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Influence of Oak and Maple Species on Soil Carbon: A Case Study

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Abstract

Forests are of immense importance as CO_2 sinks. However, the relationship that exists between forests and the carbon they sequester into their soil is still unclear. This research aims to investigate the ability of maple (*Acer rubrum, A. saccharum*) and oak (*Quercus rubra, Q. alba*), trees to enhance a soil's carbon sequestration potential. Fourteen samples each were taken from two sites: The Ohio State University's Waterman Woods and The Ohio State University's main campus (representing an "urban" sample). Comparisons were made between and among species and site, as well as between under the dripline and outside of it. It was determined that maples likely have a larger, positive impact on soil carbon sequestration because a significant positive correlation was found in a Pearson Correlation Coefficient between total soil carbon (C) stored and diameter at breast height (DBH). This conclusion also stems from the significant difference in maple tree sizes sampled between sites. For example, the OSU campus site stored a significantly higher total soil C with much larger maple trees sampled, further backing our conclusion. Additionally, no significant difference was found between carbon stored inside the dripline and outside of it, though, inside the dripline C stored was slightly higher. The difference between these species may stem from a difference in respiration rate, percentage of lignin, or litter quality/turnover rate. Follow up projects could be done to compare these finding across different tree species and/or in different soil/forestry environments on a larger scale to confirm their validity.

Keywords: Oak; Maple; Carbon; Soil carbon; Pearson Correlation Coefficient test

Abbreviations: C: Carbon; DBH: Diameter at Breast Height; GHG: Greenhouse Gas; WW: Waterman Woods; OSU: Ohio State main campus; ANOVA: Analysis of Variance; MRT: Multiple Range Test; UHI: Urban Heat Island; N: Nitrogen

Introduction

It is the interest of this study to determine what we can do to enhance the ability to sequester carbon from the atmosphere and into the soil starting with determining if there is a positive relationship between trees and carbon sequestered into the soil. Outside of what is known of fossil fuels contained within the earth – coal, hydrocarbon gas liquids, natural gas, and petroleum - the ocean, soils and forests contain the greatest amount of stored carbon (carbon stocks) on the earth. While oceans are estimated to have 30,000 Giga tons (Gt, 1 Gt = 1 billion tons) of stored carbon (C), globally soils and forests store approximately 2,500 and 400 Gt, respectively. The ocean, plants, and soil are the primary natural carbon sinks in the world. It has been estimated that soils and forests remove 25% and 30%, respectively, of all CO_2 emissions from the atmosphere globally [1]. However, these values will vary widely annually as the result of land development, soil disturbances, poor agricultural and forest management practices, wildfire, deforestation, and forest mortality. Still, soils and forests are the least expensive and most natural means by absorbing carbon from the atmosphere. Accordingly, the use of soil and forests to reduce atmospheric carbon is a strategy that can be deployed very quickly. In fact, halting the loss and degradation of forest ecosystems and promoting their restoration have the potential to contribute over one-third of the total climate change mitigation that scientists say is required by 2030 to meet the objectives of the Paris Climate Agreement.

According to the latest U.S. national greenhouse gas inventory total gross U.S. greenhouse gas emissions in 2019 were 6.6 billion metric tons of carbon dioxide equivalent, a slight decrease of 1.5% from the previous year. However, from 1990 to 2019, total emissions of CO_2 increased by 157.9MMT (3.1%). To offset these greenhouse gas (GHG) emissions and reduce atmospheric CO_2, carbon can be trapped in forests through a variety of sink activities such as forest management that increases tree growth and forestland and reduces wildfires, forest degradation, and forest losses, and in soils through improved cropland, wetland, and grassland management. Carbon capturing practices can be conducted on agricultural lands that include conservation cover crops, no-till or reduced tillage, anaerobic digestion, and improved nutrient management. It is estimated that U.S. forests and forest products remove 0.60 billion metric tons from the atmosphere annually. Adding other land-based components and aquatic ecosystems brings the total CO_2 removed from the atmosphere approximately 1.3 billion tons annually.

