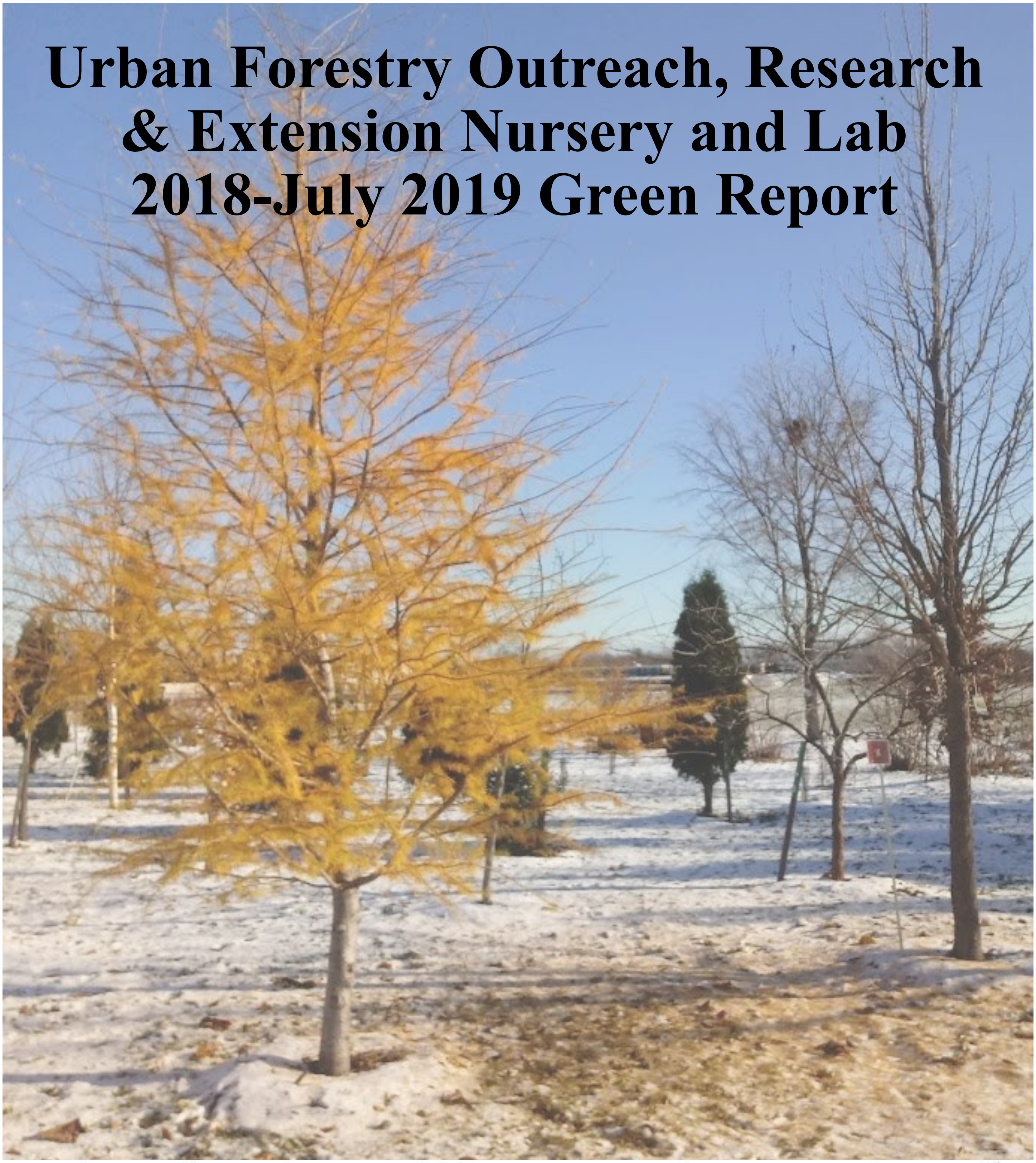
Urban Forestry Outreach, Research & Extension Nursery and Lab 2018-July 2019 Green Report



Department of Forest Resources

® UNIVERSITY OF MINNESOTA

Urban Forestry Outreach, Research & Extension Team, 2018

Forest Resources Academic, Research, and Extension Staff:

Michael Bahe, Researcher, GIS and Remote Sensing, Urban and Community Forestry
Gary Johnson, Professor/Extension Professor, Urban and Community Forestry
Chad P. Giblin, Research Fellow, Urban and Community Forestry
Brian Luedke, Arborist Technician, Youth Engagement in Arboriculture
Kylie Mackereth, Arborist Technician, Youth Engagement in Arboriculture
Ryan L. Murphy, Research Fellow, Urban and Community Forestry
Laura Nelson, Recruiting and Communications Coordinator
Monica Randazzo, Researcher, Urban and Community Forestry

Outreach Staff

Ashley Reichard, Urban and Community Forestry Volunteer Programs Coordinator

Graduate Research Assistants:

Callissa Cloutier, Graduate Research Assistant, Urban and Community Forestry
Daniel Wattenhoffer, Graduate Research Assistant, Urban and Community Forestry

Cooperative Research Staff

Changbin Chen, Assistant Professor, Horticultural Science
Stephen Brockman, Graduate Student, Horticultural Science

Undergraduate Research Assistants:

Luke Bailey
Gabe Cesarini
Kevin Chen
Alissa Cotton
Jack Faje
Tracy Few
Natalie J. Hamilton
Hannah Hinrichs
Leslee Jackson
Mathew Lochner
Alex Miller
Amy Shaunette
Amanda Stear
Taylor Stockert
Dalton Uphoff
Lydia Voth
Graham Wessberg

Report Prepared By:

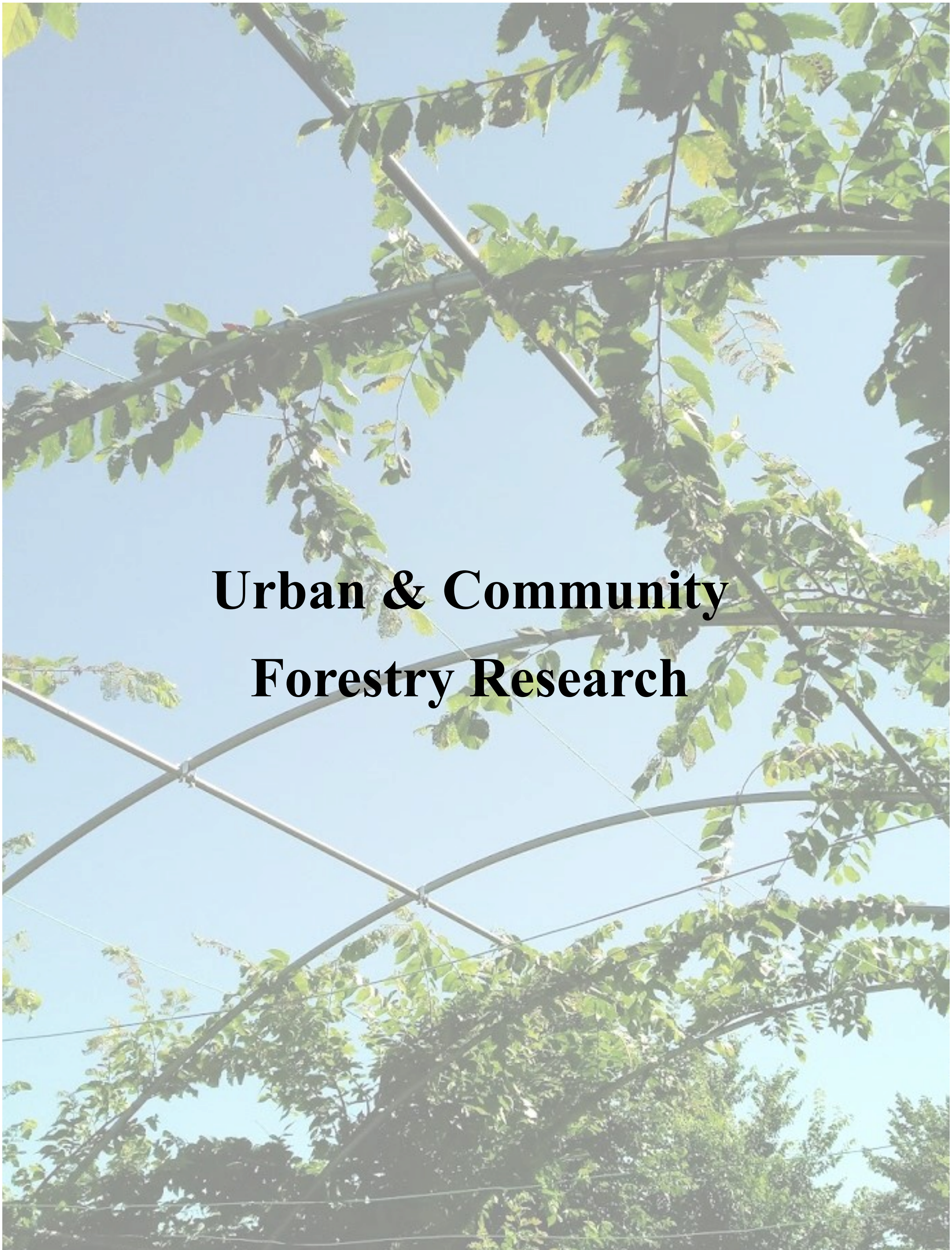
Monica Randazzo

Table of Contents

Urban & Community Forestry Research

Arboriculture & Municipal Forestry

Volunteer & Outreach Programs



Urban & Community Forestry Research

A UFore Gravel Bed Update

Tracy Few, Undergraduate Research Assistant
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
University of Minnesota, Department of Forest Resources

Background and Study Design:

Since 2006, the Urban Forestry Outreach Research and Extension nursery at the University of Minnesota has been conducting research on tree and shrub species responses to gravel bed performance (survival and root growth), and transplant success. During the 2018-2019 season, 22 tree and shrub species and/or cultivated varieties were tested for their response to growing in gravel and surviving subsequent transplanting into a soil-based landscape at the nursery (Table 1). All trees were stocked in the gravel beds during the spring of 2018, assessed for their root growth in autumn of 2018, planted out in the fields and landscapes during November and December of 2018, and finally assessed for their survival performance in June of 2019

Gravel beds for this study are located in the UFore nursery on the University of Minnesota St. Paul campus. Four gravel beds with different mixtures of sand and gravel as well as different wind and sun exposures were used: Bed 1, a 3-sided bed made of portable traffic barriers and moderate shade, ground bed, 100% pea stone, full sun; Bed 2, an in-ground bed, full sun, Bed 3, 100% pea stone, full sun and wind exposure; and Bed 4, a raised bed, 90% pea stone and 10% coarse sand, full sun, full wind exposure. Beds 2, 3, and 4 are watered four times a day -- starting at 10 a.m. at three hour intervals for ten minutes each. Bed 1 is watered four times a day at 5 a.m. and ending at 11 p.m. for 10 minutes each time. No supplemental nutrients were added to any of the gravel beds.

All trees and shrubs were measured with a caliper, six inches up from the first root. The average caliper was calculated for each group of trees being planted in its respective gravel bed. Trees were planted in holes or trenches. The first root was covered with a gravel to a depth of 10 inches. If needed, the roots were pruned when the root system was very large and unmanageable for planting. In Beds 3 and 4, trees and shrubs were planted east to west, beginning on the south end of the bed. In Bed 1 trees and shrubs were planted north to south, starting on the east side of the bed. In the Bed 2, trees and shrubs were planted east to west on the north side on the bed. The trees were planted as close together as possible, without branches or roots overlapping with one another. Trees were planted from May 18th to June 12th, 2018.

At the end of the study, each group of trees and shrubs was assessed for survival, growth rate and root mass development. Growth rate was a measure of caliper increase. Root mass development was evaluated against a white grid board (Figure 1). If minimal root development occurred, there would be a maximum amount of white background when the root system was placed against the grid board. This then would be graded as a 1. If most or all of the white background was covered with roots, this would then be graded as a 5. Grades 2, 3 and 4 would be stages between the two extremes.

Figure 1: Grading harvested root systems on a 1-5 scale.

Results:

Table 1: Gravel bed tree and shrub species for the 2018-2019 study.

Species	Number	Average Caliper (mm)	2019 Root Grades	Survival Rate%
American Mountain Ash	25	4.16	1.4	76
American Mountain Ash	25	4.4	1.1	92
Chokecherry	25	5.7	1.3	96
Chokecherry	25	5.9	1.9	100
Lilac (Syringa villosa)	25	3	2.8	100
Lilac (Syringa villosa)	25	3.3	3.2	100
Skunkbush Sumac	25	7	1.4	100
Skunkbush Sumac	25	5.9	1.7	88
Arrowwood Viburnum	15	6.4	3.8*	100
Arrowwood Viburnum	15	6.6	2.8	100
Grey Dogwood	10	4.1	3.1*	100
Grey Dogwood	10	4.8	2.1	100
Silky Dogwood	10	5	2.4	100
Silky Dogwood	10	5.5	2.3	100
Red Oak	10	8.1	1.2	100
Red Oak	10	7.5	1.3	70
Bicolor Oak	10	8.1	2.8*	100
Bicolor Oak	10	8	2	100

Serviceberry	10	3.7	1	90
Serviceberry	10	3.4	1.1	90
Bitternut Hickory	25	9.32	1.1	100
Bitternut Hickory	25	7.2	1.3	96
White Oak	15	10.9	1.6	100
White Oak	15	11.1	2.5**	
Cornelian Cherry Dogwood	5 (7')	24.6	3	100
Cornelian Cherry Dogwood	5 (6')	21	3	100
Green Mt Silver Linden	10	50.7	1.5	0.0
Eyestopper Cork Tree	10	19.5	3	100
Pacific Sunset Maple	10	35.4	3.5	70
Scarlet Oak	10	11.1	1	0.0
Zelkova serrata	5	14.6	4	20
Zelkova serrata	5	13.6	4	40
Acer x Freeman Matador ma-	20	22	2	90
Silver Queen Silver Maple	10	20.3	3.5	100
Kiwi Sunset Zelkova	5	32.8	4	0.0***
Kiwi Sunset Zelkova	5	30.6	4	0.0***
Majestic Skies Oak	10	16.7	1.7	100

**Trees and shrubs grown in 100% pea stone.*

***Trees and shrubs grown in 90% pea stone, 10% coarse sand by volume.*

****Trees actually survived but only watersprouts and suckers were alive, so the trees were considered functionally lost.*

Discussion

Most species performed reasonably well in the gravel bed and post-transplant into a soil-based landscape. The exceptions to the root development generalization were the oaks (red, white, scarlet, 'Majestic Skies' northern pin oak), bitternut hickory, serviceberry, mountain-ash and skunkbush sumac. Within all of the oaks tested, white oaks grown in the 90:10 pea stone:sand bed and bicolor oak developed very acceptable fine root masses.

Zelkova performed very well in the gravel beds yet had very low post-transplant survival rates. This should be put into the perspective that they were planted out in the soil-based landscape in early December. Air temperatures immediately plunged into an early, cold winter with no snow cover until the third week of January. It is suspected that the main cause of mortality was due to fine root mortality due to very cold soil temperatures.

Lindens continue to be unpredictable performers and silver linden ranked very low in fine root development and survival. It is recommended that when possible, bare-root lindens are planted in the landscapes or potted up in the spring rather than installed in gravel beds.

Scarlet oak was an experiment that didn't turn out well. It is marginally hardy to southeast Minnesota and the winter of 2018-2019 was exceptionally long and cold. Just too much for scarlet oak.

Of all species tested, the best performers in and after the gravel beds included the arrowwood viburnum, Cornelian cherry dogwood, the 'Silver Queen' silver maple, and the 'Eye Stopper' male cork tree. 'Pacific Sunset' maple (a *platanoides* x *truncatum* variety), also performed well although its post-transplant survival rate wasn't as good as the previously-mentioned three trees and one shrub

The Impact of Tree Protection Devices on the Growth Rates of Two Tree Species: July 10, 2017—December 5, 2018

Tracy Few, Undergraduate Research Assistant
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
University of Minnesota, Department of Forest Resources

Introduction:

Galvanized hardware cloth (aka, mesh hardware cloth) is used to protect stems from damage due to rabbits, mice, deer, and other mammals, especially in the winter when food sources are low. While it protects trees from browsing damage, using hardware cloth does pose a potential problem. The wire may physically damage tree limbs or stems through continuous contact (rubbing). It also does not provide protection from harsh environmental conditions for young trees.

An English silviculturist, Graham Tuley, created tree shelters by wrapping plastic around a mesh tree protector. This original tree shelter created a greenhouse micro-environment, allowing the tree seedling to grow faster and with less stress than trees without protection. The problems with the original tree shelters included weak stems and dieback from the tree not being able to harden off for the winter.

The problem statement for this study is whether there are differences in growth rates, survival rates, and stem stability between two tree species in galvanized hardware cloth enclosures and tree shelters and if current tree shelter technology amends the problems of the past.

Methods:

Products Used:

Two different tree protection products were used to test the differences in growth rates and stem stability. One treatment involved installing ½ x ½ inch galvanized hardware cloth enclosures around the trees, as seen in Figure 1. The wire enclosure allowed the trees to receive sunlight with no obstructions and be protected from animal damage. The other tree protection used was a tree shelter product called SunFlex™ Greenhouse™ Grow Tubes. This four feet tall tree shelter has small slits for ventilation, allows sun penetration through the thin material, and facilitates straight growth of trees. An example is shown in Figure 2.

Figure 1: Hardware cloth enclosure for American larch.

Figure 2: Installed SunFlex™ Greenhouse™ Grow Tube with support stake and bird netting.

Experimental Design:

American larch (*Larix laricina*) and Ohio buckeye (*Aesculus glabra*) 1-0 liners (12-15" height) were planted at the UMN UFore (Urban Forestry Outreach and Extension) nursery on the St. Paul campus. The Grow Tubes and hardware cloth enclosures were installed on July 10, 2017. Larch and Ohio buckeye were used because they are slow-growing species when trees are less than 1.5 feet tall. Twenty (20) American larch were used, with 10 in each tree protection device. The total number of Ohio buckeye was 30, with 15 in SunFlex™ Greenhouse™ Grow Tubes and 15 in hardware cloth enclosures. Plastic bird netting was secured over the openings of the tree shelters to prevent birds from entering the tubes and getting stuck. Figure 3 shows a closer view of the netting.

Figure 3: Bird netting attached to the stake and grow tube.

Results For American Larch:

The survival rates and average heights by protection treatment were measured on October 12, 2018. Ninety percent (90%) of the larch survived in the SunFlex™ Greenhouse™ Grow Tubes and 60% of the trees survived in the hardware cloth protections. Figure 4 shows the results of average heights for American larch by treatment. The average height was 24 inches in the SunFlex™ Greenhouse™ Grow Tubes. Average height in the hardware cloth enclosures only reached 9 inches.

