Agriculture et Agroalimentaire Canada | Agriculture and Agri-Food Canada

AgriInnovation Program Stream B

2017-2018 Annual Performance Report

Greening Canada's highways: expanding nursery and landscape market opportunities for green infrastructure

Name of Recipient: Canadian Ornamental Horticulture Alliance	
Project Title: Canadian Ornamental Horticulture Research and Innovation Cluster	
Project Number: AIP-CL20	Period Covered by Report: 2017-04-01 to 2018-03-31
Activity #: COHA 11 Name of Activity: Greening Canada's highways: expanding nursery and landscape market opportunities for green infrastructure	Principal Investigator: Darby McGrath

1. Performance Measures. See Annex A for an explanation of each measure.

Innovation Items	Results Achieved (#)	Provide a description (2-3 paragraphs) for each item produced and describe its importance to the target group or sector. Explain any variance between results achieved and targets. Use plain language.
# of new/improved practices	1	New outplanting technique proven to increase tree survival in highway/urban environments. Urban soils have low organic matter and high levels of compaction. After 5 years of research and 4 years of direct testing, we have developed a method for the remediation of urban soils using deep-ripping and the addition of organic matter to ensure the long-term survival of trees. Our research demonstrates that trees can survive beyond the critical post-transplant window in unremediated soils; mortality increases in years 3 and thereafter. Therefore, remediated soils provide the right conditions for trees to become established and survive without aftercare. We developed a remediation technique that reduces the compaction of the soil and adds in organic material to improve the plantings' conditions. Our goal with the research was to develop a remediation technique that can be modified depending on the end users' soil quality (e.g. bulk density). Based on several sites we sampled throughout Ontario and Alberta, we developed a soil remediation calculator that estimates the amount of organic amendment required to bring the soil bulk density below root limiting thresholds for trees.

Information Items	Results Achieved (#)	Provide the complete citation for each item. Please see Annex A for examples.
# of media reports	8	Scott Bryk. The secret is in the soil. Highway of Heroes Living Tribute newsletter. 2017/06/09 Tim Miller. A growing partnernship. Scott Bryk. Trenton Trentonian. 2017/10/17 Tim Miller. A growing partnership. Scott Bryk. Belleville Intelligencer. 2017/10/21 Jeanne Pengelly. Rotary Club of Trenton digs in to 'green' shoreline. Global News. 2017/10/23 Vineland contributes soil knowledge to tree-planting effort. Floraldaily.com. 2017/10/24 Soil remediation workshops at HOHLT plantings. Darby McGrath. Landscape Ontario newsletter. 2017/10/25 Tim Miller. Living tribute grows again in Trenton. The Belleville Intelligencer. 2017/11/04 Tim Miller. Living tribute grows again in Trenton. The Peterborough Examiner. 2017/11/04
# of information events	3	1. Darby McGrath, "Greening Canada's Highways: Updates from Vineland". Green Industry Show, Edmonton, Alberta. 2017/11/17 2. Darby McGrath, "How to Prepare your site for Planting" Landscape Ontario Congress GreenLive Presentation, Toronto, Ontario, 2018/01/10 Darby McGrath, "Fan Favourites: Urban Tree Selections", LOHTA Nursery Growers' Short Course, Burlington, Ontario, 2018/02/07
		Provide the # of attendees
# of individuals attending information events	210	1. 50 2. 60 3. 100

2. Executive Summary

Key Highlights -

In Ontario in 2013 we found that the main limiting factor for tree survival in highway roadside tree installations was soil structure and composition. The soils at our baseline study sites were severely compacted and were above levels that would facilitate root growth and ultimately impeded tree establishment. Due to the highly compacted nature of these soils we determined that soil remediation was critical to overcome tree establishment inertia and ensure long-term survival.

We established a soil remediation trial in 2014 to evaluate different remediation techniques, and more importantly, to determine how much remediation is required to improve soil quality with the goal of improving tree establishment. Two amendment techniques were compared, backfilling the planting hole with compost, and the preparation of a bed style planting incorporating compost. Within those treatments, we tested different rates of application of organic amendment (municipal compost) into planting beds at rates of 10, 25 and 50 % volume-to-volume. Soil bulk density (compaction) was reduced to a level that was below a root limiting level.

