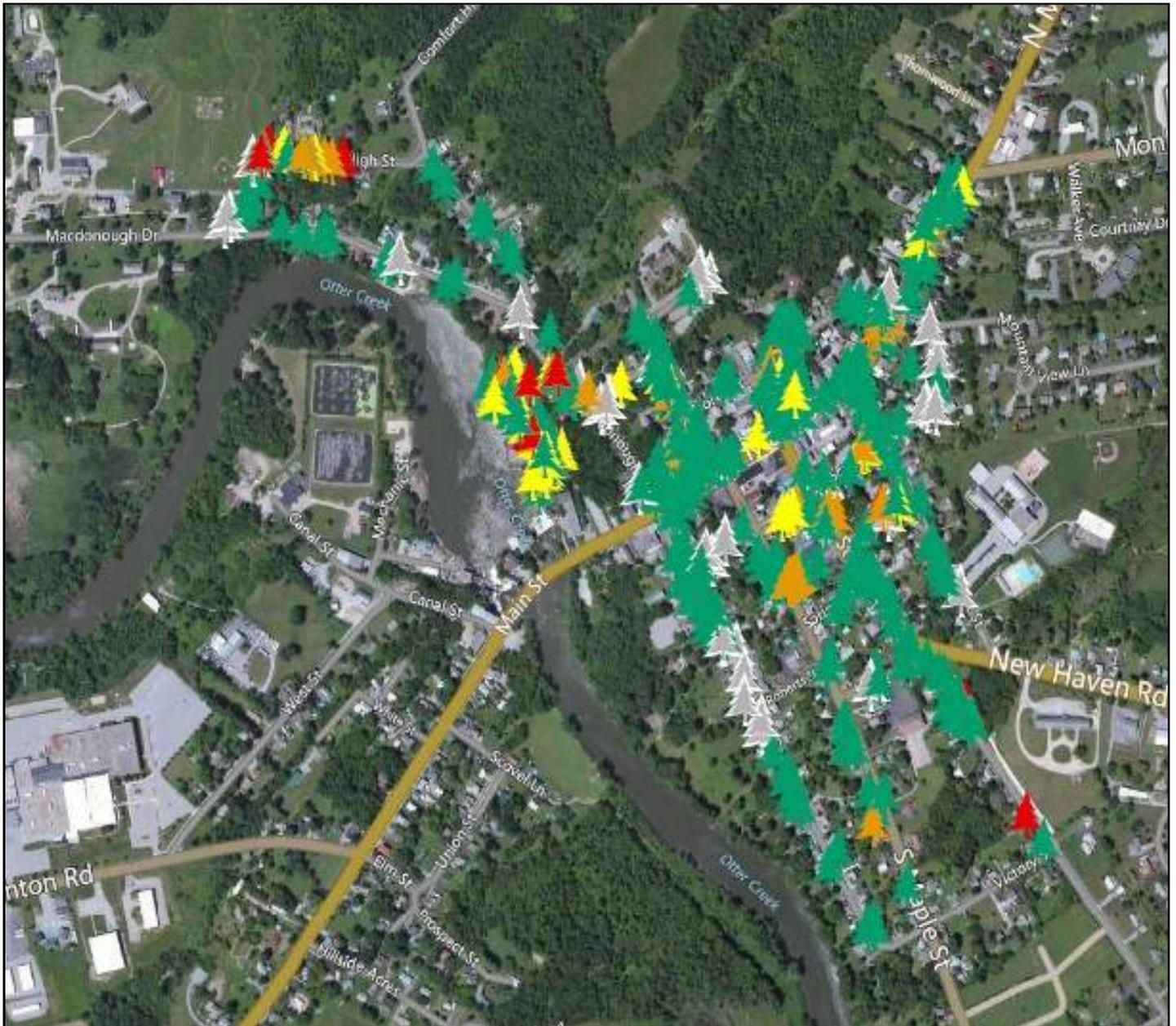# Vergennes Public Tree Inventory Report

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

Acknowledgements

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 (VT UCF) program is a collaborative effort between the Department of Forests, Parks, & Recreation, the University of Vermont Extension, and the USDA Forest Service. 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 promote civic responsibility for and participation in the stewardship of these resources for this and future generations*. Since 1991, the program has been guided by a small staff and a twenty-member advisory council. The council meets quarterly to share information and advise the program; its members come from various professional associations, non-profits, educational institutions, tree boards, regional officials, and state agencies.

The trees in our communities offer a wide variety of environmental, social, and economic benefits to the surrounding community, including 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, the program has provided assistance to over 150 Vermont communities. The program also provides local training and workshops, educational resources, and newsletters for the public. All the material and assistance provided by VT UCF is designed to further their mission of enhancing local communities across Vermont.

About LANDS

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

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

LANDS provides affordable services and high-quality products for municipalities, land trusts, state agencies, national forests and parks, and volunteer-managed conservation organizations. The program also benefits Vermonters by building collaboration between the University and local communities, and enabling partnering organizations to share their missions and increase their visibility among the next generation of conservation leaders. Since its inception in 2007, 84 LANDS students have conducted 102 projects and service activities for 33 conservation partners. LANDS provides much-needed support to conservation organizations in Vermont while creating

a knowledgeable, highly skilled cohort of professionals poised to become the future stewards of our land and resources.

Students in the fall 2014 LANDS Field Semester inventoried public trees in Bristol, Middlebury, and Vergennes. From the right, Flore Costumé, Leader Emily Brodsky, Courtney Crowley, Bonnie Ricord, Michelle DesLauriers, and Nick Brown made up the Vergennes inventory team.

Contents

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 city-owned land within the City of Vergennes. This information provides residents and decisions-makers with a better understanding of the health and benefits of Vergennes' urban forest and will allow the City of Vergennes Planning Commission to plan for future tree planting and maintenance using a map-based tree inventory system.

The inventory was commissioned by the City of Vergennes Planning Commission and was approved by the Vergennes Select Board. LANDS students completed an inventory of 518 trees located within the ROW of 20 streets and on city-owned land. They also identified 29 specific locations or strips of public land appropriate for future tree plantings. Staff from VT UCF provided technical assistance. This report was prepared in the fall of 2014 by the LANDS interns and subsequently edited and supplemented by VT UCF program staff. It presents the results of an inventory and basic assessment of the trees and canopy cover in Vergennes.

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 518 public trees that were inventoried provide an estimated $50,863 in benefits annually to the residents of Vergennes. In addition to the public trees inventoried, a tree canopy assessment was completed for the City of Vergennes, which indicated existing canopy cover of 37% and a stored carbon dioxide value of nearly $1.9 million.

Summary of Findings

Forest Diversity

- Of the 518 public trees, there are 39 different species in 25 different genera.

- The top five most common tree genera by number of trees are *Acer* (maple) at 44%, *Fraxinus* (ash) at 11%, *Ulmus* (elm) at 9%, *Gleditsia* (honeylocust) at 6%, and *Malus* (apple) at 5%.

- *Acer* and *Fraxinus* species together represent 55% percent of Vergennes' public trees. Invasive tree pests currently threaten both of these genera: the Asian longhorned beetle (ALB) and the emerald ash borer (EAB), respectively.

- The top five most common species are *Acer saccharinum* (silver maple) at 18%, *Acer plantanoides* (Norway maple) at 18%, *Ulmus americana* (American elm) at 9%, *Fraxinus pennsylvanica* (green ash) at 8%, and *Acer saccharum* (sugar maple) at 7%.

Forest Structure

- A large percentage of inventoried public trees (47%) have a diameter at breast height (DBH) measurement of 6-18"; 27% of inventoried public trees have a DBH within the 6-12" size class and 20% of the inventoried trees have DBH measurements in the 12-18" size class.

- The remaining 53% of inventoried trees were represented in the following size categories: 0-3" (9%), 3-6" (22%), 18-24" (12%), 24-30" (6%), 30-36" (2%), 36-42" (2%), and 42"+ (one tree).

Forest Cover

- There is an existing urban tree canopy (UTC) cover of 37% across the extent of Vergennes. This analysis was done on both public and private land over the full extent of the city.

- Trees could potentially cover an additional 55% of the land surface; these "possible UTC" areas include grass, agricultural land, and impervious surfaces (e.g. parking lots, paved playgrounds, and the ROW).

- The remaining 8% of Vergennes' area is buildings, streets, water, and other permanent features and is generally unsuited to UTC improvement.

Forest Health

- Nearly three quarters (373, or 72%) of the trees inventoried were assessed as being in "Good" condition. Of the remaining trees, 51 (10%) were considered to be in "Fair" condition, 68 (13%) were in "Poor" condition and 26 (5%) were "Dead".
- 129 trees were flagged as in need of a future consultation by a Certified Arborist, the Tree Warden, or other qualified individual.

Summary of Recommendations

We recommend that the City of Vergennes work on continuing to *increase the diversity* of tree species to ensure the long-term health of individual trees and Vergennes' complete urban forest. Plant a variety of species instead of high-density stands of the same species, whose close proximity may be conducive to the spreading of disease and pests. When appropriate, plant native trees with high survivability rates, pollution tolerance, salt tolerance, and long life spans. Additionally, we recommend designating and supporting a responsible party for the *management of the urban forest*. Other specific recommendations include:

Form a Vergennes Tree Committee to complete the inventory and lead maintenance and planning efforts.

Inventory the remaining public trees over time to develop a comprehensive record of the Vergennes' public trees.

Monitor tree health, specifically for signs and symptoms of emerald ash borer (EAB), Asian longhorned beetle (ALB), and other forest pests and diseases. Encourage citizens to learn to identify and report invasive pests.

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

Maintain tree health by ensuring that those who are caring for Vergennes' public trees are trained in best tree care practices; prune all public trees to promote long-term structural integrity, irrigate newly-planted trees, mulch trees as needed, and prevent mechanical damage to trees.

Plan for future removal and replacement of trees found in poor condition and for the arrival of EAB by developing a community invasive forest pest preparedness and response plan.

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

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

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

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

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

Silver maple, ash, and elm trees overlooking Otter Creek at MacDonough Park

Introduction

Project Description

VT UCF is currently working on a project funed by 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.