Table 1: Average heights and survival rates of Larix laricina at the conclusion of the study.

L. laricina	Avg height (inch)	Survival rate
Grow Tube	24.225	90%
Hardware Cloth	9.45	60%

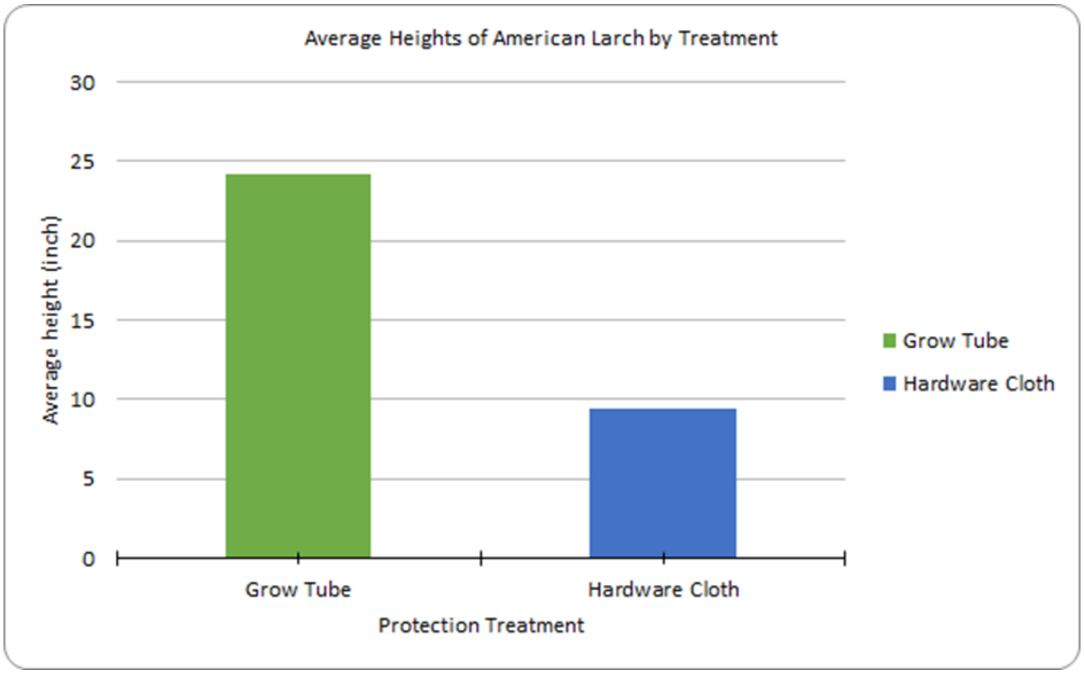


Figure 4: Average heights of American larch in Grow Tubes versus hardware cloth protection.

Results for Ohio Buckeye:

The data on survival rates and average heights were collected on October 12, 2018 and December 5, 2018. Eighty-seven percent (87%) of the trees planted in SunFlex™ Greenhouse™ Grow Tubes survived while 100% survived with hardware cloth protection (Table 2). Figure 5 displays the results of average height for Ohio buckeye. Average height in the SunFlex™ Greenhouse™ Grow Tubes was 30 inches. The average height of trees protected with hardware cloth was 23.6 inches.

Table 2: Average height and survival rate for Aesculus glabra at the conclusion of the study.

A. glabra	Avg height (inch)	Survival rate
Grow Tube	30.26666667	87%
Hardware Cloth	23.63333333	100%

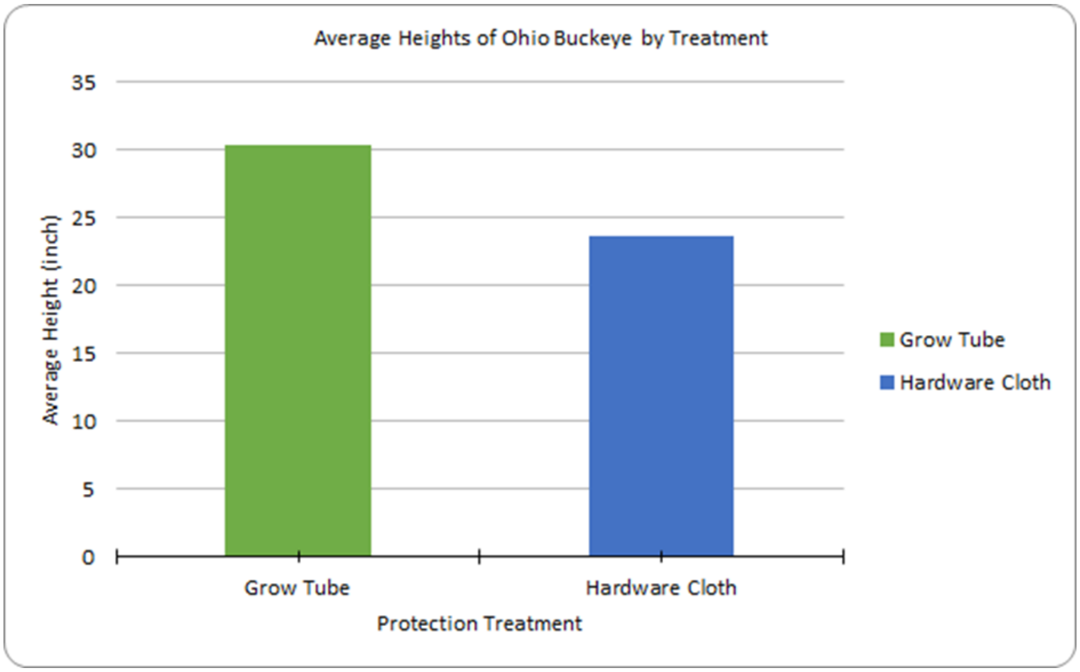


Figure 5: Average heights of Ohio buckeye in Grow Tubes versus hardware cloth protection.

Discussion:

Both American larch and Ohio buckeye had higher growth rates in SunFlex™ Greenhouse™ Grow Tubes than in the hardware cloth enclosures.

The larch needles were able to grow through the ventilation slits, as seen in Figure 6. This means the needles can receive direct sunlight in addition to filtered sunlight through the plastic.

The flexible stake in the grow tube allowed the trees to move freely, gaining height yet still developing stem strength. In Figure 7, this American larch grew more than 50 inches and did not topple over when the Grow Tube was removed. Trees grown in hardware cloth enclosures also developed strong stems. No loss of stem stability was experienced with either stem protection device for Ohio buckeyes.

Figure 6 (left): American larch needles growing through the vents of SunFlex™ Greenhouse™ Grow Tubes. Figure 7 (right): American larch with growth taller than the SunFlex™ Greenhouse™ Grow Tube (tube removed for photograph), standing straight with the protection removed.

Survival rates varied by species and treatment with American larch exhibiting the highest survival rate in the Grow Tube treatment (90% vs. 60%) while Ohio buckeye favored the hardware cloth enclosures (100% vs. 87%).

Literature Cited:

ISU Forestry Extension. 2012. *Tree Shelters for Hardwood Plantings.* Web. 7 Jan 2019.
Plantra. 2018. *Grow Tubes For Trees.* Web. 7 Dec 2018.
UMN Extension. 2018. *Protecting trees and shrubs in winter.* Web. 7 Jan 2019.

Assessing the Food Safety of Urban Grown *Ginkgo biloba* Seed

Ryan Murphy, Research Fellow
Chad Giblin, Research Fellow
Stephen Brockman, Graduate Student, Horticultural Science
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
Changbin Chen, Professor, Horticultural Science
University of Minnesota, Department of Forest Resources
University of Minnesota, Department of Horticultural Science

Introduction:

Ginkgo biloba is a long-lived deciduous shade tree commonly used in landscape plantings around the world. Ginkgo is a desirable urban tree species for a number of reasons, including its pleasant aesthetics, low maintenance, low to no pest or pathogen pressure, climatic adaptability, pollution tolerance and an ability to establish in difficult urban sites. This monotypic species is typically dioecious; however, trees exhibiting both male catkins and female ovules have been observed (Santamour et al., 1983; Crane, 2013). Male trees are preferentially planted in urban environments, as the mature seeds produce a strong odor caused by the release of hexanoic and butanoic acids (Parliment, 1995). Despite this knowledge, a number of seed producing ginkgo trees were planted in urban areas throughout the latter half of 20th Century.

There are approximately 7,000 ginkgo trees planted on public lands in the cities of Minneapolis and St. Paul. Each year, requests for removal of mature female trees are submitted by residents. Removal records in the city of St. Paul, MN indicate the removal of over 600 ginkgo trees during the past 10 years. Communication with St. Paul forestry staff suggests the vast majority of removals are due to seed production alone.

In contrast to the general disdain for ginkgo seeds amongst Western cultures, ginkgo seeds have long been utilized as a healthful food in East Asian countries. In China, modern ginkgo tree breeding programs focus on improving seed characteristics for human consumption.

The historic use of ginkgo seed as a healthy food, paired with the negative public perception of the seed in the urban environment, led us to undertake a project to assess the potential for urban produced ginkgo seed to be harvested commercially for human consumption. The benefits of collection and subsequent sale of urban ginkgo seed are two-fold; 1) collection of seed from the landscape will reduce the negative impact of the seed on residents, resulting in fewer requests for removals, thereby, preserving urban forest canopy and 2) subsequent sale of urban ginkgo seed will provide a new local food revenue source.

Initial investigations were conducted to ensure urban grown seeds do not pose any health risks to those consuming the seed. The two aspects of food safety this study is concerned with is 1) the presence and level of any heavy metals in the seed and 2) the presence and effect of ginkgotoxin (4’-O-methylpyridoxine), a known neurotoxin.

Assessing Heavy Metal Accumulation in Ginkgo Seed:

One major concern of food grown in the urban environment is that it may contain contaminants such as heavy metals which have accumulated due to human activity. Lead, for example, can be found in elevated levels throughout many urban areas due to its historic use as an additive in gasoline and house paint. Ingestion of lead can cause a number of issues, but perhaps of greatest concern is the effect, even in low doses, on cognitive development in young children.

To assess whether lead accumulates in ginkgo seed in the presence of elevated soil lead levels, ginkgo seed was sampled from various locations in St. Paul, MN. Extensive soil sampling carried out in the 1990s revealed various pockets around St. Paul in which levels of lead were higher or lower, producing a bullseye like pattern (Figure 1). Sample trees were chosen from areas previously reported as having elevated soil lead levels or more nominal levels.

Methods:

Soil and seed samples were collected from a total of 15 trees in October and November of 2017. Soil cores were taken from at least three distinct locations around each tree to a depth of 12 inches. Soil collected from the top 6" and bottom 6" of the core were analyzed separately. Soil lead levels were quantified using x-ray fluorescence (Clark et al. 1999).

Soil lead levels are presented in Table 1. Seed samples were selected for heavy metal analysis from three trees growing in soils with the highest lead levels and three trees growing in soils with the lowest lead levels. Seeds were deshelled and dried. Heavy metals testing for arsenic, cadmium, lead and mercury was completed at Medallion Laboratories in Golden Valley, MN.

Based on the results from the initial heavy metal analysis of seeds collected in 2017, four trees selected for reanalysis in 2018 – two trees which tested positive for lead accumulation in seeds and two trees which showed no detectable levels of lead in seeds. Additionally, two store bought ginkgo seed samples were submitted for analysis in 2018.

Results:

Soil samples collected from areas previously reported as having elevated lead levels were generally higher in lead compared to soil samples collected from areas with lower reported levels. Several soil samples collected in high lead zones were found to have nominal lead concentrations when analyzed. No soil samples were obtained from low lead level zones which showed elevated soil lead levels. The highest soil lead levels were obtained from boulevards with greater historic traffic pressure.

Lead was detected in three of the six seed samples sent for testing in 2017. The seed sample GB02, obtained from the tree growing in the soil with the highest reported lead level, showed the highest lead accumulation of 35ppb. Interestingly, the other two seed samples with lead accumulation in 2017, GB11 (19ppb) and GB15 (24ppb), were collected from trees growing in soils with nominal lead levels.

In 2018, both GB02 and GB11 showed increased lead accumulation compared to 2017, 68.3ppb and 33.3ppb respectively. Reanalysis GB15 in 2018 showed no detectable lead. Both store bought samples of ginkgo seed, GB40 and GB41, showed detectable levels of lead accumulation 17.6ppb and 22ppb respectively.

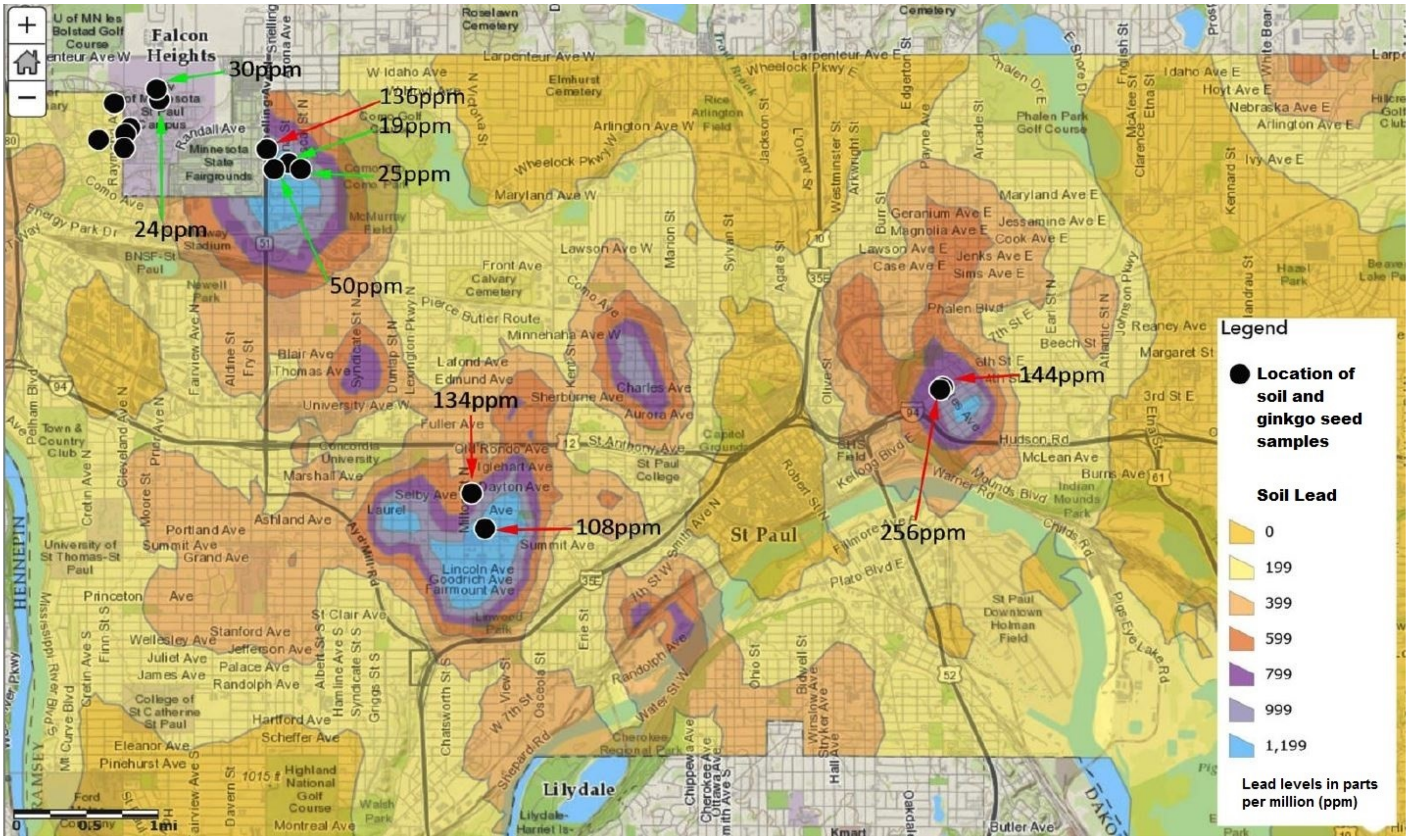


Figure 1: Sample locations and St. Paul historical soil lead levels.

Table 1. Results of soil lead (Pb) analysis. Lead levels are reported in parts per million.

TreeID	Pb 0 - 6"	Pb 6 - 12"
Gb01	136	85
Gb02	161	256
Gb03	28	11
Gb04	108	31
Gb05	134	100
Gb06	40	25
Gb07	30	22
Gb08	97	144
Gb09	41	21
Gb10	31	19
Gb11	24	15
Gb12	45	39
Gb13	23	30
Gb14	68	61
Gb15	18	15

Tree ID	Soil pb < 6" (ppm)	Soil pb > 6" (ppm)	Seed Pb in 2017 (ppb)	Seed Pb in 2018 (ppb)
GB 01	85	136	<10	-
GB 02	256	161	35	68.3
GB 05	100	134	<10	-
GB 11	15	24	19	33.3
GB 13	30	23	<10	<10
GB 15	15	18	24	<10
GB 40*	-	-	-	17.6
GB 41*	-	-	-	22

* *Commercially purchased ginkgo seeds*

Discussion:

The information gathered in this study does not clearly indicate that lead accumulation in ginkgo seed is a direct result of soil lead levels alone. However, additional soil sampling and analysis should be completed before making definite conclusions on this point, as the highest reported seed lead level was obtained from the tree growing in soil with the highest observed lead level. The conditions by which lead is accumulated in plant material is a complex interaction between soil conditions, presence of lead and the species of plant. For a detailed overview of lead accumulation in plants see Pourrut et al., 2011.

The purpose of this study was to determine whether ginkgo seed consumption may pose a health risk by exposure to heavy metals. The results of the soil lead test revealed that all locations fall under the safe threshold for lead as suggested by the U.S. Environmental Protection Agency (EPA) which sets a safe limit of 400 ppm in children play areas and 1200 ppm in non-play zones.

Guidelines describing safe levels of various food contaminants are set based on the type of food item and the contaminant. For example, the suggested maximal level of lead in milk is 20 ppb while maximal levels for berries and small fruits is 200 ppb. It is acknowledged that trace levels of heavy metals such as lead are unavoidably accumulated in some foods and, in these cases, it is generally believed to be safe for human consumption (U.S. FDA 2017).

The results obtained in this study suggest more work is warranted in regards to lead accumulation in ginkgo seeds. Furthermore, consultation from food safety experts is needed to assess whether the observed levels of lead found in these seed samples pose any threat to human health.