We found that trees responded significantly better with respect to total height, shoot extension and chlorophyll content, to the 10 % and 25 % organic amendment range. The 50 % v/v range did not improve growth above and beyond the growth resulting from the 25 % v/v rate and actually increased mortality for one site. Our findings suggest just as there is a critical rate of organics to reduce bulk density in compacted soils, there is also a maximum amount of organics that should be incorporated with respect to the gain that can be captured from the rate of application; there is a limit to the benefit that organic amendment (in this case, municipal compost) can provide to trees during establishment. We found that incorporating 50% v/v compost adds cost without adding benefit. This finding is contrary to what is suggested in the scientific literature (Bassuk and Rivenshield, 2007) which argues that adding 50% organics to a clay-loam soil is necessary to reduce bulk density to rootable levels. The previous study did not measure tree response to the soil amendment treatments; therefore, our study demonstrates that more economically feasible ranges of soil remediation also have a significant impact on tree growth in compacted urban soils (McGrath and Henry 2016).

We have also found that trees can often survive the first two years after planting even without maintenance (i.e. irrigation), therefore, two year warranties for trees are not sufficient. Additionally, after tracking the soil composition and analyzing the soils for bulk density and organic matter content, for four seasons we can see that the remediated soils have started cycling biomass. The ground vegetation recruitment is much greater on the 10% and 25% treatments. Rather than seeing a decline in organic matter content after the initial season when the soils were amended, we see that the vegetation is contributing to the biomass cycling in the 10%, 25% and 50% beds compared to the other treatments.

Success Story -

Our major success story for this project is the knowledge transfer that has been agreed upon for the use of the findings, methodology, and tools we are developing for use in the Highway of Heroes Living Tribute honour guard planting. The mission of the Highway of Heroes (HoH) Living Tribute is to honour Canada's fallen by planting 117,000 trees, one for every fallen Canadian Soldier since confederation, along the Highway of Heroes between Trenton and Toronto. This planting includes both Ontario Ministry of Transportation property, conservation authority lands, municipal lands as well as private properties. The 117, 000 trees will planted according to the scientific principles, protocols and using the urban soil remediation calculation tool and species inventory, we are developing. This past year we provided guidance on the installation of 2 major highway plantings; one in Trenton by the base and one in Ajax.

We developed website to house the predictive modelling tool for highway and other urban soils. Because of the modelling tool, the user has to take a few "grab" samples of soil that are then analyzed for texture and organic matter. Those data are inputted into the calculator and based on the background soil data we have analyzed and mapped; it predicts the level of compaction of the soil and generates a report on required soil remediation practices to bring the soil to below root limiting ranges. In addition, we developed a comprehensive species recommendation-generating tool for urban tree species that provides site-specific tree recommendations for urban sites (based on soil, environment, planned maintenance etc.). The website also has the capacity to track who is using the tools based on the reports generated and will have a reporting tool for people to monitor their plantings so we can gauge the success of the methodology.

Finally, we launched a website www.greeningcanadianlandscape.ca that houses all of the information we have accumulated in a refined, and user-friendly site. The site walks users through soil sampling and soil remediation processes and helps them input the required parameters into the soil remediation calculator. The calculator provides recommendations on how to remediate the soil. Additionally, the site houses a species selection generator that is based on inputting the environmental site conditions of the planting location. This tool also allows us to track the use and provide useful information on species choices that users are generating (and their association e.g. city name) to help producers tailor their inventories to the selections cities are making.

Overview for 2017-2018 and Final Results

We have found that the primary cause for tree establishment failure is the soil structure and composition. In order to accomplish the work and meet our objectives we have established a number of trials in Ontario and Alberta. I will only report on the significant findings because this was a large project with multiple years of data and multiple trials running across the country.

Ontario Summary

Tree height and shoot extension is significantly improved in the remediated treatment beds with the best results in the medium compost (25% compost v/v) treatment.

Table 1: Soil remediation treatment description for the Ontario site remediation trial.

Treatment	Description
1	Control – trees were planted; no remediation work occurred
2	Planting hole remediation – 50 % composted (by volume) added to the planting hole
3	Deep-ripping + 0 % compost
4	Deep-ripping + 10 % compost
5	Deep-ripping + 25 % compost
6	Deep-ripping + 50 % compost

We saw significant improvements within individual years and across all the years as demonstrated in the graphs below for the remediated (compost-amended treatments i.e. low, medium and high compost).