Vergennes has no paid arborist or professional group who maintains and plants trees, and there is currently no tree board or advisory committee in Vergennes. Vergennes City Manager Mel Hawley serves as the volunteer Tree Warden, and tree maintenance work for Vergennes is contracted out to the Northlands Training Center, the Vergennes Department of Public Works, or other private contractors. A street tree plan was developed for the City of Vergennes in 1998, but has not been extensively used and has been in need of an update. In early 2014 the City pursued grant funding for a downtown tree inventory but was not awarded the grant. Soon after, VT UCF staff reached out to the Vergennes Planning Commission regarding the City's participation in the *Care of the Urban Forest* project.

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 city-owned land within the downtown and the most densely populated residential areas of Vergennes. Students from the LANDS Field Semester program conducted a public tree inventory over the course of three field days. This inventory establishes a baseline for future inventories, management decisions, and improvements to Vergennes' urban forest.

City Profile

The City of Vergennes is located on Otter Creek in Addison County, resting between Lake Champlain, the Green Mountains, the City of Burlington, and the Town of Middlebury. Vergennes covers a land area of approximately 2.5 square miles, and has a population of 2,584 people, according to the 2012 U.S. Census. Vergennes was established as a city on September 19, 1788, making it the first in the state and third in the nation. Its name was suggested by Ethan Allen to commemorate the Comte de Vergennes, French minister of foreign affairs and negotiator of the Treaty of Paris. The city has a rich economic history based on industry and commerce that was supported by the lake trade and railroad connections. Since then, it has taken steps to revitalize the historic downtown and generate economic growth through historic building restoration projects. In addition to its historic downtown, Vergennes is also home to the Lake Champlain Maritime Museum (City of Vergennes, 2014).

Methodology

Prior to the public tree inventory, VT UCF staff met numerous times with the Vergennes Planning Commission and City Manager Mel Hawley to plan for the inventory. Twenty streets in Vergennes were chosen to be included in the inventory, as well as a number of priority city-owned properties. In total, the land area of the inventory was about 0.25 square

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 municipal 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.

mile, representing approximately 10% of the total land area of Vergennes, but including the most densely populated section of the community. Mel Hawley provided the ROW boundaries for all streets. The list of streets and sites with ROW boundaries can be found in Appendix A, and maps of the inventory area are located 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 Vergennes is available for viewing on the ANR Atlas tool and instructions are included in Appendix C.

From September 16th to 18th, 2014, five of the LANDS students walked along pre-designated streets and sites of Vergennes, 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:

$$ROW\ distance\ from\ curb = (ROW\ width - road\ width)/2$$

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 diameter at breast height, or DBH), consultation recommendation, comments, and nearest house or building number. It was also recorded if the tree needed mulching, pruning or if the tree suffered from stem-girdling roots. If any trees were encountered that could not be identified, or were of a species not listed in the "Collector" database, they were categorized as "broadleaf deciduous" or "coniferous evergreen". 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 was compiled, and subsequently analyzed and summarized using Microsoft Excel and ArcGIS. Data was also uploaded to the application i-Tree Streets in order to determine the monetary and ecological benefits of Vergennes' inventoried public trees. Additionally, the LANDS students performed a baseline full-canopy cover assessment of Vergennes, 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.

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

Table 1. Data collection parameters for the Vergennes 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.
Mulch	Yes: tree is struggling, there is bare and compacted ground beneath the tree and/or there is mechanical damage from weed-wacker/mower. No: The tree roots are not exposed and adequately covered by mulch
Prune	Yes: Flag trees for pruning if any of the following signs are present: broken branches, branches are overlapping /touching/growing on each other, the tree is overcrowded, branches are interfering with utility lines or other built infrastructures, the branches can interfere with pedestrians/vehicles/bikes, etc. No: No branch needs to the trimmed
Remove Stem-Girdling Roots	Yes: The presence of roots visibly growing in circular manner around the trees, opposed to radially out of the tree, and/or are growing over larger anchoring roots.
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.

Inventory Results

Urban Forest Diversity

Of the 518 trees inventoried within the public ROW or on city-owned land, there were a total of 39 different species in 25 different genera. The five most common tree genera, *Acer* (maple), *Fraxinus* (ash), *Ulmus* (elm), *Gleditsia* (honeylocust), and *Malus* (apple), compromise 75% of the urban forest (Figure 1). The top five most common species are *Acer saccharinum* (silver maple) at 18%, *Acer plantanoides* (Norway maple) at 18%, *Ulmus americana* (American elm) at 9%, *Fraxinus pennsylvanica* (green ash) at 8%, and *Acer saccharum* (sugar maple) at 7% (Figure 2). Complete species and genera lists can be found in Appendix B.
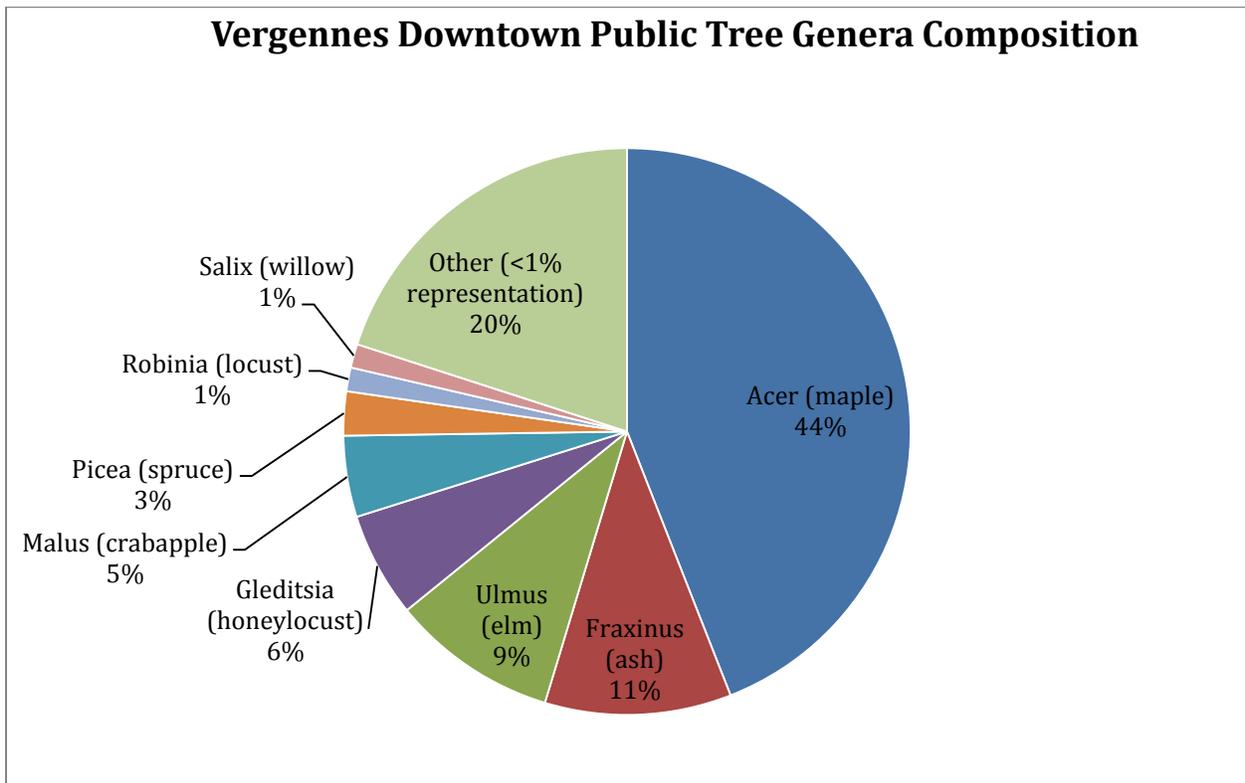

Figure 1. Most common tree genera by percent within the public ROW in Vergennes.

Vergennes Downtown Public Tree Species Composition

Pussy willow
1%

Black locust
1%

Blue spruce
2%

White ash
3%

Crabapple
5%

Honeylocust
6%

Sugar maple
7%

Green ash
8%

American elm
9%

Sugar maple
7%

Other (<1% representation)
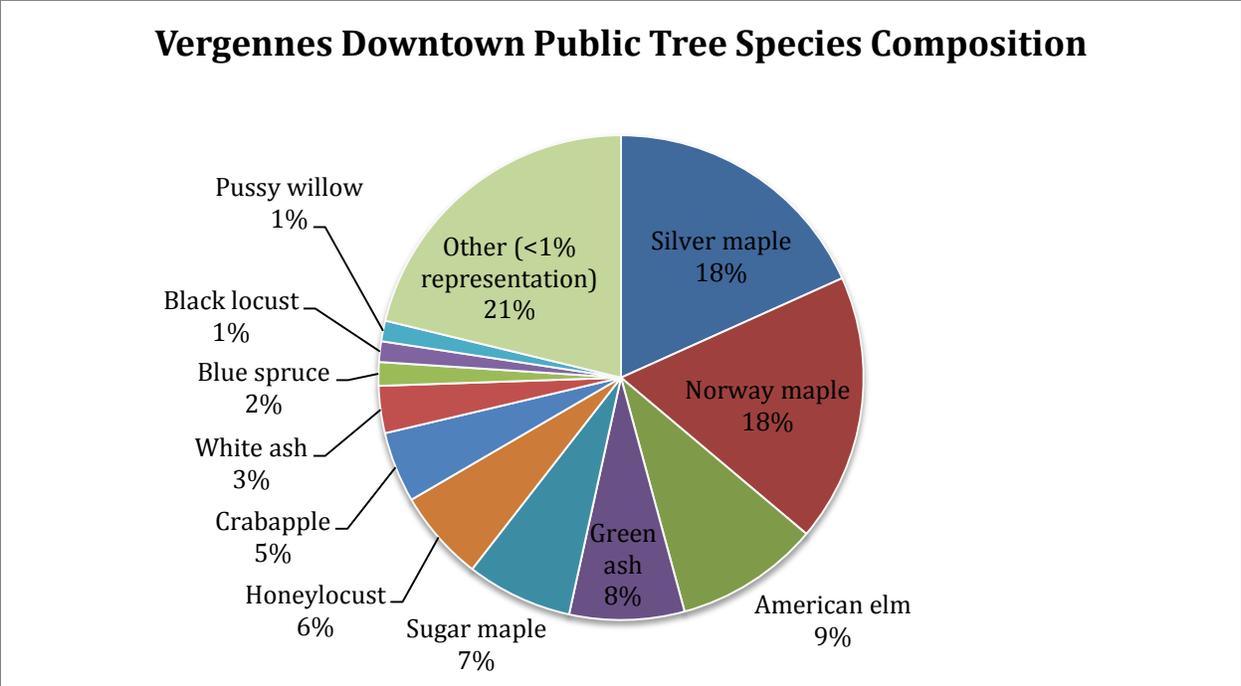21%

Silver maple
18%

Norway maple
18%

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

Urban Forest Structure

Of the 518 trees inventoried, 508 had DBH measurements taken (10 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 Vergennes' public trees is: 27% (138) at 6-12", 22% (113) at 3-6", 20% (104) at 12-18", 12% (59) at 18-24", 9% (43) at 0-3", 6% (31) at 24-30", 2% (11) at 30-36", 2% (8) at 36-42", and 0.2% (1) at 42"+ (Figure 3). The largest tree inventoried in Vergennes was a silver maple in MacDonough Park.

