sheldon Museum of Vermont History.

Methodology

Prior to the public tree inventory, VT UCF staff met with Middlebury Town Planner Eric Blair to plan for the inventory. Sixty streets in Middlebury were originally chosen to be included in the inventory, as well as a number of priority town-owned properties. Right-of-way (ROW) boundaries were determined for all streets based on information from the Middlebury Planning Office. In total, the inventoried land area was about 4.87 square miles, representing less than 12.4% of the total land area of Middlebury, but including the most densely populated section of town. The list of streets and sites with public ROW boundaries is found in Appendix A and maps of the inventory area are found 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. The entire inventory data collected on public trees in Middlebury is available for viewing on the ANR Atlas tool and instructions for viewing are outlined in Appendix C.

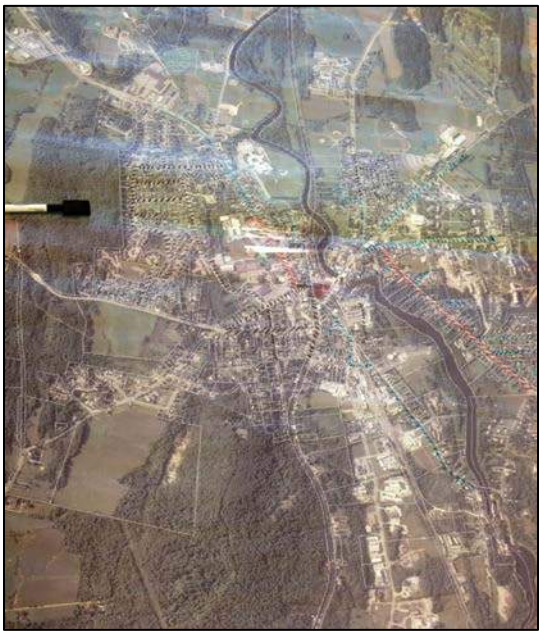
On September 16th, 17th, and 18th, 2014, six LANDS students walked along pre-designated streets and sites of Middlebury, inventorying the public trees and identifying appropriate potential planting locations or green strips (recorded as "vacant"). To ensure that only public trees were inventoried (as opposed to trees on private property), each team of students had a list of the public ROW boundaries for each street. Their first step upon reaching a new street was to determine the extent of the ROW from the curb. Operating under the assumption that ROW boundaries are designated from the middle line of any given street, 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 each curb = (ROW width - 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 below.

Table 1: Parameters for Inventory Data Collection

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: Each morning and afternoon the LANDS students met to discuss and plan the most effective routes for data collection using a large parcel map.
Right: An example of a photograph of an individual tree that is attached to a record in the "Collector" application.

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 Middlebury's inventoried public trees. The LANDS students additionally performed a baseline full canopy cover assessment of Middlebury, encompassing both private and public property, using i-Tree Canopy. i-Tree is a free software suite developed by the USDA Forest Service and available at www.itreetools.org.

Inventory Results

Urban Forest Diversity

Of the 726 trees inventoried within the public ROW or on town-owned land, there were a total of 42 different species in 25 different genera. The most common tree genera, *Acer* (maple), *Malus* (apple), *Fraxinus* (ash), *Gleditsia* (honeylocust), and *Ulmus* (elm) comprise 63% of the urban forest (Figure 1). *Malus* species (crabapples) (16.53%) were the most common, followed

by *Acer platanoides* (Norway maple) (12.25%), *Fraxinus* (green and white ash) species (8.54%), *Gleditsia triacanthos* (honeylocust) (5.65%), and *Acer saccharum* (sugar maple) (5.65%) (Figure 2). It is important to note that approximately 20 *Acer* trees were not identified to the species level in the Middlebury inventory, likely because they were hybrids or cultivars unfamiliar to the LANDS students; these trees are therefore not included in the percent species composition noted above, and are instead only included in the percent genera composition. Complete species and genera lists can be found in Appendix B. There were multiple Japanese lilac trees (*Syringa reticulata*) found in the area; however, it was not until after the report was generated that it was determined that this was the correct species, so in ArcCollector these trees were classified as "Broadleaf Deciduous", as were any other species the LANDS students were not able to identify.

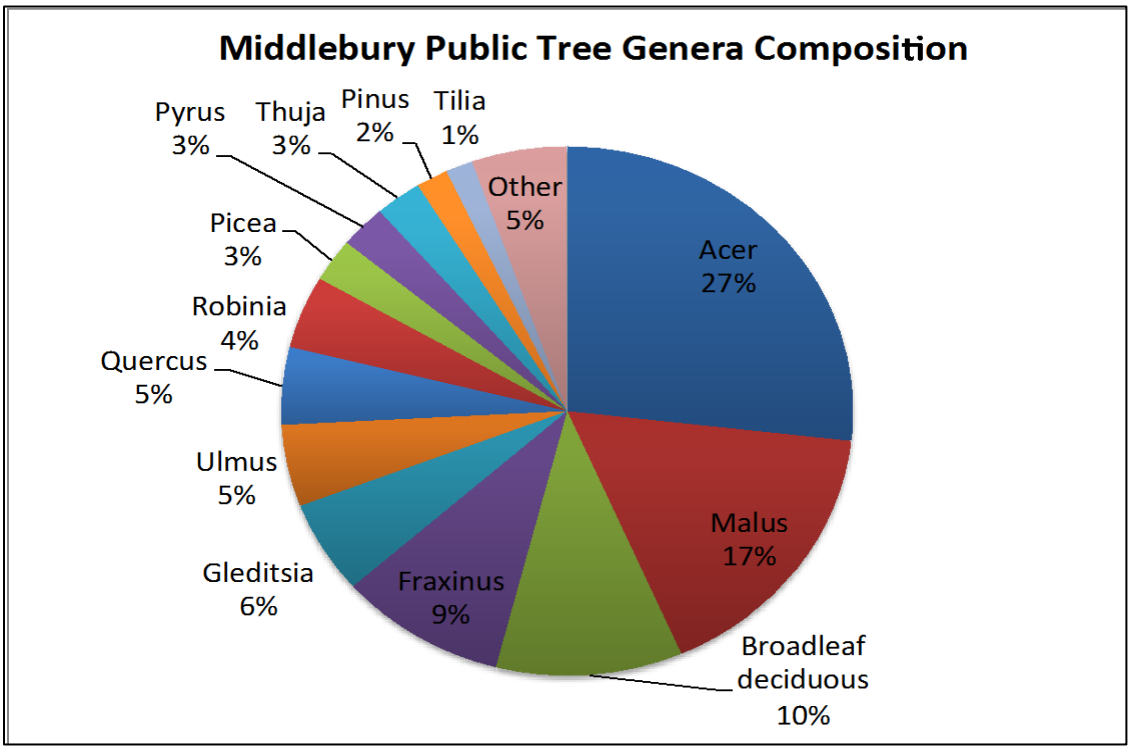


Figure 1: Genera by percent composition of Middlebury's inventoried urban forest. Note that "Other" represents a total of all the genera with less than 1% composition. Percentages are rounded to the nearest whole number.

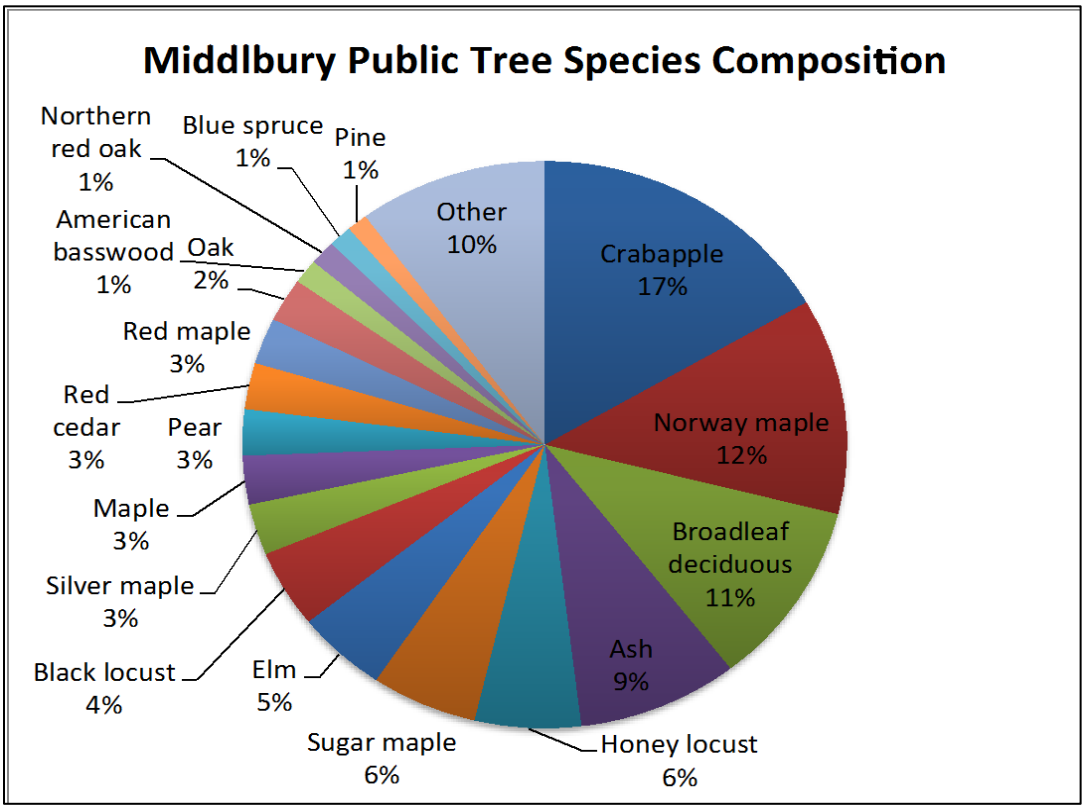


Figure 2: Species by percent composition of Middlebury's inventoried urban forest. Note that "Other" represents a total of all the species with less than 1% composition. Percentages are rounded to the nearest whole number.

Urban Forest Structure

Overall, Middlebury has a young urban forest comprised mainly of small-diameter hardwoods. Of the 726 trees inventoried, 27.55% (200 trees) had a DBH of 6-12", 23.42% (170) of the inventoried trees had a DBH of 0-3", and 12.39% (90 trees) had a DBH greater than 18" (Figure 3). The percent genera composition within each of these size classes indicates that the smaller (and presumably younger) trees in Middlebury's urban forest have greater genera diversity than the larger (presumably older) trees in the urban forest (Figure 4). This is in part due to the varied lifespans and historical availability associated with Middlebury's five most common genera. To encourage genera diversity among mature age classes, genera associated with long lifespans should be considered for future plantings. *Fraxinus* (ash) and *Acer* (maple) species comprise the greatest percentage of larger-sized and older trees in Middlebury's urban forest

(Figures 4 and 5). The presence of maturing ash species indicates a need to plan for the arrival of EAB in Middlebury; the pest has yet to be detected in Vermont but VT UCF encourages all towns with significant ash populations to prepare. The low percentage of ash trees within the 0-3" diameter size class may, however, suggest that Middlebury stopped planting ash trees in preparation for EAB. The four largest public trees in Middlebury (within the 36-42" diameter class category) were a Norway spruce located on Washington Street and three sugar maples located on Seminary Street, North Pleasant Street, and Weybridge Street, respectively.

There were 127 potential tree planting locations or strips of land identified within the public ROW (recorded as "vacant" in ArcCollector). Appendix A breaks down these locations by street. With 28 potential spots, Gorham Lane has the greatest potential for tree planting along the public ROW. LANDS did not specifically indicate which tree size (small, medium, or large) could be planted in each vacant spot. It is however recommended that a small or medium tree species be planted in any vacant locations downtown or near power lines. Vacant areas not restricted by below- or aboveground utility wires or obstructions could potentially hold medium to larger trees.

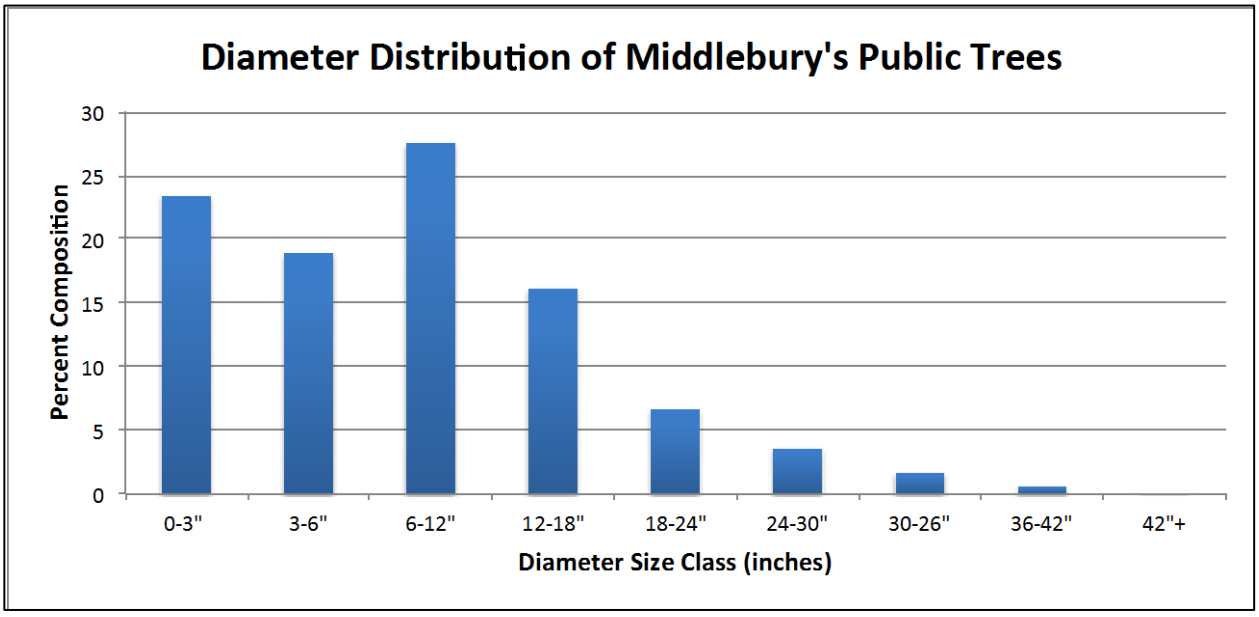


Figure 3: Percent of inventoried public trees within each diameter class (inches) in Middlebury, VT's urban forest.