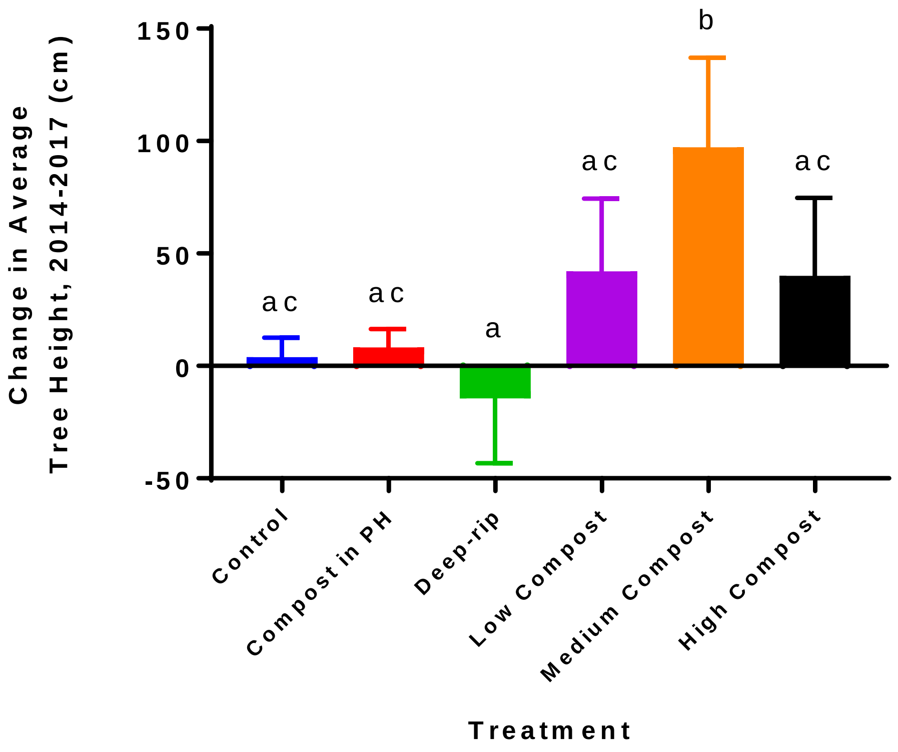

Figure 1. Cumulative change in the average tree height from 2014 to 2017 from the Beaverdams road planting site in Thorold Ontario.

The bar representing the "deep-ripping" treatment is a negative value because the trees in that treatment decreased in height due to die-back through time.

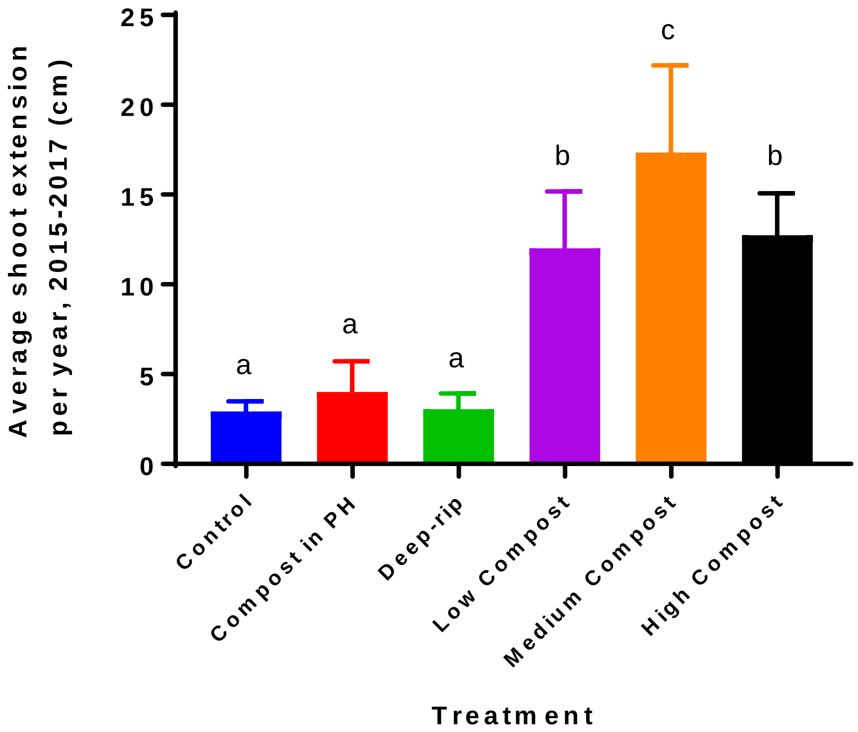

Figure 2. Average shoot extension per year measured 2015, 2016 and 2017 from the Beaverdams road planting site in Thorold Ontario.