The composition of genera and species 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 Vergennes' inventoried public trees. The three largest size classes represented, 30-36", 36-42", and >42" contain a total of 47 trees. These trees are growing within the public ROW or on city-owned land and were probably not planted as street trees but left as remnants as the city grew. Many of the larger-diameter (18"+) trees are silver or sugar maple, with some Norway maple. However, almost all of the maple trees that are 0-6" are Norway maples, indicating a shift in species preference or availability.
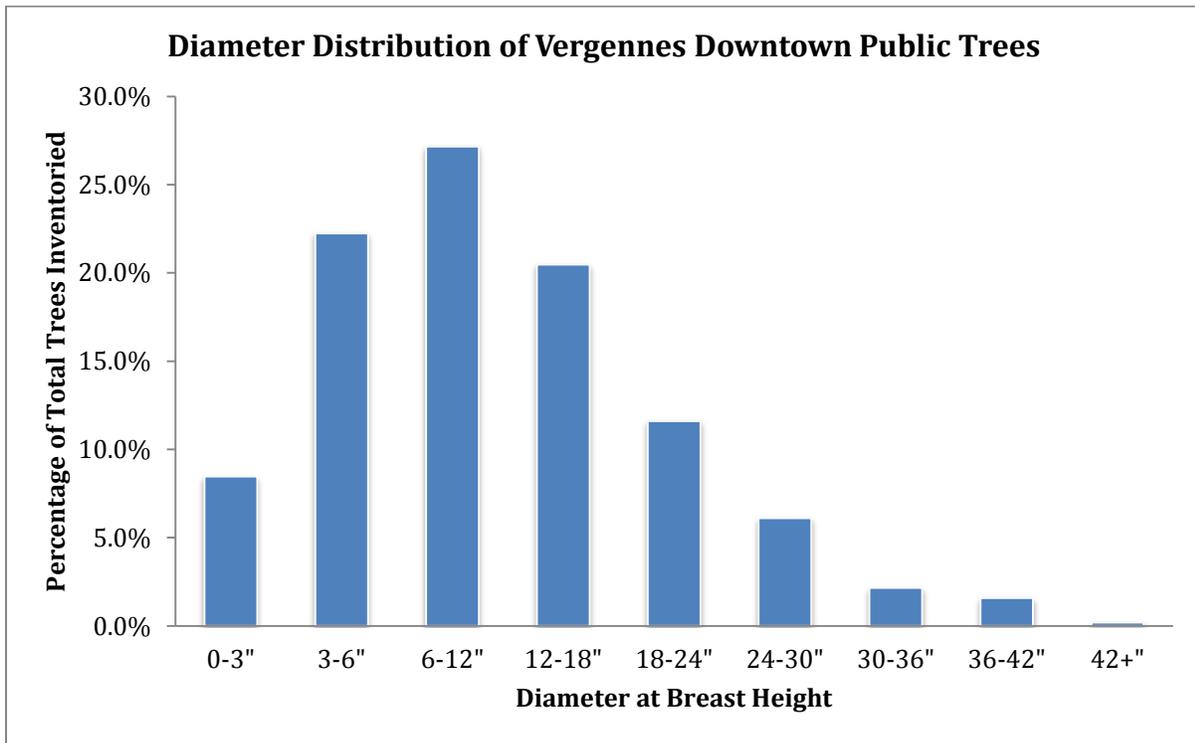
Figure 3. Percentage of trees represented in each diameter class (inches).

	0-3"	3-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42+"
Maple	15	16	53	62	39	26	9	5	1
Ash	7	7	25	13	3	0	0	0	0
Elm	8	11	20	7	3	0	0	0	0
Honeylocust	5	8	2	8	4	3	0	0	0
Crabapple	1	8	10	0	0	0	0	0	0

Figure 4. Diameter distribution for the five most common genera of Vergennes' public trees.

Diameter Class Distribution for Five Most Common Species

	0-3"	3-6"	6-12"	12-18"	18-24"	24-30"	30-36"	36-42"	42+"
■ Silver Maple	2	0	26	26	15	12	5	4	1
■ Norway Maple	12	11	21	26	14	5	1	1	0
■ American Elm	8	11	20	7	3	0	0	0	0
■ Green Ash	7	7	14	8	3	0	0	0	0
■ Sugar Maple	1	2	5	9	9	8	2	0	0

Figure 5. Diameter distribution of the five most common species of Vergennes' public trees.

There were 29 potential tree planting locations or strips identified within the public ROW (recorded as "Vacant"); Appendix A breaks down these locations by street. Of the streets inventoried by the LANDS students, MacDonough Drive, School Street, and Water Street offer the most vacant spots for tree planting. Additional consultation of these sites is necessary to plant a tree of appropriate size and species.