Ginkgotoxin (4'-O-methylpyridoxine):

A concern raised in regards to both ginkgo seed and G. biloba leaf supplement products is the presence of ginkgotoxin (4'-O-methylpyridoxine). Ingesting high amounts of the compound can cause seizure, unconsciousness, paralysis of the legs and in some cases death (Leistner & Drewke 2010). In Asian cultures where ginkgo seed is commonly used, it is well understood that only a limited number of seeds should be eaten at one time. In case studies where poisoning from excessive intake of ginkgotoxin has occurred, symptoms are reversible by vitamin B6.

Traditionally, ginkgo seeds are either roasted or boiled before eating. Arenz et al., 1996 reported ginkgotoxin in fresh seeds to be 42.24 µg/g while boiled seeds from two different sources to be 0.46 µg/g and 0.27 µg/g. The combination of boiling and consuming a small number of seeds seems to result in safe intake. Ginkgotoxin is water soluble but relatively stable at high temperatures and, therefore, can be found at higher percentages in seeds that have only been roasted versus boiled or canned (Leistner & Drewke 2010). The classic recommendation for eating a safe amount of seeds in one sitting is to eat no more than one's age in seed up until the age of 30, at which point 30 becomes the greatest number of seeds any adult over 30 years of age should eat at one time.

Ginkgotoxin analysis by reversed-phase liquid chromatography and mass spectrometry is previously reported (Scott et al., 2000). Our goal in this study was to establish an efficient methodology for the determination of ginkgotoxin in ginkgo products. Based on this method, various ginkgo seed preparations and products and can be analyzed for the presence and amount of ginkgotoxin.

Methods:

Extractions were made in a solvent of 89% water, 10% isopropanol and 1% formic acid. Seed samples were placed in the solvent in a 1.5 mL microcentrifuge tube and extracted by shaking in a SPEX Geno/Grinder with a tungsten bead. Extraction to completion experiments suggested that 15 minutes in the Geno/Grinder was sufficient for total extraction. Longer extraction times did not yield significant differences in the amount of ginkgotoxin detected.

After shaking, samples were spun in a centrifuge at 5,000 rpm for 5 minutes. The supernatant was pipetted to a new microcentrifuge tube and again spun at 5,000 rpm for 5 minutes. This process was repeated a third time.

1 µL of final extract was injected onto 2.1 x 100mm Acquity UPLC HSS T3 column. Ginkgotoxin (184.1 m/z) eluted at approximately 2.5 min with a second peak occurring at approximately 3 minutes.

Literature Cited:

Arenz, A., Klein, M., Fiehe, K., Groß, J., Drewke, C., Hemscheidt, T., Leistner, E. (1996) Occurrence of Neurotoxic 4’-O-Methylpyridoxine in Ginkgo biloba Leaves, Ginkgo Medications and Japanese Ginkgo Food. Plant Med. 62

Clark, S., Menrath, W., Chen, M., Roda, S., Succop, P. (1999) Use of a field portable X-Ray fluorescence analyzer to determine the concentration of lead and other metals in soil samples. Ann Agric Environ Med. 6(1): 27-32.

Crane, P. (2013) Ginkgo: the tree that time forgot. Yale University Press. New Haven and London.

Jiang, L., You, R.L., Li, M.X., Shi, C. (2003) Identification of a sex associated RAPD marker in Ginkgo biloba. Acta Botanica Sinica 45:742-747

Leistner, E. & Drewke, C. (2010) Ginkgo biloba and Ginkgotoxin. Journal of Natural Products, 73, 86-92

Parliment, T. (1995) Characterization of the putrid aroma compounds of Ginkgo biloba fruits. In R. Rouseff and M. Leahy (eds.) Fruit Flavors: Biogenesis, Characterization, and Authentication, Am. Chem. Soc. Symp. Ser., 596, pp. 276-279.

Pourrut, B., Shahid, M., Dumat, C., Winterton, P., Pinelli, P. (2011) Lead Uptake, Toxicity, and Detoxification in Plants. Reviews of Environmental Contamination and Toxicology, Springer Verlag, vol. 213, pp. 113-136.

Santamour Jr., F.S., He, S., Ewert, T.E. (1983) Growth, Survival and Sex Expression in Ginkgo. Journal of Arboriculture 9(6): June.

Scott, P.M., Lau, B.P.Y., Lawerence, G.A., Lewis, D.A. (2000) Analysis of Ginkgo biloba for the presence of Ginkgotoxin and Ginkgotoxin 5’-Glucoside. Journal of AOAC International. Vol. 83, No. 6.

N United States of America Food and Drug Administration (2017) Supporting Document for Recommended Maximum Level for Lead in Candy Likely To Be Consumed Frequently by Small Children. Found online on 2/22/2018 at: <https://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm172050.htm>

Comparative Analysis of UAS Data and WorldView-02 Data for Classifying Individual Trees Crowns in an Urban Landscape

Michael Bahe, Researcher

University of Minnesota, Department of Forest Resources

Introduction:

Advancements in remote sensing has broadened the spectrum of opportunities for assessments of natural resources. Technologies such as sensor equipped unmanned aerial systems (UAS), and available high resolution satellite imagery, coupled with computers capable of efficiently processing large amounts of data, has made investigations of complex urban area scenes possible. The rapid expansion of these areas from a growing human population has increased the need for sustainable green infrastructure. The urban forest component is a common focus due to its comparatively high return on investment in monetary terms (Sander, Stephan, & Haight, 2010), and in ecosystem services (Byrne & Jinjun, 2013).

The initial stage of an ecologically focused project is to have a current inventory and condition of the interest area (Schipperijn, Pillmann, Tyrväinen, Mäkinen, & O'Sullivan, 2005). Surveys utilizing UAS show promise for rapid inventory of urban forests. In early stages of this project, individualization of tree canopies in an urban park setting using 0.5m ground sampling distance (GSD) UAS imagery, and a short rule set in eCongnition (Trimble, 2017) yielded results near 80 percent accuracy (Bahe, 2017). This was consistent with research investigating UAS systems for land classification (Ahmed, et al., 2017). Speculatively, a more complex rule set, and utilization of higher resolution data for classification, may boost accuracy increasing usability for management of urban ecosystems.

Unmanned aerial systems have progressed rapidly. Similarly, high resolution satellite imagery has become increasingly accessible. Resulting uses have been many including the monitoring and assessment of ecological systems (Eckert, Ghebremicael, Hurni, & Kohler, 2017) and urban forest species identification (Shojanoori, Shafri, Mansor, & Ismail, 2018). Ease of end user acquisition makes satellites a formidable platform for applications that UAS have become popular for. Here, a comparison of the two is investigated for urban tree canopy classification.

Research Objectives:

Objective 1: Compare available satellite imagery to UAS collected data for tree canopy delineation and tree individualization.

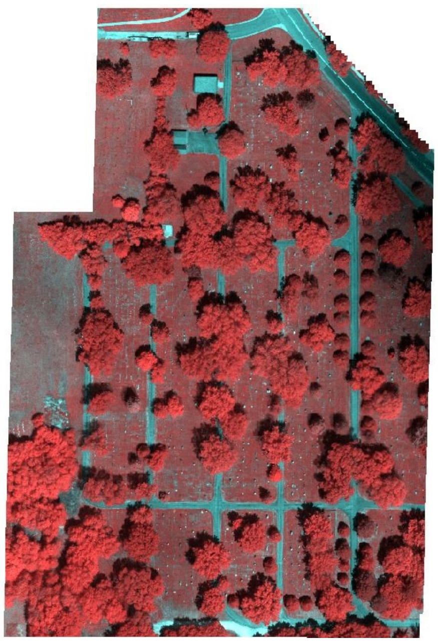
Objective 2: Use object-based image analysis (OBIA) advanced classifier algorithms to classify individual trees with greater than 85 percent accuracy using 0.04m GSD UAS imagery.

Objective 3: Use OBIA advanced classifier algorithms to classify individual trees with greater than 80 percent accuracy using 1.69m GSD eight-band satellite acquired imagery.

Methods:

Imagery: UAS

Imagery from UAS being used in this project was collected in June 2017 (Figure 1A). Data was acquired using a 3DR Solo quadcopter with a static belly mounted sensor gimble. The sensor was a MAPIR Survey2 camera (Peau Productions , 2018) which uses band-pass filters to capture data in the 660nm band (red) and an 850nm band (near infrared). Imagery was processed to a GSD of 0.04m with Pix4D Cloud service (Pix4D, 2018), and spectrally calibrated utilizing the MAPIR Calibration Target Version 1 and MAPIR calibration software plug-in for QGIS 2.18 (QGIS, 2017). The orthomosaic and point cloud files were utilized. A normalized digital surface model (nDSM) of the site was produced with the point cloud using the LAStools (rapidlasso GmbH, 2017) suite, and a normalized difference vegetation index (NDVI) layer was calculated from the red and near infrared (NIR) bands in ArcMap 10.5 (Esri, 2017) with the Image Analysis tool. These red, NIR, nDSM and NDVI layers were the four used in this project.

A. 

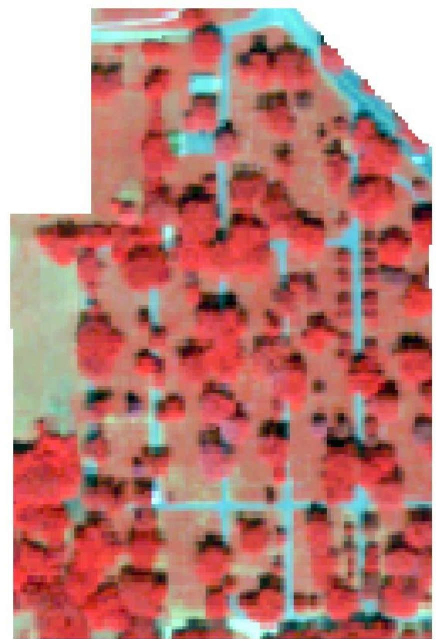
B. 

Figure 1: Image a: UAS study imagery in 2 band false color composite (red and NIR bands). Image b: WorldView-2 study imagery 3 band false color composite (blue, red, NIR-R1)

Imagery: WorldView-02

Satellite imagery was obtained from Digital Globe (Digital Globe, 2018) collected June 2017 coinciding with the UAS data (Figure 1B). The scene acquired for analysis was an eight-band image captured by the WorldView-2 (WV02) satellite at 1.69m GSD (Figure 1B) and includes a panchromatic band at 0.46m GSD. Cloud free imagery was only available for about 60 percent of the original project site. This collection was still accepted for use as it gives enough of the area to provide sufficient comparison, and the temporal similarities between the images being compared is ideal. WV02 layers used in this classification were red, blue, yellow, green, red edge, NIR-R1, NIR-R2.

Due to the two-dimensional nature of the WV02 data, a Lidar point cloud acquired in 2011 was used in conjunction for tree delineation. The data was collected at 1.5 points per square meter (Minnesota Geospatial Commons, 2011) and the point cloud was processed with the LAStools software suite into an nDSM at the same 1.69m GSD as the WV02 imagery. In addition, an NDVI layer was developed, using the WV02 NIR-R1 and red layers for the calculation. This was completed in ArcMap 15.1 using the Image Analysis tool. The final layers used for analysis were the NDVI, nDSM, and the seven bands from WV02.

Image Classification

Image classification was completed with eCognition software (Trimble, 2017) using object-based image analysis (OBIA) algorithms. The objectives of this project are to focus on individual tree canopies therefore only two classes were developed for each of the acquired data platforms. Classification categories of “Trees” and “Not-Trees” were in the final rule set.

Image Classification: UAS

Initial segmentation of the UAS obtained data utilized a multi-threshold segmentation algorithm using the nDSM to filter with a threshold value of 1.5m. This classified objects above the threshold as “_Tall” and below as “Not-Trees”. Next, a multiresolution segmentation algorithm with each layer having equal weight was used to divide the “_Tall” class into smaller objects. The NDVI layer was then used to differentiate tall vegetation objects from other tall objects in the “_Tall” classification with the assign-class rule. Objects with low NDVI were classified to the “Not-Trees” class. Following this, assign class was again used to move objects with low brightness, the mean intensity value of all layers summed, to “Not-Trees”.

The “_Tall” and “Not-Trees” classified objects were then merged to those adjacent of the same class by applying the merge region rule to each classification. The merged “_Tall” class was then segmented again with multiresolution segmentation, this time utilizing exclusively the nDSM and NDVI classes with weights of one and five respectively. Next, all “_Tall” objects less than four meters were classified as “Not-Trees” and the remaining objects under nine meters were classified at “Short Trees”. The “Short Trees” class was then segmented with multiresolution segmentation again weighting only the nDSM and NDVI layers. Finally the “_Tall” and “Short Trees” classes were reclassified as “Trees”, “Not-Trees” that fell outside the map boundary were classified as “[Null]”, and the remaining “Not-Trees” were merged together (Figure 2).

The processing of high resolution UAS data is computer intensive making the process less efficient when compared to the same area with lower resolution data. The initial classification of the tree canopy was processed quickly, but further segmentation into individual tree crowns required significant time per algorithm. For this reason, a sample tile of the UAS derived data was clipped in ArcMap and was utilized for developing a more complex rule set. Once the rule set was established it was applied to the entire data set for classification. In addition, high resolution data presented challenges with pixel variation within tree crowns making over segmentation a concern. Utilizing the spike free nDSM built from the point cloud in LAStools eliminated this for initial classification but was still an issue for crown individualization.

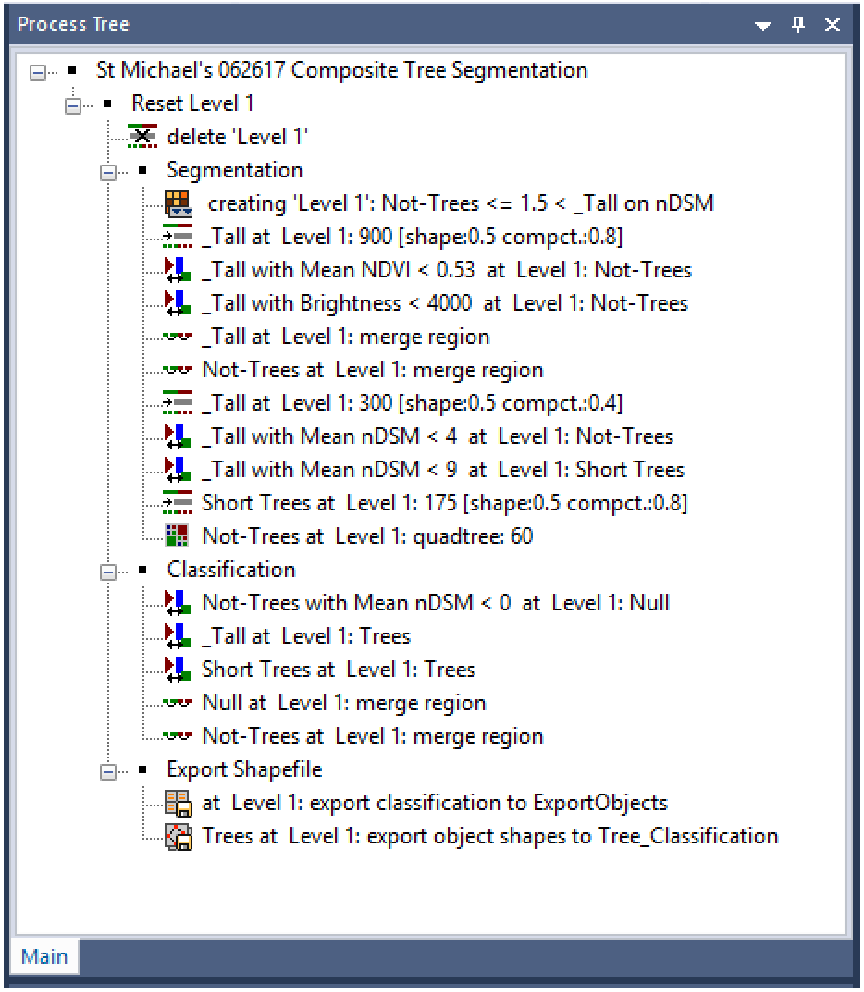


Figure 2: Process tree window in eCognition showing the rule set for UAS data classifications

Image Classification: Worldview-02

Classification of the WV02 satellite imagery required segmentation based on spectral values with no photogrammetric point cloud. Elevation data when available is an asset for tree canopy delineation. Therefore, the 2011 Lidar derived nDSM was utilized for classification. Features taller than 1.5m were classified as "_Tall" all others as "Not-Trees", in the same manner as the UAS data. Next, the multiresolution segmentation algorithm for initiation of individual crown delineation was executed, with only the nDSM and NDVI layers weighted at one and five respectively. The "Not-Trees" class was also segmented with multiresolution segmentation using all layers weighted at one except the NDVI, weighted at three, and the nDSM at zero.

Following this segmentation, the WV02 scene classes required finalization. The initial assign-class algorithm put any object outside the project boundary in a "[Null]" class to be removed from further classification consideration. Next, any "_Tall" objects with a mean NDVI below 0.55 was classified as "Not-Trees". From the remaining "_Tall" classification, objects with an NDVI greater than 0.72 were classified as "_MaybeTrees". The objective of this class was to isolate pixels that were high in NDVI but did not get associated with the initial classification from the nDSM. This was due to low point density of the Lidar relative to the UAS point cloud. Lidar based "_Tall" objects were then merged with adjacent "_MaybeTrees" objects with the pixel-based object resizing algorithm and cycled two times. Remaining "_MaybeTrees" objects were assigned to the "Not-Trees" class and then merged together for the finalization, and the "_Tall" was assigned to the final "Trees" class (Figure 3).

Accuracy Assessment

Determining the accuracy of the classification was done for the overall canopy and then the individual tree objects. ArcMap 15.1 tools were utilized for this process. Canopy validation data was the highest resolution imagery available taken in coincidence with the processed layers. The false color infrared at 0.04 GSD (Figure 1a) was used for the UAS classification, and the panchromatic band collected with the multispectral bands for the WV02 classification. Individual tree object accuracy utilized a vector point layer from a terrestrial inventory completed in the summer of 2016.