We have consistently seen a difference in the chlorophyll content of the trees among treatments since the year of planting but the differences are segregating more through time. In particular, this season we saw a distinct segregation of the treatments into groups where the amended beds (low, medium and high compost) were separated and significantly different than the control, compost in planting hole and deep-rip + 0% treatment as shown below in figure 3. This suggests that the amended treatments were experiencing less stress and were more "green" and grow longer than the non-amended treatments.

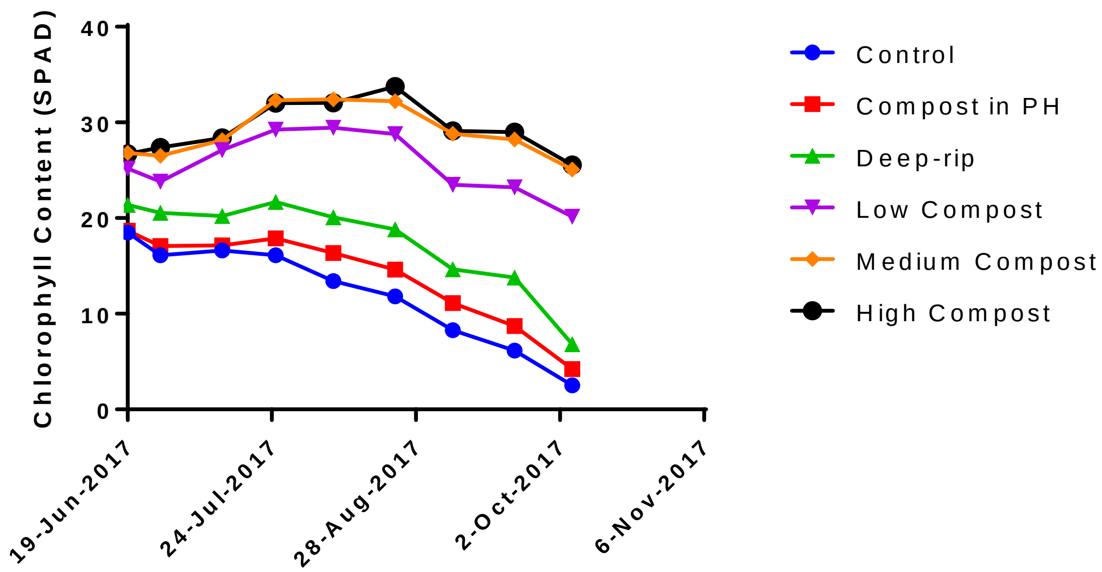

Figure 3. Tree chlorophyll content among treatments as measured from the 2017 season Beaverdams road planting site in Thorold Ontario.

The soil composition at the Ontario sites was significantly different in the compost-amended treatments. Specifically, the bulk density of treatment of the 50% compost v/v differed significantly from the control for the 0-10 cm depth in 2017 as shown below in Figure 4.

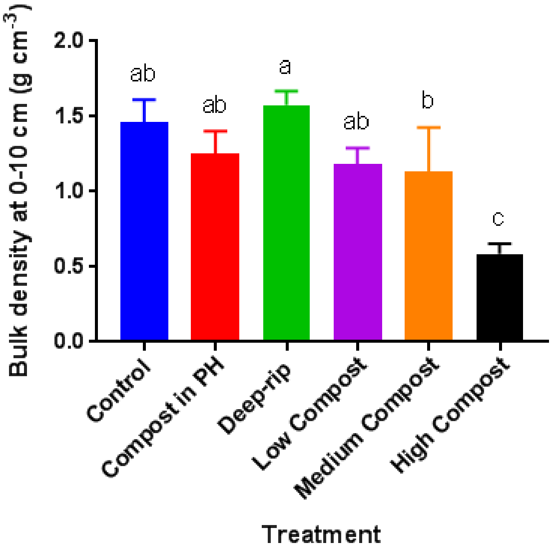

Figure 4. Bulk density at the 10-20 cm depth for an Ontario trial site in 2017.