Urban Forest Health

Almost three quarters (72%, or 373) of Vergennes' inventoried public trees were assessed as being in "Good" condition; of the remaining trees, 51 (10%) were considered in "Fair" condition, 68 (13%) were in "Poor" condition, and 26 (5%) were "Dead" (Figure 6). The trees in genera *Acer* (maple), *Fraxinus* (ash), and *Ulmus* (elm) had the most trees in fair or poor condition; however, these genera also comprise the highest percentage of overall trees inventoried. The dead trees that were identifiable were primarily *Acer* (maple), *Fraxinus* (ash), and *Ulmus* (elm) (Figure 7). Appendix D includes maps detailing the location of inventoried trees by condition.
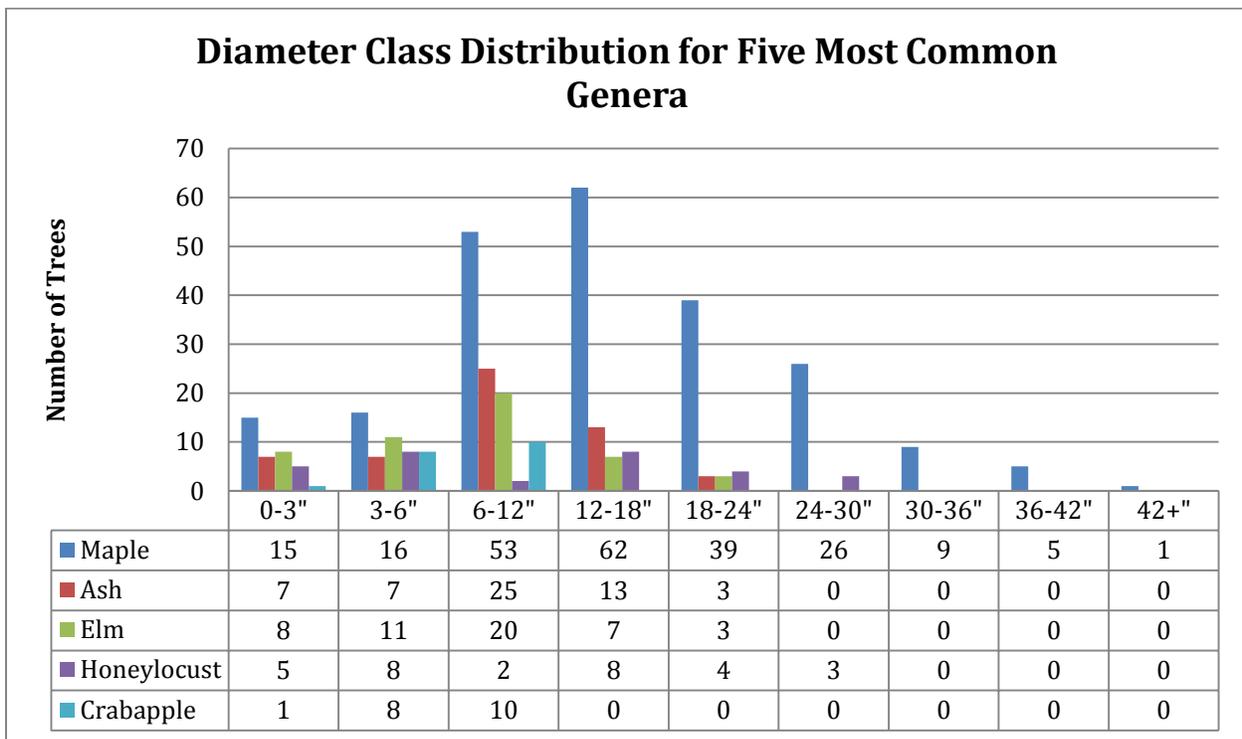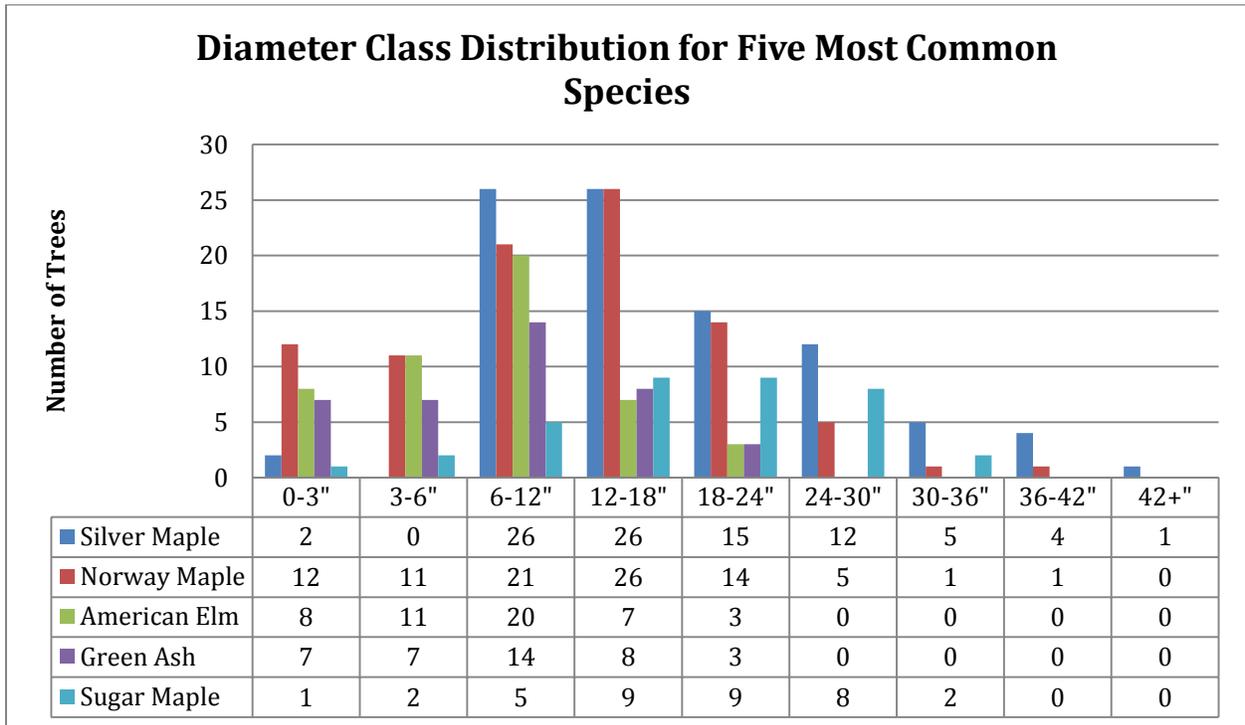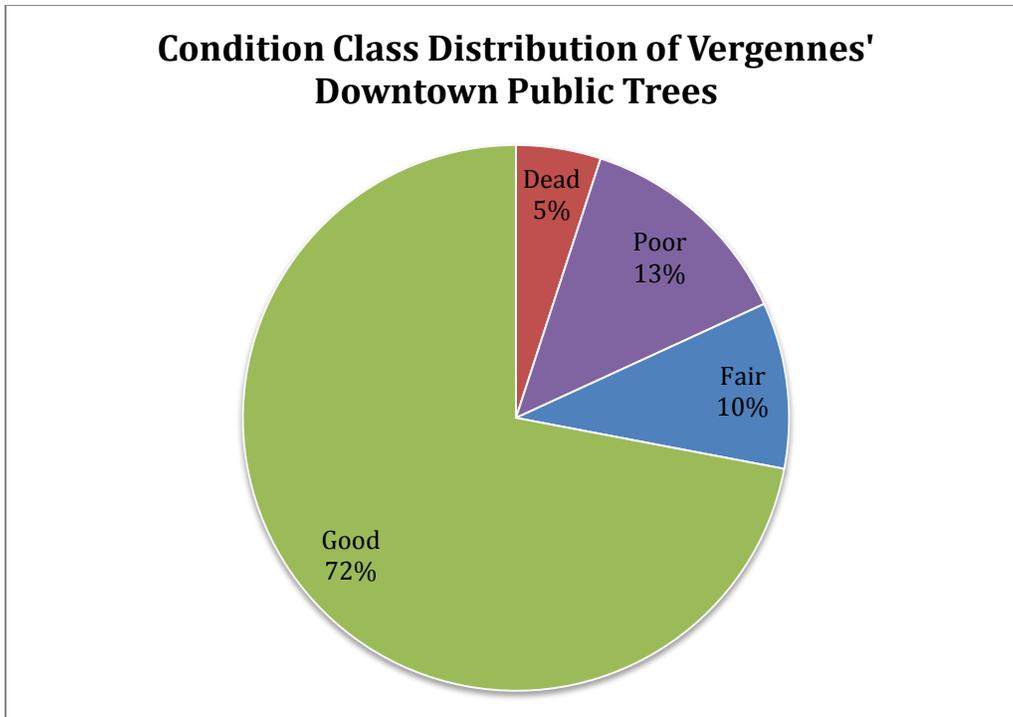
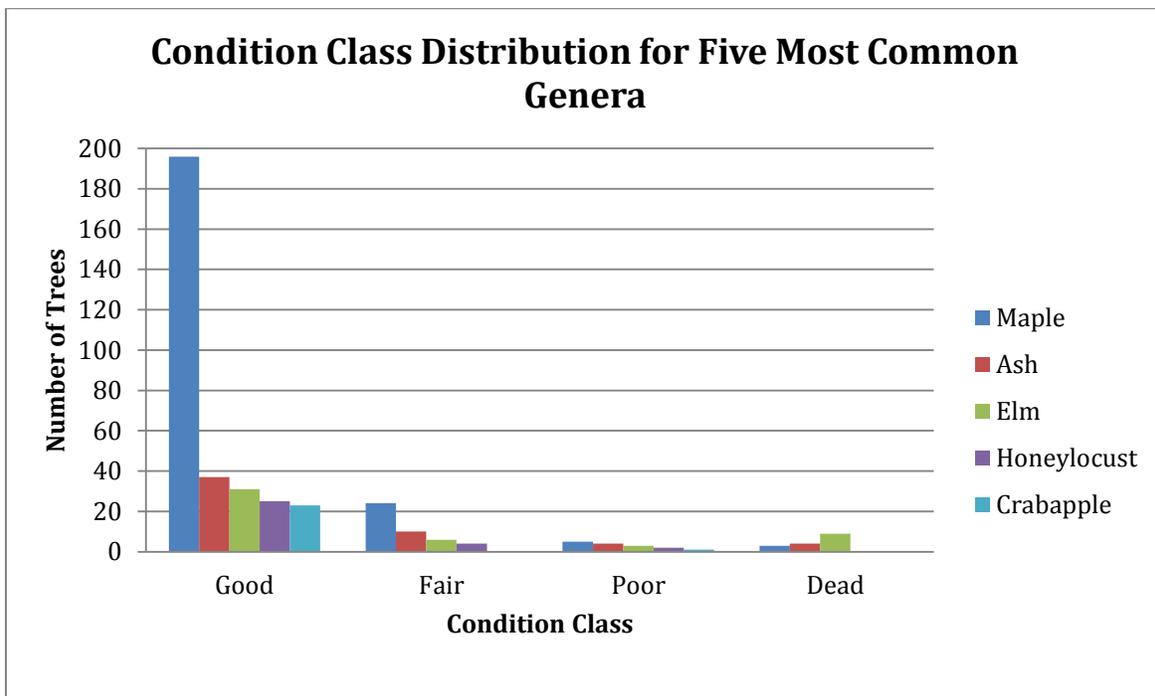Figure 6. Percentage of trees in each condition class.

Figure 7. Number of trees within the five most common genera displayed according to condition.

There were 129 trees (25%) that were flagged for a consult during the inventory and should be reassessed by Certified Arborist, the Vergennes Tree Warden, or another qualified individual 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/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 a sign or symptom of infestation by the emerald ash borer (extensive woodpecker flecking, bark blonding, epicormic branching/water sprouts, and/or suspicious exit holes).

Monetary Value and Ecosystem Services

Vergennes' public tree inventory data was analyzed using i-Tree Streets software to determine the monetary value of the ecosystem services provided by Vergennes' trees. The 518 trees provide a total of $50,863.00 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 $100.12 annually in savings or services.

Figure 8 and Table 2 provide an overview of each ecosystem service provided by the Vergennes public trees. Energy conservation and property value increase are the most significant services provided by these trees in terms of their monetary value. The full reports produced through the i-Tree Streets program for Vergennes are available from VT UCF upon request.

It is important to recognize that the trees inventoried through this project are located on approximately 0.25 square mile of Vergennes' 2.5 square miles of total land area; expanding the inventory to all Vergennes roads would increase these figures dramatically. It is also noteworthy that larger and long-living trees provide substantially more benefits than young, small trees. Regular maintenance and care are needed to provide for urban tree health, longevity, and maximized urban forest benefits.
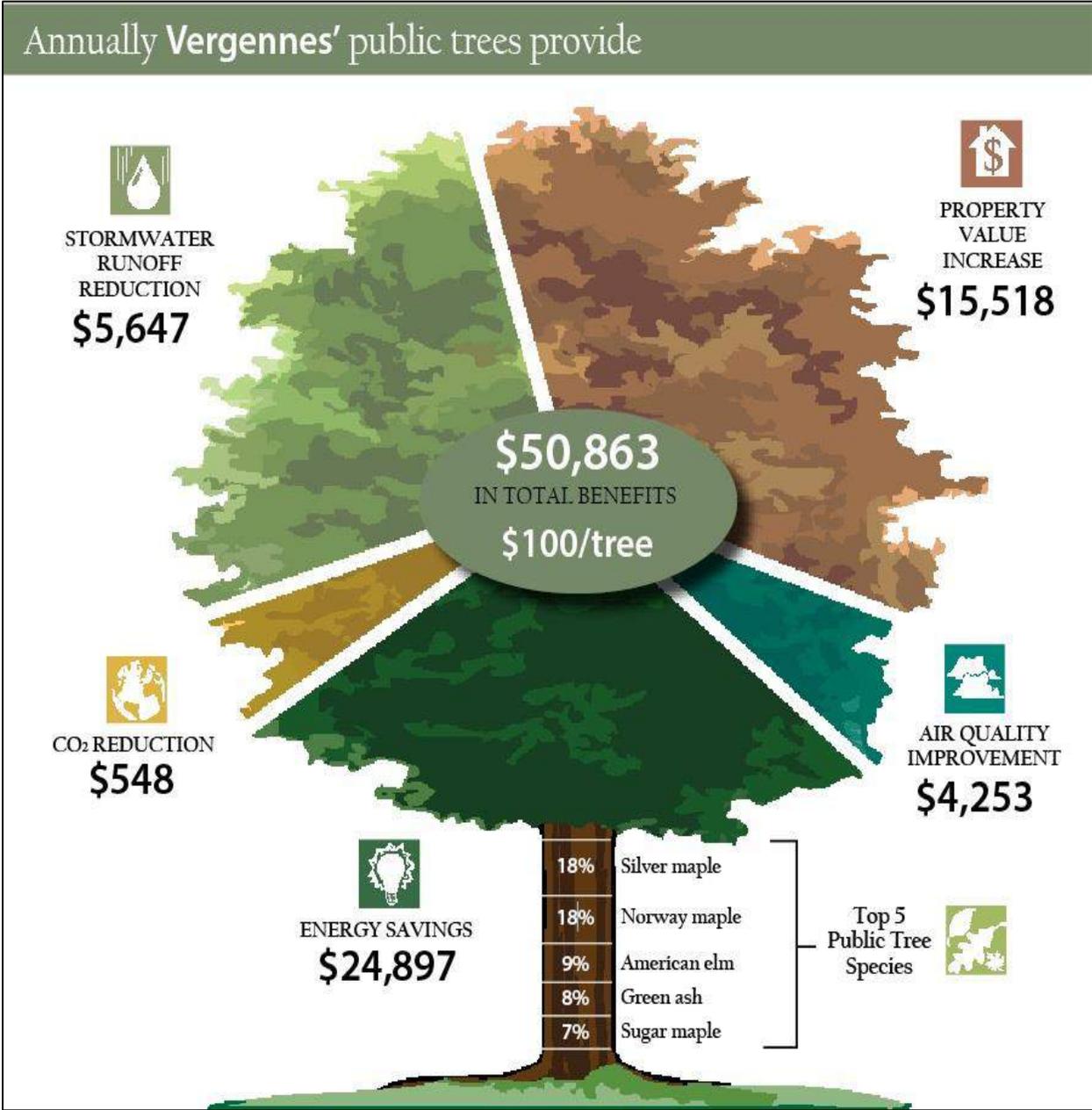
Figure 8. Summary of the benefits provided by Vergennes' public trees inventoried through this project, according to the i-Tree Streets assessment. Tree graphic concept courtesy of City of New York Department of Parks & Recreation