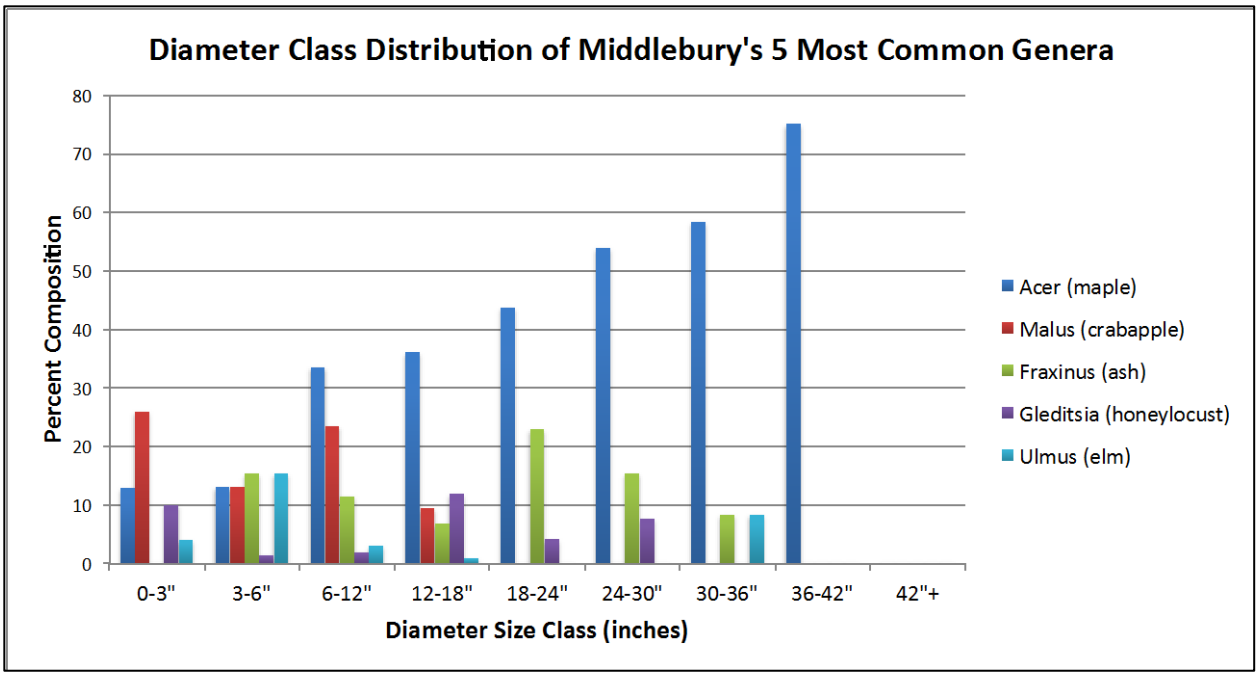


Figure 4: Percent composition of the five most common genera within each diameter (inches) size class in Middlebury's urban forest.

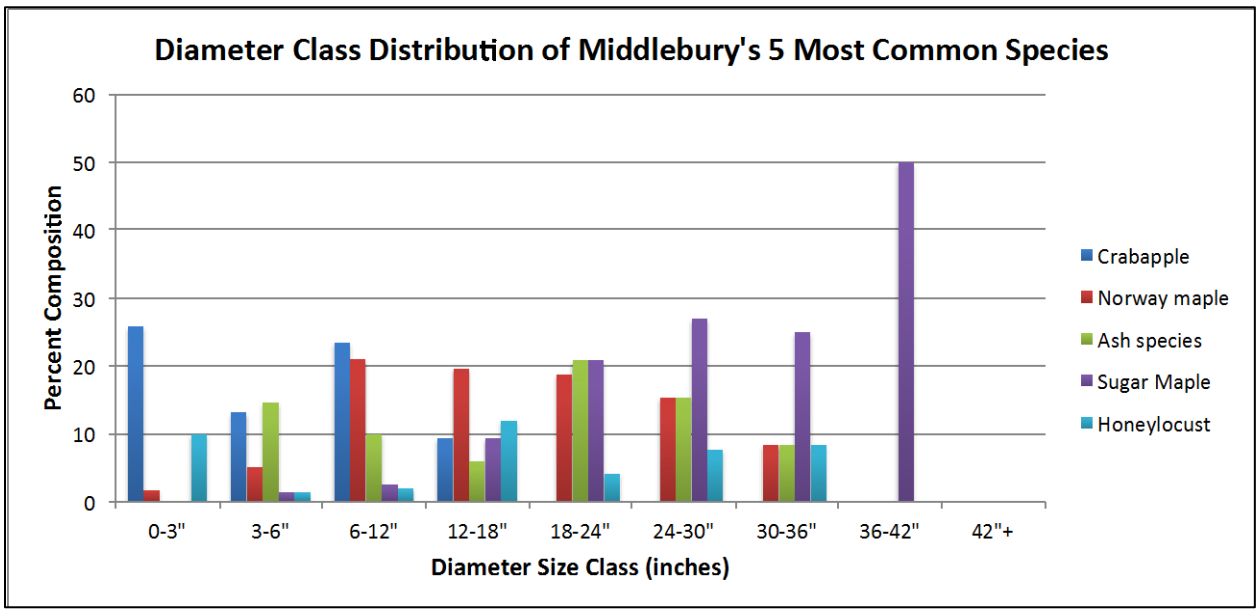


Figure 5: Percent composition of the five most common species within each diameter class (inches) in Middlebury's urban forest.

Urban Forest Health

An overwhelming majority (93% or 676) of Middlebury's inventoried public trees was assessed as being in "Good" condition. Of the remaining trees, 5% (36) was considered to be in "Fair"

condition, 2% (12 trees) was in “Poor” condition, and only 0.4% (3 trees) was “Dead” (Figure 6). *Fraxinus* (ash) and *Acer* (maple) genera comprised the greatest percentage of trees in “Fair” and “Poor” condition (Figure 7). Although both of these genera are threatened by the spread of invasive pests, their percent composition within the “Fair” and “Poor” condition classes is likely due to their relative abundance and unlikely due to the presence of the EAB or the ALB. The tree dead trees were a crabapple located on South Pleasant Street and two unidentifiable species on Court Street and South Main Street, respectively. Refer to the map in Appendix D for the specific locations of these trees.

Twenty-one trees (2.89%) were flagged for a consult during Middlebury’s inventory and should be reassessed by a professional arborist, the Middlebury Tree Warden, or a qualified community representative. 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/cars,
- The tree was growing into utility wires,
- The tree was dead or in poor condition, or
- The tree was of the genera *Fraxinus* (ash) and was showing evidence of potential infestation by the emerald ash borer (signs included extensive woodpecker flecking, bark blonding, epicormic branching/water sprouts, and/or suspicious exit holes).

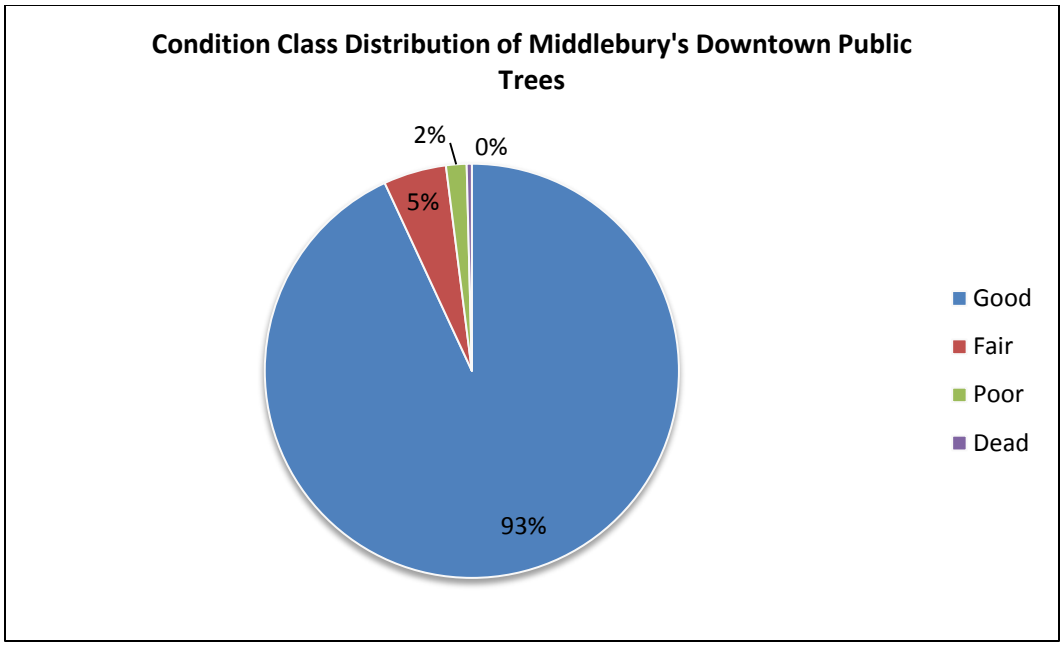


Figure 6: Percent of inventoried public trees in each condition class in Middlebury, VT. Note that each percent composition was rounded to the nearest whole number.

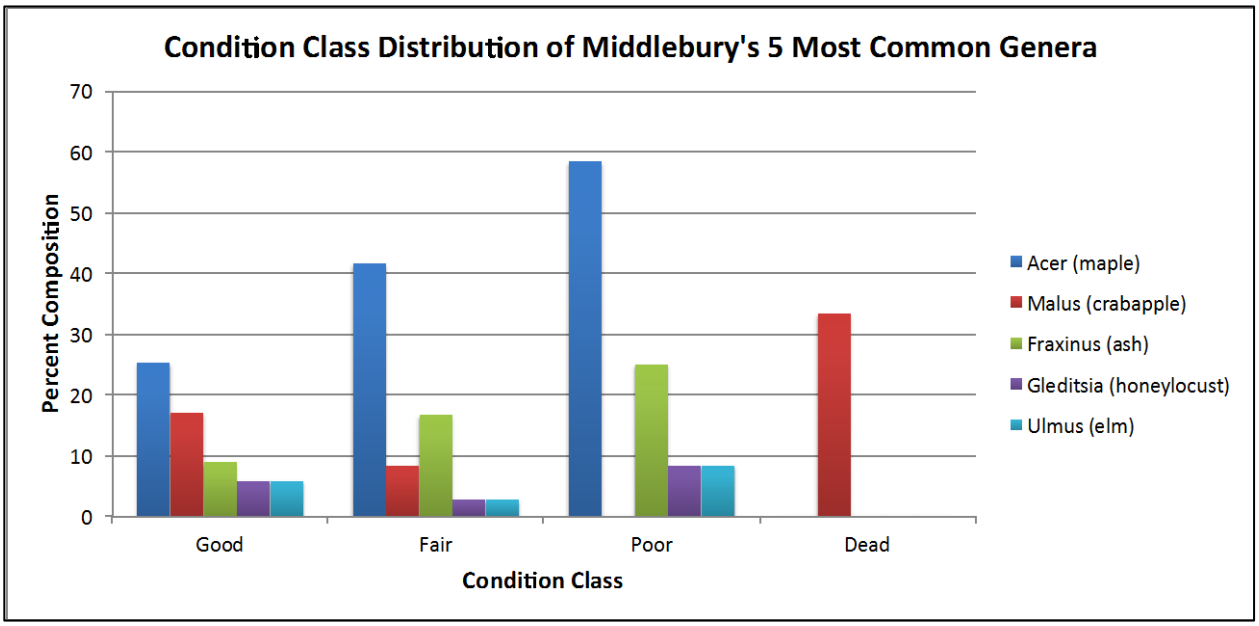


Figure 7: Percent composition of five most common genera within each condition class in Middlebury's urban forest.

Monetary Value and Ecosystem Services

Middlebury's urban forest data were analyzed using the free online i-Tree Streets application to determine the monetary value of the ecosystem services provided by the Town's trees. i-Tree Streets uses sophisticated models developed by researchers at the Davey Institute of Tree Sciences and US Forest Service scientists to assign monetary values to the services provided by individual trees in urban landscapes. The 726 trees provide a total of $59,922 in annual benefits by filtering air pollutants, mitigating stormwater runoff, sequestering carbon dioxide (CO_2), conserving energy, and increasing property values. On average, each public tree offers $84.16 annually in savings or services.

Figure 8 and Table 2 provide an overview of each ecosystem service provided by Middlebury's public trees. Energy conservation ($25,769) and property value increase ($23,888) are the most significant services provided by these trees in terms of their monetary value. The full reports produced through the i-Tree Streets assessment for Middlebury are available upon request through VT UCF.

It is important to recognize that the trees inventoried through this project are located within approximately 4.87 square miles of Middlebury's 39.2 square miles of total land area. Expanding the inventory to all of Middlebury's roads would increase these figures dramatically. It is also noteworthy that larger and long-lived trees provide substantially more benefits than young, small trees. Since tree age is correlated to diameter size and only 42 of Middlebury's inventoried public trees have a DBH greater than 24" (zero trees have a DBH of 42" or greater), it is important that Middlebury officials manage for tree longevity to maximize its urban forest benefits. Regular maintenance and care are needed to promote urban tree health, longevity, and maximized urban forest benefits.