The bulk density the 25% and 50% compost v/v differed significantly from the control, compost in the planting hole and deep-ripping + 0% organic matter for the 20-30 cm depth in 2017 as shown below in Figure 5. This depth is the most critical for bulk density is it where the majority of the active tree root growth is happening, particularly in the early post-transplant years.

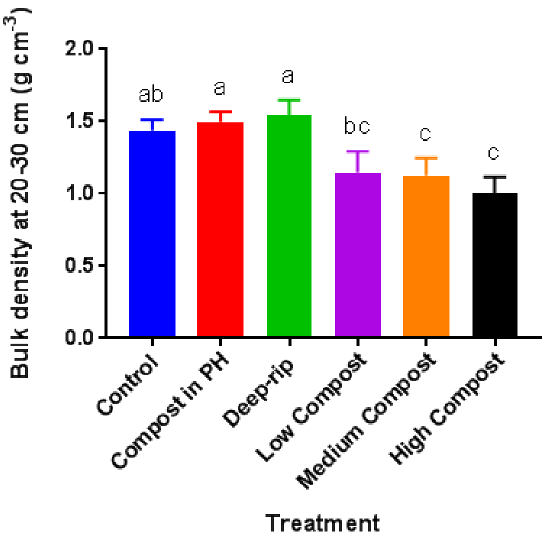

Figure 5. Bulk density at the 20-30 cm depth for Ontario trial site in 2017.

The bulk density of the 50% compost v/v treatment differed significantly from the control as shown below in Figure 6. We have noticed that through time, the amended treatments are beginning to differentiate from the control suggesting that the organic matter and biomass cycling is moving downwards in the soil profile.

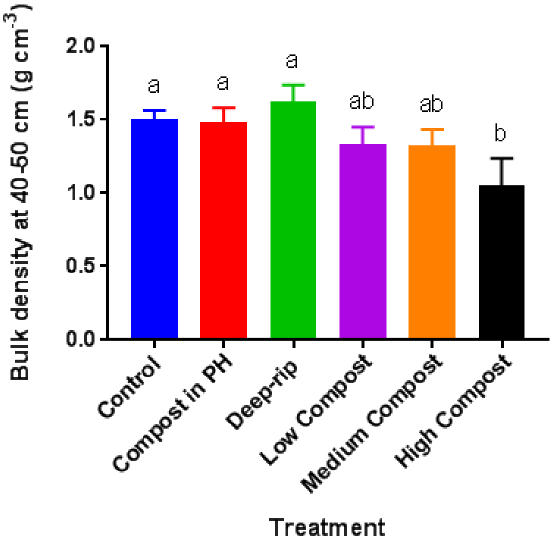

Figure 6. Bulk density at the 40-50 cm depth for an Ontario trial site in 2017.

The soil organic matter content of 50% compost v/v differed significantly from all other treatments for 2017 as shown in Figure7, below.

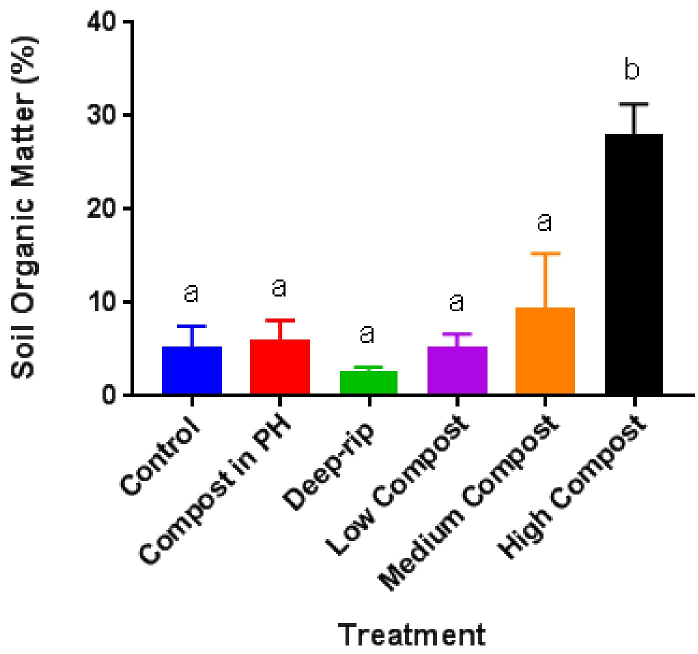

Figure 7. Soil organic matter content at the 0-10 cm depth for an Ontario trial site in 2017.