In 2019 it was estimated that Ohio's forests contained 231.5 million metric tons of carbon stocks, which is an increase of 10% since 1990. These forests plus the harvested wood and urban trees removed on average 3% of all CO_2 emissions in Ohio (compared to a 14% average for the U.S.). The stored carbon is equivalent to 11 years of all CO_2 emissions produced in the state [2]. While forests and soils are considered to be the best natural mechanism to absorb CO_2 out of the atmosphere, it is of interest to know how much trees influence the storage of carbon in soils. It is the objective of this study to determine if trees enhance the soil's ability to store carbon. We predict that oaks will sequester more carbon than maple trees and that the natural site, Waterman Woods, will sequester more carbon and that there will be more carbon stored under the tree's dripline than outside it due to the higher root concentration in that area.

Methods

Waterman woods (WW), a 28-acre woodlot owned by The Ohio State University (40.0174 N, 83.0456 W) and the Ohio State main campus (OSU) located in Columbus, Ohio (40.0067° N, 83.0305° W) were utilized as study sites. These sites were chosen for convenience as well to illustrate how the difference in land use history, in addition to tree species could impact C sequestered into the soil. Waterman woods represents a natural, untouched forest with no history of construction, farming, or any other use of the soil, with a high tree density. The OSU campus has had extensive land use history involving construction and shuffling of the soil which would hypothetically push some of the carbon deeper into the soil. Waterman woods is a mixed hardwood forest comprised of oak (*Quercus rubra*, *Q. alba*), maple (*Acer rubrum*, *A. saccharum*), black cherry (*Prunus serotina*), elms (*Ulmus americana*, *U. rubra*) and remnants of ash (*Fraxinus americana*, *F. pennsylvanica*) following the emerald ash borer invasion. Ohio State campus primarily houses oak and maple tree varieties. Oak and maple trees were selected for this study based on the overall prevalence in both study sites, as well as for their commonality in the US. The soil type of each site was the same- Crosby silt loam. Fourteen trees were randomly selected from each sample site with seven representing oak species and seven representing maple species for a total of 28 trees. For this study species were only separated by genus (*Quercus* and *Acer*). Each tree served as a plot center with the dripline of the tree crown defining the plot boundaries. Once the boundary of one tree was determined and sampled, care was taken not to sample any tree that had overlapping visible canopy or branches in that area to avoid cross-contamination of results, therefore outside of the dripline was an area of open space theoretically not under the influence of any tree species. The goal was to see how much a single tree affected soil sequestration abilities.

The diameter-at-breast-height (DBH) and crown diameter was measured for each tree. The quadratic mean of the crown diameter was used and determined by taking the square root of the product of the major axis (widest crown diameter) and the minor axis (diameter 90° to the major axis) (Figure 1).

The plot around each tree was divided into quadrants (Figure 1), and a soil core 5 cm in diameter and 30 cm deep was extracted with a hand soil auger probe to determine total C content. These four samples were combined to represent the soil sample for a particular tree, placed into soil collection containers, and brought back to the lab for further analysis. This process was repeated outside the plot boundary (dripline). Soil samples were taken inside of the tree dripline essentially as a representative of the tree effects on C sequestered because this is where the roots are most concentrated. Therefore, the area outside of the dripline where the root's of the tree of sampled are less clustered represents an area further from or outside of the influence of the sampled tree's ability to sequester C. This resulted in a total of 56 soil samples with 28 samples from each sampling site - 14 samples within the tree dripline and 14 samples outside the dripline. Sampling was done first at Waterman Woods starting September 13th, 2021 and ending October 12th, 2021. OSU sampling was started on the 13th of October, 2021 and finished November 8th, 2021. Samples were not all taken at the same time of day due to variations in class schedule for the student researcher taking the samples. Variations in time of year, time of day, and weather patterns could all play a part in the C findings of the soil samples.

