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ASSESSING COLLEGE CAMPUS CARBON SEQUESTRATION ESTIMATION USING I-TREE CANOPY IN CORTLAND COUNTY, NEW YORK

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ABSTRACT: *Carbon sequestration is a significant factor in reducing the greenhouse effect. It is the absorption of carbon dioxide (CO_2) at natural and man-made sinks, reducing the volume of carbon in the atmosphere. The analysis in this study examines the possible impact of geographic setting and scale on the estimation of carbon sequestration from trees. This was conducted using i-Tree Canopy 7.1 and ArcGIS Desktop 10.8 for the State University of New York College (SUNY) at Cortland, SUNY Cortland Hoxie Gorge State Forest Preserve, Cortlandville, the City of Cortland, the Town of Homer, the Village of Homer, and Cortland County. Results indicated these municipalities held the most urbanized land cover in the county and tree canopy cover is inversely related to the extent of urbanization, therefore proportionally affecting estimated carbon sequestration and storage. The county had an average of 474,080 and 15,179,990 tons, respectively, while SUNY Cortland had the least with averages of 81.39 and 2,606.15 tons. Additionally, these findings indicate i-Tree Canopy produced reliable estimates with no influence from geographic setting or scale and consistency in carbon sequestration estimates using 300 points in i-Tree Canopy.*

Keywords: *carbon sequestration, New York, i-Tree Canopy*

INTRODUCTION

The climate crisis is one of the largest issues facing society today. Society can only combat this problem by reducing our own individual impact as well as institutional fossil fuel emissions. When discussing sustainability, a crucial measurement is carbon sequestration. This is the absorption of CO_2 from the atmosphere into the biomass of trees. The oxygen is then released into the atmosphere while the carbon aids with tree growth (USDA Forest Service, 2016). This measurement is especially valuable for college campuses, cities, and states which have pledged to become carbon neutral. Meaning emission sources of carbon are equaled by either natural or man-made absorption sinks, causing no impact from the release of CO_2.

In the past, similar investigations on estimates, geographic scale, carbon sources, and campus sequestration have been conducted. These consist of the identification of the effect of scale on accurate calculations of ecosystem services, discovering the influence of extent when assessing anthropogenic carbon sources, and determining the impact of campus carbon sequestration on carbon emissions. However, there have not been many studies focused on the effect of scale on the estimation of carbon sequestration from forest canopy cover, or the specific amount of carbon sequestration happening at and around SUNY Cortland.

The motivation for this project came from the lack of research on these subjects and the availability of newly recent geographic information system (GIS) based estimation tools, such as i-Tree Canopy. Even so, the reliability of the latest version of this tool has not yet been analyzed. As a result, this study's contribution will incorporate an understanding of the impacts of geographic setting, whether an area is rural or urban, and scale on carbon sequestration, the carbon sequestration estimates occurring in Cortland County, and the advantages of using i-Tree Canopy software.

LITERATURE REVIEW

Ecosystem services are any natural processes that benefit humans. This includes carbon sequestration as it is used to offset human generated carbon emissions. In calculating this service an accurate measure of tree canopy cover is needed, which is where scale becomes an important measure. Scale is the amount an image is zoomed into an area. As concluded in Nowak and Greenfield's study taking tree canopy coverage data at different scales results in either an over or under estimation. The estimates were taken at the same location using the National Land Cover Database (NLCD) tree cover data from 2001 and higher resolution imagery from Google Earth. It was seen that due to the differences in methodology the NLCD data underestimates tree canopy cover compared to the photo-interpreted coverage values. This was caused by Google Earth imagery displaying a greater amount of detail, such as smaller areas of trees which were invisible in the NLCD data (Nowak & Greenfield, 2010). This study uses tree canopy cover values derived from two data sets to show how estimates can be influenced by what is and is not visible at different scales.

A related hypothesis was tested in a study focused on anthropogenic, or human-generated, carbon sources. A substantial portion of carbon emissions are produced from large industrial facilities such as power plants. Though, an important factor when viewing these emissions is the extent of where the products are being utilized. This means who is being held accountable for the emissions; the geographic area they are produced at or the area the electricity is being used in. Due to differing local and state laws the liability varies. It is considered by the authors in this study that those locations consuming the electricity should take responsibility for the emissions caused by production. This would be possible as carbon has global effects. The location of its source is insignificant when it comes to the environmental consequences (Singer et al., 2014). Since the geographic area of the source of carbon is irrelevant, the emissions should be the concern of those taking advantage of the product.