The soil organic matter content of the 10%, 25% and 50% compost v/v treatments differed significantly from the control for 2017 as shown in Figure8, below.

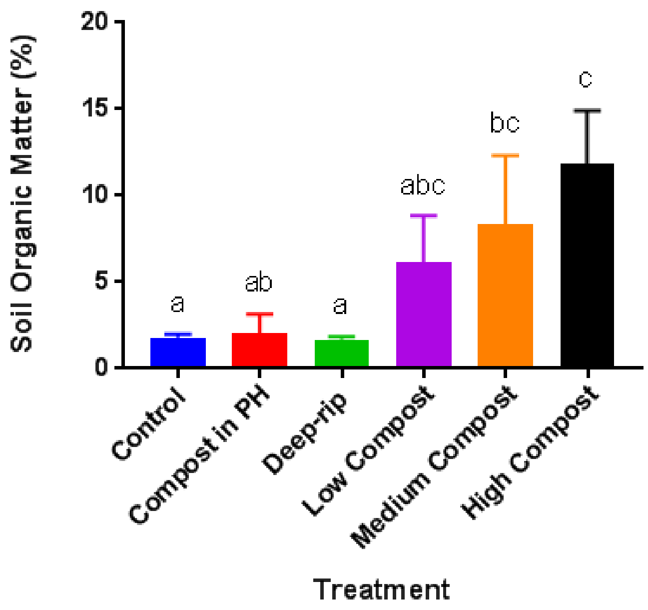

Figure 8. Soil organic matter content at the 20-30 cm depth for an Ontario trial site in 2017.

The soil organic matter content of the 25% and 50% compost v/v treatments differed significantly from the control for 2017 as shown in Figure 9, below.

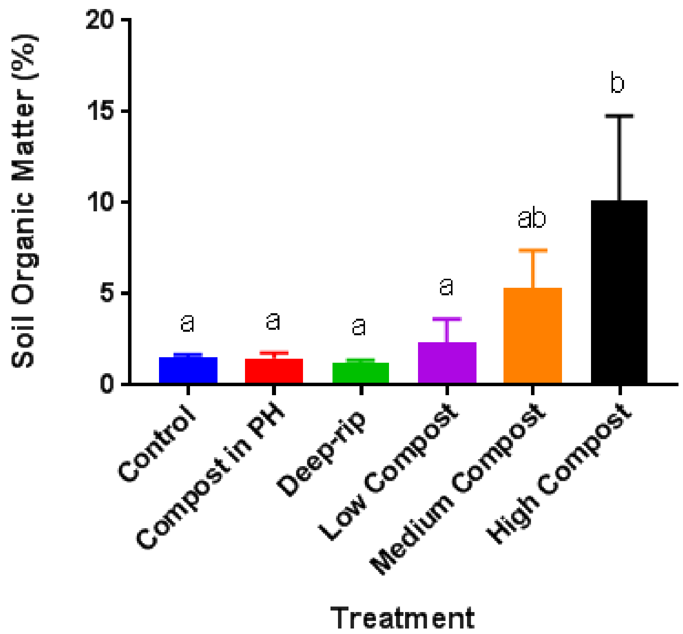

Figure 9. Soil organic matter content at the 40-50 cm depth for an Ontario trial site in 2017.

Ontario Conclusions

With the addition of organic amendment soil bulk density was reduced to a level that was below a root impacting limit after 4 years. We found that there was no additional benefit to adding 50% compost v/v in terms of tree growth. In fact, at 50% compost we saw increased mortality because the temperature was too high in the first year. Therefore, we recommend that a calculated amount of organic amendment be incorporated in with the native soil. Not all sites are created equal for soil quality. Factors that will influence soil quality include time since disturbance, vegetation and the topsoil quality that is added. We recommend calculating the amount of compost required to remediate the soil based on these site characteristics allowing for a tailored approach to amending the soil at a given site and following the tools and guidelines outlined on our website.