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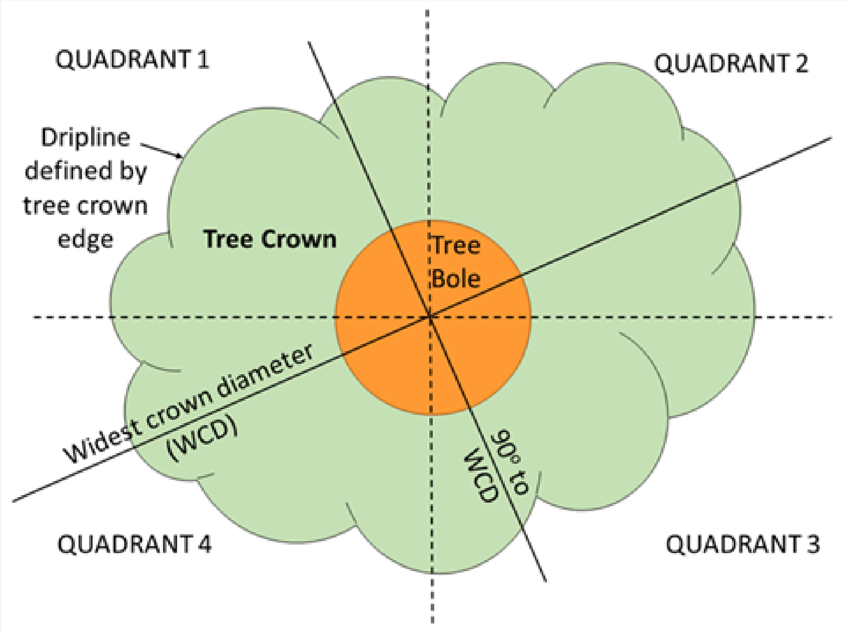

Figure 1: A diagram displaying how data was collected for each tree in this study.

The soil samples were air-dried in the lab at 25°C - 35°C for 48 hours. A grab sample of approximately 50.0 g was collected from the air-dried samples and ground to pass a 2 mm sieve and put into glass cap vials. These vials were placed on a roller to ensure maximum mixing and dryness for 2-3 days. Samples of 10-12.0 mg were processed in an Elementar Americas, Inc., Vario Max Carbon Nitrogen Combustion Analyzer to determine the percent total carbon by weight.

Analysis of variance (ANOVA) and Duncan's multiple range test (MRT) were performed to determine if differences in total soil C content between/among sites, tree species and inside/outside of the tree dripline were present. Regression analysis and Pearson's correlation coefficient were performed to confirm if DBH or tree species affected the amount of total C within the soil.

Results

With this project we utilized two different study sites as examples of urban and undisturbed (natural) soils to aid in our search to find if trees positively impact a soil's ability to sequester carbon. With all species and location combined, the total soil C was significantly higher in samples taken from the OSU campus (urban site) compared to Waterman Woods (natural site) (Figure 2A). In addition, with all species and sites combined there was no significant difference found in soil C between inside and outside the tree dripline (Figure 2B) even though the amount of soil carbon was slightly higher inside the dripline than outside. Comparing the total soil C inside and outside the dripline between sample sites did not yield any significant differences (Figure 2C and 2D). Even though the differences were not significant, the OSU campus samples displayed slightly higher carbon content under the dripline than samples taken from Waterman Woods. Oak and maple species were compared to determine if any differences in carbon sequestration were visible. We also compared C data on soil taken from under the tree's dripline to soil outside of the tree's dripline. In the OSU campus, the total soil C content (inside + outside the tree dripline) collected under maple trees was significantly higher than that collected under oak trees (Figure 3A).

However, the reverse was true with total soil C samples collected from Waterman Woods, as the soil under oak trees was significantly higher than what was collected under maple trees (Figure 3B). Soil samples collected within the dripline from the OSU campus revealed that the total soil C under maple trees was significantly higher than that collected under oak trees (Figure 3C). This also was true for samples collected just outside the dripline (Figure 3D). Soil samples collected within the dripline for both species groups on the OSU campus displayed slightly higher total C compared to what was collected just outside the dripline. Soil samples from Waterman Woods revealed different results as soil C under oak trees were higher than what was recorded under maple trees (Figure 3E and 3F). Total soil C was higher inside and outside the tree dripline of oak species compared to maple species, although not significant. Also, the soil C content was slightly higher

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outside the dripline of oak trees compared to inside the dripline. These were slightly unexpected results. Based on our prediction, we had anticipated a more drastic difference between inside and outside the dripline than what was shown, but a higher C content is still in-line with predications.