Table 2. Annual environmental and monetary benefits provided by Vergennes' 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	$24,897	$ 49.01
Carbon dioxide	Annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.	$548	$ 1.08
Air quality	Quantifies the air pollutants (O_3, NO_2, SO_2, PM10) deposited on tree surfaces and reduced emissions from power plants (NO_2, PM10, VOCs, SO_2) due to reduced electricity use. Also reported are the potential negative effects of trees on air quality due to BVOC emissions.	$ 4,253	$ 8.37
Stormwater	Reductions in annual stormwater run-off due to rainfall interception by trees.	$5,647	$ 11.12
Aesthetic/other	Tangible and intangible benefits of trees reflected in increases in property values.	$ 15,518	$ 30.55
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.	$ 5,860*	$ 11.54*

Vergennes Full Canopy Assessment

As a complement to the public tree inventory, the LANDS semester students completed an i-Tree Canopy assessment for Vergennes. 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. Based on the Vergennes' i-Tree Canopy assessment, approximately 37% of the area of Vergennes is currently occupied by tree canopy (Figures 9 and 10). Currently 4% of the total area is occupied by buildings, and is not suitable for tree planting (although this is likely a higher percentage in the downtown area). In consideration of the other land cover types present, Vergennes could potentially increase its total tree canopy cover by an additional 35% on open lands of low-lying vegetation, and 18% on agricultural lands. 4% of the land is water or wetlands, which while not suitable for tree planting provides many other benefits. The remaining 2% is impervious surface (parking lots, playgrounds, roads and the ROW), but with strategic planning initiative, some of this could be converted to canopy. In total, there is currently potential to increase overall tree canopy cover in Vergennes by 55%, though a portion of this land is privately-owned and/or used for other purposes such as agriculture (Figure 9).
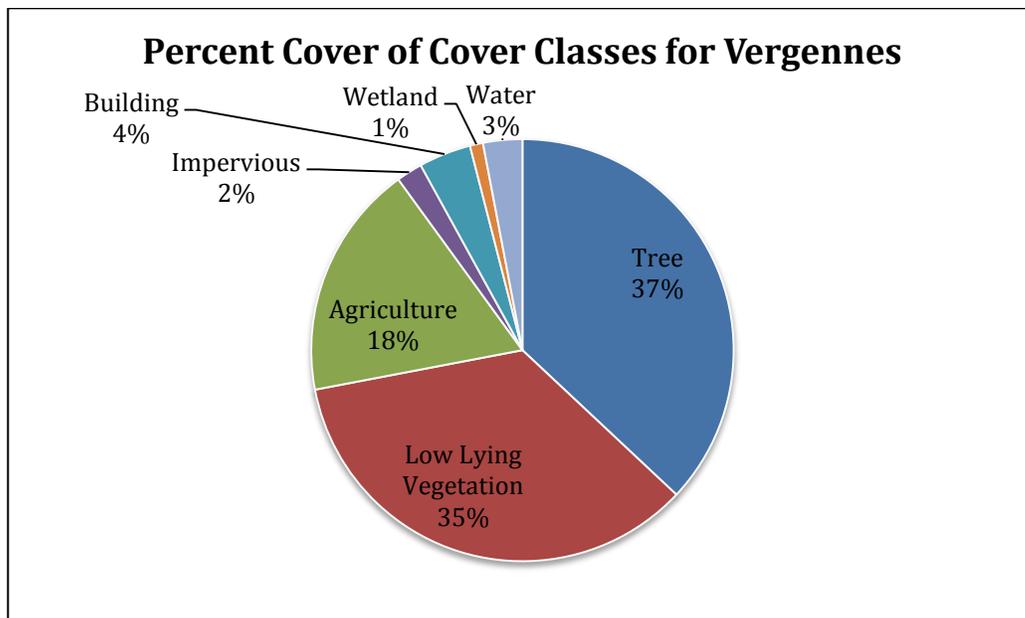
Figure 9. Land cover of Vergennes (includes public and private land).

	Percent Cover (±SE)						
37.0 ±4.83	35.0 ±4.77	18.0 ±3.84	2.00 ±1.41	4.00 ±2.00	1.00 ±1.00	3.00 ±1.73	0.00 ±0.00

Cover Class	Description	Abbr.	Points	% Cover
Tree	Tree, non-shrub	T	37	37.0 ±4.83
Low Lying Vegetation		LLV	35	35.0 ±4.77
Agriculture		A	18	18.0 ±3.84
Impervious		I	2	2.00 ±1.41
Building		B	4	4.00 ±2.00
Wetland		WL	1	1.00 ±1.00
Water		W	3	3.00 ±1.73
Other		O	0	0.00 ±0.00
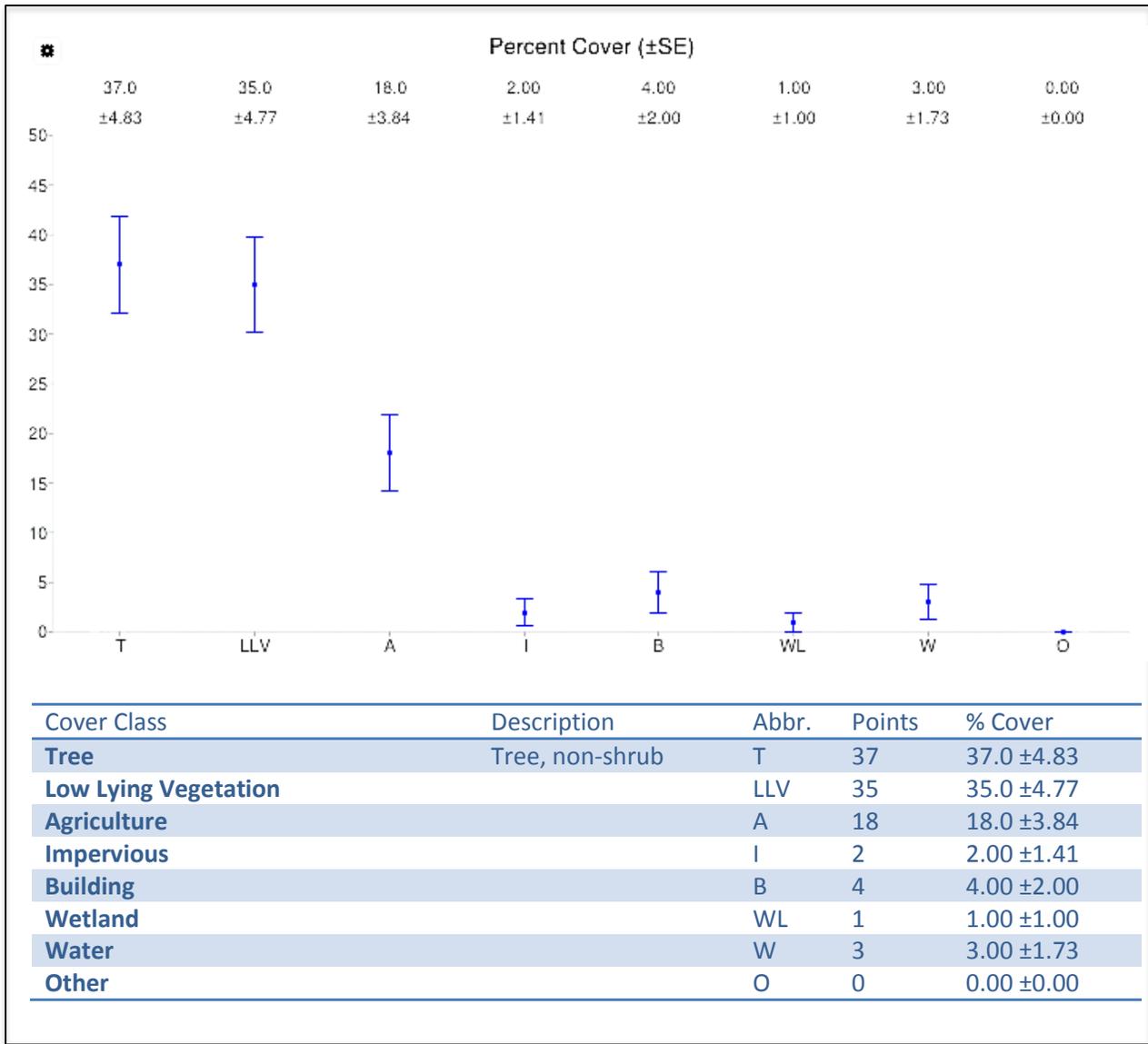
Figure 10. i-Tree Canopy assessment for the area of Vergennes, Vermont, including both public and private land. The above image shows the ground cover composition distribution.

Figure 11 (below) compliments the i-Tree Streets analysis of the monetary value of benefits provided by Vergennes' public trees by estimating the air quality benefits and corresponding monetary value for the full urban forest canopy. Of note is an estimated $1,854,692.62 in CO_2 storage and $51,371.85 in annual CO_2 sequestration value.