Alberta Summary

The findings on the Alberta sites are continuing to emerge through time and the differences among the treatments are beginning to segregate. As we found in Ontario, the treatment effects on the trees is not evident immediately, which is why longer term studies are necessary to be able to determine the true impact of a change in planting practice. Additionally, in Alberta planting larger tree stock is the norm, therefore, the trees in the study were planted as 60 mm ball and burlap/ wirebasket stock. When larger field dug nursery stock is transplanted, root: shoot balance must be restored before normal vegetative growth resumes. Trees require approximately 1 year of growth after planting for each inch of caliper and larger trees undergo a longer period of slow top growth after being transplanted. Therefore, we expect to see greater differentiation among the treatments through time. To provide insight into the trial findings I will summarize the data from the Calgary test site (Brandon elm). Table 2 outlines the treatments tested at all three Alberta trial locations.

Table 2. Treatments and methods for the Alberta soil remediation trial established prepared in the fall of 2015 and planted in spring 2016 at Calgary, Airdrie and Edmonton.

TREATMENT	METHODS
1	Deep ripping + 15% v/v pulp and paper residuals
2	Deep ripping + 15% v/v municipal compost
3	Deep-Ripping + 0% amendment
4	Control (standard city planting spec)

Tree performance and growth was improved in the remediated treatments where organic amendment was added (treatments 1 and 2) as compared to the city standard and the deep-ripping (treatments 3 and 4 which had no addition of organic amendment). The response of the trees to stress was improved in treatment 1 (the addition of composted pulp and paper residuals) and was significantly different than the other treatments as demonstrated in figure 10, below.

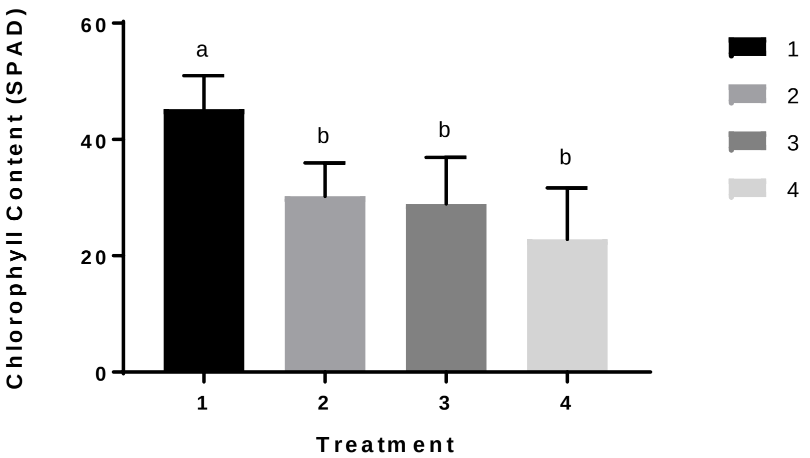

Figure 10. Chlorophyll content readings for 2017 'Brandon' elm trees among treatments at the Calgary trial location.

Tree growth, measured as caliper increase and shoot extension, was significantly better than the city specification standard planting. Average caliper growth over the 2016 and 2017 growing seasons was significantly different in the organic amendment treatments (treatment 1 and 2) shown below in Figure 11. Average shoot extension of trees in 2017 was significantly different from the control in the composted pulp and paper treatment and the deep-ripping treatment shown below in Figure 12. We hypothesize that Treatment 1 will continue to be differentiated from the control and the other treatments through time at the Alberta trial sites.

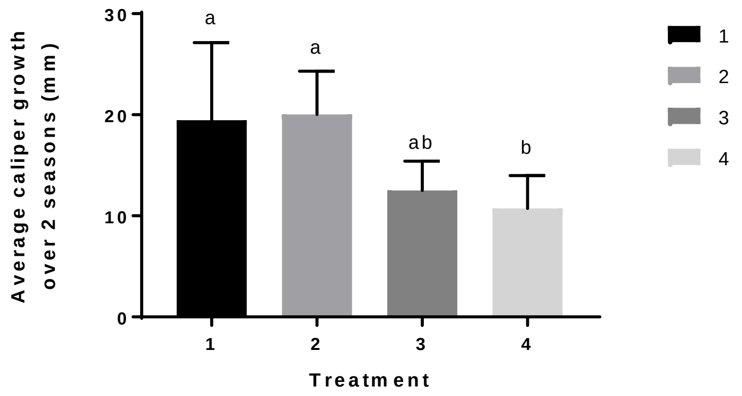

Figure 11. Average caliper growth over two seasons (2016 and 2017) 'Brandon' elm trees, among treatments at the Calgary trial location.