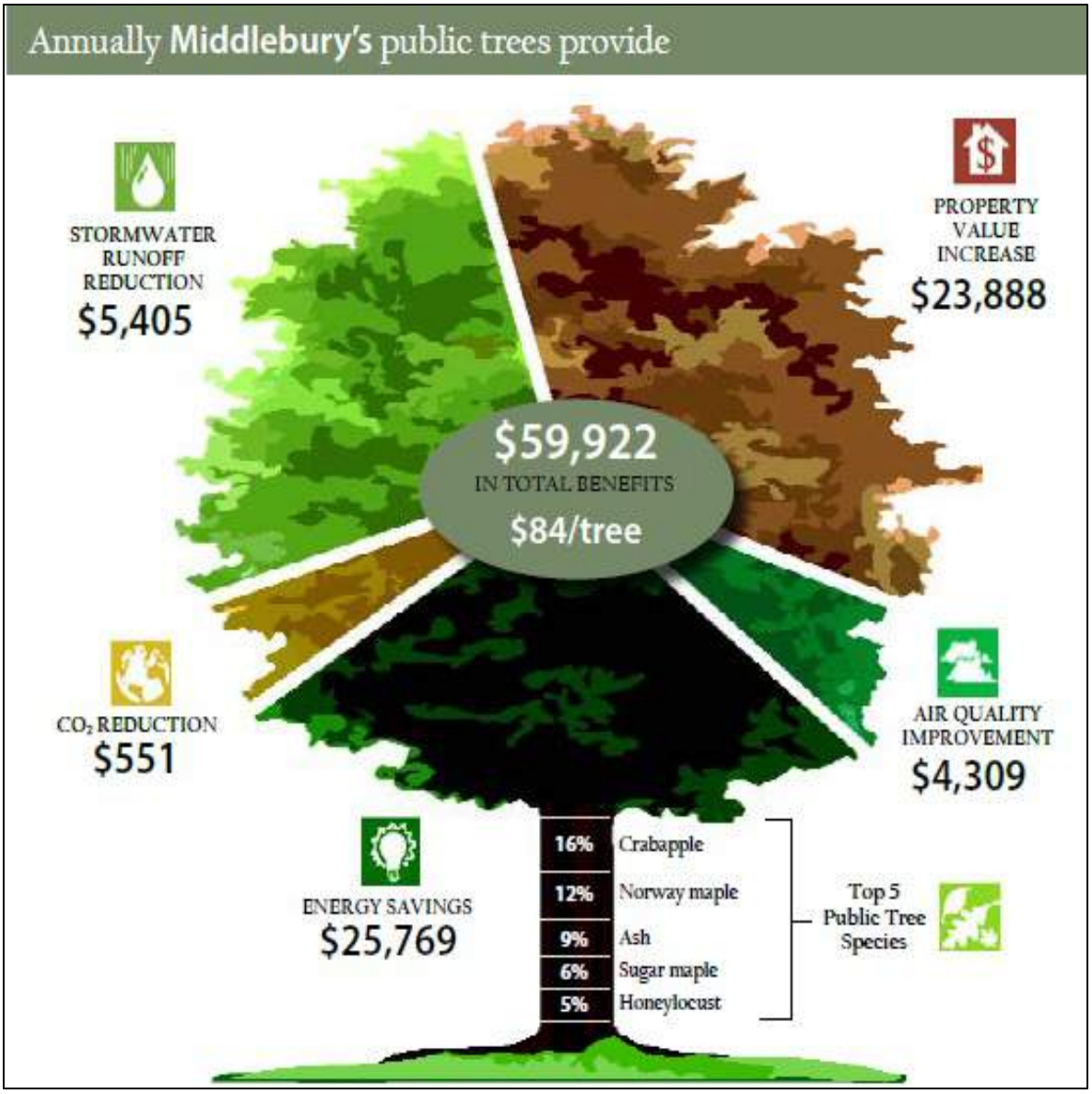


Figure 8: Summary of benefits provided by Middlebury's public trees. Tree graphic concept courtesy of City of New York Department of Parks & Recreation

Table 2: Annual environmental and monetary benefits provided by Middlebury's inventoried public trees, as reported in the i-Tree Streets assessment.

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	$ 25,769	$ 36.19
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.	$ 551	$ 0.77
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.	$ 4,309	$ 6.05
Stormwater	Reductions in annual stormwater run-off due to rainfall interception by trees.	$ 5,405	$ 7.59
Aesthetic/other	Tangible and intangible benefits of trees reflected in increases in property values.	$ 23,888	$ 33.55
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.	$ 4,803*	$ 6.75*
Totals		$ 64,725	$ 90.90

Middlebury Full Canopy Assessment

As a complement to the public tree inventory, the LANDS Field Semester students completed an i-Tree Canopy assessment for the inventory area in Middlebury. 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 dollar values to the benefits associated with the overall tree canopy cover. The aim of this type of assessment is to help citizens and decision-makers better understand the existing and potential

tree canopy in their community. The i-Tree Canopy assessment was conducted in the area surveyed by the LANDS semester students (approximately 4.87 square miles or 12% of the total land area of Middlebury). Based on the Middlebury i-Tree Canopy assessment, approximately 44.9% of this area is currently occupied by tree canopy (Figure 9). In consideration of the other land cover types present, Middlebury could potentially increase its total tree canopy cover by an additional 24.5% on agricultural and open lands of low-lying vegetation (including private lawns). Additionally, 14.3% is impervious surface (parking lots, playgrounds, roads and the ROW) and with strategic planning could be converted to canopy. In total, there is currently potential to increase overall tree canopy cover in Middlebury by 38.8%. 16.3% of the area is occupied by buildings, wetlands, or water, and is not suitable for tree planting (Figure 10).

Figure 11 complements the i-Tree Streets analysis of the monetary value of benefits provided by Middlebury's public trees by estimating the air quality benefits and corresponding monetary value for the full urban forest canopy. Of note is an estimated $817,198.15 in long-term CO_2 storage and $32,411.63 in annual CO_2 sequestration value.

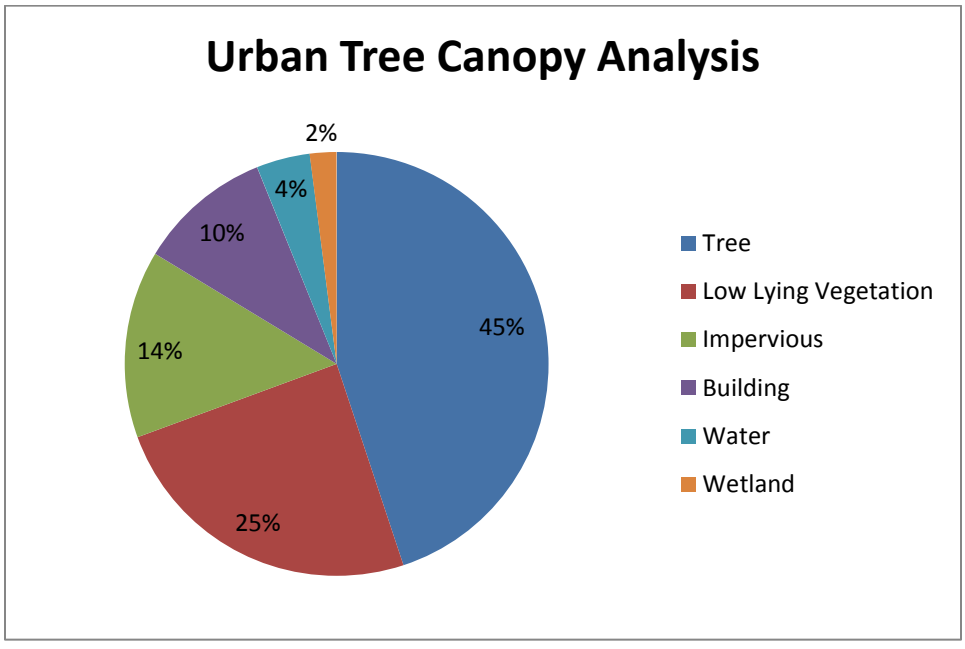
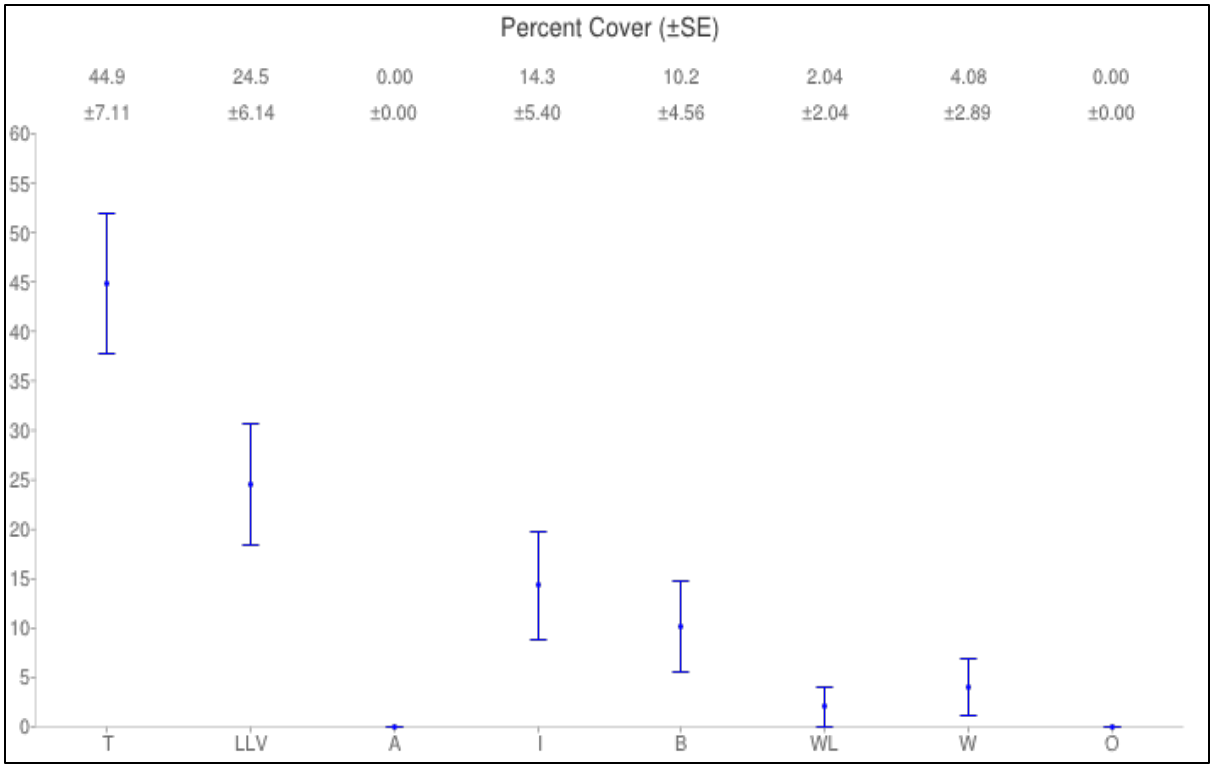


Figure 9: Land cover class distribution for Middlebury, VT based on randomized assessment through iTree Canopy.



Cover Class	Description	Abbr.	Points	% Cover
Tree	Tree, non-shrub	T	22	44.9 ±7.11
Low Lying Vegetation		LLV	12	24.5 ±6.14
Agriculture		A	0	0.00 ±0.00
Impervious		I	7	14.3 ±5.40
Building		B	5	10.2 ±4.56
Wetland		WL	1	2.04 ±2.04
Water		W	2	4.08 ±2.89
Other		O	0	0.00 ±0.00

Figure 10: i-Tree Canopy assessment for the inventoried area in Middlebury, VT. This displays the benefits of urban trees with the estimated confidence interval of actual cover in Middlebury.

Tree Benefit Estimates

Abbr.	Benefit Description	Value	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	$12.83	±2.03	302.75 lb	±47.91
NO2	Nitrogen Dioxide removed annually	$22.09	±3.50	1,650.81 lb	±261.26
O3	Ozone removed annually	$1,150.64	±182.10	8.22 T	±1.30
PM2.5	Particulate Matter less than 2.5 microns removed annually	$2,378.59	±376.44	798.91 lb	±126.44
SO2	Sulfur Dioxide removed annually	$3.86	±0.61	1,040.30 lb	±164.64
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	$835.34	±132.20	2.75 T	±0.44
CO2seq	Carbon Dioxide sequestered annually in trees	$32,411.63	±5,129.48	1,673.87 T	±264.91
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	$817,198.15	±129,330.18	42,203.37 T	±6,679.13

Figure 11: i-Tree Canopy monetary estimates for air quality benefits of Middlebury's full 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: *Acer*) in a tree population and no more than 10% of one species (for example: *Acer saccharum*). Resistance to disease and insect infestation is one of the many reasons that diversity within the urban forest is of paramount concern. A more diverse forest will be more resistant to environmental stressors, and therefore remain healthy and resilient in the face of change. Furthermore, by maintaining higher diversity a community can prevent a rapid loss of canopy due to insect and disease issues.

In Middlebury, 27% of public trees inventoried were in the *Acer* (maple) genus, which is more than the recommended representation within the community's urban forest. Specifically, Norway maple, sugar maple, red maple, silver maple, and unidentified maple (hybrids and cultivars) represent 12%, 6%, 3%, 3%, and 3% of the species diversity, respectively. Norway maple is the second most prevalent species

Components of a Vibrant and Resilient Urban Forest Management Program

A successful urban forestry program requires a combination of organized leadership, comprehensive information about the tree population, dedicated personnel, and effective public relations. We recommend the following components for successful urban forest management.

Public Policies: A tree ordinance or policy provides authority for conducting forestry programs, defining municipal responsibility for public and private trees, passing regulations and setting minimum standards for urban forestry management.

Leadership: Define who is responsible for the oversight of the community forest, including formulating policies, advising, administration, management, representation and/or advocacy.

Partnerships: A well-managed urban forest takes the work of many. Seek strategic partnership to meet a shared vision. At a minimum the tree warden, a local advisory committee like a tree board or conservation commission and municipal staff (parks, roads, planning) should collaborate.

Responsibility: A clear understanding of which trees and areas will be managed is an important first step. Street trees, parks and village greens, cemeteries and schools are typical areas of municipal responsibility.

Assessment: A complete public tree inventory, including tree locations, species, condition, and management needs provides the necessary information to manage the resource. An inventory is the foundation to developing a strategic management plan.

Management Plan: A management plan provides a vision for the long-term management of the community forest. It should include strategies, budgets, and responsibilities for meeting that vision.

Staffing: The care of urban forest requires a certain skill set that can be found in-house with professional staff or through consultants. Whether creating a staff position for a certified arborist or urban forester, or contracting with them on an as-needed basis, professional assistance will have some of the greatest and most immediate impacts on a community forestry program.

Tree Canopy Goals: Consider a community's entire tree canopy to reduce loss and maximize gains over time by protecting undeveloped forest and impacts of land development, enhance the health condition and function of forests, and reforest through active replanting or allowing regeneration.

inventoried in Middlebury, 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*) comprise 9% of Middlebury's public tree canopy. Both ash and maple trees are currently threatened by invasive tree pests; 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 to-date 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. *Malus* (apple) is the second most common genus in Middlebury. Although apple trees are hardy, short-growing, and an aesthetically-pleasing street tree, it is recommended that the proportion of apple trees be kept under 20% of the overall diversity of the urban forest. Limiting the proportion of species to fewer than 20% increases the diversity and resilience of urban forests.

We recommend diversifying Middlebury's community forest by maintaining the existing urban trees, creating age diversity with routine planting, and creating a level of resiliency against pests and diseases by planting a variety of tree species. This will promote long-term health of the urban forest.

<u>Recommended action practices</u>

- We advise against planting high-density stands of the same species (monocultures) whose close proximity may be conducive to the spreading of disease.
- We suggest planting tree species that have grown successfully in the area that show no major signs of disease or deformity, and that are not non-native invasive species (specifically Norway maple).
- We suggest planting native coniferous species to increase the conifer – hardwood ratio in Middlebury's urban forest. Most conifers are evergreen and have comparably greater

biomass than hardwoods. Having a greater percentage of conifers in Middlebury's urban forest can therefore help to maximize its ecological and societal benefits.

- Existing ash trees should be consulted and regularly monitored for signs of EAB, and additional ash trees should not be planted.

- Plan for the arrival of Emerald Ash Borer by using the Community Preparedness Toolbox, available at 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 in both species composition and age structure, refer to the 127 identified vacant planting locations within the public ROW and develop a strategic planting plan.