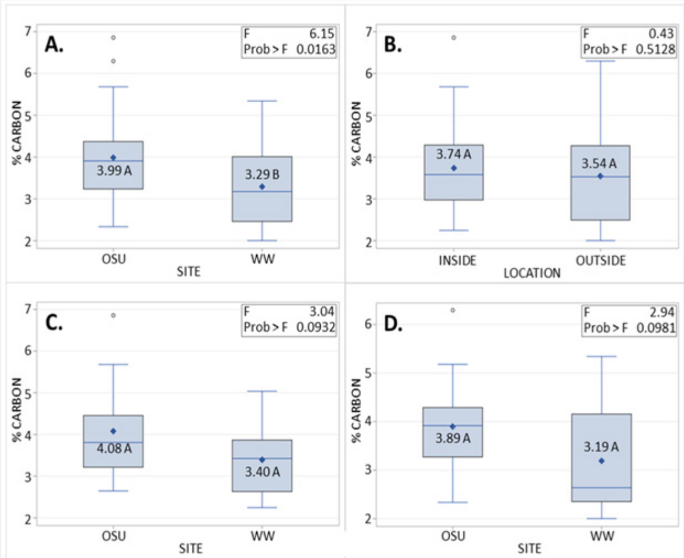

Figure 2: Box plots of total soil carbon (%) sampled under and around oak (*Quercus*) and maple (*Acer*) species combined by sample site (graph A), by dripline location for species and sample sites combined (graph B), inside the tree dripline for species combine by sample site (graph C), and outside the dripline for species combined by sample site (graph D). Mean values are displayed in each box plot and means followed by the same letter are not significantly different, Duncan's MRT (p=.005).

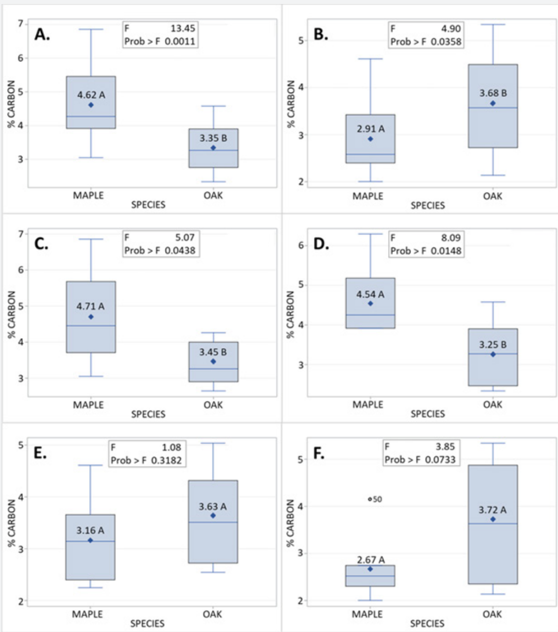

Figure 3: Box plots of total soil carbon (%) for oak (*Quercus*) and maple (*Acer*) species combined by sample location (inside/outside dripline) for the OSU sample site (graph A), for the WW sample site (graph B), inside the tree dripline for the OSU sample site (graph C), outside the dripline for the OSU sample site (graph D), inside the tree dripline for the WW sample site (graph E), and outside the dripline for the WW sample site (graph F). Mean values are displayed in each box plot and means followed by the same letter are not significantly different, Duncan's MRT (p=.005).

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Diameter at breast height measurements were taken for each tree sampled to determine if any correlations could be found between tree size and C sequestered. In the WW site, most of the oaks had much larger diameter-at-breast height (DBH) than the maples. All oaks had a DBH >30 cm, while only two maples had a DBH >30. The trees sampled on the OSU site were larger overall compared to the WW site, especially the maples (Table 1). At the WW site, only two of the maples had a DBH <30 cm. This is probably a reflection of the higher tree density at the WW site. The increased tree density prevented the sampling of larger maples to best avoid any overlapping of tree driplines.

Table 1: The mean DBH of oak (Quercus) and maple (Acer) species examined in this study.

Site	Species	N	DBH (cm)
OSU	Oak	14	65.07
	Maple	14	48.24
WW	Oak	14	56.73
	Maple	14	26.04

Table 2: The Pearson correlation coefficient relating total soil C with DBH (cm) of tree species in this study.