There are multiple ways in which carbon emissions can be reduced. One that could be a tool used by communities, college campuses, or cities is carbon sequestration. College campuses are large emitters, but many now have policies in place to become carbon neutral. One thing that aids in this transition is calculating the carbon sequestration occurring on campus. For many of the campuses which have done this it is evident the levels are not high enough to make a significant impact. For Pusan National University in South Korea only 0.66 percent of emissions were being absorbed by the trees on campus (Jung et al., 2016). At Kiwi College in New Zealand only about ten percent of their emissions were being absorbed (De Villiers et al., 2014). A study was also conducted at California State University, Northridge which saw a less than one percent offset to emissions. The total estimate of carbon sequestration for the main portion of the campus's trees was 154 metric tons a year. The average student emits about one metric ton of carbon per year commuting. As a result, this section would only account for the transportation of 154 students, out of a total of 35,000, not including any of the other emissions occurring on campus (Cox, 2012). At these institutions it was seen that carbon sequestration is not a significant factor when compared to the total carbon emissions at a single college.

METHODS

i-Tree Canopy version 7.1 was utilized to obtain the data in this analysis. This is a highly accessible and dynamic urban forest assessment service. The software was created by i-Tree Cooperative along with the United States Department of Agriculture Forest Service, Davey Tree Company, Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and SUNY College of Environmental Science and Forestry (i-Tree, 2023). It should be noted that as with any tool, i-Tree Canopy has some limitations in calculating the sequestration for specific types of trees and vegetation.

The i-Tree Canopy tool is part of the broader i-Tree suite. Specifically, it is a web-based point sampling tool over the latest Google Map imagery, with a random point generator. To begin, the region and statistics were inputted. The shapefile boundary was then uploaded, the land cover classes were left as the defaults, and the county was defined. Next, the area was labeled as rural or urban, the type of currency was chosen, and the units to display quantities was selected. After the configuration was complete, the location of points was randomly generated and designated by the user as one of the land cover classes. The default land cover classes are tree canopy, grass and herbaceous, soil and bare ground, impervious buildings, impervious road, impervious other, and water. For the most accurate measure it is suggested by the software to use between five hundred and a thousand points per site (i-Tree, 2023). These numbers are recommended based on the optimization of the performance of the sampling. Studies have found that this range produces the most consistent results and when there is over a thousand points, the estimates increased in accuracy but without any further gains (Figure 1). This process of importing the shapefile and producing an optimal number of points was then completed for the SUNY Cortland campus, SUNY Cortland Hoxie Gorge, Cortlandville, the City of Cortland, the Town of Homer, the Village of Homer, and Cortland County.

Once the number of points that provides the most accurate estimate was reached, the report was evaluated. The report describes the statistics of the land cover classes such as the number of points, the amount of area they cover, and tree benefits. The tree benefits contain the quantity of carbon and CO_2 equivalent sequestered annually in trees, or the rate at which a section of trees absorbs carbon or CO_2 equivalent from the atmosphere each year (All About Trees, 2018). CO_2 equivalent is the conversion of other greenhouse gasses into the equivalent amount of CO_2 based on global warming potential (EPA, 2013). In addition, the sum of carbon and CO_2 equivalent stored in trees is calculated, or the amount of carbon or CO_2 equivalent taken from the atmosphere in total (Dunne, 2018). The benefits also include the standard errors of the estimates, monetary values, and other greenhouse gasses absorption rates. Following the review of the report, the points were exported as comma-separated values, or CSV, files. These files were then edited in ArcGIS Desktop version 10.8, or ArcMap, which is a desktop GIS application used to create maps.