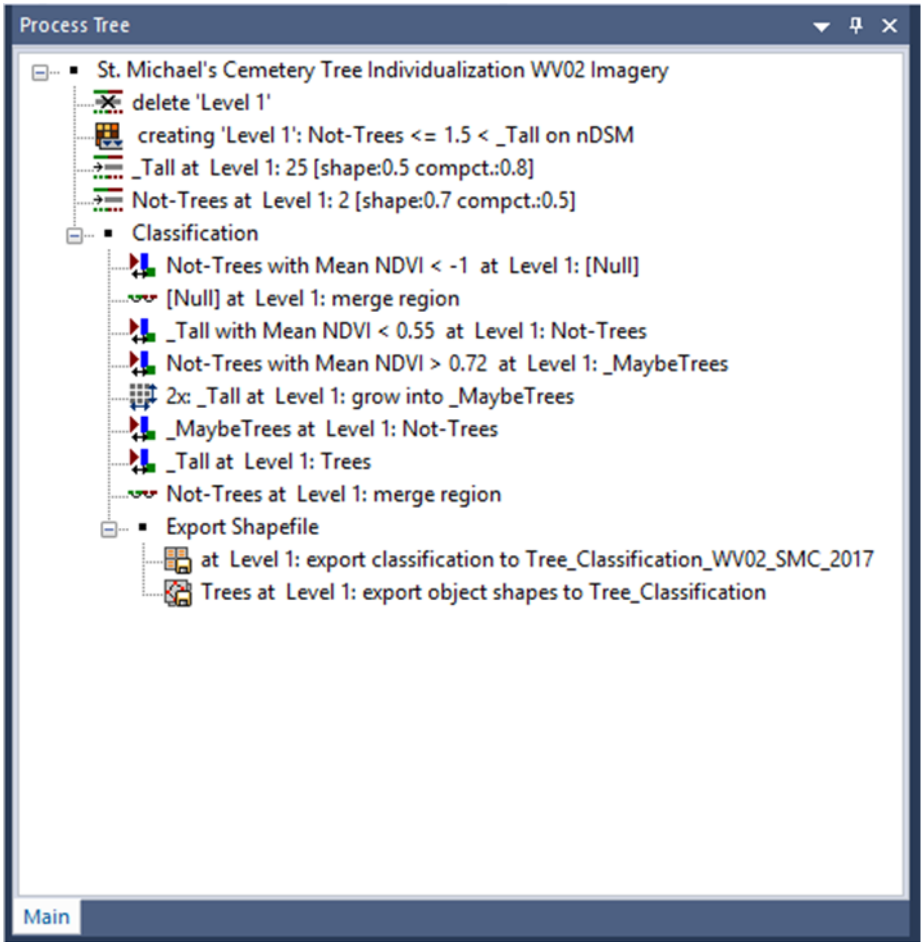


Figure 3: Process tree window in eCognition showing the rule set for WV02 data classifications.

A pixel based, random sample method of accuracy assessment was used for the canopy. This was preferred due the similarity in area size between the two classes being assessed. Points were developed with the random point generator in ArcMap 15.1. Due to the simplicity of the statistical calculations, Microsoft Excel 2016 was utilized and an error matrix was produced.

For tree individualization accuracy, the vector point data of trunk locations collected with digital tablets with non-averaged GPS was used. The resulting point accuracy was not better than three meters. Tree canopies are spatially large and the survey point may fall on any pixel within the canopy. Therefore, points that were near but not contained in tree objects that overlaid a tree canopy, were manually adjusted into the tree classified polygons. This was accomplished through visual interpretation of the high resolution imagery for each platform.

Many tree polygons had multiple tree survey points. Therefore the metric used for image platform comparison, and objective confirmation was the ratio derived from the number of actual trees divided by number of classified tree objects.

Results:

Overall accuracy of tree canopy classification at St. Michael's Cemetery increased over the initial project in 2017 for the UAS data, but decreased for the WV02 data. The increased complexity of the eCognition rule set and classifying at the UAS native resolution aided the accuracy. The WV02 data was more course than that of the original project and resulted in less accurate classification.

UAS Classification

The UAS data had an overall canopy classification accuracy of 98 percent (Figure 4A). Consumer and producer accuracies were identical percentages for the "Tree" and "Not-Tree" classes at 97 percent and 98 percent respectively. A total of 82 randomly sampled verification points were used out of 100 produced. Eighteen points fell within the area of the raster classified as [Null] and not used in analysis. Points on the reference raster used in the statistical analysis consisted of 35 trees and 47 not trees. An error matrix was produced for this assessment (Figure 5).

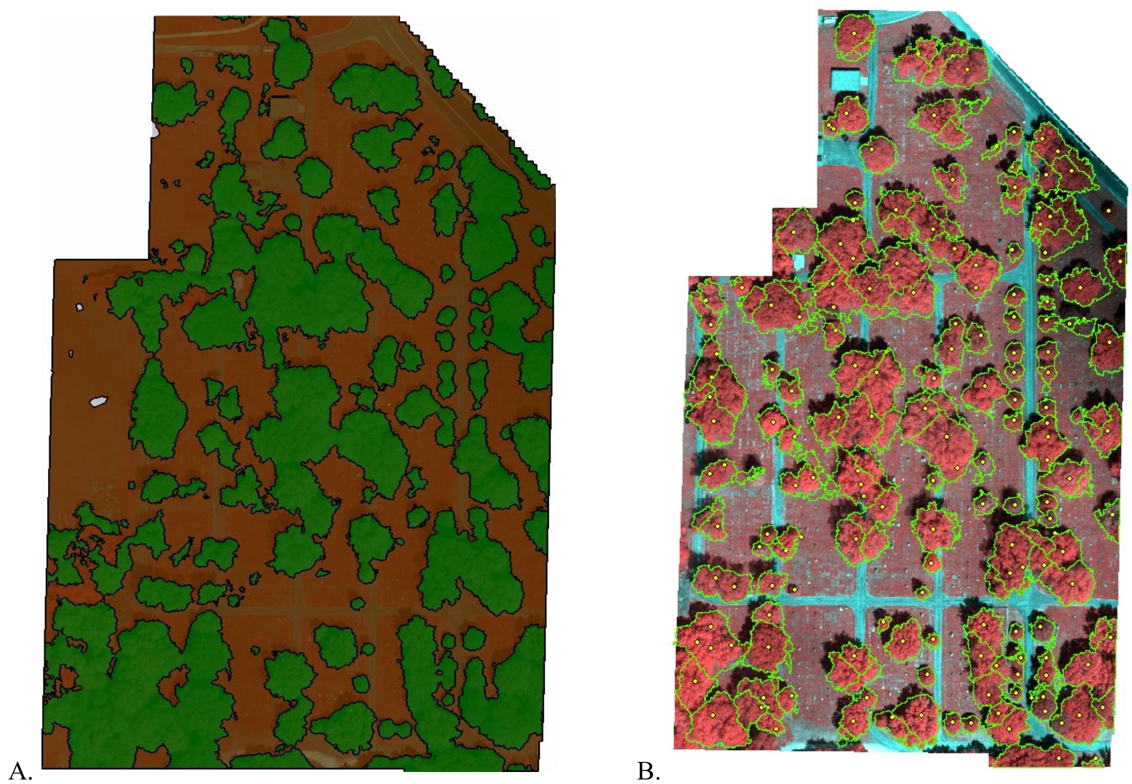


Figure 4: Image A shows UAS tree crown classification in green. Image B shows individual tree objects in green outline with tree vector points in yellow on verification image of project area.

Individualization of trees from the canopy with the UAS classification had two measurements of accuracy. The number of classified objects to actual trees, and number of tree points that were within tree class polygons. The first measure of objects to trees had and accuracy of 86 percent. There were 177 actual trees in the study area and 202 tree objects. This resulted in an absolute value error of 25. The error of 25 was deducted from the total number of actual trees and that value, 152, was divided by the total number of trees to determine the accuracy percentage. The second measure, number of tree points in polygons, was 94 percent accurate. This was calculated by dividing the number of tree points in polygons, 166, by the total number of actual trees (Figure 4B).

		Reference Data		
		Tree	Not-Tree	Row Total
Classified Data	Tree	34	1	35
	Not-Tree	1	46	47
	Column Total	35	47	82

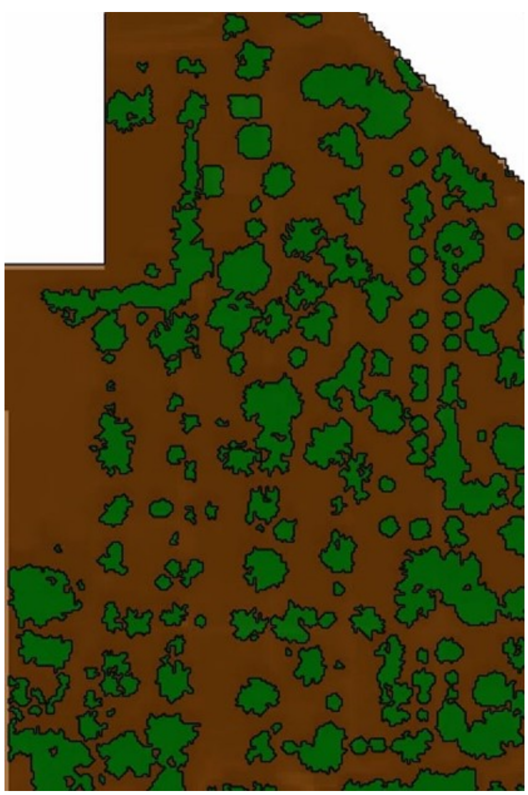
Figure 5: Error matrix for UAS canopy accuracy assessment verification points.

WorldView 2 Classification

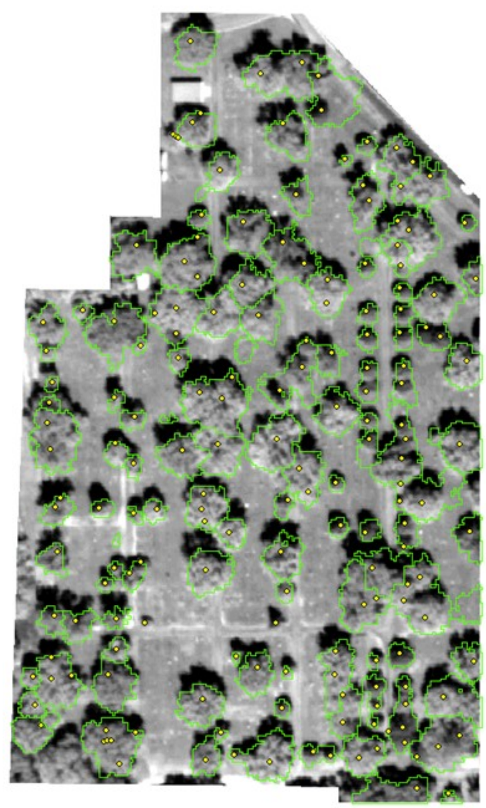
The WV02 data had an overall canopy classification accuracy of 89 percent (Figure 6A). Consumer and producer accuracies for the "Tree" class were 94 and 80 percent respectively, and for the "Not-Tree" class they were 86 and 96 percent respectively. A total of 91 randomly sampled verification points were used out of 100 produced. Nine points fell within the area of the raster classified as [Null] and not used in analysis. Points used in the statistical analysis consisted of 41 trees and 50 not trees on the reference raster. An error matrix was produced for this assessment (Figure 7).

Figure 6. Image A shows WV02 tree crown classification in green. Image B shows individual tree objects in green outline with tree vector points in yellow on verification image of project area.

A.



B.



In the same process as with the UAS data, individualization of trees from the canopy with the WV02 classification had two measurements of accuracy. The measure of objects to trees had and accuracy of 71 percent. There were 177 actual trees in the study area and 126 tree objects. This resulted in an absolute value error of 51. The error of 51 was deducted from the total number of actual trees and that value, 126 was divided by the total number of trees to determine the accuracy percentage. The second measure of accuracy, the number of tree points in polygons was 97 percent. This was calculated by dividing the number of tree points in or near polygons, 172, by the total number of actual trees (Figure 6B).

		Reference Data		
		Tree	Not-Tree	Row Total
	Tree	34	1	35
Classified Data	Not-Tree	1	46	47
	Column Total	35	47	82

Figure 7: Error matrix for WV02 canopy accuracy assessment verification points.

Discussion:

Overall the UAS products outperformed the WV02 imagery. It was more accurate in classifying the tree canopy at 98 percent versus WV02 at 89 percent. The UAS imagery at 0.04m GSD was significantly higher resolution than the WV02 data at 1.69m GSD. Lower GSD provides more detail to the OBIA software for segmentation and reduces the size of mixed edge pixels on the canopy boarders. In addition, the point cloud for the UAS layers were derived from the imagery. Point clouds developed in this way increase accuracy by requiring no georeferencing between the layers. Once the UAS point cloud was normalized into an nDSM, initial multi-threshold segmentation algorithms were run, and the majority of the canopy was isolated from the non-tree features.

The complexity of the UAS data did pose some issues in the eCognition rule set development for initial canopy classification. Higher resolution data made the shadows more significant in the image when compared to the WV02 data complicating the multiresolution segmentation. These required additional algorithms to be added to the rule set to remove the shadows from tree classifications, and will need to be adjusted for different ambient light conditions such as cloudy or hazy environments on future projects.

Worldview-02 results for canopy was acceptable, but required ancillary Lidar data for more precise classification. The WV02 imagery has a GSD nearly forty times coarser than the UAS. This was a significant issue in deciphering tree crowns. There is a greater mixing of land objects per pixel than with UAS imagery making edges fuzzy and classification more difficult. Realizing this was the impetus for the Lidar point cloud inclusion. The nDSM calculated from the Lidar data allowed for the initial "_Tall" canopy classification.

Unlike the UAS data, the Lidar acquisition was from six years prior to the satellite collection. This was acceptable considering crown size of trees in a mature urban forest likely has not changed significantly in that time period relative to the GSD. Mature trees will typically grow less than the 1.69m pixel size over that period. Even so, the point cloud was sparse in comparison to the photogramtric UAS point cloud. Initial classifications using the height data produced small in area objects in relation to the trees being classified. This was addressed by growing the tree objects produced from the nDSM into the adjacent objects with similarly high NDVI values (Figure 4).

Tree canopy classifications had high accuracies. As a result, segmentation of those classes for the purpose of individualizing tree crowns into objects, and analyzing for accuracy, was feasible. If canopy classes had low accuracy with non-tree objects within the class, then applying individualization algorithms would not necessarily be isolating trees and analysis of that process would be impractical.

The UAS imagery objective of 85 percent for the verified tree to classified object ratio was met by having individualization accuracy of 86 percent. The WV02 objective of 80 percent fell short at 71 percent accuracy. It was expected that the pixel homogeneity of the WV02 imagery would make crown delineation difficult, therefore the objective percentage was lower than that of the UAS. The high resolution imagery and the dense photogrammetric point cloud of the UAS were again primary components in the precision of the individual tree class by being geometrically coincident and having a higher density of points than the Lidar used with the WV02. In addition, the high resolution NDVI layer derived from the UAS bands, along with the individual red and NIR bands, show more variation between neighboring pixels. This resulted in more definitive boarders between neighboring tree canopies.

Conclusion:

Satellites and UAS are making high-resolution imagery more accessible to researchers and the public. The current platforms give UAS the advantage on spatial and temporal resolution, but satellite imagery is logistically easier to obtain for the end user and large areas can be collected at one time. Each has costs associated with their output data and the decision to use either one is often a question of area size and detail needed.

This research provided evidence to which platform performs better for individual tree crown delineation. Deciphering the results of this project, the UAS data has great potential for overall canopy delineation and individual tree crown classification. The WV02 data, even at a relatively high-resolution for satellites, is too coarse to get crown classification with accurate results.

Information garnered from this process will better inform remote sensing professionals on the capabilities of the two platforms regarding classifying urban vegetation. Professionals outside the remote sensing field that are utilizing the information here within will better understand what platform is best suited for their organizational needs.

Future research should include UAS tree delineation with red, green, blue, and NIR bands collected at one time. The extra visible bands may increase the potency of the data for OBIA. Higher-resolution satellites such as Worldview-04 should also be investigated for more accurate classifications especially where stereo pairs are available for creating photogrammetric point clouds.

References:

Ahmed, O. S., Shemrock, A., Chabot, D., Dillon, C., Williams, G., Wasson, R., & Franklin, S. E. (2017). Hiearchical land cover and vegetation classification using multispectral data acquired from an unmanned aerial vehicle. *International Journal of Remote Sensing, 38*(8-10), 2037-2052. doi:doi.org/10.1080/01431161.2017.1294781

Bahe, M. (2017). *A Method for Individual Urban Tree Rapid Assessment Using Low Altitude Multispectral Imagery.* Internal Report, University of Minnesota, Forest Resources. Retrieved from https://trees.umn.edu/research-rapidassessment

Byrne, J., & Jinjun, Y. (2013). Can urban greenspace combat climate change? Towards a subtropical cities research agenda. *Australian Planner*, 36-43. doi:doi.org/10.1080/07293682.2009.10753420

Digital Globe. (2018, February 20). *Digital Globe Satellite Information*. Retrieved from Digital Globe: https://www.digitalglobe.com/resources/satellite-information

Eckert, S., Ghebremicael, S. T., Hurni, H., & Kohler, T. (2017). Identification and classification of structural soil conservation measures based on very high resolution stereo satellite data. *Journal of Environmental Management, 193*, 592-606.

Esri. (2017). *ArcMap*. Retrieved from ArcGIS Desktop: http://desktop.arcgis.com/en/arcmap/

Hexagon Geospatial. (2016). *ERDAS IMAGINE*. Retrieved from Hexagon Geospatial: https://www.hexagongeospatial.com/en/products/power-portfolio/erdas-imagine

Minnesota Geospatial Commons. (2011). *LiDAR Elevation, Twin Cities Metro Region, Minnesota, 2011*. Retrieved from Minnesota Geospatial Commons: https://gisdata.mn.gov/dataset/elev-lidar-metro2011

Peau Productions . (2018). *Peau Productions*. Retrieved from https://www.peauproductions.com/

Pix4D. (2018). *Pix4Dmapper.* Retrieved from Pix4D: https://www.pix4D.com

QGIS. (2017). Retrieved from QGIS Project: http://www.qgis.org

rapidlasso GmbH. (2017). *LAStools*. Retrieved from rapidlasso: https://rapidlasso.com/lastools/

Sander, H., Stephan, P., & Haight, R. G. (2010). The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. *Ecological Economics, 69*, 1646-1656. doi:http://dx.doi.org/10.1016/j.ecolecon.2010.03.011

Schipperijn, J., Pillmann, W., Tyrväinen, L., Mäkinen, K., & O'Sullivan, R. (2005). Information for Urban Forest Planning and Management. In *Urban Forest and Trees: a reference book* (pp. 399-417). New York: Springer.

Shojanoori, R., Shafri, H. Z., Mansor, S., & Ismail, M. H. (2018). Generic rule-sets for automated detection of urban tree species from very high-resolution satellite data. *Geocarto International, 33*(4), 357-374. doi:10.1080/10106049.2016.1265593

Trimble. (2017). *eCognition*. Retrieved from Trimble: www.ecognition.com

The Effects of Soil Amendments at Planting Time on Basswood Survival and Growth Rate: June 19, 2017– October 19, 2018

Tracy Few, Undergraduate Research Assistant
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
University of Minnesota, Department of Forest Resources

Introduction:

Trees in cities and other urban environments are commonly transplanted to their final site rather than naturally regenerating from forests or seeds. During the transplant process, trees lose many fine roots that are used to transport essential water and nutrients. This can create a stress during the transplant period lasting at least one year after the tree is planted, resulting in higher rates of mortality compared to non-transplanted trees, stunted growth, and the need for more regular maintenance such as watering.