Pearson correlation coefficient,			
Species	N	Total soil C with DBH	Prob > |r| under H0: Rho=0
Oak	28	0.2611	0.1796
Maple	28	0.6593	0.0001

To test whether the age or size of the tree impacts C sequestered Pearson Correlation Coefficient and regression analysis were performed. The results of regression analysis show that DBH is not strongly correlated to the amount of C stored in the soil at either site for oak species (Figure 4). However, regression analysis displays a stronger link with the amount of carbon in the soil with the tree DBH (Figure 4). For both species, there is a positive correlation of total soil C increase with increasing DBH. Moreover, if a Pearson Correlation Coefficient is performed, a significantly positive correlation is found with maple species but not with oak species (Table 2). This shows for the maples sampled, the size of the tree has more effect on how much C is sequestered.

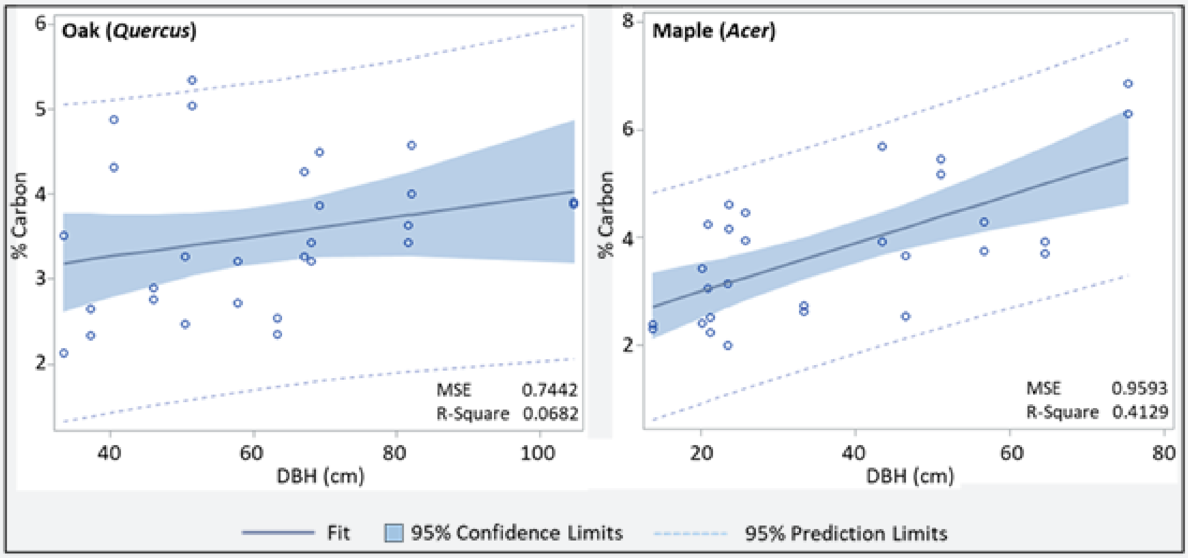

Figure 4: Regression analysis displaying the relationship of total soil C with tree DBH by species for both sample sites (OSU and WW) and location (inside/outside tree dripline) combined.

Given these results, it is reasonable to conclude that maples have a larger effect on the amount of carbon sequestered into the soil than oaks in this environment, during the time of year sampled. This conclusion stems from the significantly larger size of maples sampled in the OSU site compared to the maples sampled in the WW site, and the corresponding significant difference in carbon sequestered (Figure 3, graph A & Table 1). Additionally, in the WW site the DBH of the oak trees sampled were significantly larger than the DBH of the maple trees sampled, yet there was overall less C stored in the WW site (Figure 2, graph A). Lastly, maples showed a significantly positive correlation between DBH and C stored (Figure 4), yet this is not seen with oak trees.

While maple and oak trees are both hardwood, deciduous trees they have some key differences that may explain their C sequestration data. Although oak trees have a higher wood densi-

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ty, maple trees have a slightly higher growth rate [3]. Maples also have higher soil and litter C turnover than oaks; a faster litter turnover rate has been shown to be correlated with a greater amount of C in the topsoil [3]. Maple trees' fast decomposition rates and high litter quality likely has to do with their lower levels of lignin; oak trees have a high amount of lignin which takes a long time to decay, resulting in an overall lower litter quality [4]. In addition to their greater maintenance respiration, maples have significantly greater stem, branch, and foliage biomass as well as leaf area than oaks of a similar diameter [5]. This would amount to the maple tree intaking more carbon from the atmosphere, more quickly than oaks of a similar age/size explaining the significant positive correlation between DBH and C sequestered that we saw with maple species.