- In planning for future tree plantings, minimize grey infrastructure conflicts (sidewalks, streets, buildings, etc.), consider obstructions aboveground (power lines) and belowground, available soil volume, species mature size (height and spread), branching patterns, environmental tolerances (exposure, salt, and drought), and desired function when choosing species. For more information on site assessment and species selection, refer to the VT Tree Selection Guide available at www.vtcommunityforestry.org.

- Encourage residents to plant native trees on their properties to 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" 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.

We recommend establishing a routine maintenance cycle, implemented by trained municipal employees, 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 Middlebury in order to plan for a routine maintenance regime for all town-managed trees.
- Work with VT UCF or Middlebury College Arborist, Tim Parsons, 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 Middlebury 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 Middlebury's canopy.
- Explore options for enlisting engaged Middlebury residents in the regular maintenance of street trees.

Urban Forest Health

Overall, Middlebury appears to have a healthy population of public trees. Approximately 7% of Middlebury's public trees were either considered to be in "Fair" or "Poor" condition and only 3 "Dead" trees were found. Twenty-one trees were flagged for consult by a professional arborist

or another qualified professional. 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 Middlebury, and a map indicating the locations of the 21 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.

We recommend continuing to monitor trees in "Good" and "Fair" condition, plan to lose trees in "Poor" condition, and remove "Dead" trees to increase overall urban forest health. Pay special attention to ash and maple trees for evidence of the EAB and the ALB.

<u>Recommended action practices</u>

- Visit and assess the 21 trees flagged for consultation in a systematic and timely fashion.
- Remove the 3 dead public trees identified.
- Closely monitor the health of the 12 public trees in "Poor" condition and plan for their removal and replacement in the near future.
- Continue to monitor the health of the trees in "Good" and "Fair" condition in future updates of the public tree inventory and record any changes in tree health.
- Monitor Norway maple seedlings, as Norway maple is an invasive species and limiting its spread is important for maintaining local forest health.
- Focus efforts at the junction between College Street and South Main Street, an area of high use and high value to the public that contains a relatively large number of trees in "Poor" condition.

Assessment Tools

Using free i-Tree software the value and potential expansion of Middlebury's urban tree canopy was assessed. i-Tree Streets determined the economic value of the ecosystem services provided by the 726 inventoried public trees in Middlebury. Middlebury's urban forest generates about $59,922 annually through the benefits of air quality improvement, carbon sequestration, electricity and natural gas use reductions, aesthetics, and storm water control. On average, each tree offers $84 in services or savings every year. Middlebury's trees provide services to the town in the following ways:

- **Aesthetics**: Community trees make an urban or suburban environment a more pleasant and satisfying place to live, work, and visit (Dwyer et al. 1991). In monetary terms, presence of shade trees can significantly increase property value. There are also numerous health benefits to trees. For example, hospital patients with window views of trees can 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 regulating 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 mitigate climate change by storing carbon in their biomass 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 stormwater treatment by retaining or slowing flow of precipitation.

Based on assessing land cover types by using a random sample method, i-Tree Canopy measured the overall tree canopy cover at 45% within the boundaries of the inventory area, capturing both private and public tree canopy.

We recommend using 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 Middlebury 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. Middlebury officials should consider this report's recommendations based on the Town's long-term vision and current capacity.

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

Street/site name	ROW Extent (feet)	Number of Trees	Number of Vacant Spots or Strips
Bakery Lane	20' North of Cross, 25' South of Cross	9	0
Benedict Lane	50	6	0
Brookside Drive	50	0	4
Buttolph Drive	50	6	2
Charles Avenue	60	15	0
Chipman Heights	44	n/a*	n/a*
Chipman Park	44	17	4
College Street	66	8	17
Colonial Drive	50	n/a*	n/a*
Court Street	82.5	142	12
Cross Street	49.5	22	0
Danyow Drive	50	n/a*	n/a*
Duane Court	50	4	0
Dwire Circle	50	n/a*	n/a*
East Road	50	2	0
Elm Street	50	8	0
Fairview Circle	50	n/a*	n/a*
Forbes Circle	50	2	0
Forrest Lane	50	n/a*	n/a*
Foster Circle	50	n/a*	n/a*
Gambrel Court	50	n/a*	n/a*
Gorham Lane	50	0	28
Green Mountain Place	Access 25'	0	5
Harrow Way	50	2	0
High Street	52.8-28 to east, 24.8' west of centerline	14	0
Locust Lane	50	n/a*	n/a*
Maple Street	49.5	16	2
Mary Hogan Drive	50	23	1
Meadow Way	50	1	0
Merchants Row	50-60 (ROW boundaries apparent)	n/a*	n/a*
Middlebury Court Square	n/a	12	0
Middlebury High School	n/a	n/a*	n/a*
Middlebury Middle School	n/a	n/a*	n/a*
Middlebury Town Green	n/a	52	0
Mill Street	49.5	n/a*	n/a*
Monroe Street	50	4	0
Morningside Drive	45	4	10
Murdock Court	30	0	2

North Main Street	48.4	n/a*	n/a*
North Pleasant Street	82.5	42	0
North Street	30	n/a*	n/a*
Park Street	35-50 (ROW boundaries apparent)	n/a*	n/a*
Peterson Terrace	50	n/a*	n/a*
Riverfront Park	n/a	n/a*	n/a*
Rogers Road	50' North of Danyow Dr North and South of Danyow Dr South, 40' in between	n/a*	n/a*
Seminary Street	80.25	61	1
Seminary Street Ext.	66	n/a*	n/a*
Seymour Street	82.5	22	2
Seymour Street Ext.	49.5	15	6
Shannon Street	50	1	3
South Main Street	92.4' Park St. to South St., 79.5' South St. and south	58	20
South Pleasant Street	74	20	0
South Street	66	53	2
Springside Road	28' from Seminary St to Locust Land, 45' northward	n/a*	n/a*
Stewart Lane	50	n/a*	n/a*
Swanage Court	50	n/a*	n/a*
Thomas Street	40	n/a*	n/a*
Valley View Drive	50	2	0
Washington Street	52.5' from court square to high street	9	0
Washington Street Ext.	49.5	n/a*	n/a*
Water Street	49.5 from Cross St. to Charles St.	9	0
Weybridge St	66	46	4
Willard Street	28	n/a*	n/a*
Woodland Park	50	19	2

n/a* = Street/Site was not inventoried by the LANDS students because of time constraints

** = only partially completed

Appendix B: Full Species and Genera List for Middlebury's Public Trees

Common Name	Scientific Name	Number of Trees	% of Total Population
Crabapple	*Malus sp.*	120	16.53%
Norway maple	*Acer platanoides*	89	12.26%
Broadleaf deciduous other*	*n/a*	76	10.47%
Ash sp. (most likely green)	*Faxinus pennsylvanica*	62	8.54%
Honeylocust	*Gleditsia triacanthos*	41	5.65%
Sugar maple	*Acer saccharum*	41	5.65%
Elm sp.	*Ulmus sp.*	35	4.82%
Black locust	*Robinia pseudoacacia*	32	4.41%
Silver maple	*Acer saccharinum*	21	2.89%
Maple sp. Other	*Acer sp.*	20	2.75%
Pear	*Pyrus sp.*	19	2.62%
Eastern red cedar	*Juniperus virginiana*	19	2.62%
Red maple	*Acer rubrum*	19	2.62%
Oak sp. Other	*Quercus sp.*	18	2.48%
American basswood	*Tilia americana*	10	1.38%
Northern red oak	*Quercus rubra*	10	1.38%
Blue spruce	*Picea pungens*	9	1.24%
Pine sp. Other	*Pinus sp.*	8	1.10%
Honeysuckle sp.	*Lonicera sp.*	7	.964%
American beech	*Fagus grandifolia*	6	.826%
White ash	*Fraxinus americana*	6	.826%
Bur oak	*Quercus macrocarpa*	5	.689%
Eastern white pine	*Pinus strobus*	5	.689%
Red spruce	*Picea rubens*	5	.689%
Broadleaf evergreen other*	*n/a*	5	.689%
Horsechestnut	*Aesculus hippocastanum*	4	.551%
Boxelder	*Acer negundo*	3	.413%
Cherry	*Prunus sp.*	3	.413%
Eastern hophornbeam	*Ostrya virginiana*	3	.413%
Shagbark hickory	*Carya ovata*	3	.413%
Spruce sp. Other	*Picea sp.*	3	.413%
American plum	*Prunus sp.*	2	.275%
Northern catalpa	*Catalpa speciosa*	2	.275%
Norway spruce	*Picea abies*	2	.275%
Quaking aspen	*Populus tremuloides*	2	.275%
Willow sp. Other	*Salix sp.*	2	.275%
American elm	*Ulmus Americana*	1	.138%
Chokecherry	*Prunus virginiana*	1	.138%
Dogwood sp.	*Cornus sp.*	1	.138%
Hawthorn sp.	*Crataegus sp.*	1	.138%
White oak	*Quercus alba*	1	.138%

* "Broadleaf deciduous" and "Broadleaf evergreen" refer to unidentifiable species or species that were not listed in the ArcCollector database.

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

Anyone with internet access can view all of Middlebury and East Middlebury's inventoried 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 Middlebury or East Middlebury 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.
    - 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.
    - 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.

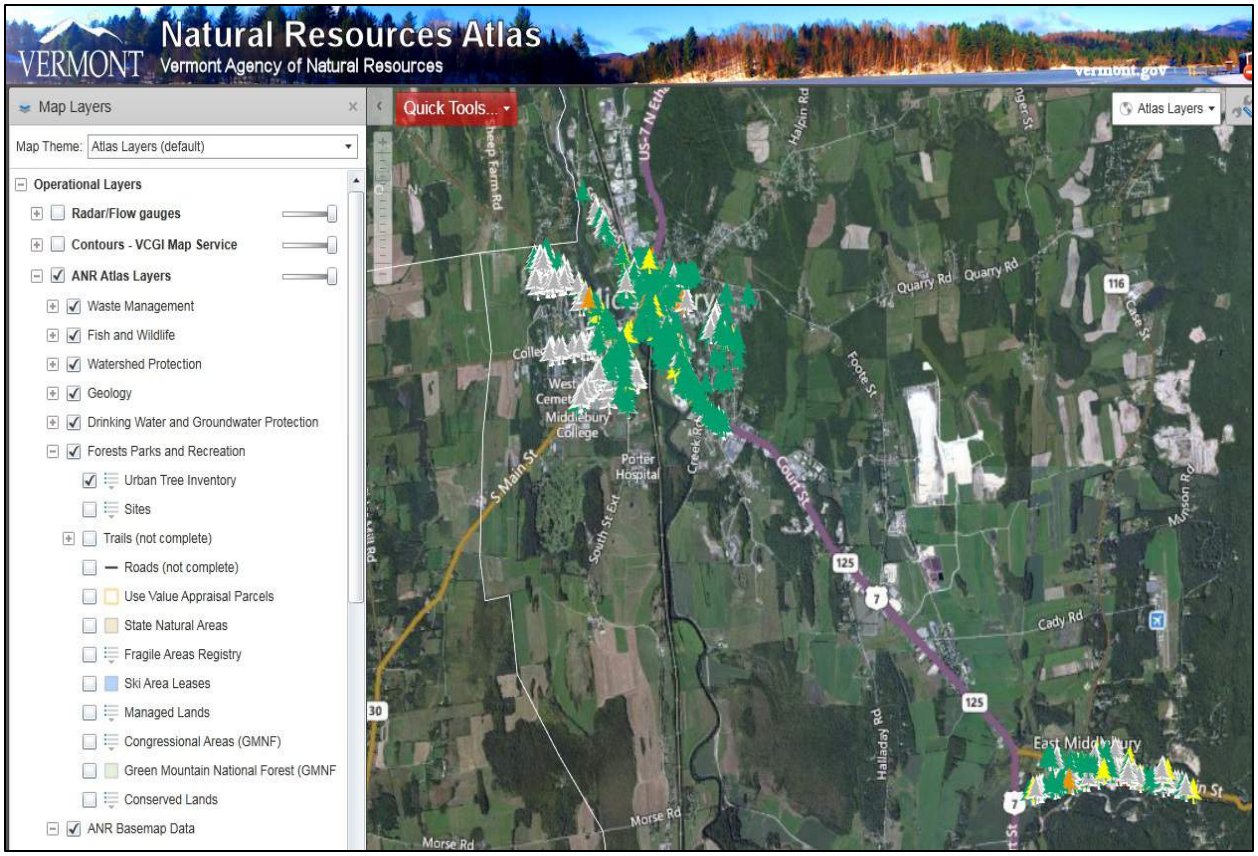
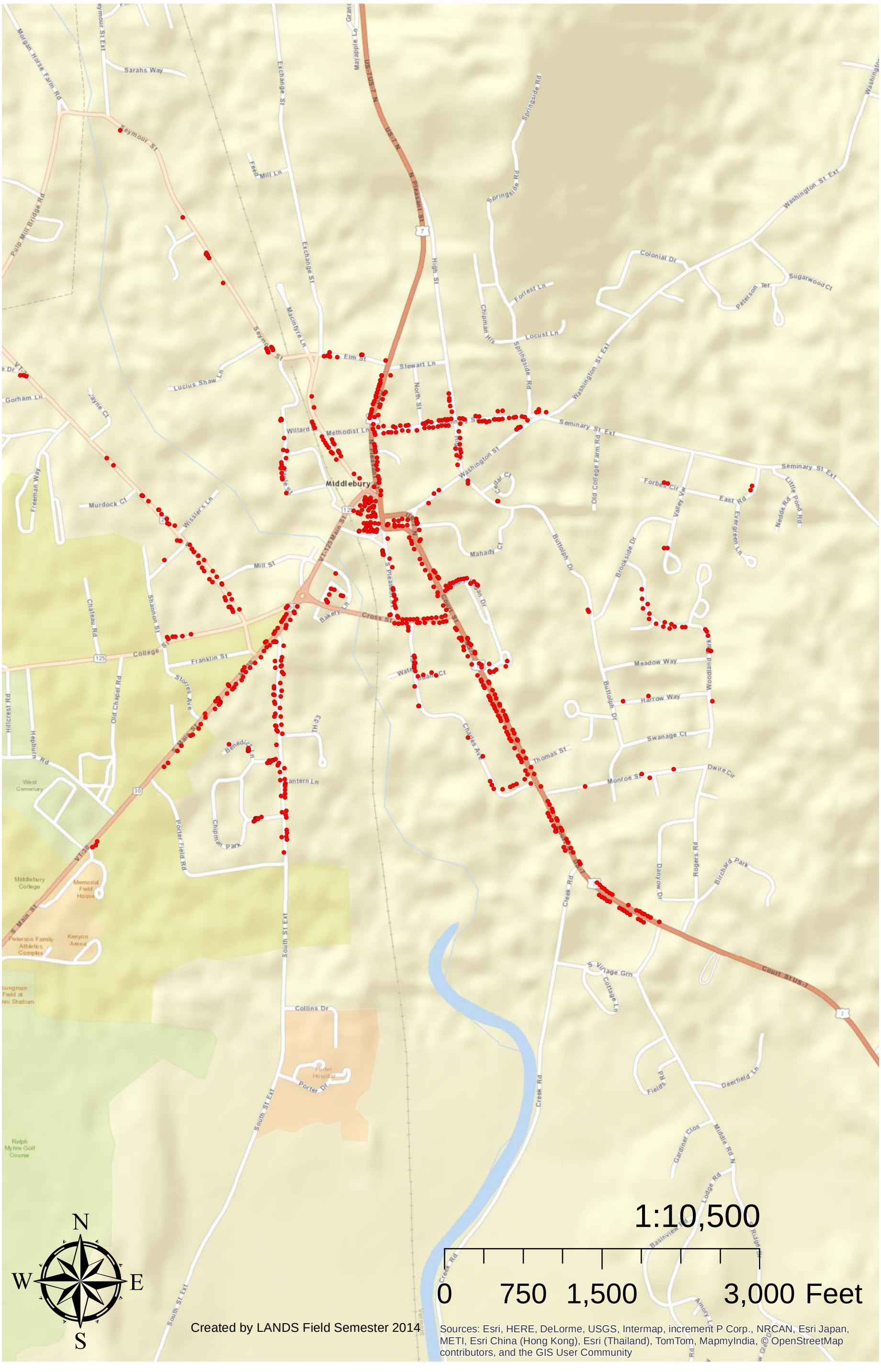


Figure 1: Screen shot of the Middlebury and East Middlebury public trees as seen through the ANR Atlas mapping tool.