Tree Benefit Estimates

Abbr.	Benefit Description	Value	±SE	Amount	±SE
CO	Carbon Monoxide removed annually	$8.25	±1.08	515.42 lb	±67.26
NO2	Nitrogen Dioxide removed annually	$12.41	±1.62	1.64 T	±0.21
O3	Ozone removed annually	$866.40	±113.05	15.08 T	±1.97
PM2.5	Particulate Matter less than 2.5 microns removed annually	$2,234.94	±291.63	1,920.27 lb	±250.57
SO2	Sulfur Dioxide removed annually	$2.27	±0.30	1,982.29 lb	±258.66
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	$321.24	±41.92	2.23 T	±0.29
CO2seq	Carbon Dioxide sequestered annually in trees	$51,371.85	±6,703.39	2,653.05 T	±346.19
CO2stor	Carbon Dioxide stored in trees (Note: this benefit is not an annual rate)	$1,854,692.62	±242,014.48	95,783.73 T	±12,498.59

Figure 11. i-Tree Canopy assessment estimates for air quality benefits of Vergennes' 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 saccharinum*). 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 Vergennes, 44% of public trees inventoried were in the maple (*Acer*) genus, which is more than double the recommended representation within the community's urban forest. Specifically, silver maple, Norway maple, and sugar maple – all members of the *Acer* genus - represent 18%, 18%, and 7% of the species diversity respectively. Norway maple is one of the two most prevalent species in Vergennes, 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 (*Fraxinus*) make up 11% of the public tree canopy of Vergennes. Both ash and maple trees are currently threatened by invasive tree pests; the emerald ash borer (EAB) threatens the former, and the Asian longhorned beetle (ALB) is a threat to the latter. While neither of these pests has been discovered to-date in Vermont, the largest ALB infestation in North America is just over 50 miles to our 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. High-density stands of both ash and maple were observed in MacDonough Park during the inventory. Together, they comprised a majority of the total number of trees located within the park. The overall lack of species diversity in MacDonough Park is of concern because it is limiting to the area's resilience in the face of natural disturbances, insects, and disease.

Recommendation:

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

Recommended Action Practices:

- We advise against planting high density stands of the same species (monocultures)

Components of a Managed, Vibrant, and Resilient Urban Forest

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.

whose close proximity may be conducive to the spreading of disease.

- Due to the high number of existing maple (*Acer)* trees in Vergennes, we suggest selecting non-maple trees for future plantings.

- We suggest planting tree species that have been grown successfully in the area that do not show any signs of diseases and deformity, and that are not non-native invasive species (specifically Norway maple). For more information on site assessment and species selection, refer to VT UCF's Tree Selection Guide at http://www.vtcommunityforestry.org/resources/tree-care/tree-selection.

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

- Plan for the arrival of EAB by using the Community Preparedness Toolbox, available at http://www.vtinvasives.org/tree-pests/community-preparedness.

- Encourage citizens to participate in the Vermont Forest Pest First Detector Training to expand local capacity to identify and monitor for invasive forest pests.

- In order to diversify in both species composition and age structure, refer to the identified vacant planting locations within the public ROW in Appendix A, and develop a strategic planting plan.

- In planning for future tree plantings, consider obstructions above ground (power lines) and below ground, minimize grey infrastructure conflicts (sidewalks, streets, buildings, etc.) available soil volume, species mature size (height and spread), branching patterns, environmental tolerances (exposure, salt, and drought), and desired function when choosing species.

- Encourage residents to plant trees on their private 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 inches in diameter to provide clearance for pedestrians and vehicles
- Crown reduction: removing individual limbs from structures or utility wires

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

Recommendation:

Establish a routine maintenance cycle, implemented by trained professionals and overseen by the Vergennes Tree Warden and/or Planning Commission for all public trees to promote tree health and reduce any threat to public safety.

Recommended Action Practices:

- Form a tree board or advisory committee to lead efforts to maintain and plant trees and to oversee and promote Vergennes' public trees.
- Complete a full inventory of all public trees in Vergennes in order to establish a routine maintenance regime for all city-managed trees.
- Work with VT UCF to ensure municipal tree maintenance staff is trained in best management practices.
- Establish a systematic pruning cycle (multi-year) 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 Vergennes 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 Vergennes' canopy.

Urban Forest Health

Overall, Vergennes appears to have a healthy population of public trees, and dedicated maintenance and care would further increase the health of the urban forest. Approximately 23% (119) of Vergennes' public trees were either considered to be in "Fair" or "Poor" condition and 26 trees were designated to be "Dead". There are high concentrations of "Fair", "Poor", and "Dead" trees in McDonough Park and on High Street. There were 129 trees flagged to be revisited by a certified arborist, the Tree Warden, or another qualified individual. Many of these trees overlap those designated to be in "Poor" condition or "Dead", and others were likely noted because of conflict with utility wires or other infrastructure. See Appendix D for a map detailing the locations of trees in Vergennes by condition and a map indicating the location of the 129 trees requiring a consult.

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

Recommendation:

Monitor and care for trees in good and fair condition, plan to lose trees in poor condition, and remove dead trees to increase overall urban forest health.

Recommended Action Practices:
- Visit and assess the 129 trees flagged for consultation in a systematic and timely fashion.
- Remove the 26 dead public trees identified.
- Closely monitor the health of the 68 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 and record any changes in tree health.
- Focus efforts on MacDonough Park, an area of high value to the public that contains a large number of trees in poor condition.
- Create and implement a consistent pruning cycle, with special attention to trees growing around power lines.

Assessment Tools

Using free i-Tree software developed by the USDA Forest Service, we were able to assess the value and potential expansion of Vergennes' urban tree canopy. i-Tree Streets allowed us to determine the economic value of the ecosystem services provided by the 518 inventoried trees in Vergennes. Vergennes' urban forest generates about $50,863 annually through the benefits of air quality improvement, carbon storage, electricity and natural gas, aesthetics, and storm water control; on average, each tree offers approximately $100 in service or savings every year. The trees of Vergennes provide services to the city in the following ways:

- **Aesthetics**: Urban trees can make an urban or suburban environment a more pleasant and satisfying place to live, work, and spend leisure time (Dwyer et al. 1991). In monetary terms, presence of shade trees can significantly increase property value. There are also numerous health benefits to trees. For example, hospital patients with window views of trees have been shown to recover faster than patients without such views (Ulrich 1984).
- **Air quality**: Trees improve air quality by removing air pollutants through their leaves, altering emissions from building energy use, and by lowering air temperature.
- **Energy use**: Trees influence thermal comfort and energy use by providing shade, transpiring moisture, and reducing wind speeds. Over 100 million trees have been established around residences in the U.S. and it saves $2 billion annually in reduced energy costs (Akbari et al. 1988).
- **Stored Carbon Dioxide**: Urban trees can affect climate change by storing carbon in their tissues and reduce 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.

Using a random sample method and based on assessing land cover types, i-Tree Canopy allowed us to measure the overall tree canopy cover within the boundaries of the inventory area, capturing both private and public tree canopy.

Recommendation:

Use the information generated through the i-Tree Streets and i-Tree Canopy programs to promote investment in urban forest management and local stewardship. 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 City of Vergennes 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; they should considered by the Planning Committee based on long-term vision and current capacity. Looking ahead, the City of Vergennes should focus efforts on maintaining the quality of the urban trees. With improved monitoring, the potential for a healthy, sustainable urban forest is attainable.

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Appendices

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

Street/site name	ROW Extent (feet)	Number of Trees	Number of Vacant Spots or Strips
Alden Place	50	1	2
Battery Hill	42	5	2
Comfort Hill	50	6	0
East Street	42	22	1
Falls Park	n/a	n/a*	n/a*
Green Street	66	39	0
High Street	50	39	3
King Street	42	3	1
MacDonough Drive	50	21	6
Main Street	99	45	1
Maple Street	42 from north end to Main Street; 50 South of Main Street	43	0
Meadowbrook Road	50	23	0
Mountainview Lane	50	n/a*	n/a*
North Street	50	10	0
Park Street	42	1	0
School Street	50	24	7
Short Street	50	51	0
Spring Street	42	2	0
Vergennes Library	n/a	11	0
Water Street	66	27	5
City Green	n/a	23	0
McDonough Park	all landscape trees	122	0
TOTAL		**518**	**29**

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

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

Common Name	Scientific Name	Number of Trees	Percent of Total Population
Silver maple	*Acer saccharinum*	93	17.92%
Norway maple	*Acer platanoides*	91	17.53%
Broadleaf Deciduous other	n/a	55	10.60%
American elm	*Ulmus americana*	49	9.44%
Green ash	*Fraxinus pennsylvanica*	39	7.51%
Sugar maple	*Acer saccharum*	36	6.94%
Honeylocust	*Gleditsia triacanthos*	31	5.97%
Crabapple	*Malus sp.*	24	4.62%
White ash	*Fraxinus americana*	16	3.08%
Blue spruce	*Picea pungens*	8	1.54%
Black locust	*Robinia pseudoacacia*	7	1.35%
Pussy willow	*Salix discolor*	7	1.35%
Boxelder	*Acer negundo*	5	0.96%
Dogwood	*Cornus sp.*	4	0.77%
Northern catalpa	*Catalpa speciosa*	4	0.77%
Balsam fir	*Abies balsamea*	3	0.58%
Black walnut	*Juglans nigra*	3	0.58%
Horsechestnut	*Aesculus hippocastanum*	3	0.58%
Littleleaf linden	*Tilia cordata*	3	0.58%
Red maple	*Acer rubrum*	3	0.58%
Spruce other	*Picea sp.*	3	0.58%
Conifer Evergreen other	n/a	2	0.39%
American beech	*Fagus grandifolia*	2	0.39%
Oak other	*Quercus sp.*	2	0.39%
Paper birch	*Betula papyrifera*	2	0.39%
Birch	*Betula sp.*	1	0.19%
Cherry plum	*Prunus sp.*	1	0.19%
Eastern Cottonwood	*Populus deltoides*	1	0.19%
Eastern red cedar	*Juniperus virginiana*	1	0.19%
Ginkgo	*Gingko biloba*	1	0.19%
Japanese tree lilac	*Syringa reticulata*	1	0.19%
Lilac	*Syringa vulgaris*	1	0.19%
Northern red oak	*Quercus rubra*	1	0.19%
Norway spruce	*Picea abies*	1	0.19%
Pear	*Pyrus sp.*	1	0.19%
Pine other	*Pinus sp.*	1	0.19%
Quaking aspen	*Populus tremuloides*	1	0.19%
River birch	*Betula nigra*	1	0.19%
Scotch pine	*Pinus sylvestris*	1	0.19%
Western red cedar	*Thuja plicata*	1	0.19%
White spruce	*Picea glauca*	1	0.19%