The tree type was not the only difference between the two sites. The OSU site offered a more urban setting, and the WW site was a more natural, wooded area further from the city, this difference is essential to the C sequestration findings. Previous research has shown that oak and maple trees in urban environments grow faster than those in forested environments [3]. This is possibly due to the urban heat island (UHI) effect causing elevated temperatures in urban areas or an excess of inorganic & organic nutrients in urban air. The faster growth of the urban maple trees sampled, may have allowed them to sequester more carbon in the same amount time compared to their forested counterparts. As temperatures rise, such as in climate change, deciduous trees have been shown to undergo respiration more than photosynthesis, allowing them to grow more [3]. As we continue to input more CO2 into the air and create more heat islands, trees and other vegetation will become invaluable tools to reduce to harsh impacts of these UHIs. UHIs create a feedback loop of uncomfortable living conditions for humans by raising the temperature. These rises in temperature are then accompanied by greater use of air conditioner and other cooling methods, which need energy, the production of which leads to the output of more CO_2 and a greater UHI effect [6]. A small path of vegetation has been shown to cool an area by 1.5 degrees C and reduce energy use enough to compensate the energy expended on air-conditioning many times over [7].

The results of this project show the usefulness of trees as positive effectors of carbon sequestration. Owing to the continued input of CO_2 into the air by us, the use of trees and other methods will become more prevalent. The mitigation of climate change cannot be done solely through trees and other vegetation, but we offer with this research that they could be of beneficial use in any plan to reduce emissions. Once the C has been put into the soil or the trees biomass, it will remain there nearly indefinitely (accounting for the amount lost through CO_2 respiration). Akbari [8] found that each tree planted in an urban environment could save up $200, sequester roughly 18 kg of CO_2 annually (in a large city e.g., Los Angeles), reduce smog, reduce heating bills by 10% in the winter for urban areas, and ultimately garner yearly benefits of $270 million 15-20 years post planting. Therefore, trees offer cheap, effective means to mitigate CO_2 emissions and UHI effects.

We looked at the difference under the crown and outside of the crown with the idea that the carbon captured would be concentrated under the tree's dripline. The effect of the tree on soil C should, in theory, be correlated to its root concentration as they undergo root respiration, grow and decay [9]. The roots are most concentrated under the tree's crown and as the distance from the crown increases, their number decreases exponentially. Furthermore, this exponential decrease in root biomass is accompanied by a proportional exponential decrease in soil respiration [10]. This would explain the slight increase in SOC found inside of the tree's dripline compared to outside. Although our results didn't show a significant difference in C captured under the dripline, previous studies have found a significantly greater C concentration under the tree canopy at a similar sampling depth of 0-25 cm with cork oak trees [11]. In one study, the sampling depth determined C sequestered more than any other factor, including tree species and distance from tree. They found a significant inverse relationship between sampling depth and C sequestered: as depth increases, C sequestered decreases. This study also yielded a slightly higher, yet not significant, SOC percentage closer to the tree similar to our findings [12].

Though sampling was done with the intention of taking four samples inside and four samples outside of the tree dripline, with no overlap from other tree or root systems, there are possible confounding variables. Due to the relative proximity of trees to each other, sometimes of different species, there may have been overlap in the root systems from the surrounding forest ecosystem. There exists in tree ecosystems the mycorrhizal exchange of C between trees with overlapping roots, meaning that some of the higher results we observed, particularly in the WW site, could be because of more than one tree/ tree species [13]. The time of sampling could also play a part in the results of this study, as fine roots hold the most amount of C in the Spring months and the lowest in October [14]. Further, oaks were found to have higher respiration rates in August than other months [3]. However, sampling was done in October-November, outside of the peak times for oak tree respiration.