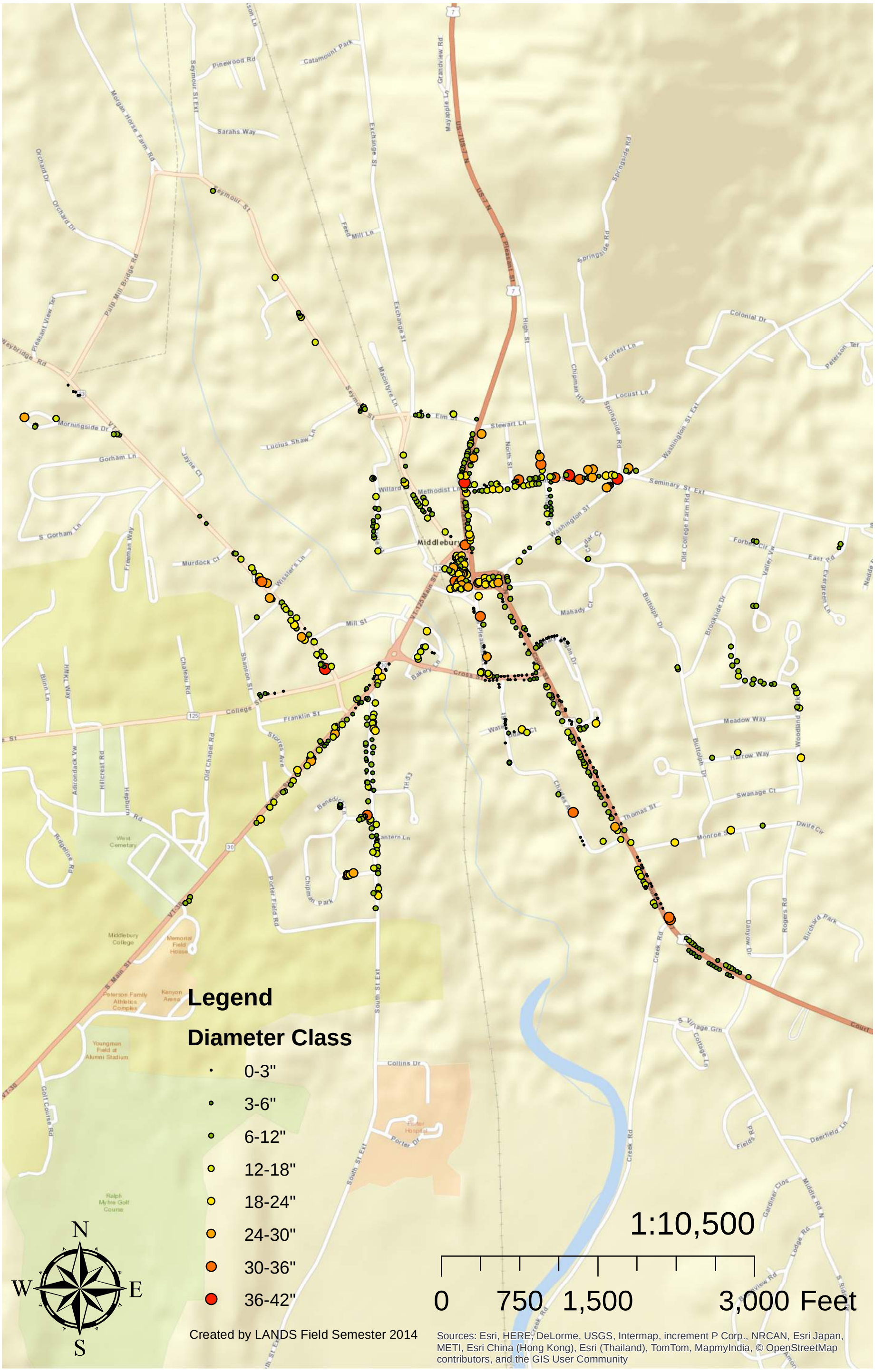
Appendix D: Middlebury Inventory Maps

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

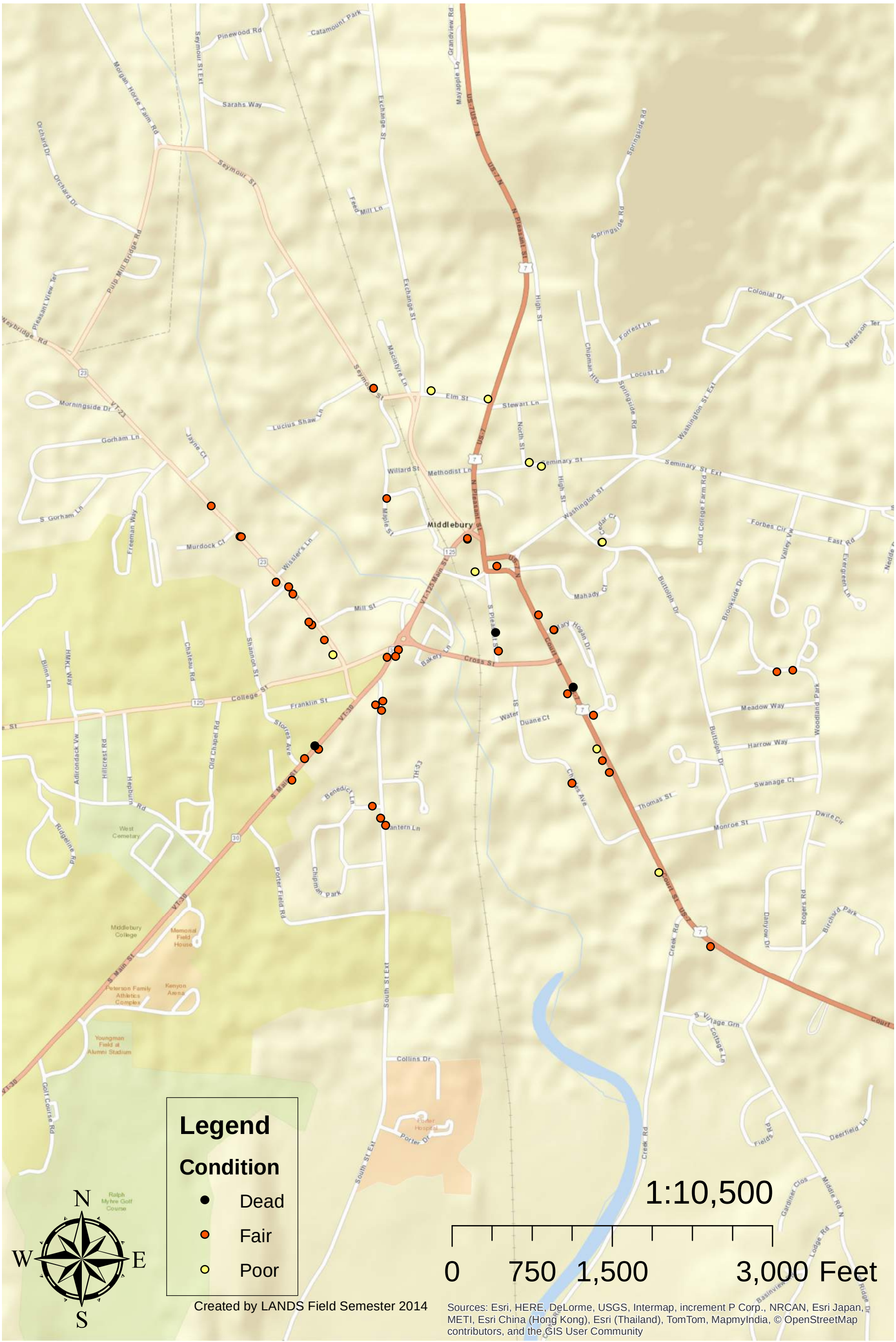
All Trees Inventory Middlebury



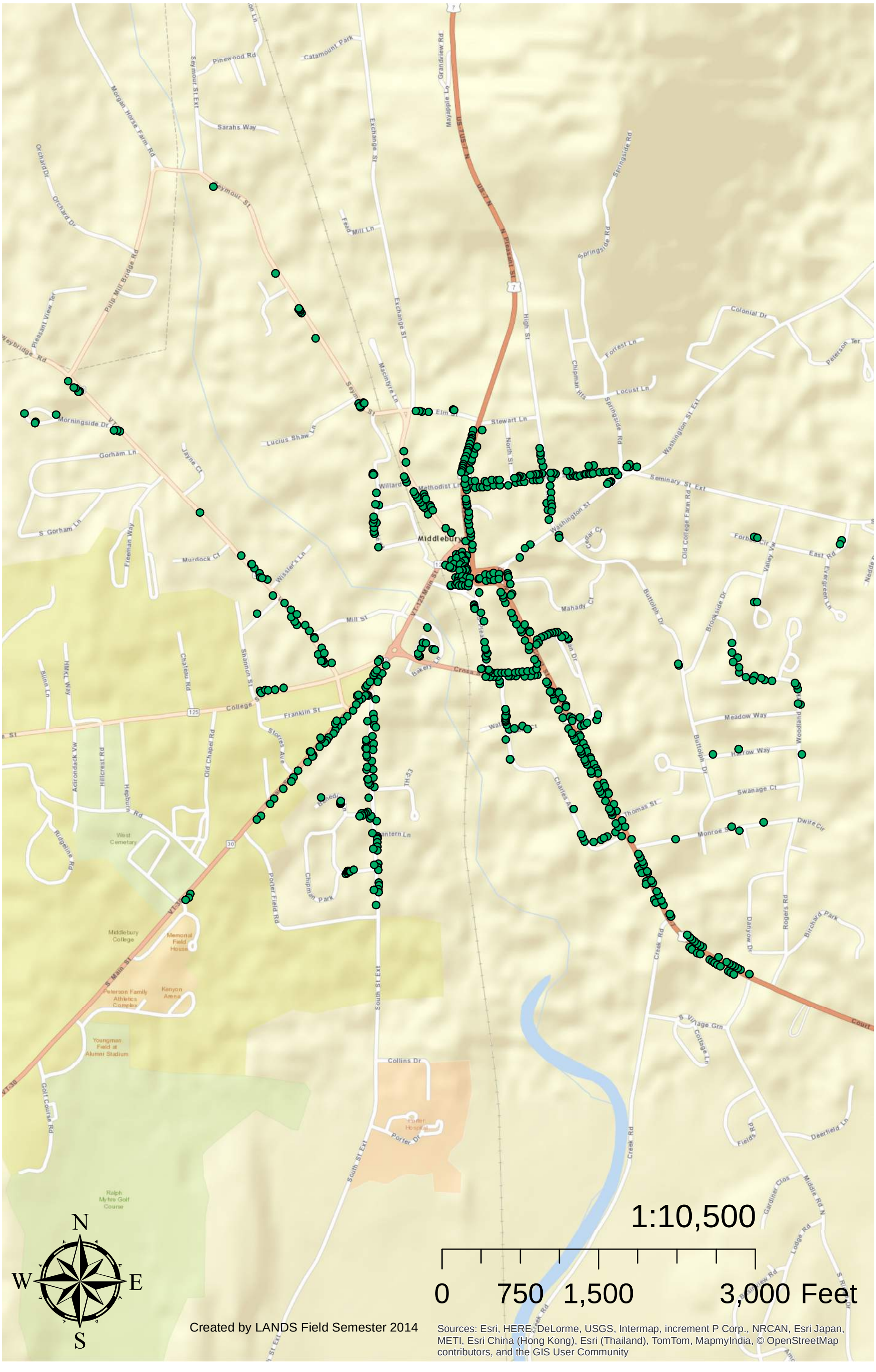
All Trees Inventoried by DBH Class



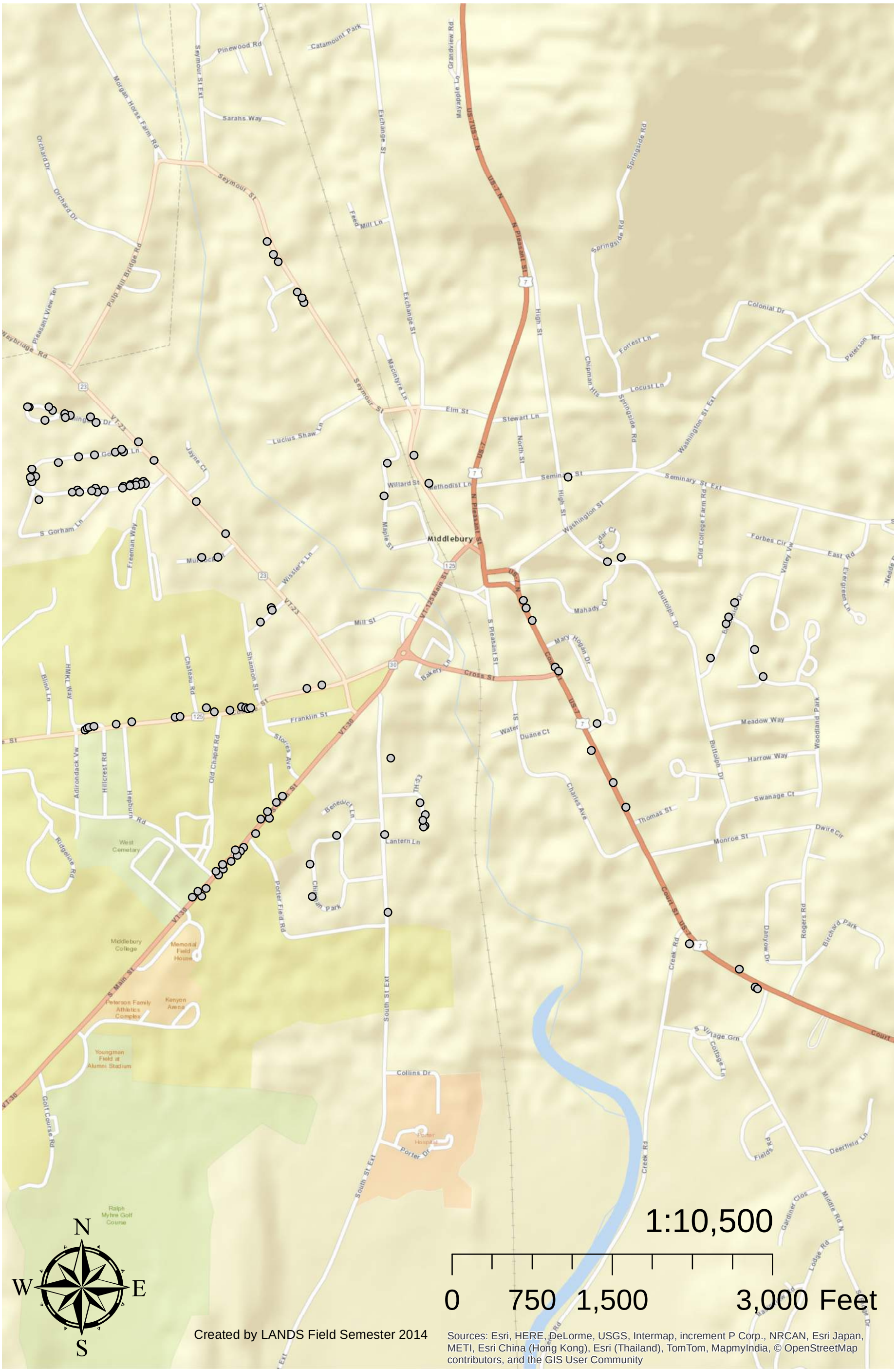
Trees Designated to be in "Fair," "Poor," or "Dead" Condition



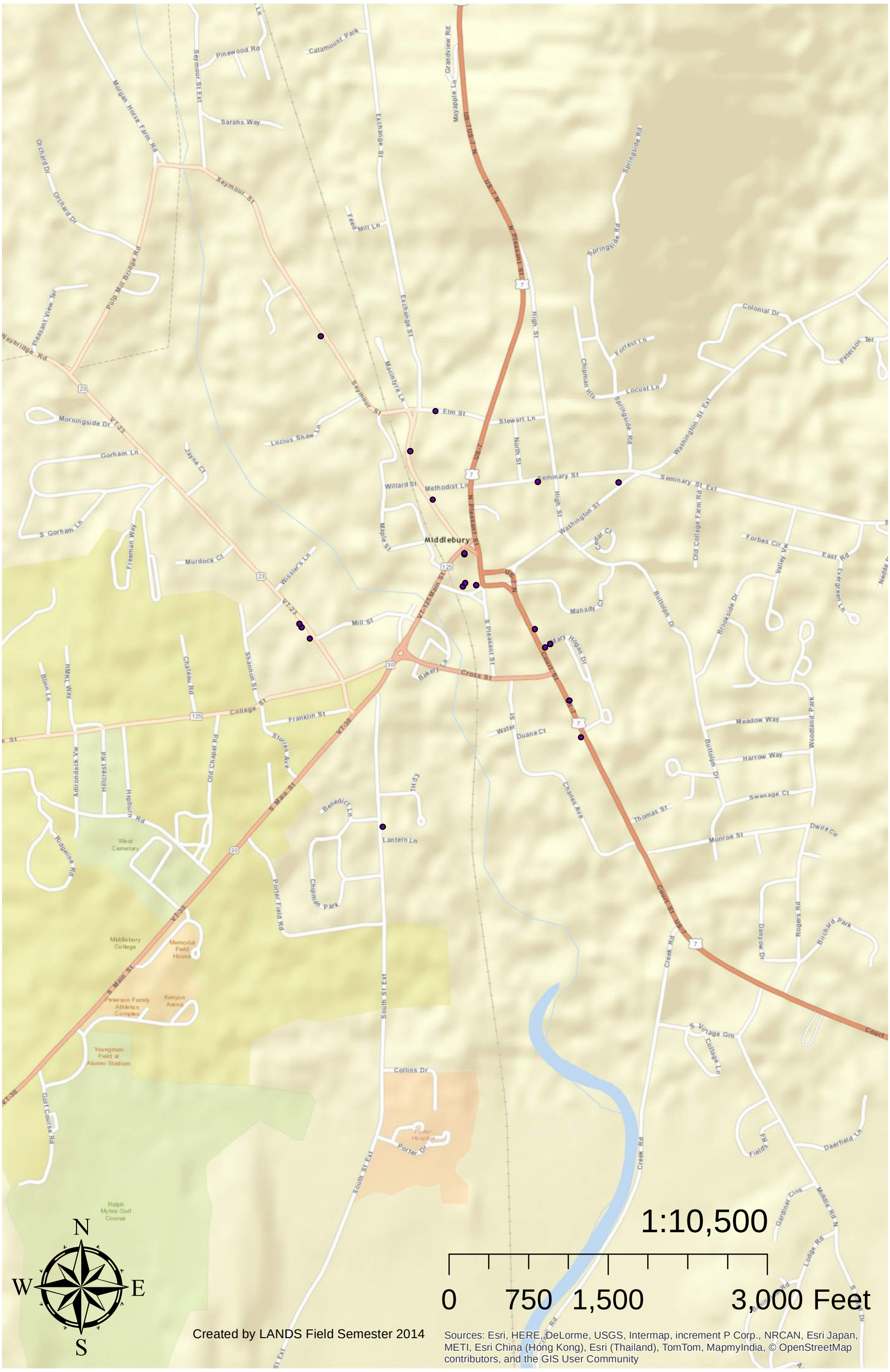
Trees Designated in "Good" Condition



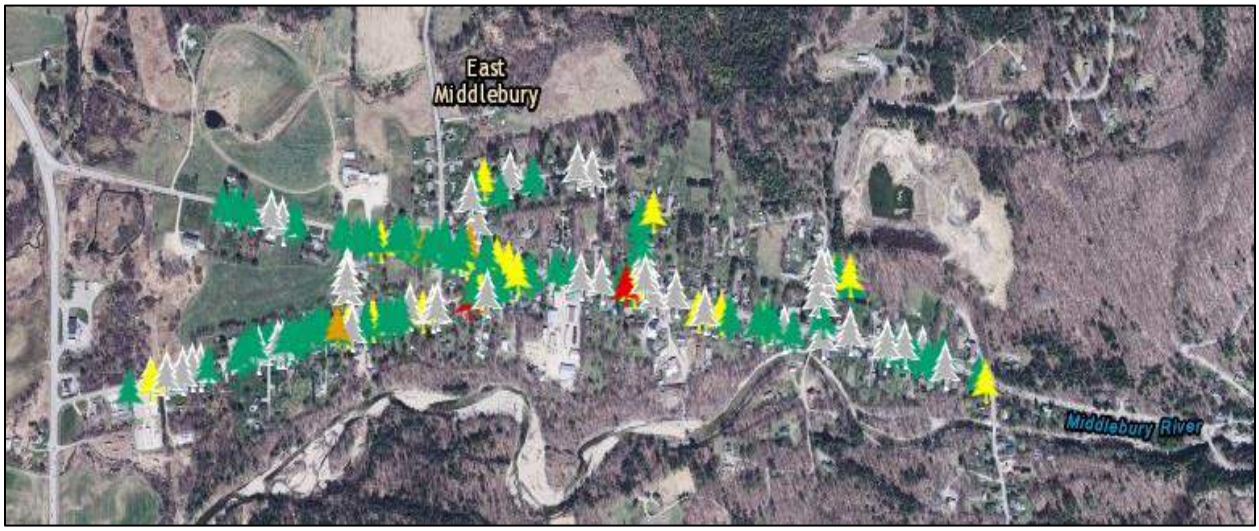
Potential Tree Planting Locations within Right-of-way and Town Property



Trees Requiring a Consultation



Appendix E: East Middlebury Inventory Report



Summary of Findings:

Forest Diversity

- Of the 126 inventoried public trees, there are 22 different species within 15 different genera.
- The five most common tree genera: *Acer* (maple), *Malus* (apple), *Thuja* (cedar), *Quercus* (oak), and *Pinus* (pine), comprise 76.19% of East Middlebury's public trees.
- *Acer* represents nearly half (45.24%) of East Middlebury's public trees.
- *Malus* (11.90%)*, Thuja* (7.14%)*, Quercus (*6.35%), and *Pinus* (5.56%) are the other most common genera represented by East Middlebury's public trees.
- The five most common species: *Acer saccharum* (sugar maple) (15.08%), *Acer saccharinum* (silver maple) (12.70%), *Malus* species (crabapple) (11.90%), *Acer platanoides* (Norway maple) (11.11%), and *Thuja occidentalis* (northern white cedar) (7.14%), comprise 57.94% of East Middlebury's public trees.

Forest Structure

- Overall the East Middlebury age distribution (size distribution) is spread out well across the different age (size) classes. Although all age (size) classes are represented in East Middlebury's community forest, there is poor species diversity within most size classes.
- The majority of East Middlebury's inventoried public trees (33 or 26.2%) are between 6-12" in diameter.
- 10 (8%) public trees have a diameter between 0-3" and 9 (7.1%) public trees have a diameter between 3-6".
- 26 (20.6%) public trees have a diameter between 12-18", and 19 (15.1%) public trees have a diameter between 18-24".
- 7 (5.6%) public trees have a diameter between 24-30".
- 10 (7.9%) public trees have a diameter between 30-36".
- Only 4 (3.2%) public trees have a diameter between 36-42".
- 9 (7.1%) public trees have a diameter greater than or equal to 42".

Forest Health

- The majority (100 or 79.4%) of East Middlebury's inventoried trees were assessed as being in "Good" condition. Twenty-four trees were considered to be in "Fair" (15.9%) or "Poor" (3.2%) condition.
- Only two inventoried trees (1.6%) were dead; a Norway maple on Ossie Road and a boxelder on East Main Street.
- 17 (13.5%) trees were flagged as in need for a consult.

Recommendations

- We recommend maintaining and encouraging the long-term species and age diversity of East Middlebury's urban forest. This should be a management priority for East Middlebury, as *nearly half* of its species composition is within *Acer* genera. Maintaining and increasing species diversity within East Middlebury will ensure the long-term health of individual trees and the complete urban forest by reducing the threat and spread of the invasive pests currently threatening this genus (ALB).