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

Anyone with internet access can view all of the inventoried Vergennes 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 Vergennes 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 city-level so that you can see the street names on the map).
3. In the information pane on the left of the screen switch 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 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.
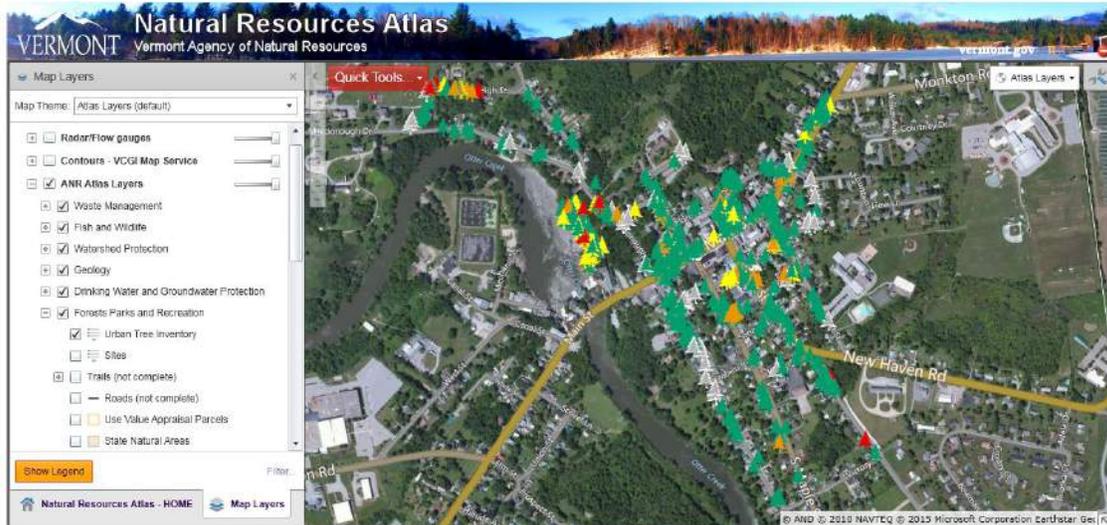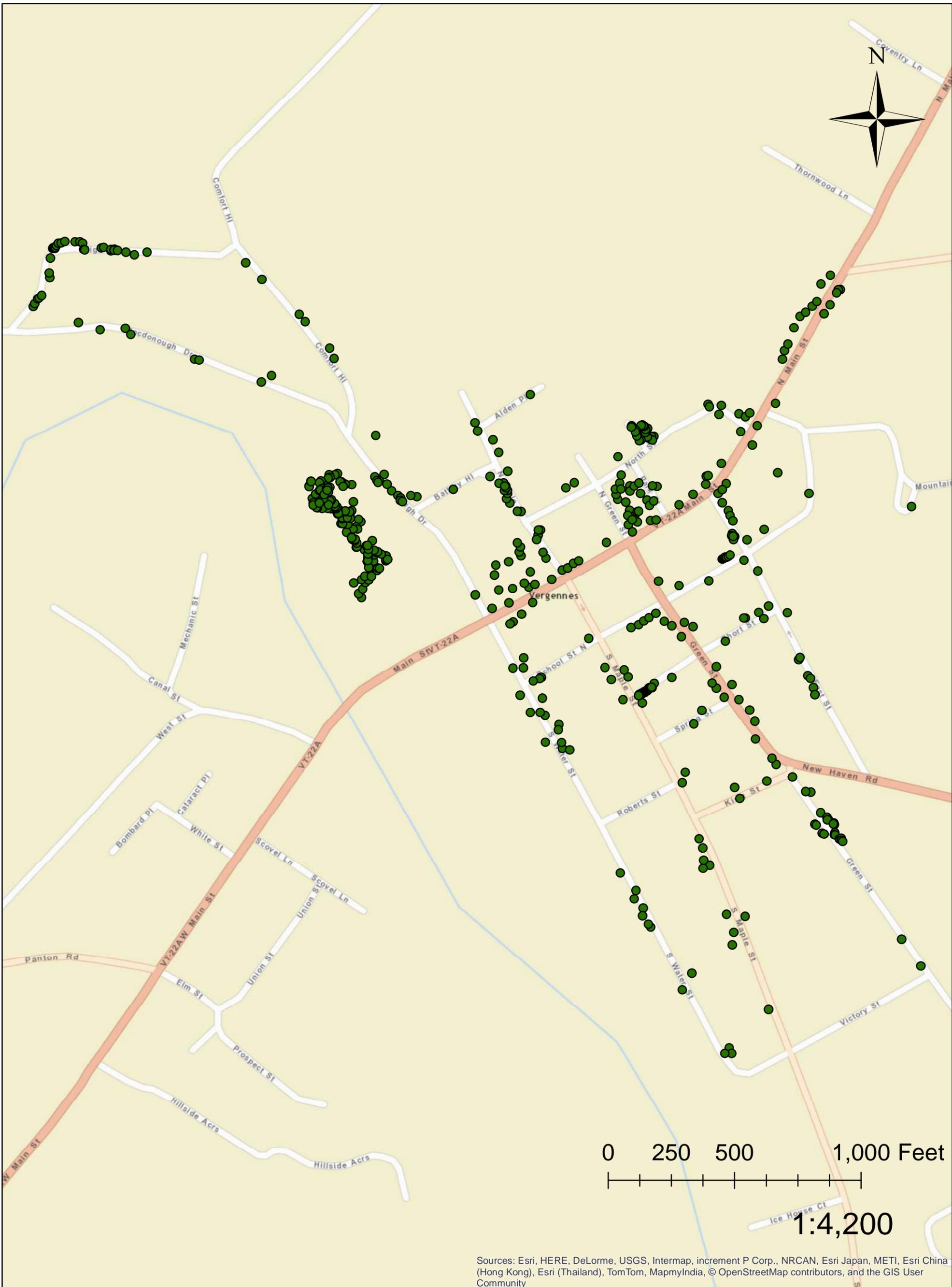

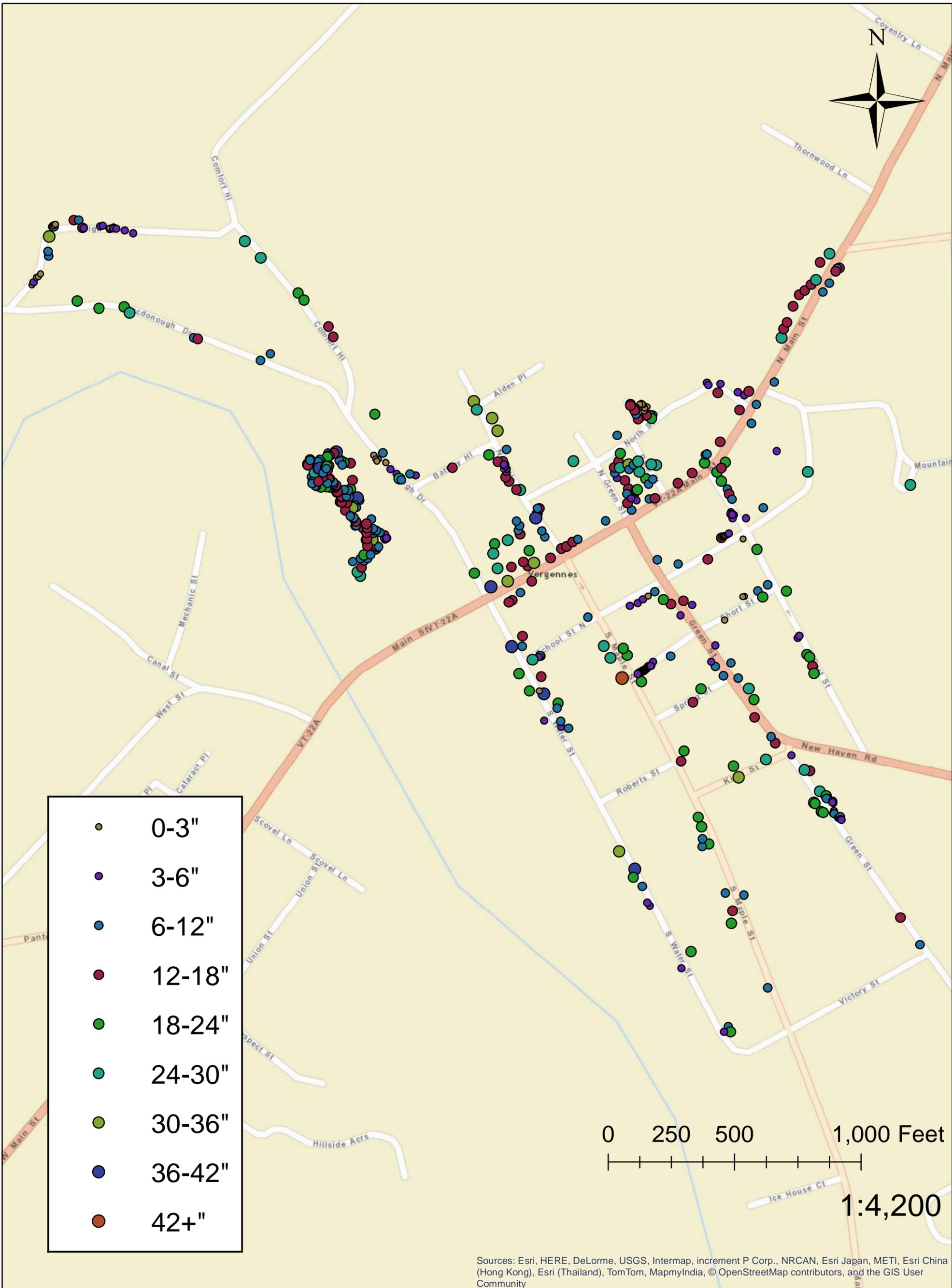**Screen shot of the Vergennes public trees as seen through the ANR Atlas mapping tool.**