A common recommendation to promote tree growth and health above and below ground is to add soil amendments at planting time. Amendments include anything that is considered deficient in the soil and often are added in the form of fertilizers and/or composts that offer essential nutrients, such as nitrogen, phosphorus, and potassium.

Synthetic fertilizers such as 10-10-10 (10% nitrogen, 10% phosphorus, 10% potassium by volume) are available at hardware stores, home improvement centers and garden centers for relatively low prices. They are considered quick release sources of nitrogen for up to a couple of months. A problem with quick release fertilizers is that nitrogen leaching (moves through the soil in solution with water) frequently occurs, sometimes before the transplanted trees even regenerate new fine roots, those roots that primarily absorb those nutrients. Therefore, newly transplanted trees may realize few to no benefits from these short-lived nitrogen sources.

There are also slow release fertilizers such as Suståne® 8-2-4, an organic slow release fertilizer that provides nutrients including nitrogen for six to twelve weeks or longer. They are often more expensive than a synthetic, fast-release fertilizer, but the nutrients are more likely to be efficiently used by the plants and usually require less frequent applications. They also have the advantage of adding carbon to the soil which increases the Cation Exchange Capacity (CEC), that is, the soil's ability to hold nutrients, effectively slowing down the leaching process.

Mushroom compost is comprised of decomposed mushrooms mixed with organic matter, such as peat. It is also a slow release soil amendment that will add nutrients to the soil. New Plant Life® Premium Mushroom Compost does has an advertised NPK (nitrogen, phosphorous, potassium) ratio of 0.30% nitrogen,0.03% phosphorus, and 0.03% potassium. Like Sustane, mushroom compost can also increase the water holding capacity of the soil.

There were two questions driving this study. Will any of these soil amendments increase the survival of transplanted trees? Will any increase the growth rate during the one year transplant period?

Methods:

This study was installed the week of June 19, 2017. Basswood (*Tilia americana)* was used because it is a commonly planted tree in the urban environment. Trees were purchased as 2-0 liners (two years old from cutting, never transplanted) from a Minnesota nursery, 24 inches in height, 12 mm in caliper measured at 15 cm above ground. Calipers were measured in metric units for greatest accuracy of growth increases.

Three soil amendments were utilized in groups of 15 trees. Two (2.0) ounces of a generic 10-10-10 fertilizer was mixed into the backfill during planting. Suståne® and sand comprised the next soil amendment group. The proportion of Suståne® and sand used was 1:1 by volume in the backfill. The third treatment group used New Plant Life® Premium Mushroom Compost and sand in the backfill, 1:1 by volume. For both the Sustane:sand treatment and the mushroom compost:sand treatment, the total volume of treatment was 173 cu. In. the volume of a #1 nursery container. The final 15 trees were in the control group and received no soil amendment additions to the backfill.

The three soil treatments and the controls were planted at the UMN UFore (Urban Forestry Outreach Research and Extension) nursery on the St. Paul campus. The basswoods in the study were protected from animal damage using fencing and 1⁄2 x 1⁄2 inch galvanized hardware cloth enclosures around individual trees.

Each tree used in the study was pruned to a single central leader, when necessary, to encourage best tree form.

The data for tree caliper was collected on September 28 and October 5, 2018. Each tree's diameter was measured 15 cm (six inches) from the soil line using a digital tree caliper. The heights were measured on October 19, 2018. Tree height was measured from the soil line to the terminal bud of the central leader.

Results:

The only tree that was in decline was a part of the Suståne® and sand treatment.

The Suståne® and sand soil amendment treatment produced the shortest mean heights at about 53 inches. Both the mushroom compost and sand treatment and 10-10-10 fertilizer had mean heights of 67

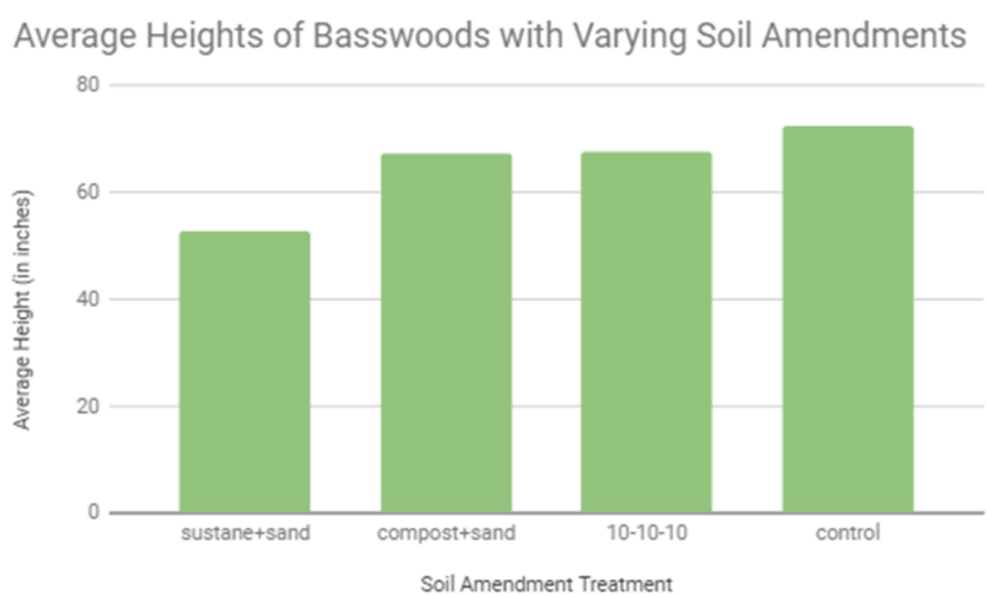


Figure 1: Average height of basswoods with three different soil treatments.

inches. The mean height of the control trees was 72 inches.

The average caliper for the Suståne® and sand treatment was 16 mm. The compost and the 10-10-10 fertilizer also had similar average diameters, 21 mm. The control group had an average caliper of 22 mm.

The only treatment that was operationally different from the control group was the Sustane:sand treatment.

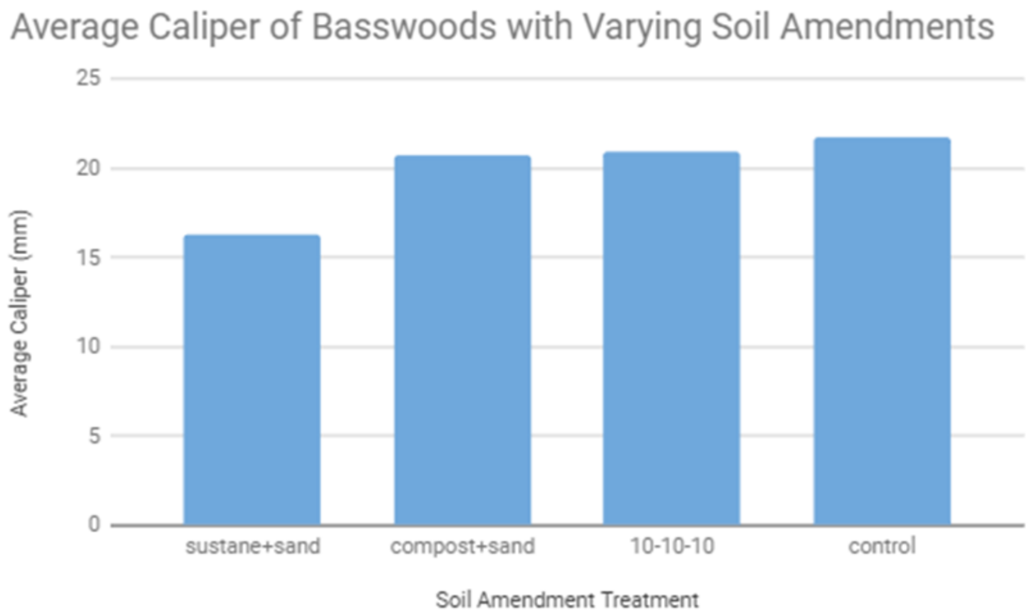


Figure 2: Average caliper of basswoods by their soil amendment treatments.

Discussion:

The results show using no soil amendments had the greatest average height and caliper growth for the transplanted trees. Additional studies would have to be done to learn how transplants of different tree species would fare with the soil amendment treatments used in this study. No treatment had a detrimental effect on tree survival and growth, despite the one declining tree in the Sustane:sand treatment.

Observations during the pruning led us to believe that the control group had the best form because they required little to no pruning, exhibiting a strong central leader that is characteristic of *Tilia americana*. An example of basswood form is in figure 3.

Figure 3: Basswood (Tilia americana) form with a strong central leader.

Literature Cited:

Lincoln Oakes Nursery. *Linden, American.* Web. 5 Feb 2019.

Sustane Naturally. *Sustane 8-2-4.* Web. 7 Feb 2019.

Markman Peat. *New Plant Life Mushroom Compost with Organic Matter.* Web. 7 Feb 2019.

OSU Extension Service. 2003. *What is mushroom compost?* Web. 8 Feb 2019.

Root Pouch Decomposition Rates and Their Effect on Root Systems: August 24, 2017—November 11, 2018

Tracy Few, Undergraduate Research Assistant
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
University of Minnesota, Department of Forest Resources

Introduction:

When trees are grown in plastic pots their root systems are subject to circling roots (aka, pot-bound) that can decrease the tree's ability to absorb water and nutrients, its stability and often its lifespan. An alternative to plastic pots are root bags or pouches. One such bag is the product Root Pouch™ which is made of a mix of recycled plastic bottles and "natural recycled materials." It has a tight fabric weave that allows water and nutrients to pass through. The Root Pouch fabric also causes entrapment pruning. This means the roots cannot grow through the woven material or in a circular pattern as with smooth plastic containers, thereby producing a more fibrous root system within the container medium.

The pouches can be made out of materials that may only partially degrade. Products may take anywhere from one to six years to decompose. The product used in this study was advertised to semi-degrade in twelve to fifteen months when soil is on both sides of the pouch. This study examined if the root pouches degraded within that time frame and if there was any impact on root growth.

Methods:

The root pouch decomposition study was installed on August 24, 2017 in a raised bed area at the UMN UFore (Urban Forestry Outreach and Extension) nursery on the St. Paul campus. Forty-six (46), 1-0 tree seedlings (30 *Quercus prinus, and* 16 *Q. muehlenbergii)* were put in 3.8 liter, 15 cm x 19 cm, Thin Black Fabric bags from Root Pouch, pictured in Figure 1. The Root Pouch was filled with an organic potting soil up to 2.5 inches from the top of the Root Pouch.

The 46 bags were subject to three treatments. The 12 control trees were planted with the pouch removed. Fifteen (15) trees were in the sliced treatment, that is, the root bag was sliced on four sides; an example is shown on the left side of Figure 2. The final 19 trees were in intact bags, shown on the right side of Figure 2. Each Root Pouch was planted in rows in a raised

Figure 1: Root Pouch fabric grow bag. Image courtesy of A.M. Leonard.

liner bed, sandy-loam soil, with the soil completely surrounding an as-needed basis, that is, when the soil was beginning to dry out, as determined by physically monitoring the soil moisture.

Results:

Data collection took place from October 24, 2018 through November 11, 2018. Each root pouch was removed from the soil and evaluated. None of the intact and sliced treatments had any degradation of the root pouch after being in the ground between 14 and 14.5 months. Each tree was classified into groups based on root penetration. Root penetration meant new roots grew through the root pouch fabric or through the slits in the fabric into the surrounding soil. The root pouch penetration classes are: no roots, 1-5 roots, 6-10 roots, 11-15 roots, 16-20 roots, 21-24 roots, and 25 or more roots.

Figure 2: The left pouch shows the slice treatment in the four corners of the fabric. The right pouch is the intact bag treatment.

The results for root penetration are shown in Figure 3. Of the 19 intact Root Pouches, 11 had no root penetration, five had 1-5 roots, two had 6-10 roots, and one had more than 25 roots penetrate the fabric. The sliced treatment had five pouches with no root penetration, five with 1-5 roots, one with 6-10 roots, three with 11-15 roots and one with 25 or more roots.

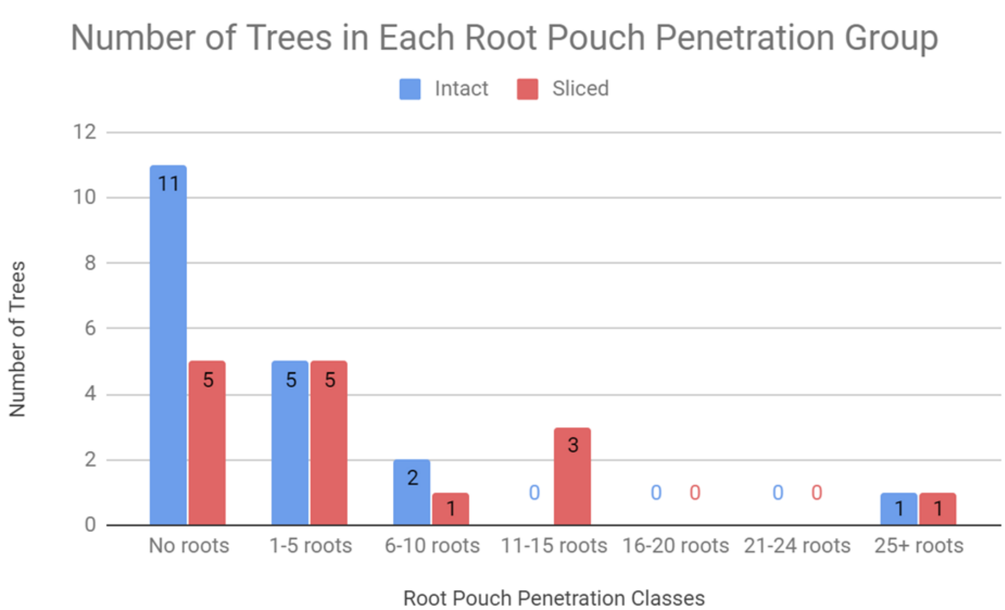


Figure 3: Results of tree root growth in Root Pouches.

Discussion:

The Root Pouch had slower degradation rates than the advertised 12 to 15 month degradation period.

Based on the length of the study, we are not able to say if the root pouches impeded the health of the root systems or caused early deaths. If there is a concern about the Pouch's slow degradation rate, the trees should be removed from the root pouch when planting.

Literature Cited:

Root Pouch. *The world's most prominent tree growers use Root Pouch containers.* Web. 9 Jan 2019

Arboriculture & Municipal Forestry

Tree Transplant Recommendations for Olson Memorial Highway Blue Line Construction

Michael Bahe, Researcher
Amanda Stear, Undergraduate Research Assistant
Luke Bailey, Undergraduate Research Assistant
Chad Giblin, Research Fellow
Gary Johnson, Professor, Urban and Community Forestry/Extension Professor
University of Minnesota, Department of Forest Resources

Introduction:

In 2003, several cultivated varieties of elms (*Ulmus* spp.) were planted in the median of Olson Memorial Highway (OMH) in Minneapolis, Minnesota from Van White Memorial Boulevard to Thomas Avenue North. This was a collaboration between the University of Minnesota, Department of Horticultural Science and the Minneapolis Park and Recreation Board (MPRB). Since that time, responsibility was assumed by the Department of Forest Resources at the University of Minnesota (UMNFR). The research conducted was part of a longitudinal study to assess ten elm varieties that have been recognized and released to the public as resistant to Dutch elm disease (*Ophiostoma novo-ulmi*). Measurement data collected for each tree included stem caliper at 15cm and a quantitative condition rating from 0-4 for both the crown and stem (Figure 1 & Appendix C). Data was collected in 2006, 2007, 2008, 2010, 2011, 2012, and 2017. Collection was planned to continue every 5 years going forward.

Expansion of the Metro Blue Line light rail within the Olson Memorial Highway corridor is expected to begin with heavy construction in 2019 (Metropolitan Council, 2018). The 2019 phase will result in all study elms being removed, leading to the MPRB decision to seek transplant recommendations for selected trees from the study area to new locations. The scheduled 2017 data collection was completed by UMNFR staff in May of 2017. Additional data categories collected in 2017 were diameter at 4.5 feet above grade (DBH), and tree height. UMNFR staff made one additional visit in December 2018 to make a final assessment, collect final DBH measurements and take photos.

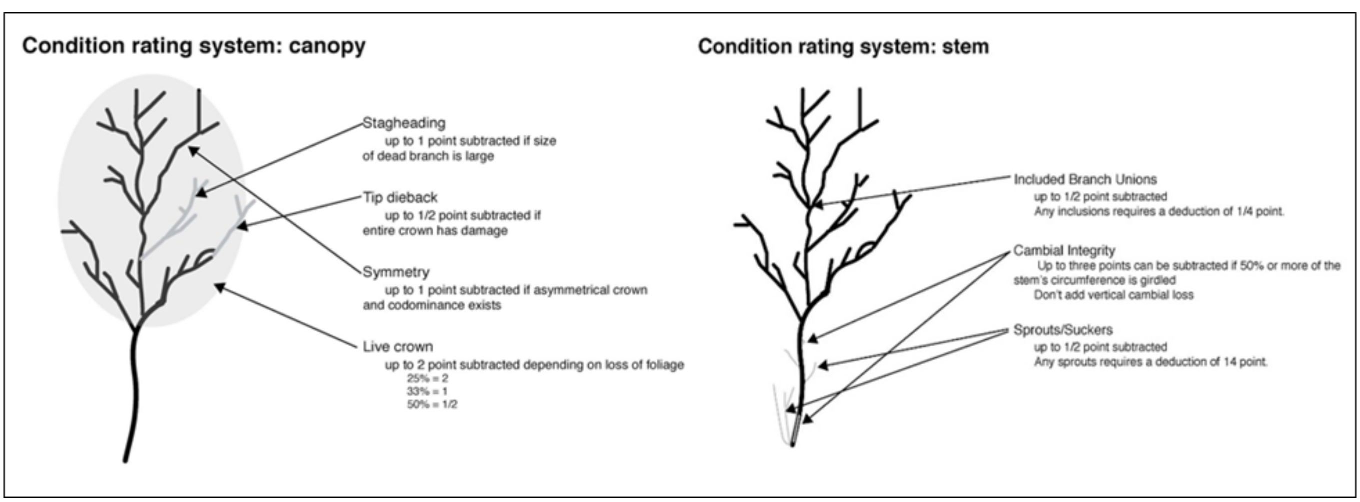


Figure 1: Crown and stem condition subtraction protocol. This figure illustrates what deficiencies require a reduced condition rating from the evaluator.