- We recommend routine consultations on the 13.5% of trees identified as in need of consult, and on the species classified in "Fair" or "Poor" conditions.
- We recommend planning to remove the two inventoried dead trees as soon as possible.
- There is a significant amount (44) of potential planting sites ("Vacant"). The Town should prioritize planting native, size-appropriate trees in these suggested locations.
- We suggest that the four remaining streets in East Middlebury be inventoried in the future to have a complete assessment of the Town's urban forest (see Table 1 for complete list of streets).
- Include East Middlebury's trees in urban forest planning and management for the Town of Middlebury.

East Middlebury Inventory Results

The East Middlebury public tree inventory was completed in one day in September 2014 by two Vermont Urban & Community Forestry Program staff and one graduate intern. The 126 trees inventoried in East Middlebury were located on six streets, detailed in Table 1 below. Also noted are the four streets in East Middlebury that were not inventoried because of time constraints.

Table 1: Streets inventoried in East Middlebury

Inventoried Streets	Right-of-Way Extent (feet)	Segments Inventoried	Number of Inventoried Trees	Number of Vacant Spots
East Main Street	50	Rt. 7 (west) to Lower Plain Road (east)	67	16
Kings Row	40	Full road	6	5
Maple Court	49.5	Full road	5	2
Ossie Road	State	Rt. 7 (west) to East Main Street (east)	40	13
School House Hill Road (including Harold Curtis Park)	49.5	East Main Street (south) to Piper Road (north)	8	5
Wilmar Street	50	Full road	0	3
Streets Not Yet Inventoried	**Right-of-Way Extent (feet)**	**What to Inventory**		
Cones Road	50	Full road		
Grist Mill Road	49.5	Full road		
Lower Plains Road	66	East Main Street (north) to Blueberry Lane		
Piper Road	50	Full road		

Urban Forest Diversity

Of the 126 trees inventoried within East Middlebury's public ROW, there were a total of 22 different species in 15 different genera. The common tree genera *Acer* (maple), *Malus* (apple), *Thuja* (cedar), *Quercus* (oak), and *Pinus* (pine), comprise about 76% of East Middlebury's public trees. *Prunus* (cherry), *Picea* (spruce), *Tilia* (basswood), *Abies* (fir), and *Fraxinus* (ash) comprise about 18% of East Middlebury's community forest. The ten most common genera therefore make up about 94% of the public trees in East Middlebury (Figure 1). Four *Acer* species are among the ten most common tree species inventoried in East Middlebury, three of which are within the five most common species (Figure 2). *Acer saccharum* (sugar maple) (15.08%) is the most common species in East Middlebury. *Acer saccharinum* (silver maple) (12.70%) is the second most common tree species in East Middlebury, followed by species within the *Malus* (crabapple) (11.90%) genus, *Acer platanoides* (Norway maple) (11.11%), and *Thuja occidentalis* (northern white cedar) (7.14%). As mentioned in Middlebury's inventory report, Norway maple

is a non-native species, and its presence should not be promoted through future tree plantings. Complete species and genera lists can be found in Figure 3 and Figure 4 below.