This research shows that there is great potential in the application of good forestry techniques to reduce our C footprint. Based on our findings, it's likely that trees (particularly maple) positively affect soil C sequestration. From here, the best tactics to maximize sequestration are analyzed. While nitrogen (N) was not a key

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component of this research, past research has shown that adding a N-fixing tree or another source of N can significantly aid in carbon sequestration through slowing the decay of organic carbon [15,16]. Additionally, it has been discovered [17] that converted monoculture Chinese fir tree (*Cunninghamia lanceolata*) stands to mixed stands, with Chinese sweet gum (*Liquidambar formosana*) along with crop tree release, increased the total tree biomass by roughly 15%. Furthermore, mixed stands of *Cunninghamia*/*Alnus* stands increased C in the trees as well as C sequestered into the soil by 11% after 15 years [18]. In our project, the more mixed stand, (WW site), displayed lower rates of C sequestered. However, these trees were closer together. The study by Zhang et al. [16] involved crop tree release, a method to reduce tree density and allow certain trees to thrive more. The trees at our OSU site naturally had vastly more space individually than any one tree sampled at the WW site. This could represent a similar environment to trees that have undergone crop tree release, eliminating all competition for each OSU tree sampled, allowing them to thrive and thus sequester more carbon. Zhu et al. [18] tested the efficacy of crop tree release on carbon sequestration. They found that light thinning significantly increased the frozen carbon content, that is the C content of a sample after freeze drying, of one species of tree, the Korean Pine (*Pinus koraiensi*), and improved sequestration of others. Importantly, this study found that larger trees didn't benefit and in some cases were harmed by thinning. This would mean that for the larger oaks sampled, they were likely in a good environment to sequester carbon, eliminating that as a possibility variable from our results. Overall, these results show the utility of crop tree release on a case-by-case basis and further solidify our findings.

Our findings leave the door open for many experiments to follow. Follow up projects could be done that looked at the C held under a tree dripline in different tree species, soil types, the effect that mixed stands have on these results, etc. For example, Devi [19] noted that mixed stands sequester more C than non-mixed stands. In his study, Norway spruce and European beech trees were used in a synergistic manner- the spruce sequestered a greater amount of C into the forest floor, while the beech tree with its faster root turnover, was able to incorporate that C into the soil where it can be sequestered long term. Regarding tree type, some researchers have found that it is likely deciduous, or hardwood tree types will hold the most carbon under their crowns due to the overall wood density [21]. The ash (*Fraxinus* sp.) tree is of note for future research as Vesterdal et al. [21] found that it had the highest soil turnover rates & soil respiration rates of their sampled hardwood tree species. Others have found that coniferous trees may hold more SOC, showing that a more solid conclusion has yet to be made [22,23]. Different soil types may also offer valuable information. The soil sampled in this project was high in silt which has been shown to be positively correlated with high levels of organic carbon [19]. Soils with high percentages of clay have been noted to have high C mineralization rates, while sandy soils are noted as poor sinks for C [21,23]. A larger sample size that included a vast array of trees of different sizes would be valuable too. With this information, we could more solidly conclude our correlation that maples have a stronger link to C sequestered than oaks and back up our Pearson Correlation Coefficient test. A more longitudinal study that viewed two stands over time could also assess the impact that growth and age have on sequestration ability.

Conclusion

The goal of this study was to determine the effect that trees have on a soil's ability to sequester carbon. A slight increase in SOC stored in the soil was found inside of the tree's dripline vs outside of the tree's dripline. Additionally, the OSU site stored significantly more C than the WW site. This, combined with the larger size of maples sampled hints that maples could affect C sequestered greater than oaks, possibly due to their greater maintenance respiration and litter quality. Future research is needed to solidify these findings by looking at different factors in different environments such as soil type, comparisons of different tree types, or sampling at another time of year.