Transplant Methodology Recommendations:

Trees selected for transplant should be moved with a tree spade that is sized to encompass enough of the root system for successful establishment at the new location. Current recommendations specify the use of a tree spade that has a diameter equal to or greater than 10 times the trunk diameter of the largest tree. For example, a tree with a five-inch trunk diameter requires a tree spade diameter of equal to or greater than 50 inches (Johnson, 2002).

When possible, root pruning is recommended at least one season before the transplant is to occur. This involves cutting the roots while the tree is still in its original location to encourage development a denser and more compact root root system which will help in reducing transplant stress. Root pruning utilizes the same formula for determining spade size, making a ring around the tree at the calculated distance with the tree trunk centered in the circle. At that distance, cuts should be made vertically into the soil 24–36 inches deep. For small trees this can be done by hand, with large trees like those on this site, using a tree spade to accomplish this (without removing the tree) would be most effective (Johnson, 2002).

Transplant Tree Selection Methods:

Selection of trees for transplant had two criteria: 2017 condition ratings and 2018 DBH data. Trees with a DBH greater than ten inches and a condition rating for stem or crown lower than 2.75 were rejected as transplant candidates due to excessive large stem diameter or poor crown and/or stem condition. Trees up to this diameter threshold will require at most up to a 100in diameter tree spade to transplant, per the methodology above. The trees falling outside the rejection criteria were put into ranked categories (1-114) based on their condition values weighted by the lower rating from the stem or canopy. For example, Tree A with a canopy/stem rating of 4/2.75 would be in a lower rank category (16) than Tree B with a canopy/stem rating of 3.5/3 (13). This result is due to Tree A's 2.75 stem rating being lower than both ratings of Tree B (Table 1). An interactive map of the site can be found at: https://arcg.is/10XCbP

References:

Metropolitan Council. (2018). Tracking the Blue Line Extension. *Issue 11*. Retrieved from https://metrocouncil.org/Transportation/Projects/Light-Rail-Projects/METRO-Blue-Line-Extension/Publications-And-Resources/Newsletters/2018/Tracking-the-Blue-Line-Extension-Issue-11-(April-2.aspx

Fillmore, J. F. (2014). Olson Memorial Highway Elm Evaluation Study. *Green Report*. Urban and Community Forestry, Forest Resources Department, University of Minnesota.

Johnson, G. (2002). It Might Be Worth Saving, Transplanting Trees and Shrubs-Part I: Preparing for the Move. Department of Forest Resources, University of Minnesota. Retrieved from http://www.myminnesotawoods.umn.edu/wp-content/ uploads/2009/ 11/ part1transplant ing_preparingthemove.pdf

Appendices:

Appendix A:

Summary of Trees Selected as Transplant Candidates

Accolade
8 transplants
DBH range of 6.9” – 10.9”, Average DBH of 9.1”
2017 Crown Condition Rating range of 3.25 – 4, Average of 3.5.
2017 Stem Condition Rating range of 3 – 4, Average of 3.4.

Cathedral
8 transplants
DBH range of 4.2” – 10.3”, Average DBH of 8.4”
2017 Crown Condition Rating range of 3.25 – 4, Average of 3.6
2017 Stem Condition Rating range of 3.25 – 4, average of 3.8

Discovery
11 transplants
DBH range of 4.8” – 10.2”, Average DBH of 8”
2017 Crown Condition Rating range of 3 – 3.75, Average of 3.4
2017 Stem Condition Rating range of 3 – 4, Average of 3.6

Pioneer
6 transplants
DBH range of 6.4 – 9.7”, Average DBH of 8.1”
2017 Crown Condition Rating range of 3.25 – 4, Average of 3.75
2017 Stem Condition Rating range of 3.5 – 4. Average of 3.9

Princeton
9 transplants
DBH range of 6.5” – 7.7”, Average DBH of 7.3”
2017 Crown Condition Rating range of 3 – 3.25, Average of 3.1
2017 Stem Condition Rating range of 3 – 3.75, Average of 3.3

Prospector
1 transplant
DBH of 9.3”
2017 Crown Condition Rating of 3.75
2017 Stem Condition Rating of 3.75

Rebella
1 transplant
DBH 6.9”
2017 Crown Condition Rating of 3.75
2017 Stem Condition Rating of 2.75

Triumph
3 transplants
DBH range of 9.5 – 10.7”, Average DBH of 10.2”
2017 Crown Condition Rating range of 3.75 – 4, Average of 3.8
2017 Stem Condition Rating range of 3.5 – 3.75, Average of 3.7

Vanguard
4 transplants
DBH range of 9.9” to 10.7”
2017 Crown Condition Rating range of 3 – 3.25, Average of 3.1
2017 Stem Condition Rating range of 3.5 – 4, Average of 3.7

Unknown
6 transplants
DBH range of 4.9” to 9.1”, Average DBH of 6.8”
2017 Crown Condition Rating range of 3.5 – 3.75, Average of 3.8
2017 Stem Condition Rating range of 3.5 – 4, Average of 3.8

Appendix B

Table 1
Olson Memorial Highway Trees Recommended for Transplant
Note: Trees are ordered in planting position from west to east. Map URL: https://arcg.is/10XCbP

Map ID #	Tree Tag #	Rank Category (1 - 114)	Elm Variety	2018 DBH (in.)	Crown Condition Rating	Stem Condition Rating	2017 Height (ft.)
2	2163	2	Discovery	8.9	3.75	4.00	24
3	2162	7	Accolade	10.9	4.00	3.25	29
11	2154	13	Discovery	9.0	3.50	3.00	21
12	2153	5	Cathedral	10.3	3.75	3.50	30
13	2152	1	Cathedral	6.4	4.00	4.00	22
14	2150	2	Cathedral	4.2	3.75	4.00	17
15	2147	1	Pioneer	6.4	4.00	4.00	21
16	2416	4	Unknown	6.2	3.50	4.00	22
17	2145	7	Cathedral	8.8	3.25	4.00	24
18	2144	6	Unknown	7.1	3.50	3.50	22
19	2413	1	Pioneer	6.8	4.00	4.00	27
20	2142	2	Triumph	9.5	4.00	3.75	31
21	2141	4	Cathedral	10.1	4.00	3.50	29
30	2132	9	Vanguard	9.9	3.25	3.50	31

Table 1 continued.							
Map ID #	**Tree Tag #**	**Rank Category (1-153)**	**Elm Variety**	**2018 DBH (in.)**	**Crown Condition Rating**	**Stem Condition Rating**	**Height (ft.)**
39	2123	5	Triumph	10.3	3.75	3.50	33
42	2120	17	Rebella	6.9	3.75	2.75	29
49	2113	5	Discovery	9.0	3.75	3.50	27
51	2111	12	Vanguard	10.6	3.00	3.75	36
52	2110	3	Discovery	6.9	3.75	3.75	22
55	2106	2	Pioneer	9.2	3.75	4.00	26
57	6318	7	Discovery	10.2	3.25	4.00	27
60	6315	8	Discovery	8.4	3.75	3.25	18
61	6314	9	Pioneer	9.7	3.25	3.50	35
62	6313	11	Vanguard	10.7	3.00	4.00	30
64	6311	4	Cathedral	8.3	3.50	4.00	22
66	6309	9	Cathedral	9.6	3.50	3.25	27
67	6308	7	Cathedral	9.6	3.25	4.00	33
71	6304	2	Pioneer	8.5	3.75	4.00	26
72	6303	13	Vanguard	10.5	3.00	3.50	25
74	6301	3	Accolade	10.5	3.75	3.75	30
75	6300	2	Unknown	7.5	3.75	4.00	27
77	6298	2	Unknown	5.9	3.75	4.00	20
79	6296	2	Unknown	4.9	3.75	4.00	20
81	6294	5	Unknown	9.1	3.75	3.50	26
82	6293	3	Prospector	9.3	3.75	3.75	23
85	6290	8	Discovery	6.7	3.25	3.75	16
86	6289	7	Accolade	10.6	3.25	4.00	26
87	6288	12	Discovery	7.7	3.00	3.75	16
88	6287	10	Accolade	8.4	3.25	3.25	21
89	6286	10	Discovery	7.3	3.25	3.25	16
90	6285	9	Accolade	8.3	3.50	3.25	23
91	6284	12	Discovery	8.3	3.00	3.75	18
92	6283	12	Accolade	6.9	3.75	3.00	19
93	6282	9	Accolade	8.0	3.25	3.50	20
94	6281	6	Accolade	8.9	3.50	3.50	24
98	6275	6	Discovery	4.8	3.50	3.50	15
103	6269	9	Princeton	7.5	3.25	3.50	25
104	6268	13	Princeton	7.5	3.00	3.50	26
105		13	Princeton	7.5	3.00	3.50	27
106	6266	8	Princeton	6.5	3.25	3.75	26
108	6264	15	Princeton	7.5	3.00	3.00	26
112	6260	15	Princeton	7.0	3.00	3.00	25
113	6259	14	Princeton	7.1	3.25	3.00	25
114	6258	14	Princeton	7.5	3.00	3.25	26
115	6257	10	Princeton	7.7	3.25	3.25	29

Note: Several trees were planted without identity after original study start date, those trees are included in the Unknown elm variety category.

Appendix C

A Quantitative Condition Rating System for Urban Forestry Research

Chad Giblin and Gary Johnson

Department of Forest Resources – University of Minnesota

Condition ratings are collected in teams of two evaluators. Each rating is evaluated individually and independently (i.e. evaluators should not discuss their ratings until both have stated their condition). If the condition rating differs greatly between the two persons making evaluations, they can compromise by discussing the merit/fault of each rating or by averaging both ratings.

Both canopy and stem condition ratings are based on a zero to four point scale, allowing for individual cuts at quarter point increments. Urban and community forest managers can quickly scan data or graphs to get an estimate of tree condition based on any number of factors. Scaling is based on the scoring system developed by the CTLA (2000), with additional language regarding maintenance issues. General recommendations for the points-scale are as follows:

4 - No obvious problems or defects

The obvious goal is to have all trees near a rating of 4 or *approaching* that rating. This score does not imply the tree is perfect; it just lacks anything that is visibly defective at the time it was evaluated.

3 - Minor problems and/or defects which are recoverable and/or repairable

This may include: pruning wounds, temporary transplant shock, etc. Anything that will, most likely, be easy to recover from.

2 - Significant problems which may be difficult to recover and/or repair

This tree is on the way to decline and requires immediate attention to decrease possibility of irrecoverable defects.

1 - Irrecoverable defects and/or problems

This tree has major problems and should probably be a candidate for removal as soon as possible.

0 – Dead

No obvious living above-ground material.

Canopy Condition

Stagheading

Stagheading describes a condition where an entire branch is dead back to the main stem. Up to one point can be subtracted based on the size of the dead branch and the percentage of the crown that has been lost due to its death.

Tip Dieback

Tip dieback may be due to transplant shock, winter injury, deicing salt, or a combination of these and other factors. Up to one-half point can be subtracted due to this condition, usually if the entire crown exhibits this condition. If the dieback is less pervasive, only one-quarter point is subtracted.

Symmetry

This condition factor addresses the problems associated with an asymmetrical crown and, potentially, the divergence of a central leader and loss of apical dominance. Because this condition can have severe long-term effects on the mature form of a tree, up to one point can be subtracted.

Live Crown Ratio

Live crown ratio (LCR) is an important part of resource balance. This is probably the most subjective factor rated, and species-specific rating systems should be developed to avoid rating divergent tree forms excessively low or high, especially with conifers. As a general rule, deciduous trees with less than 25% LCR should lose two points, a LCR of 33% would lose one point, and a 50% LCR could lose up to one-half point.

Stem Condition

Cambial Integrity

This point addresses issues of stem girdling, and covers any loss of cambium due to pruning wounds, accidental damage, vandalism, winter injury. Up to three points can be subtracted if 50% or more of the stem's circumference is girdled. Use this recommendation to calculate lower rates of girdling (e.g. a tree that is 25% girdled would lose about one and one-half points). Don't add vertical cambial loss, but do add up circumferential loss.

Sprouts/Suckers

Excessive temporary vegetative growth detracts from the allocation of resources to the crown of the tree and creates potential nuisance and maintenance issues. Subtract up to one-half point if excessive. The presence of any sprouts requires a deduction of one-quarter point.

Included Branch Unions

If not addressed in a timely manner, branch inclusions can compromise the main stem of the tree through breakage and tearing during storms and other loading events. Depending on the number of inclusions, and their severity, a maximum of one-half of a point can be subtracted.

Bur Oak (*Quercus macrocarpa*) Survival and Establishment Using Grow Tubes and Soil Organic Matter Amendments

Jack Faje, Undergraduate Research Assistant
Chad Giblin, Research Fellow
Lydia Voth, Undergraduate Research Assistant
Melissa Lenius, Undergraduate Research Assistant
University of Minnesota, Department of Forest Resources

Abstract:

Many communities are interested in increasing the amount of urban forest canopy, especially in areas that have soils and other site conditions that may limit tree establishment and long-term success. Organic matter amendments used at the time of planting may improve tree establishment by reducing soil compaction and supplementing nutrients in these soils. Additionally, grow tubes may aid in reducing the pressure of herbivory and promote tree growth and survival rate through a positive effect on the microclimate and enhanced growing conditions. In this study two types of tree shelters were examined, Tubex Combi and Plantra SunFlex. For each tree shelter type three heights were tested: four, five, and six feet. To examine the effects of soil organic matter amendments, two rates of Precision Organics Test Product (POTP) organic matter amendment were added to the planting hole backfill: half rate (350 mL) and full rate (700 mL), including a control treatment that received no amendment. In this study, these cultural practices were tested over the course of five years on bur oak seedlings (*Quercus macrocarpa*). Trees planted using Planta SunFlex generally showed more favorable results than the Tubex Combi in both survival and final height of the seedlings. Organic matter amendments did not have a significant effect on the growth or survival of the seedlings.

Introduction:

Urban forests are facing increasing threats from invasive pests and pathogens that may significantly affect canopy in relatively short periods of time. Rapid regeneration of the canopy is critical, however, decreased rates of survival for newly planted trees in urban environments limits the success of this regeneration (Miller and Miller 1991; Levinsson 2015). Budgets are frequently limited and alternatives to planting larger stock balled-and-burlapped, potted, or bare root trees are needed. Planting trees as seedlings requires additional steps in order to protect the tree, increase survival rates, and enhance growth for it to be a viable option. In this study two cultural practices used in seedling regeneration: the addition of organic matter amendments and the design of tree grow tubes and their impact on the survival and growth of seedlings.

The addition of soil amendments at planting may increase the survival of seedlings planted in degraded urban soils by altering and improving the soil characteristics of the planting site. Incorporating organic matter amendments into the planting hole in a heavily compacted site can reduce bulk density (Somerville et al. 2018; Ferrini et al. 2005) and supplement nutrients that are limited in the soil (Ferrini et al. 2005). This is contested by other research studies that show reduced survival rates in trees when fertilizing amendments were applied

(Ferrini and Baietto 2006; Hough-Snee and Pond 2014). This may in part be due to stress brought on by nutrients in high concentrations or may be due to high variability in soil conditions.

Natural resource managers commonly use grow tubes to prevent animal browse (Shea et al. 1998) and weed competition (Dubois et al. 2000). Survival rates and height growth of seedlings increased when planted within a tree shelter (Ponder 2003; Sharrow 2001). Past research has also shown that grow tubes influence the light dynamics and microclimate within the tube including temperature and CO_2 concentrations and can thus enhance tree growth (Devine and Harrington 2008; Peterson et al. 2001; Sharew et al. 2005; Sharrow 2001). Sharrow (2001) observed that trees experience earlier bud break because of the microclimate within the tube resulting in a longer growing season for the tree. Trees also produce more leaves when planted in tree shelters, which may in part explain the increase in survival rates and increased height (Devine and Harrington, 2007).

The design of grow tubes can have a large impact on how they affect the seedling planted within. The design of the tube may be detrimental to the survival of the tree if the environment created in the tube does not fit the tree's requirements, such as a tube that does not permit enough light to enter for the survival of the tree (Jacobs and Steinback 2001). Design characteristics that may influence survival and growth include opacity, thickness of the wall, ventilation, height, and diameter of the tube. In this experiment we will look at the light transmission and height of the tube. Managers typically decide the height of the grow tube based on what herbivore is being deterred from foraging on the tree and matching tree protection needs with the specific requirements of the tree species is a critical consideration.

This study was initiated to examine the effects of two different grow tube types (Tubex Combi, and Plantra SunFlex) on tree mortality, establishment, and growth when combined with three different rates of organic matter (Precision Organics Test Product) incorporated at the time of planting (no amendment, 350 mL amendment, 700 mL amendment).

Materials and Methods:

Study Site

The study site was a recently restored natural area within Trout Brook Nature Sanctuary in Saint Paul, Minnesota. Before undergoing restoration to a natural area the site was a brownfield, with industry and railroads occupying the site. Saint Paul has a climate consisting of hot wet summers and cold winters. Mean January temperature is -9.1°C, mean July temperature is 32.2 °C, and mean annual precipitation is 814 mm (Saint Paul, MN 1981-2010). The trees were planted on a slope with a northeast exposure. The planting of the bur oak (*Quercus macrocarpa*) seedlings took place in May of 2014.

Experimental Design

Two different brands of grow tubes were used for the planting, Plantra SunFlex (SunFlex™ Greenhouse™

Grow Tube System, Plantra, Inc., Eagan, Minnesota, USA) and Tubex (Tubex® Tree Shelters, Tubex, Berry Plastics Company, Aberdare, UK). The key difference between these two shelters is that Plantra SunFlex is more translucent and allows for greater light to reach the plant, however light transmission was not quantitatively measured as part of the study. Three different height treatments of each brand were used: four, five, and six feet tall. Two rates of an organic matter test product (POTP) (Precision Organics, LLC, Orono, MN, USA) were added to the planting-hole: half rate (350 mL) and full rate (700 mL), as well as a control with no amendment added. POTP is an organic soil amendment that has a high carbon to nitrogen ratio designed to build and enhance soil productivity. This design resulted in twenty four seedlings in each tree shelter brand and height combined treatment and forty eight trees in each amendment treatment. Each factorial combination was replicated eight times and randomly assigned to be planted in one of the 144 available planting locations at Trout Brook Nature Sanctuary.

<u>Planting</u>

At planting, trees were two-year old seedlings grown in air pruning propagation trays (RootMaker Products Company, LLC, Stillwater, OK, USA). Seed was collected from a mature stand of bur oak at Newell Park in Saint Paul, MN, USA. Seedlings were graded by basal diameter, height, and number of leaves to ensure equal distribution of all sizes and grades across treatments. All trees were planted into 8-inch-wide by 4 to 6 inches deep hand-dug holes and assigned an individual identification number to be tracked throughout the study. Organic matter treatments were uniformly incorporated into existing backfill at planting. All tube treatments were installed according to instructions and materials supplied by the manufacturer at the time of planting.