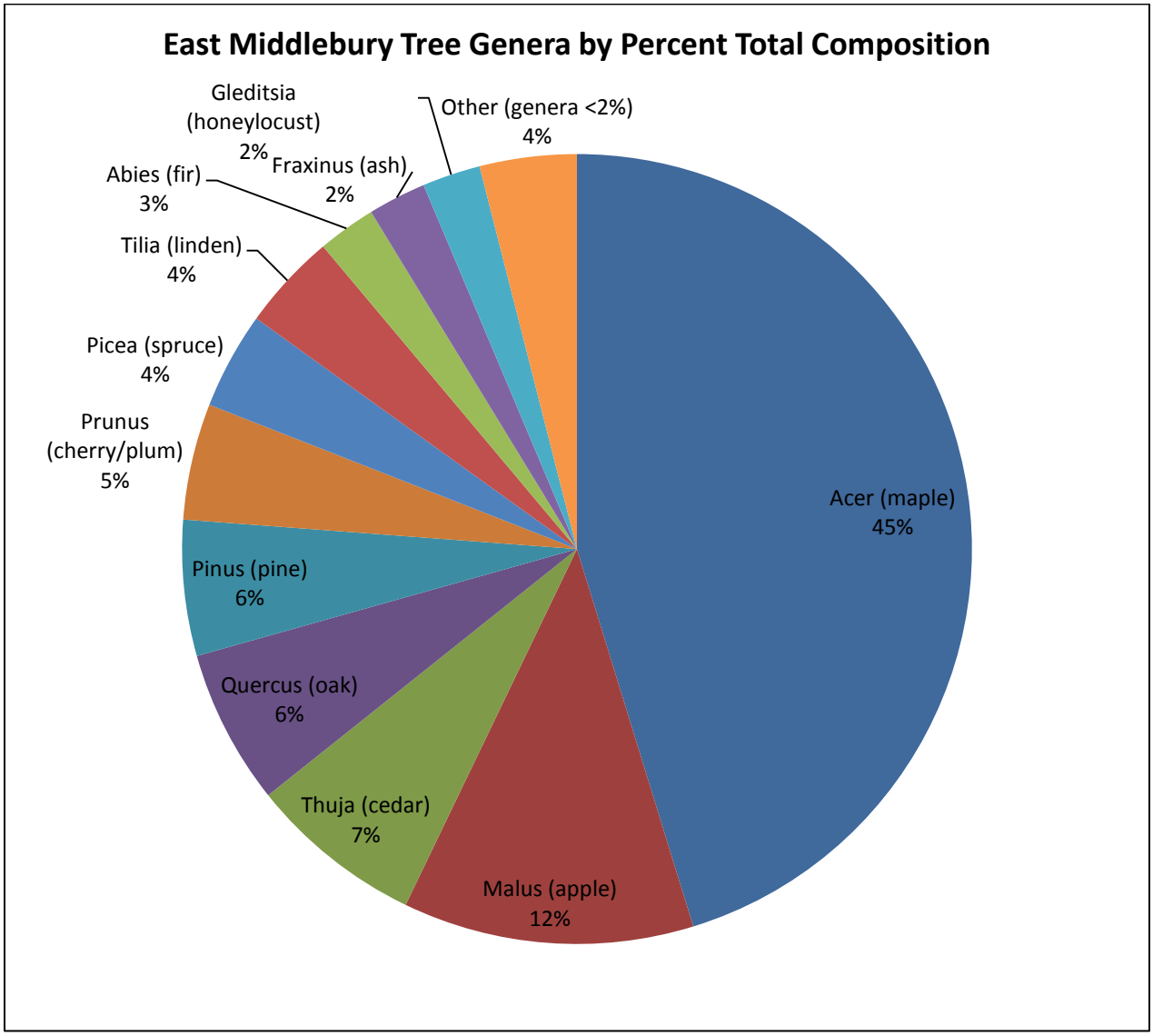


Figure 1. Tree genera by percent composition in East Middlebury, VT. Note that "Other" represents a total of all the species with less than 2% composition. Percentages are rounded to the nearest whole number.

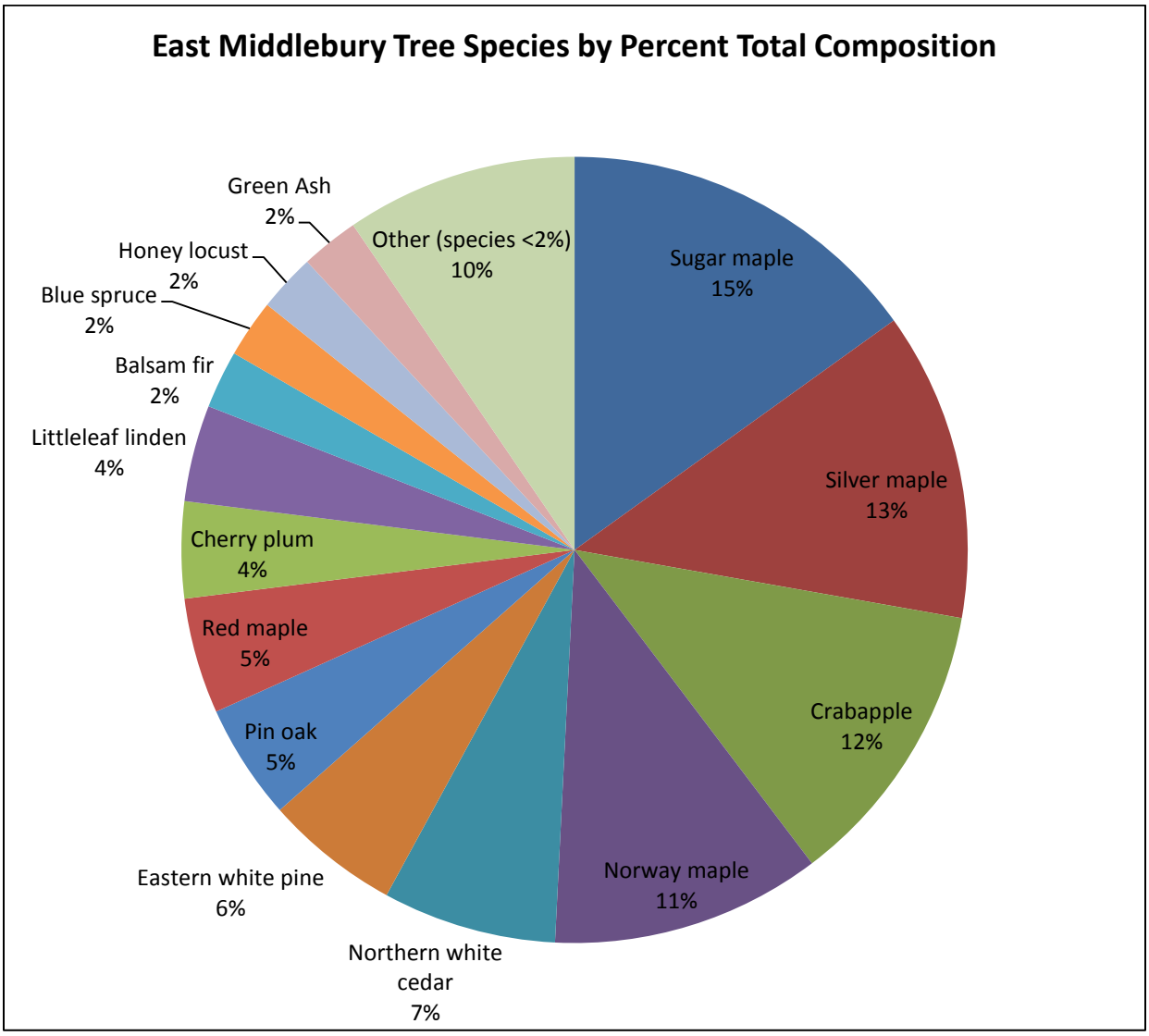


Figure 2. Tree species by percent composition in East Middlebury, VT. Note that "Other" represents a total of all the species with less than 2% composition. Percentages are rounded to the nearest whole number.

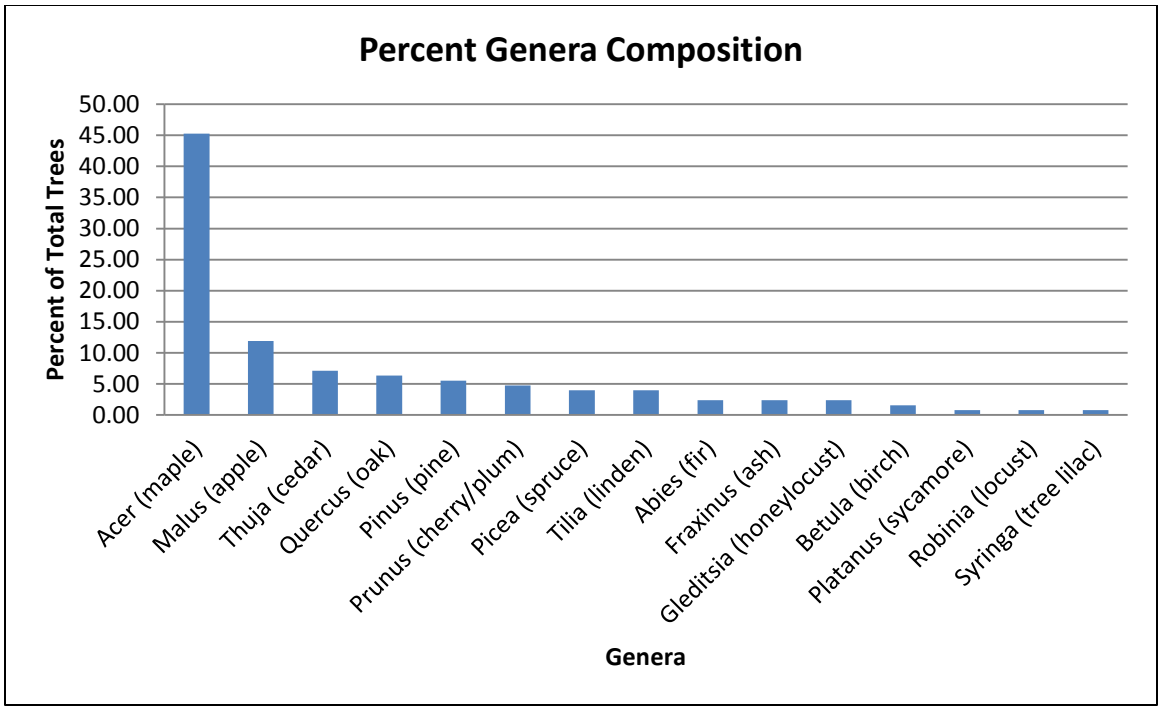


Figure 3. Public tree genera and total percent of the population in East Middlebury, VT

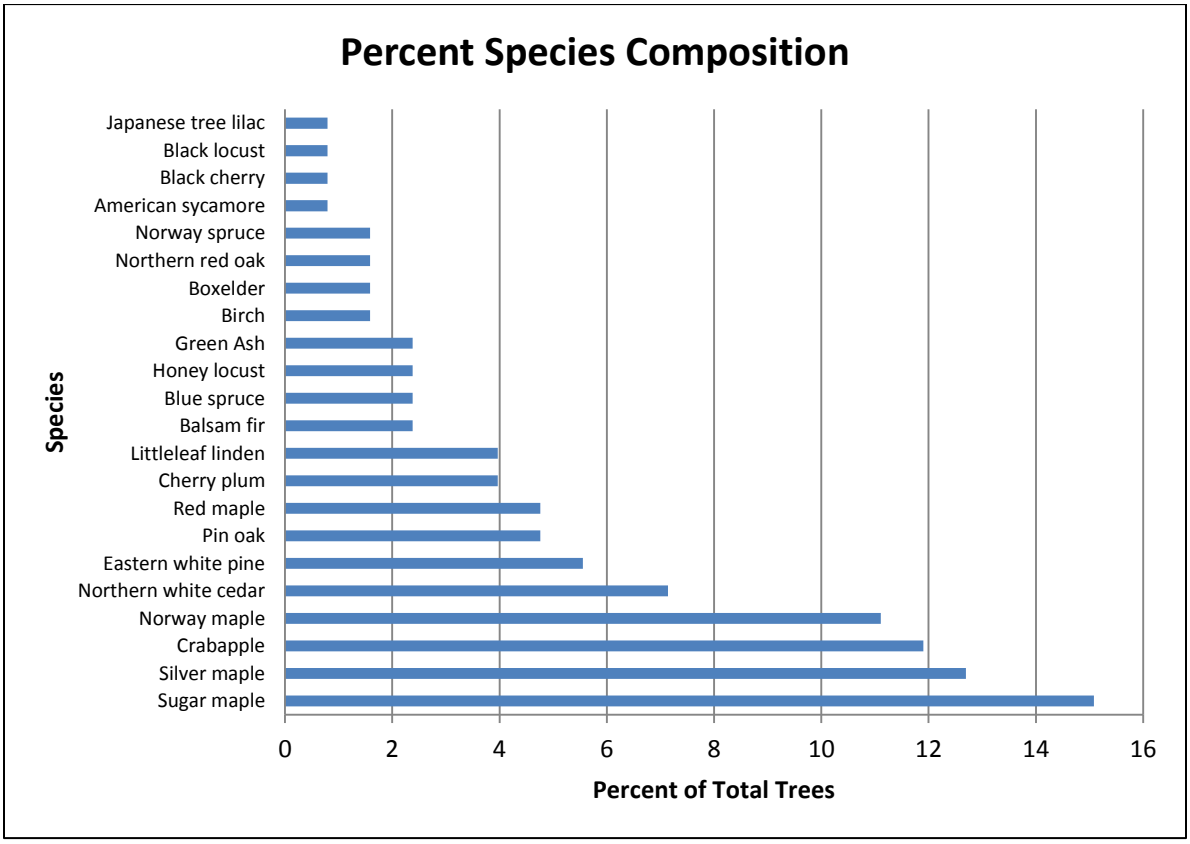


Figure 4. Public tree species and total percent of the population in East Middlebury, VT

Urban Forest Structure

Most of East Middlebury's inventoried trees (33 trees or 26%) have a diameter at breast height (DBH) between 6-12". Based on their medium diameter size (12-24 inches), 35% (45) of inventoried trees are assumed to be approaching or at their 'middle age'. About 15% (20 trees) are assumed to be relatively young based on their small diameter class (0-6"). Tree abundance within the 24-30" (5.5%), 30-36" (7.9%), and 42"+ (7.2%), are relatively equally distributed. Assuming that street tree diameter size class correlates to tree age, East Middlebury's urban forest is reaching middle age (Figure 5).

The genera and species composition within each of these size classes (Figures 6 and 7) prove informative for the development of East Middlebury's management plan. *Acer* is the only genus represented in each diameter size class. It is also the only genus in the larger diameter classes (36-42" and 42"+) indicative of mature age (Figure 4). This is not only likely due to the longevity associated with *Acer* species, but also to *Acer*'s historic seed and plant availability and population abundance. The age distribution of the *Acer* genus in East Middlebury's community forest is of particular importance, as it is the most common genus in East Middlebury and is at risk of future pest invasion. It is therefore recommended that East Middlebury officials diversify the tree population in nearly all age classes.