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References

1. Kayler Z, Janowiak M, Swanston C (2017) Global Carbon US Department of Agriculture, Forest Service, Climate Change Resource Center.
2. FRA (2020) Forest carbon report: Ohio. Forest Resource Association (FRA) State Carbon Fact Sheet p. 1.
3. Sonti NF, Hallett RA, Griffin KL, Sullivan JH (2019) White oak and red maple tree ring analysis reveals enhanced productivity in urban forest patches. Forest Ecol Manag 453(1): 117626.
4. Kaczmarek DJ, Rodkey KS, Reber RT, Pope PE, Ponder F (1995) Carbon and nitrogen pools in oak-hickory forests of varying productivity. In: Gottschalk KW, Fosbroke SLC, (Eds). Proceedings, 10th Central Hardwood Forest Conference; 1995 March 5-8; Morgantown, WV: Gen. Tech. Rep. NE-197. Radnor, PA: US. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station pp. 79-93.
5. Chapman JW, Gower ST (1991) Aboveground production and canopy dynamics in sugar maple and red oak trees in southwestern Wisconsin. Can J Forest Res. 21(10): 1533-1543.
6. Nuruzzaman M (2015) Urban heat island: causes, effects and mitigation measures - A Review. Int J Environ Monit Anal 3(2): 67-73.
7. Kleerekoper L, van Esch M. Salcedo TB (2012) How to make a city climate-proof, addressing the urban heat island effect. Resour Conserv Recy 64: 30-38.
8. Akbari H (2002) Shade trees reduce building energy use and CO2 emissions from power plants. Environ Pollut 116: S119-S126.

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9. Chiavegato M (2023) The role of roots on carbon sequestration. J Nutr Manage.

10. Lee JS (2018) Relationship of root biomass and soil respiration in a stand of deciduous broadleaved trees—A case study in a maple tree. J Ecol Environ 42(1): 19.

11. Howlett DS, Moreno G, Losada MRM, Nair PKR, Nair VD (2011) Soil carbon storage as influenced by tree cover in the Dehesa cork oak silvopasture of central-western Spain. J Environ Monitor 13(7): 1897-1904.

12. Wotherspoon A, Thevathasan NV, Gordon AM, Voroney RP (2014) Carbon sequestration potential of five tree species in a 25-year-old temperate tree-based intercropping system in southern Ontario, Canada. Agroforest Syst 88(4): 631-643.

13. Terzaghi M, Di Iorio A, Montagnoli A, Baesso B, Scippa GS, et al. (2016) Forest canopy reduction stimulates xylem production and lowers carbon concentration in fine roots of European beech. Forest Ecol Manag 379: 81-90.

14. Kaye JP, Resh SC, Kaye MW, Chimner RA (2000) Nutrient and carbon dynamics in a replacement series of eucalyptus and albizia trees. Ecology 81(12): 3267-3273.

15. Resh SC, Binkley D, Parrotta JA (2002) Greater soil carbon sequestration under nitrogen-fixing trees compared with eucalyptus species. Ecosystems 5(3): 217-231.

16. Zhang H, Zhou G, Wang Y, Bai S, Sun Z, et al. (2019) Thinning and species mixing in Chinese fir monocultures improve carbon sequestration in subtropical China. Eur J For Res 138(3): 433-443.

17. Wang Q, Wang S, Zhang J (2009) Assessing the effects of vegetation types on carbon storage fifteen years after reforestation on a Chinese fir site. Forest Ecol Manag 258(7): 1437-1441.

18. Zhu Y, Zhao B, Zhu Z, Jia B, Xu W, et al. (2022) The effects of crop tree thinning intensity on the ability of dominant tree species to sequester carbon in a temperate deciduous mixed forest, northeastern China. Forest Ecol Manag 505: 119893.

19. Devi AS (2021) Influence of trees and associated variables on soil organic carbon: A review. J Ecol Environ 45(1): 5.

20. Jandl R, Lindner M, Vesterdal L, Bauwens B, Baritz R, et al. (2007) How strongly can forest management influence soil carbon sequestration? Geoderma 137(3): 253-268.

21. Vesterdal L, Elberling B, Christiansen JR, Callesen I, Schmidt IK (2012) Soil respiration and rates of soil carbon turnover differ among six common European tree species. Forest Ecol Manag 264: 185-196.

22. Lu C, Kotze DJ, Setälä HM (2021) Evergreen trees stimulate carbon accumulation in urban soils via high root production and slow litter decomposition. Sci Total Environ 774: 145129.

23. Côté L, Brown S, Paré D, Fyles J, Bauhus J (2000) Dynamics of carbon and nitrogen mineralization in relation to stand type, stand age and soil texture in the boreal mixedwood. Soil Biol Biochem 32(8): 1079-1090.

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