<u>Maintenance</u>

At the time of planting all trees were well-watered. After planting care of trees were maintained using the Grow Tube Method (GTM) (internal publication). The weedy plants on the site were maintained mechanically in fall of year two and in the summer of year five. In addition to this the site was sprayed with a post emergent herbicide in the spring of year four. By year five, weeds were still prevalent on site and were removed in one by one-meter square plots surrounding each tree to prevent competition with the trees. Polyethylene mulch mats (Plantra Water-Saver Weed Mat 40in X 40in, Plantra, Inc., Eagan, MN, USA) were installed the summer of year four around each tree to reduce weed competition.

<u>Data Collection</u>

Data collection was performed one, three, and five years after planting, beginning in the fall of 2014. This data consisted of a mortality rating and total tree height. In year five the diameter of each tree was measured 15 cm above the ground. Diameter of the stem was not measured at the time of planting, therefore only the final stem diameter could be used in analysis, not stem diameter increase.

Data Analysis

Data was analyzed utilizing IBM SPSS 25 statistical analysis software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). A post-hoc Tukey HSD test was performed to analyze the effect of tube type on height and diameter as well as the impact of amendment on height growth and diameter. Chi-Square tests were performed to analyze the relationship between the amendment treatment and mortality and tube treatment and mortality. In analysis p-values less than 0.05 were considered significant. Of the 144 bur oak saplings originally planted, 27 trees were removed from analysis because they could not be identified, the tube was removed, or were missing for unknown reasons.

Results:

Tube Type and Tree Survival

There was a non-significant trend (p=0.120) in tree mortality observed due to grow tube treatment with Plantra SunFlex grow tubes having 13.3% mortality and Tubex Combi having 24.6% mortality (Fig. 1). There was no significant effect of grow tube height on tree survival.

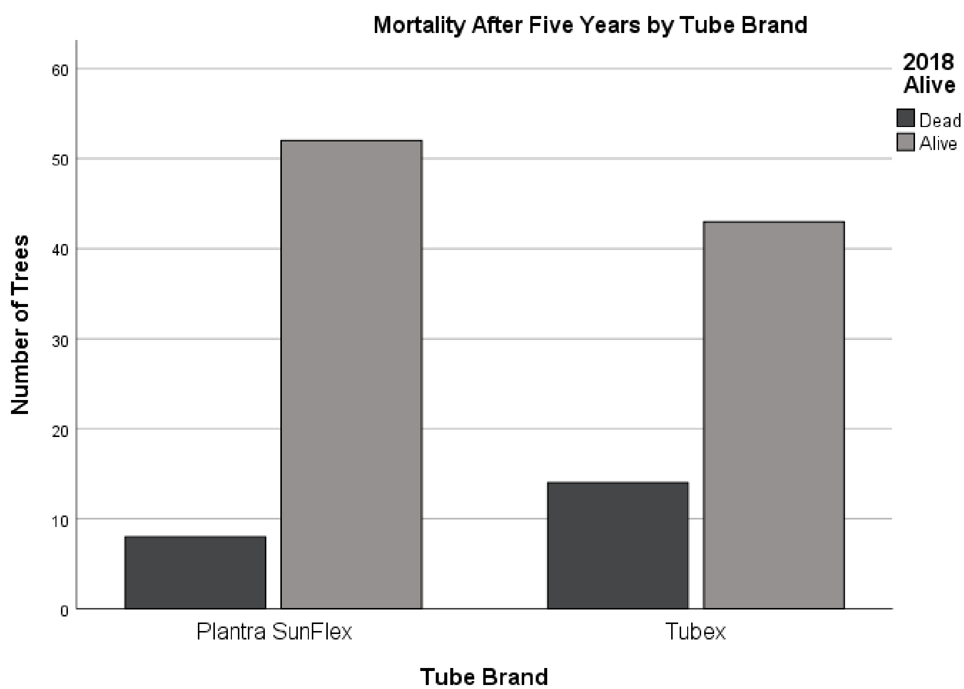


Figure 1: Tree mortality after five years between grow tube treatments.

Tube Type and Height Growth

The brand of grow tube had a significant effect on height after five years, with mean of 98.4 cm and 60.4 cm for Plantra SunFlex and Tubex respectively (Fig. 2). Overall, the grow tube with the greatest height was the 5 ft Plantra SunFlex with 117.5 cm of growth after five years, which was significantly greater than the 4 ft Tubex (53.5 cm) and 5 ft Tubex (56.7 cm) tubes (Fig. 3). Within each grow tube type treatment the height of the tube did not have a significant effect on tree growth.

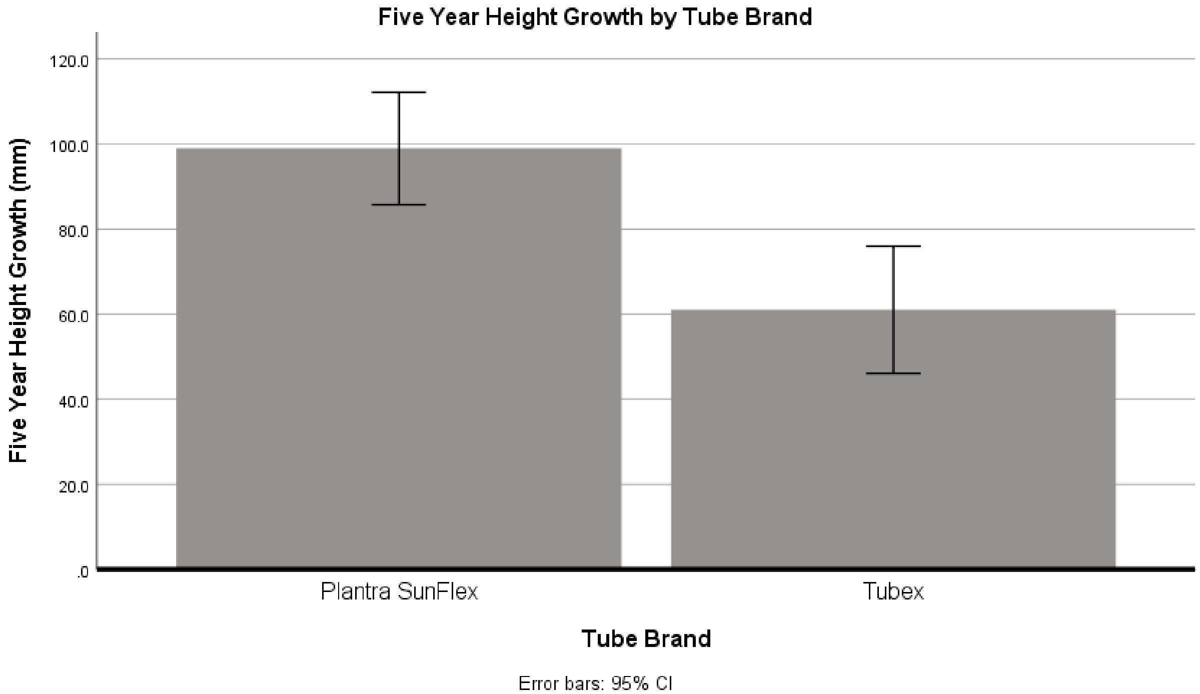


Figure 2: Five year tree height growth by tube type.

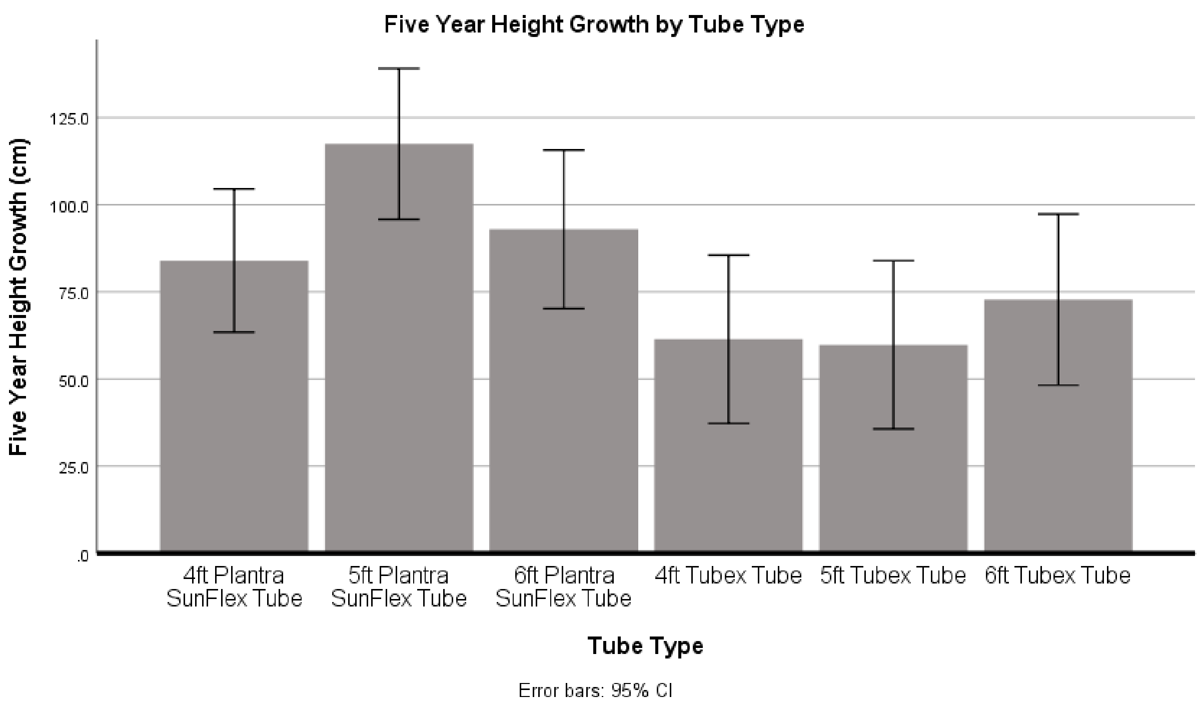


Figure 3: Five year tree height growth by tube type and size.

Tube Type and Stem Diameter

Tube brand also had a significant effect on the stem diameter measured at 15 cm above ground after five years. Treatments including the use of Plantra SunFlex grow tubes resulted in approximately twice the stem diameter than Tubex Combi grow tubes (Fig. 4). Within each tube type, the height of the tube did not have a significant effect on tree diameter.

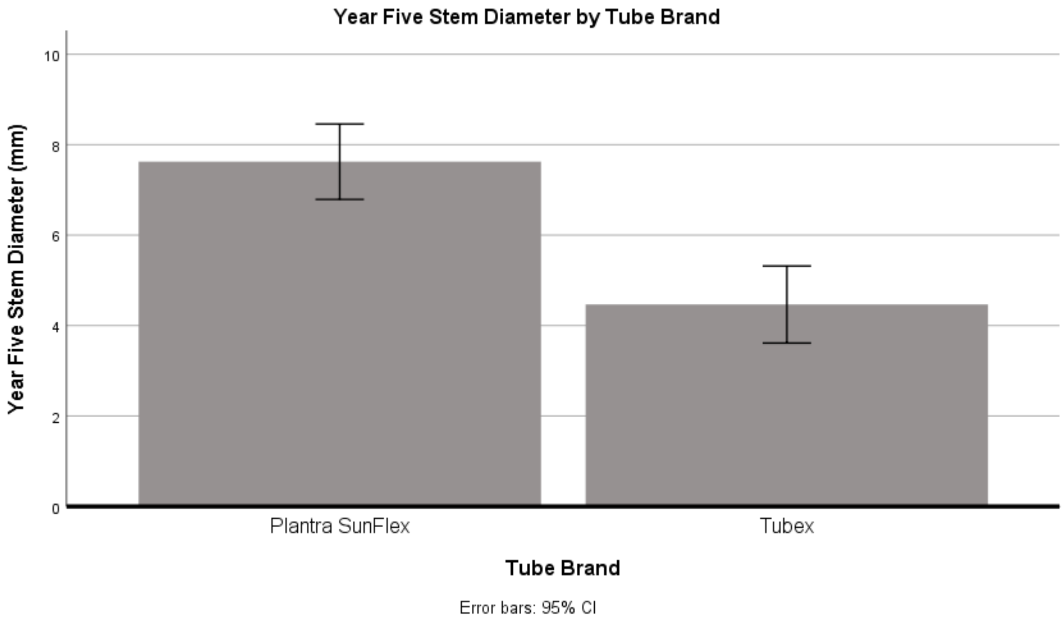


Figure 4: Stem diameter by tube brand at year five.

POTP Amendment and Tree Survival and Growth

Amendment treatments did not have a significant effect (p=0.266) tree mortality (Fig. 5), height, or diameter measured after five years. Control treatments (no amendment) resulted in height growth of 85.5 cm, POTP half rate 73.3 cm, and the full rate 90.6 cm (Fig. 6). Amendment treatment did not significantly influence stem diameter measured after five years.

Figure 5: Mortality after five years compared across amendment treatments

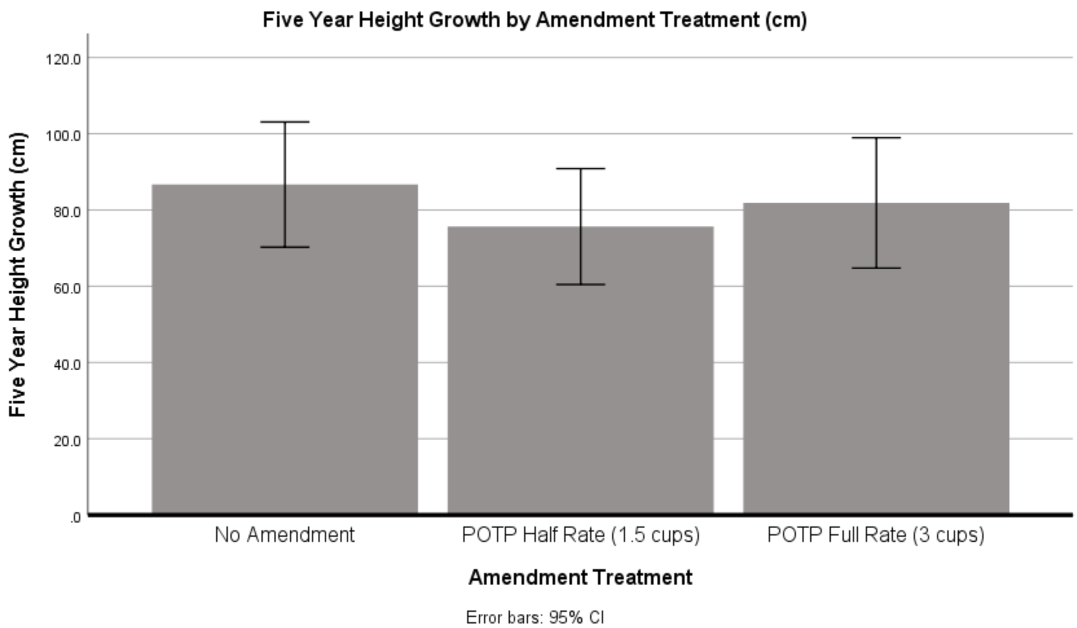


Figure 6: Height growth by soil amendment treatments at year five.

Discussion:

The use of Plantra SunFlex grow tubes resulted in an increase in height growth and survival rate of bur oak (*Quercus macrocarpa*) when compared to Tubex Combi tubes. This may be due to increased light transmission observed in Plantra SunFlex, when compared to the Tubex Combi. The reason the opacity of the tube has a significant effect in this study is because bur oak is a shade intolerant species, and the shade of the Tubex Combi grow tube may have been greater than a level at which this species can grow at its full potential. The shade requirements that a species requires for survival and growth can have a large influence on which tree shelter is best for that species (Devine and Harrington 2008). Depending on the design of the tube, light levels within a tube can fall below a level detrimental to the survival of very shade tolerant seedlings (Jacobs and Steinback 2001). Previous studies have shown increases in both height and diameter with higher levels of light transmission (Jacobs and Steinback 2001; Sharew et al. 2005). Results may have differed if the planted species had different growth requirements, such as shade tolerance.

Although the height of the tube did not have a significant effect on the survival or height growth of the tree, a taller tube may assist the tree in developing a more desired form and clearly offers additional protection, especially from deer browse. In this study, it was noted that trees tended to branch out when they reached the top of the tube, where they had full access to sunlight. A taller grow tube may result in the tree branching higher up the stem, which can be a desired characteristic for urban trees. This tree form is desired in the urban landscape not only for aesthetics, but also so that the clearance of branches is high and sightlines are open. The architecture of young trees is typically controlled through pruning, however resources to developmentally prune all young trees may be limited in some situations and locations; grow tubes may be part of the solution to attaining better tree form as well as establishment and growth rate. Future research should examine the cost effectiveness of grow tubes as a partial alternative to pruning.

Soil organic matter amendments did not have a significant impact on either tree height or survival. Prior research conflicts in results as to whether amendments have a positive effect on the survival and growth of trees (Ferrini and Baietto 2006; Gilman 2004; Stuckey et al. 2001). This may be because soils are highly variable in characteristics and properties. Previous research agrees that one aspect of the soil that amendments can help improve is bulk density (Somerville et al. 2018; Rivenshield and Bassuk 2007). When soils are characterized by a high bulk density, amendments may improve this soil for increased tree growth. Plants generally exhibit poorer growth in soils with high bulk density because they have decreased access to oxygen and may have difficulty establishing roots in heavier soils (Chen and Weil 2010; Watson and Kelsey 2006). Soil bulk density was not measured in this study, so no conclusion can be made about whether the amendment had an effect on bulk density of the soil in this experiment.

These results are limited to just one tree species, future research should focus on examination of other species, especially those that have different shade tolerances. Additionally, different site conditions should be examined to determine how and where organic matter amendments may offer positive influence on tree growth. Light transmission inside grow tubes, photosynthesis, and other variables will offer additional insight into how grow tubes influence tree growth.

Literature Cited:

Chen G, Weil RR. 2010. Penetration of cover crop roots through compacted soils. Plant and Soil. 331(1-2): 31-43.

Devine WD, Harrington CA. 2008. Influence of four tree shelter types on microclimate and seedling performance of Oregon white oak and western red cedar. US Dept. of Agriculture, Forest Service. Pacific Northwest Research Station.

Devine WD, Harrington CA, Leonard LP. 2007. Post-planting treatments increase growth of Oregon white oak (*Quercus garryana* Dougl. ex Hook.) seedlings. Restoration Ecology, 15(2): 212-222

Dubois MR, Chappelka AH, Robbins E, Somers G, Baker K. 2000. Tree shelters and weed control: effects on protection, survival and growth of cherrybark oak seedlings planted on a cutover site. New Forests. 20(2): 105-118.