The only diameter size class in which all five most common genera are represented is 12-18". There is otherwise little genera diversity within small (0-6") and large (30-42"+) size classes (Figure 4). There is no diameter size class in which all of East Middlebury's five most common tree species are represented (Figure 5). Crabapple tree species within the *Malus* genus are only represented in diameters equal to or less than eighteen inches (Figures 4 and 5). *Acer saccharinum* (silver maple) is the dominant mature tree species inventoried in East Middlebury. It is the only tree species with a diameter size equal to or greater than thirty-six inches (Figure 5). Silver maples were the largest trees inventoried in East Middlebury and are mostly located on East Main Street and Ossie Road. Although all of the inventoried silver maples were recorded to be in "Good" condition, they are fairly weak trees, and those in larger size classes,

that are presumably mature in age, should require routine consults. For this reason, it is important for East Middlebury officials to not only maintain and manage the Town's mature species, but to also ensure that a more diverse species composition within smaller diameter size classes reaches maturity. In all, East Middlebury's species and genera diversity within size classes must be promoted.

Forty-four "vacant" potential tree plantings or strips of land were identified in East Middlebury's public ROW. Table 1 on page 47 above breaks these locations down by street. With 16 identified vacant locations, East Main Street has the greatest potential for future tree plantings in East Middlebury. Ossie Road, however, also has a notable opportunity to plant trees within the 13 vacant locations identified. Of the 44 inventoried vacant locations, 10 were explicitly indicated to be appropriate for a small tree, 2 would suite a small or medium tree, 20 would be appropriate for a medium tree, and 12 locations are suitable for a large tree.

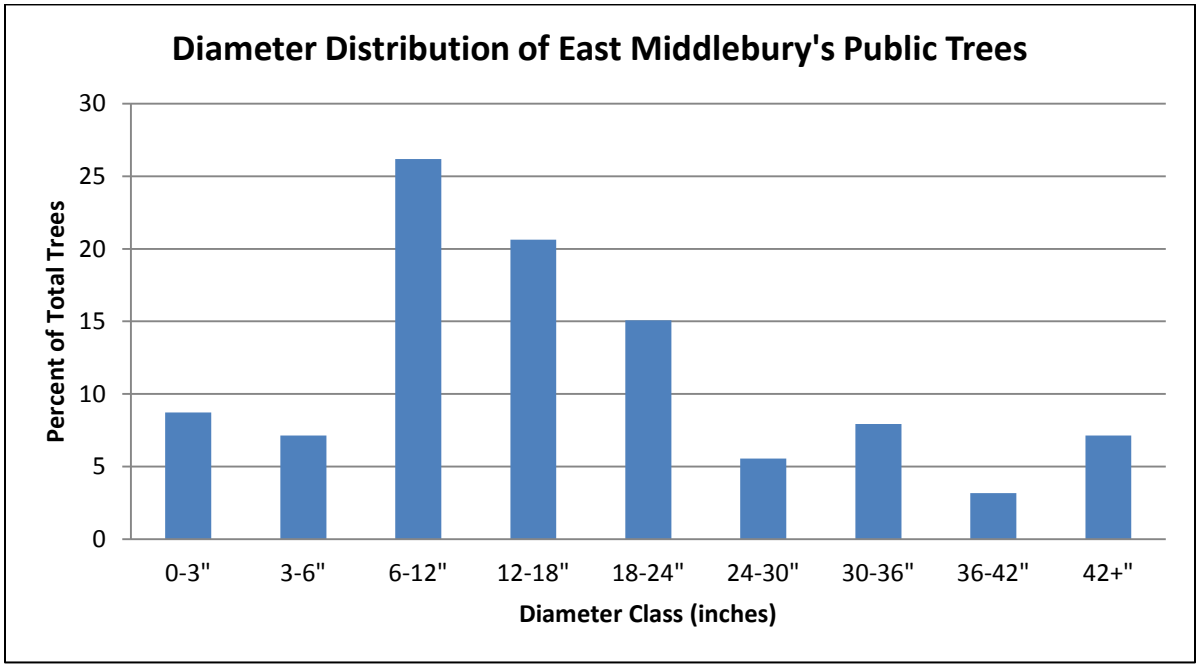


Figure 5. Percentage of trees within each diameter class (inches) in East Middlebury, VT

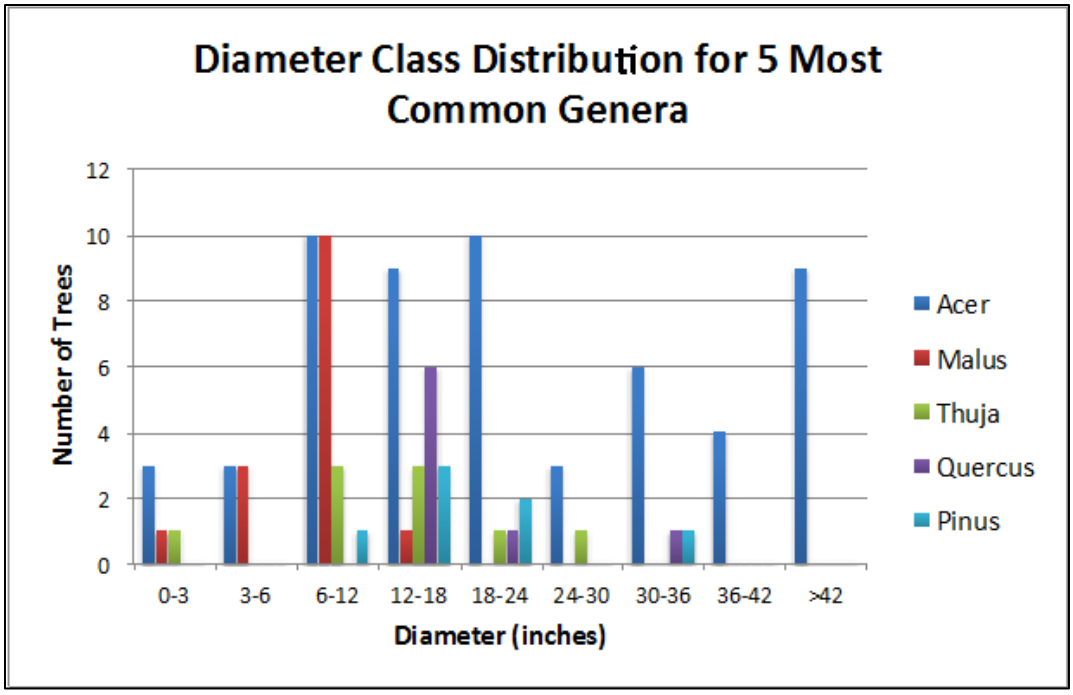


Figure 6. Diameter (inches) distribution for the five most common genera in East Middlebury, VT

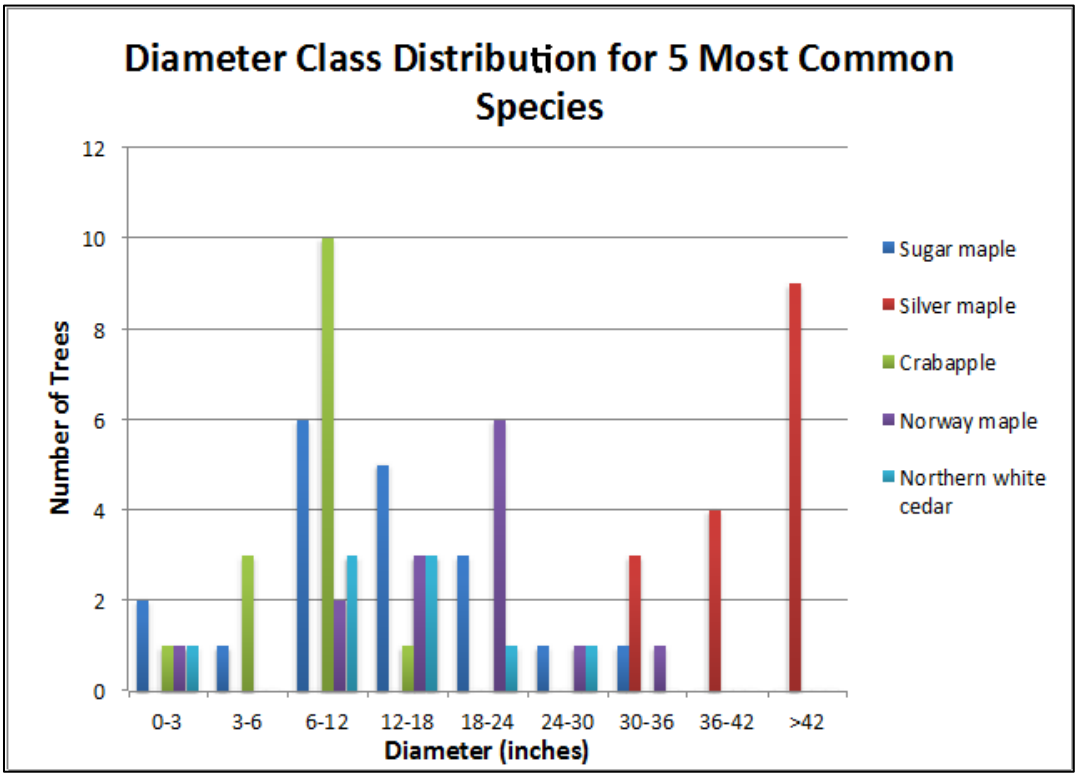


Figure 7. Diameter (inches) distribution for the five most common species in East Middlebury, VT

Urban Forest Health

The majority (79.37%) of East Middlebury's public trees were assessed as being in "Good" condition. Of the remaining trees, 20 (15.87%) were considered to be in "Fair" condition, 4 (3.17%) were in "Poor" condition, and 2 (1.59%) were dead (Figure 8). The two inventoried dead trees; *Acer negundo* (boxelder) and *Acer platanoides* (Norway maple), are within the five most common genera (Figure 9). The genus *Acer* has the most trees in each condition class (Figure 0), which is likely because it comprises the highest percentage of all inventoried trees. Most of the species within the *Acer* (maple) genus are in "Good" condition, but are important to monitor for if or when the ALB is detected in VT.

Seventeen public trees (13.49%) were identified as in need of consult during the inventory. A professional arborist or qualified member of East Middlebury's community should reassess each of these trees within 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 had stakes placed during planting that need removal, or
- The tree was dead, in decline or in poor condition.

Although 11 species within the *Acer* genus were inventoried as in need of a consult, none of the inventory comments indicate evidence of ALB infestation.

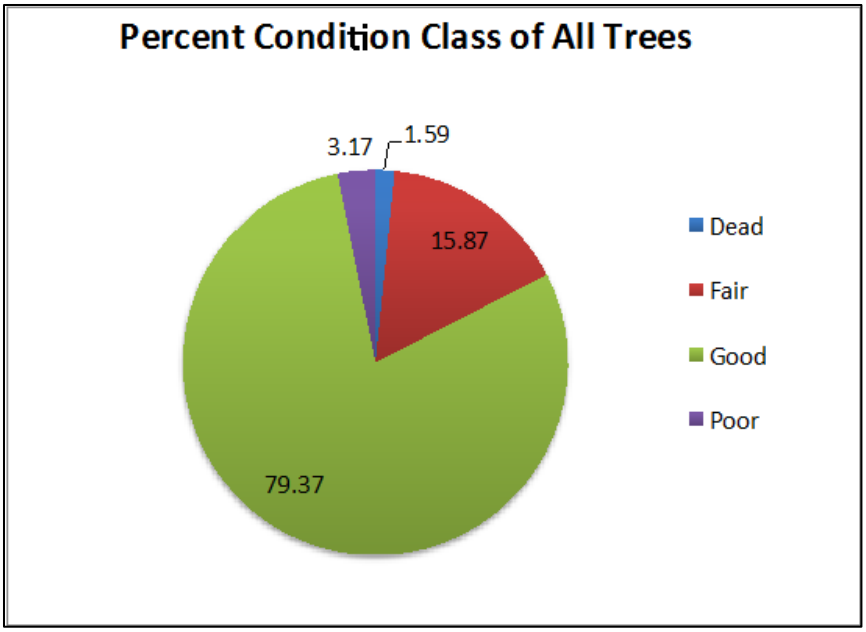


Figure 8. Percent of East Middlebury's inventoried trees within each condition class

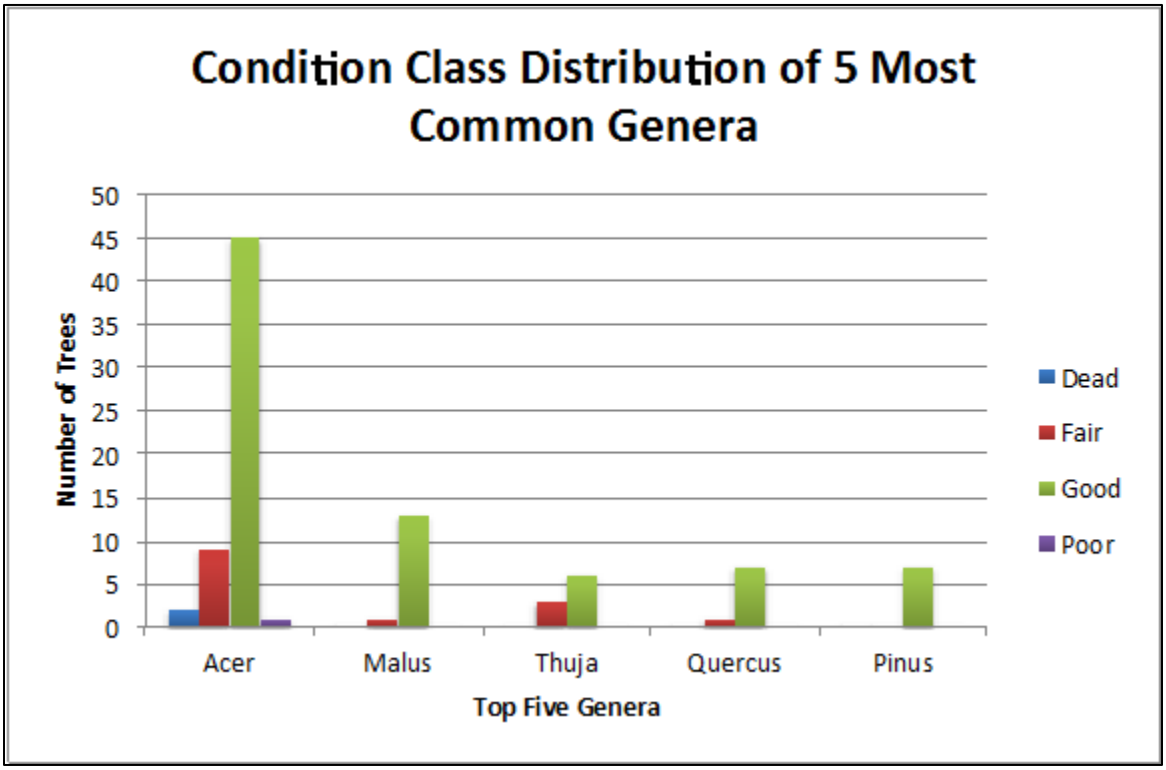


Figure 9. The number of trees within East Middlebury's five most common genera displayed according to condition