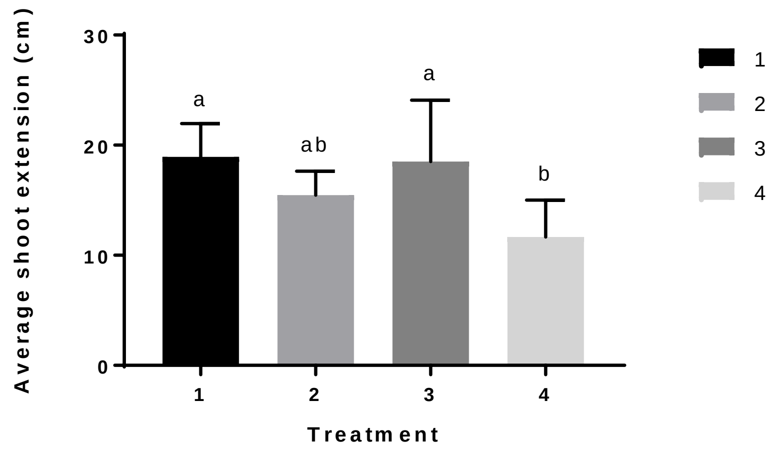

Figure 12. Average shoot extension for 2017 'Brandon' elm trees among treatments at the Calgary trial locations.

Alberta Conclusions
With the addition of the pulp and paper residuals, soil bulk density was reduced to a level that was below a root impacting limit for the Calgary and Airdrie sites where the original bulk densities were the highest. We hypothesize that the municipal compost volume would need to be increased to significantly reduce the bulk density. Tree growth and stress was improved most consistently in the pulp and paper residual treatment. Brandon elm demonstrated greater differences among treatments than did green ash. This is consistent with our findings from Ontario were there are often species specific responses to the treatments within the year of transplanting. Additional years of monitoring are necessary to better understand both ash and elm responses to the treatments.

It is important to note that survival can be a misleading benchmark for success in urban plantings; we have observed that trees may be alive for multiple seasons but are not actually established (i.e. no significant changes in their growth have been observed indicating that root growth has rebounded after planting). Identifying a planting as a success in seasons 1 and 2 after a planting because a tree is still "alive" is not a good gauge for concluding the tree will have any longevity in these types of environments. On-going monitoring will allow us to continue to detect the trends among treatments at these sites and develop specific formulas for remediation and recommended practices for Alberta soils.

Deliverables/Outputs

The following deliverable and outputs have been developed for the project this year:

- Online manual for Alberta and Ontario tree planting completed and website launched, with special invitation to partners (e.g. MTO)
- Soil remediation techniques completed on the website
- Final data collection for Ontario and Alberta trial sites is completed
- Final project report disseminated to partners
- Final draft of OPSS 802 (Construction specification for topsoil) completed and disseminated to the Ontario Provincial Standards and Specifications
- Stakeholder demonstration days were completed in Ontario (in the field) and in Alberta via their AGM
- CNLA webinar to be completed on February 14th

3. Lessons Learned:

One key lesson we have learned has to do with the challenges of timing of the work. The permitting process to gain access to sites (from the MTO) can be cumbersome for contractors. Therefore, we hope to create a manual on the required permits and a step-by-step process for completing work on MTO sites that we can share with landscape contractors with estimated timelines so they can properly prepare for how long these projects take to complete.

4. Future Related Opportunities:

This work has primarily been focused on what are considered to be “highway” roadsides or right-of-ways. The outputs from this research e.g. findings on soil specifications, remediation techniques, species and community planting design, are also relevant for other urban areas. In fact, in the last year we have had expression of interest from municipalities (e.g. a new partnership with York Region and the City of Montreal) to adapt our findings to their particular land-use challenges. The interest in adoption of our specifications and recommendations for soil remediation and species selections and designs is expanding. We hope to take our findings on tree survival to boulevard plantings (e.g. issues of soil volume, physical constraints, pollution, species choices, root management in the nursery etc). There is also interest from municipalities in working on a research project that identifies challenges in urban plantings and has growers producing stock to specification for the identified challenges. There are also appeals for us to design and pilot a contract program for several municipalities in Ontario and elsewhere in Canada. This is an excellent opportunity for growers to expand the potential opportunity for locally-sourced products and tap into the goals many cities have for expanding their urban canopy and we hope to accomplish this in the new project we have been designing.

NOTE TO READER: This report has been edited from the original for formatting purposes only. There have been no changes made to the information provided by the researcher.