Jacobs DF, Steinbeck K. 2001. Tree Shelters Improve the Survival and Growth of Planted Engelmann Spruce Seedlings in Southwestern Colorado. Western Journal of Applied Forestry. 16(3): 114–120.

Ferrini BF, Giuntoli A, Nicese FP, Pellegrini S, Vignozzi N. 2005. Effect of Fertilization and Backfill Amendments on Soil Characteristics, Growth, and Leaf Gas Exchange of English Oak (Quercus Robur L.). Journal of Arboriculture. 31(4): 182–190.

Ferrini BF, Baietto M. 2007. Effect of compost-amended backfill and paved surface on leaf parameters and physiology of Norway maple (Acer platanoides L.). Arboriculture and Urban Forestry, 33(6): 386–391.

Gilman EF. 2004. Effects of amendments, soil additives, and irrigation on tree survival and growth. Journal of Arboriculture, 30(September): 301–304.

Hough-Snee N, Pond R. 2014. Soil Amendment Increases Tree Seedling Growth but Reduces Seedling Survival at a Retired Gravel Mine. Ecological Restoration. 32(3): 231-235.

Jim CY. 1993. Soil Compaction as a Constraint to Tree Growth in Tropical & Subtropical Urban Habitats. Environmental Conservation. 20(1): 35–49.

Levinsson A. 2015. Urban tree establishment [dissertation]. Acta Universitatis agriculturae Sueciae 50 p.

Miller RH, Miller RW. 1991. Planting survival of selected street tree taxa. Journal of Arboriculture. 17(7): 185-191.

Literature Cited (Cont'd):

Peper PJ, McPherson GE, Simpson JR, Vargas KE, Xiao Q. 2009. Lower Midwest Community Tree Guide: Benefits, Costs, and Strategic Planting. Albany, California: USFS.

Peterson JA, Groninger JW, Seiler JR, Will RE. 2001. Tree shelter alteration of seedling microenvironment. Proceedings for the Eight Biennial Southern Silvicultural Research Conference; 1994 Nov 1-3; Auburn (Al). p. 305-310.

Ponder F. 2003. Ten-Year Results of Tree Shelters on Survival and Growth of Planted Hardwoods. Northern Journal of Applied Forestry. 20(3): 104-108

Rivenshield A, Bassuk NL. 2007. Using organic amendments to decrease bulk density and increase macroporosity in compacted soils. Arboriculture and Urban Forestry, 33(2): 140–146.

Sharew H, Hairston-Strang A. 2005. A comparison of seedling growth and light transmission among tree shelters. Northern Journal of Applied Forestry, 22(2): 102-110.

Sharrow, SH. 2001. Effects of shelter tubes on hardwood tree establishment in western Oregon silvopastures. Agroforestry systems, 53(3): 283-290.

Shea KL, Stange EE. 1998. Effects of deer browsing, fabric mats, and tree shelters on Quercus rubra seedlings. Restoration Ecology. 6(1): 29-34.

Somerville PD, May PB, Livesley SJ. 2018. Effects of deep tillage and municipal green waste compost amendments on soil properties and tree growth in compacted urban soils. Journal of Environmental Management, 227: 365–374.

Stuckey HT, Hudak PF. 2001. Effects of compost on Loblolly Pine tree growth in Northeast Texas. Compost Science & Utilization, 9(1): 65-72.

Watson GW, Kelsey P. 2006. The impact of soil compaction on soil aeration and fine root density of *Quercus palustris*. Urban Forestry & Urban Greening, 4(2): 69-74.

Volunteer and Outreach Programs

Minnesota Tree Care Advocate

Ashley Reichard, Volunteer Programs Coordinator
University of Minnesota, Department of Forest Resources

Minnesota Tree Care Advocate works to educate volunteer members about the benefits and best management practices of the state's urban forests so in turn they may volunteer within their communities. The Minnesota Tree Care Advocate program is comprised of multiple community-based programs that have evolved after the creation and success of the Tree Care Advisor Program (TCA). The Citizen Pruner program began in 2013 in Rochester, Minnesota and the Tree Steward program has recently taken off in 2016 in multiple communities throughout the state.

Minnesota Tree Care Advisor:

Since the first Tree Care Advisor class in 1993, 252 volunteers in urban forestry have completed the 30+ hours of core course education and contributed 104,945 hours of volunteer time. Minnesota Tree Care Advisors aid the community forestry field by becoming local stewards for their cities to share education to the public.

Core Course Training:

Tree Care Advisors are trained in many aspects of the urban and community forestry field. The original core course is 40+ hours and covers a wide range of topics. Tree Care Advisors are also required to complete 4 hours of education every year to stay up to date on research-based information and to reinforce knowledge of topics that were covered in the core course. These topics include but are not limited to:

- Communicating with the public
- Tree identification
- Plant selection
- Best planting practices
- Small tree structural pruning
- Predicting and preventing storm damage
- Volunteer management for small groups

The 2018 Tree Care Advisor Program offered three Core Course locations on specific days. These offerings included the Twin Cities Metro weekend course, the Central Minnesota weekend course, and the St. Paul campus evening course. In total, 13 participants completed the Core Course training and became active Tree Care Advisor volunteers.

Tree Essential Classes:

Tree Essential Classes have been hosted by the University at the UFore Nursery on the Saint Paul campus throughout the summer and fall months as update training classes. These two hour classes are primarily offered on Friday mornings, with a few afternoons sprinkled in, and cover specific topics for each class. The class topics are as follows:

- *Best Planting Practices**
- Grafting 101
- Gravel Bed Primer
- *Edible Landscapes***
- *Pollinator Friendly Trees & Shrubs***
- Maintaining Shrubs & Vines
- Managing Aggressives/Invasives
- Nontraditional Pruning
- Plant Health Issues - Diagnostics
- Plant Selection
- Predicting and Preventing Storm Damage
- Pruning Young Trees
- Tree Identification

**This class was cancelled due to a sick staff member and the lack of replacement to fill in.*

***These classes had no attendees show up and were cancelled on site.*

In 2018, a total of 56 attendees took advantage of the training opportunities spread over 11 workshops (disregarding cancelled and no attendee workshops). Attendees consisted of Tree Care Advisors, Master Gardeners, Master Naturalists, Minnesota Tree Inspectors, and other interested Minnesota residents. The University of Minnesota will be hosting similar classes in 2019 and also change the time of the workshops to hopefully include more participants.

"Ask a Tree Care Advisor" State Fair Booth:

In 2013, the Minnesota Pollution Control Agency (MPCA) invited the Tree Care Advisor Program to host a booth in the Eco Experience building related to climate change. After a successful year, the program was invited to return and has been a permanent structure to date. In 2018, 31 individuals dedicated approximately 600 hours toward staffing, preparing and commuting to and from the "Ask a Tree Care Advisor" booth. Over the course of 48 question and answer shifts (equal to 192 hours), volunteers answered over 3,301 question from the public. In addition to the question and answer portion of the exhibit, there were 24 volunteer shifts dedicated to engaging youth in the building-wide Bingo game. Over the course of the 24 shifts (equal to 96 hours), volunteers engaged with over 3,311 youth.

Forest Resources Outreach Line:

The Forest Resources Outreach Line has been staff by Tree Care Advisors since 2013. Minnesotans can contact the information help desk throughout the year via two ways: by phone or by e-mail. Once the phone or email messages are received, Tree Care Advisor volunteers research the resident's tree-related questions and provide them with a non-biased resolution and resources to help answer their questions, including how to contact an ISA Certified Arborist. In 2018, the Outreach Line was staffed by Annette LeDuc and Mary Magers. Since 2014, volunteers have answered 858 questions from the public, with 100 of those being answered in 2018.

2018 Tree Care Advisor Accomplishments:

In 2018, 57 active Tree Care Advisors completed a total of 3,395.5 volunteer hours for the state, their city and for non-profits in need of volunteers. On average, each volunteer completed 59.57 hours of service. Below is a breakdown of three general categories of volunteer work: community activities, community engagement, and outreach:

- Community activities: 783.00 hours
- Community engagement: 398.00 hours
- Outreach: 2,214.50 hours

Money Matters:

The organization Independent Sector has calculated an hourly dollar rate for volunteer contributions. Based on volunteer 2016 figures, the hourly rate is $27.58 per hour, resulting in a total worth of $93,647.89 of volunteer work done by Tree Care Advisors in 2018. This money is the state, county, city, and non-profit savings thanks to the work of volunteers. This savings reduces unnecessary expenses due to professionals pursuing work that requires more technical skill and allowing volunteers to assist with simple tasks. Tree Care Advisors also generate more demand professionals by educating citizens on the importance of timely and professional tree care. Collectively, monetary contributions from Tree Care Advisors between 1993 and 2018 totals $2,802,688.11.

Minnesota Citizen Pruner:

As budgets continue to be cut and the increase in priority over certain disease and pest infested trees take priority, aid from citizens becoming increasingly more important. These volunteers are able to manage smaller branches near the ground like suckers, sprouts, young tree structural pruning. Completing this work is vital for clearing sightlines and sidewalks for the safety of the public.

Training:

Minnesota Citizen Pruner curriculum is planned with the community and the University staff to tailor the program to suit the needs of the community. Some communities wish to have volunteers work solely to remove suckers and reachable sprouts, while some communities wish to volunteers structurally prune young trees that need more care and attention. The class topics cover but are not limited to:

- Pruning safety and limitations
- Communicating with the public and city staff
- Tools and cleaning protocol
- Tree identification
- Proper pruning techniques
- Fundamentals of pruning

Training:

Minnesota Citizen Pruner curriculum is planned with the community and the University staff to tailor the program to suit the needs of the community. Some communities wish to have volunteers work solely to remove suckers and reachable sprouts, while some communities wish to volunteers structurally prune young trees that need more care and attention. The class topics cover but are not limited to:

- Pruning safety and limitations
- Communicating with the public and city staff
- Tools and cleaning protocol
- Tree identification
- Proper pruning techniques
- Fundamentals of pruning

2018 Volunteer Accomplishments:

In 2018, 49 active Citizen Pruners completed a total of 619.5 volunteer hours for their community in Minnesota. The average volunteer completed 12.64 hours of volunteer work that contributed toward the health and safety of the trees in their community.

Money Matters:

The organization Independent Sector has calculated an hourly dollar rate for volunteer contributions. Based on volunteer 2016 figures, the hourly rate is $27.58 per hour, resulting in a total of $17,085.81 for volunteer work done by Citizen Pruners in 2018. This money is the city/county savings thanks to the work of volunteers. This savings reduces unnecessary expenses due to professionals pursuing work that requires more technical skill and allowing volunteers to assist with simple tasks. Collectively, monetary contributions from Citizen Pruners between 2013 and 2018 totals $63,261.09.

Minnesota Tree Steward:

The Tree Care Advocate's newest program, Tree Steward, is a great new way for individuals to get involved in their local urban and community forestry. Volunteers are able to assist with a range of activities from planting to watering and from pruning to monitoring tree health.

Training:

The Minnesota Tree Steward curriculum is planned with the community and the University staff to tailor the program to suit the needs of the community. Some communities wish to have volunteers work solely to plant and water trees, while other communities need the help of volunteers to monitor the many newly planted trees in their community throughout the first few years. The class topics cover but are not limited to:

- Best planting practices
- Watering devices and cost
- Proper pruning practices & fundamentals
- Monitoring young trees
- Monitoring general canopy health
- Communicating with the public and city staff

Communities:

Since the first Tree Steward class in 2016, the program has taken off communities across the state have held a training class and hosted pruning events. In 2018, Tree Steward training was hosted in 5 communities: Hennepin County, Maple Grove, Morris, North St. Paul, and Richfield. In 2018, Tree Steward volunteer hours were reported in the following communities: Arlington, Hennepin County, Hutchinson, Mankato, Maple Grove, Morris, Richfield, Rochester, and St. Paul. Hour down is as follows:

- Arlington: 107 hours
- Hennepin County: 92.5 hours
- Hutchinson: 41 hours
- Mankato: 15 hours
- Maple Grove: 240.5 hours

- Morris: 87.5 hours
- Richfield: 2.5 hours
- Rochester: 55.75 hours
- St. Paul: 52 hours

2018 Tree Steward Accomplishments:

In 2018, over 49 active volunteers completed a total of 693.75 volunteer hours for their community in Minnesota. The average volunteer completed roughly 14.16 hours of volunteer work that contributed toward the health and safety of the trees in their community.

Money Matters:

The organization Independent Sector has calculated an hourly dollar rate for volunteer contributions. Based on volunteer 2015 figures, the hourly rate is $27.58 per hour, resulting in a total of $19,133.63 for volunteer work done by Tree Stewards and additional community volunteers in 2018. This money is the state savings thanks to the work of volunteers.

Acknowledgements:

Thank you to all Tree Care Advisor, Citizen Pruner and Tree Steward volunteers.

Thank you to all Citizen Pruner and Tree Steward community contacts for bringing Tree Care Advocate programs to their communities and citizens.

Thank you to the Minnesota Pollution Control Agency for their support at the Minnesota State Fair.

Youth Engagement in Arboriculture

Lydia Voth, Undergraduate Research Assistant
Alissa Cotton, Research Associate
Chad Giblin, Research Fellow
Laura Nelson, Recruiting and Communications Coordinator
Monica Randazzo, Urban and Community Forestry Researcher
University of Minnesota, Department of Forest Resources

Trees are an extremely valuable resource, but who is going to take care of them in the future? A deep appreciation for and enjoyment of trees cultivates a desire and sense of duty to protect them. Many children love to climb trees, but few give them a second thought when it becomes time to decide what to be when they grow up. The Youth Engagement in Arboriculture program (YEA) helps secure the prospects of urban forests as it seeks to inspire young people to learn more about trees and even pursue careers caring for them. YEA provides unique opportunities for kids to learn by doing in a setting not commonly offered elsewhere, while striving to diversify the field by intentionally serving underrepresented groups and communities of color.

Figure 1: A climber ascending with an aerial technician

The Department of Forest Resources at the University of Minnesota implemented YEA in 2016 to educate youth anywhere from elementary school to high school about arboriculture and urban forestry. Funding is provided by grants from the Minnesota Turf & Grounds Foundation, the Minnesota Society of Arboriculture, the USDA Forest Service, and Minnesota Department of Natural Resources. In 2018, YEA programs received volunteer support from local tree care professionals, hosting arborists from City of Saint Paul, Four Seasons Tree Care, Jubert Tree Care, Minneapolis Park & Recreation Board, Northeast Tree, Rainbow Tree Care, SavATree, and Vineland Tree Care.

A major highlight of YEA is tree climbing field trips and camps. Both on the ground and high in the treetops, youth are engaged in thrilling experiences that improve their knowledge and their physical abilities. Each workshop provides opportunities for kids to climb trees like professional arborists. While undertaking fun and rewarding challenges, they learn about proper safety and communication, as well as about academic and career paths that involve trees and tree care. Games involving the rigging and suspension systems allow youth to work and learn in teams, and each person is given personal instruction from an expert during their chances to ascend trees. All events maintain

Figure 1: A climber setting out on a limb walk

full compliance with the Standard for Safety Requirements for Arboricultural Operations (ANSI Z133) and coordinate with ISA Certified Arborists® to ensure that safety and expertise are prioritized. YEA shines through its accessibility; there is no basic degree of skill or fitness necessary to participate in any activity. Kids of all levels have equal opportunities to have fun and learn. A variety of techniques are taught, which also gives participants a chance to discover their personal strengths. In addition to climbing events, YEA has hosted field trips on a myriad of topics, such as remote sensing, dendrology, nursery production systems, and tree propagation.

Figure 3: A climber ascending a tree using additional holds

Another exciting facet of YEA is the Arbor Month Poster contest, carried out in conjunction with the City of Saint Paul. This contest aims to actively engage children in Arbor Day/Arbor Month participation. Every spring, third grade students in elementary schools throughout Saint Paul learn about Arbor Month and the importance of trees. They then create posters following an annual tree theme; in 2018, it was "My Favorite Tree." The posters are judged by Saint Paul's Tree Advisory Panel (TAP), with the top three students receiving recognition at their schools. The first place student and poster are honored at a special Arbor Day ceremony at the winning school, where a city official makes an Arbor Day Proclamation and everyone gets to help plant a tree. Through this, kids are given a chance to get outside of the classroom and make a lasting mark on their world. The 2018 ceremony was held at Capitol Hill Elementary School, where a Korean maple was planted in honor of the first place winner.

Over 1,200 youth between second and twelfth grade participated in YEA programming in 2018, with nearly 100 hours dedicated by University and municipal staff at these partnering schools:

- Capitol Hill Elementary School
- Como Park Elementary School
- Eastern Heights Elementary School
- Four Seasons A+ Elementary School
- Great River School
- Highland Park Elementary School
- Highwood Hills Elementary School
- Hmong College Preparatory Academy

Figure 4: Chad Giblin and Karl Mueller speaking to a classroom about tree science and arboriculture

- L’Etoile du Nord Elementary School
- Mississippi Creative Arts Elementary School
- Twin Cities German Immersion School

In addition to these schools, a group of Minnesota 4-Hers were given an introduction to urban forestry in a summer workshop. YEA also partnered with UMN Rec and Wellness Youth Program summer camps for two weeks of tree climbing camps for 10-12 year olds and 12-15 year olds. These camps were a special chance for youth to begin a week with the very basics of tree ascension and end with the ability to fly through the canopy with creative and challenging courses set up for them to follow.

Many young people have never heard of urban forestry or its plethora of benefits before coming to a YEA event, but through their participation they receive a new perspective of natural resources and exhilarating memories that they will bring into their futures.

Figure 1: A climber working through the crux of their ascent, while a fellow camper and camp counselor discuss the route from below

A huge thank you to all the staff and volunteers that made YEA such as success in 2018!

Volunteers:

- Caius Anderson, Northeast Tree
- Noah Buraglio, City of Saint Paul
- Gabe Cesarini, Jubert Tree Care

- John Elward, Minneapolis Park & Recreation Board
- Ian Freeburg, SavATree
- Kyle Henning, Rainbow Tree Care
- Daniel Jovanovich, Rainbow Tree Care
- Tom Madison, City of Saint Paul
- Karl Mueller, City of Saint Paul
- Charlie Perington, Four Seasons Tree Service
- Danielle Ringle, Northeast Tree
- Rod Rodman, Four Seasons Tree Service
- Lydia Voth, City of Saint Paul
- Brian Volz, Minneapolis Park & Recreation Board

UMN Staff:

- Chad Giblin
- Laura Nelson
- Brian Luedtke
- Kiley Mackereth
- Monica Randazzo
- Mike Bahe
- Alissa Cotton
- Jack Faje
- Tracy Few
- Danny Heinze
- Amanda Stear
- Dalton Uphoff
- Lydia Voth
- Graham Wessberg

Equipment Donations and Support:

- DMM
- Sherrill Tree
- TreeStuff
- Wesspur Tree Equipment