Appendix D: Maps

1. All Public Trees Inventoried in Vergennes

2. All Public Trees Inventoried in Vergennes by DBH Class

3. Public Trees in Vergennes Designated as in "Good" Condition

4. Public Trees in Vergennes Designated as in "Fair", "Poor", or "Dead" Condition

5. Public Trees Requiring a Consult in Vergennes

6. Potential Public Tree Planting Locations in Vergennes

All Trees Inventoried in Vergennes

0   250   500   1,000 Feet

1:4,200

Created by LANDS Field Semester 2014

All Trees Inventoried by DBH Class

Legend:
- 0-3"
- 3-6"
- 6-12"
- 12-18"
- 18-24"
- 24-30"
- 30-36"
- 36-42"
- 42+"

0   250   500   1,000 Feet

1:4,200

Created by LANDS Field Semester 2014

Trees designated to be in "Good" condition

0   250   500   1,000 Feet

1:4,200

Created by LANDS Field Semester 2014

Trees designated to be in "Fair," "Poor," or "Dead" Condition
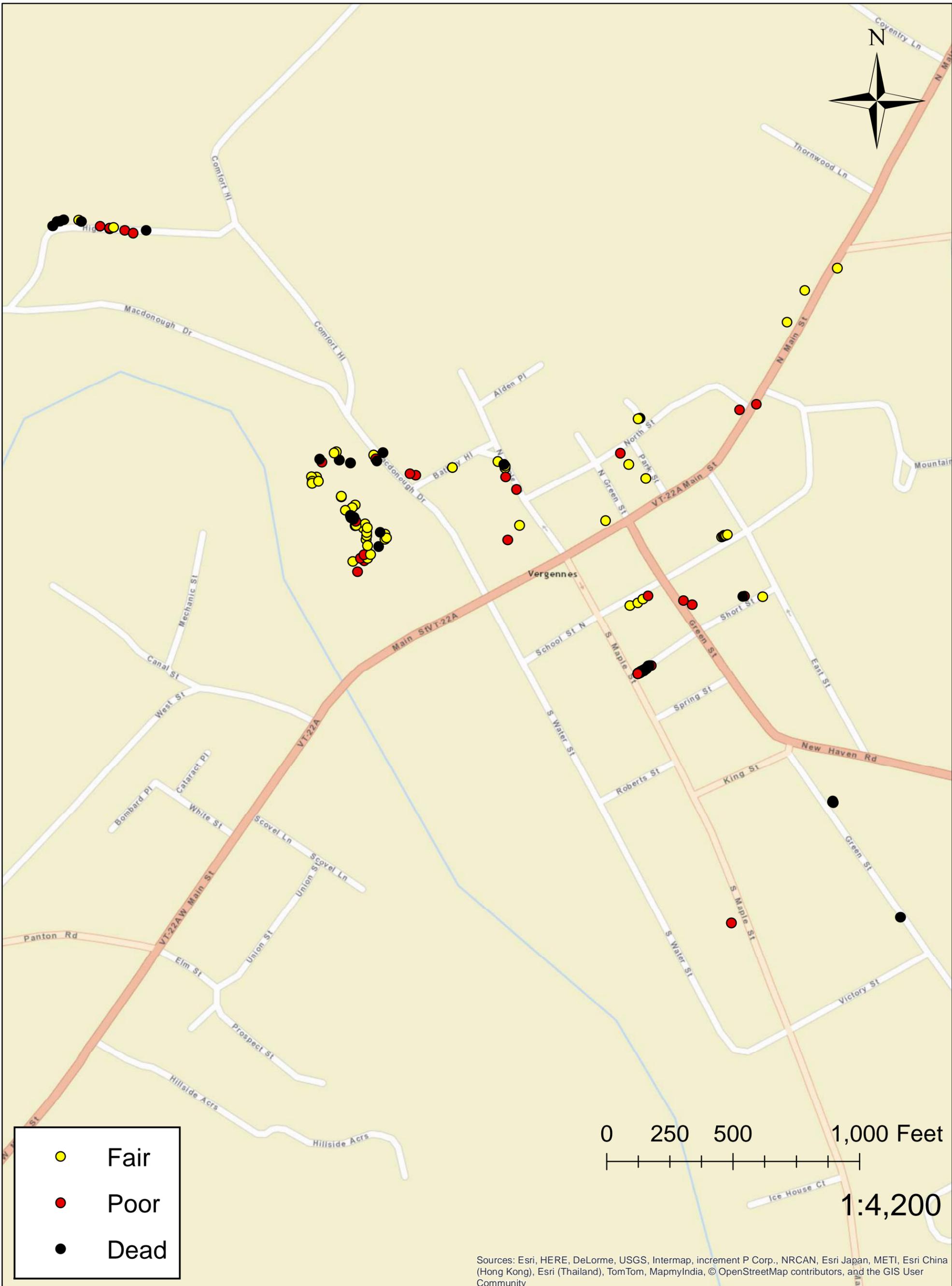
N

Coventry Ln

N Main St

Thornwood Ln

Comfort Hl

Macdonough Dr

Comfort Hl

Alden Pl

Mountain

North St

Park St

VT-22A Main St

Macdonough Dr

Baldt Hl

N Green St

Vergennes

Short St

Green St

Mechanic St

Main St/VT-22A

School St N

S Maple St

Spring St

East St

Canal St

VT-22A

West St

S Water St

Roberts St

King St

New Haven Rd

Cataract Pl

Bombard Pl

White St

Scovel Ln

Scovel Ln

Union St

Union St

S Maple St

Green St

Panton Rd

VT-22A W Main St

Elm St

Prospect St

Victory St

Hillside Acrs

Hillside Acrs

Ice House Ct

	0	250	500		1,000 Feet

Legend

- ● Fair
- ● Poor
- ● Dead

1:4,200

Created by LANDS Field Semester 2014

Trees Requiring a Consultation
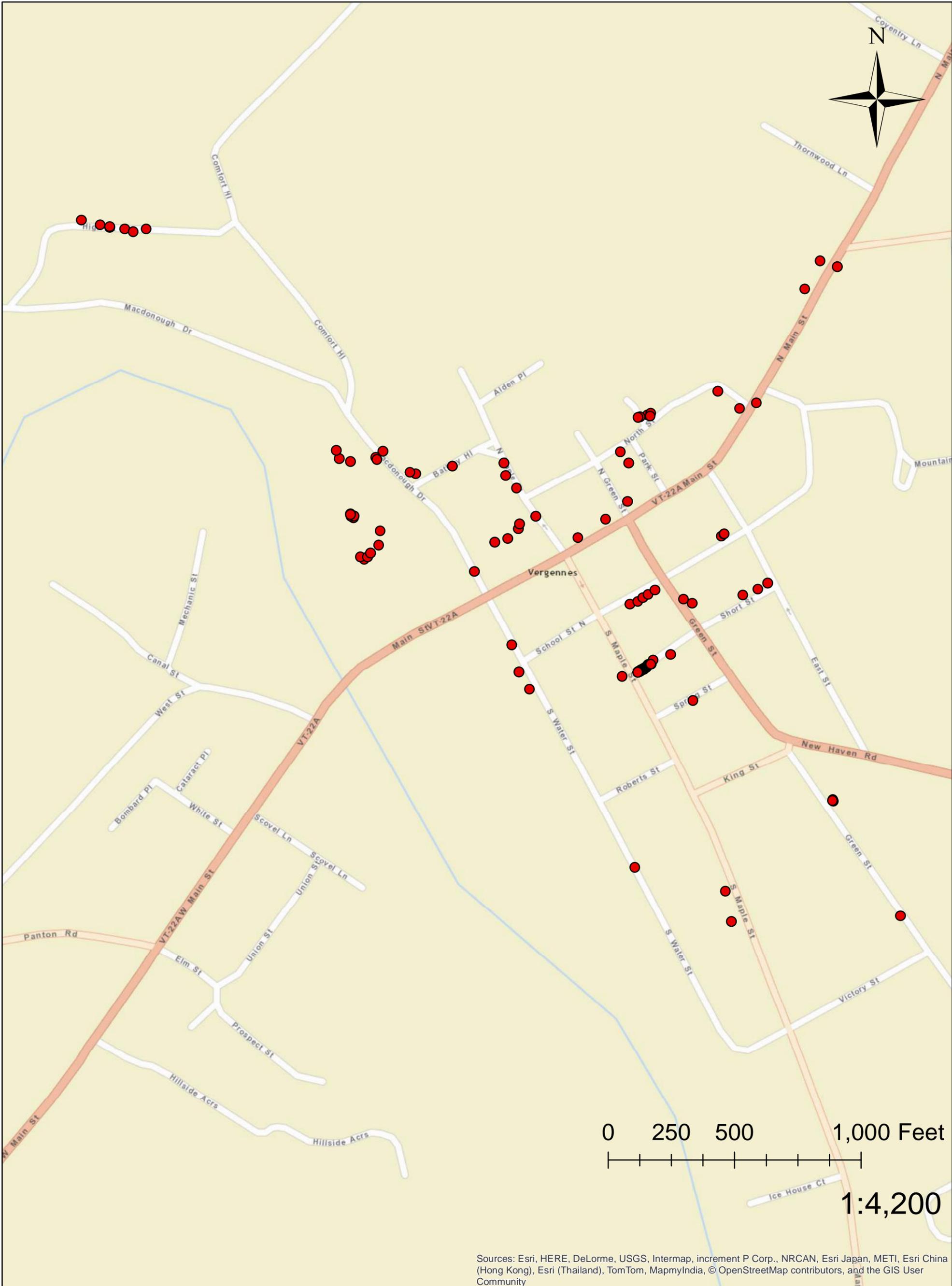
N

0   250   500   1,000 Feet

1:4,200

Created by LANDS Field Semester 2014

Potential tree planting locations within the Public ROW or on town-owned property

N

Comfort Hl

Thornwood Ln

Coven

High St

Macdonough Dr

Comfort Hl

N Main St

Alden Pl

Macdonough Dr

North St

N Maple St

Battery Hl

N Green St

Park St

VT-22A Main St

Vergennes

Short

Main St VT-22A

VT-22A

School St N

S Maple St

Green St

East

Mechanic St

Canal St

S Water St

Spring St

New Haven Rd

West St

Roberts St

ng St

Green St

VT-22A

Bombard Pl

Cataract Pl

White St

Scovel Ln

Scovel Ln

Union St

S Maple St

S Water St

Victory St

Panton Rd

VT-22AW Main St

Union St

Elm St

Prospect St

Hillside Acrs

VT-22AW Main St

Hillside Acrs

Ice Hous

| 0 | 250 | 500 | 1,000 Feet |

1:4,200

Created by LANDS Field Semester 2014