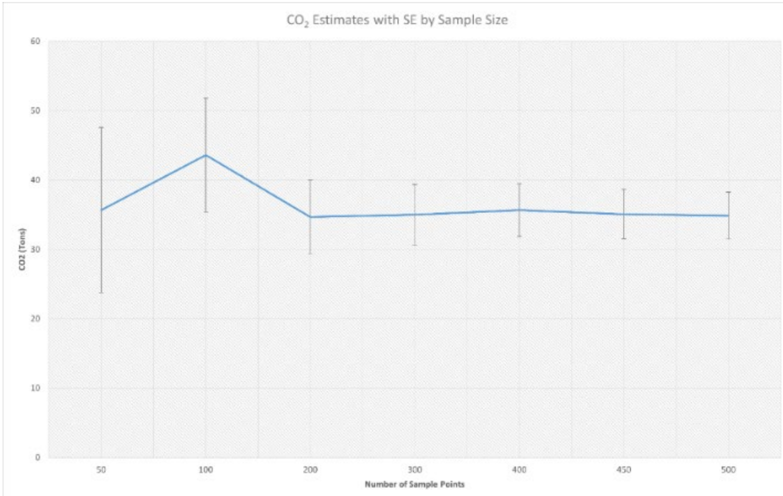
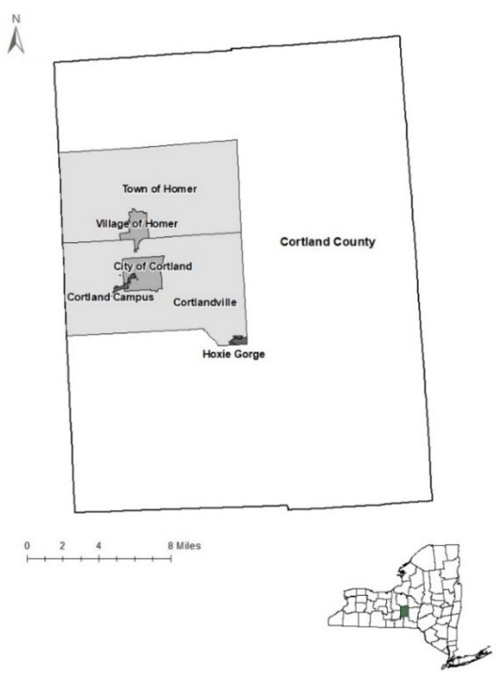


Figure 1: i-Tree Canopy carbon dioxide estimates with standard error by sample size.

RESULTS

The locations in this study were SUNY Cortland, SUNY Cortland Hoxie Gorge, Cortlandville, the City of Cortland, the Town of Homer, the Village of Homer, and Cortland County (Figure 2). In Cortland County, the distribution of individuals and urban areas is not equal, as it is a rural county. The municipality with the highest population is the City of Cortland, while the Town of Homer and Cortlandville have the second-highest populations (Figure 3). This means that the areas focused on in this research, are the most urbanized in the county.



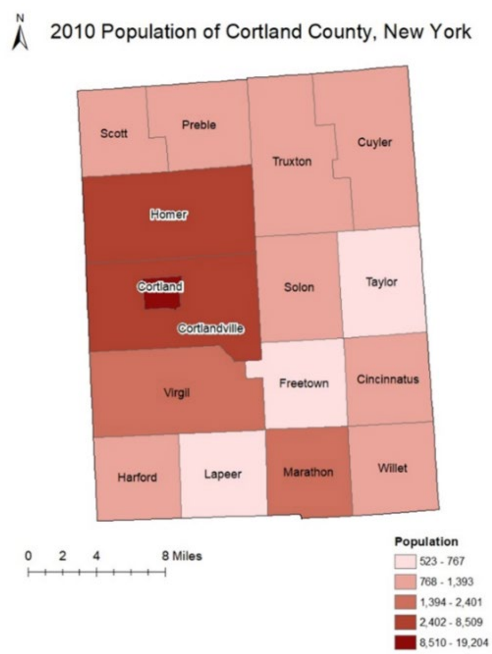


Figure 2: Municipality Locations in Cortland County, New York.

Figure 3: Population of Cortland County, New York.

For Cortland County and SUNY Cortland, maps of the i-Tree Canopy land cover points were created (Figure 4). These show the distribution of the randomized points and where the different land cover classes are located. These maps can then be compared to the land cover classification map for the county. These are the classifications of land cover types defined by the NLCD, which is a cooperation between the United States Geological Survey (USGS) and the Multi-Resolution Land Characteristics Consortium, or MRLC (National Land Cover Database, 2019). Likewise, the NLCD defines the percentage of tree canopy cover across the United States which displays where the greatest number of trees are located. When the land classification and tree canopy cover maps were compared to the i-Tree Canopy points it was seen that i-Tree Canopy data was more detailed. This is due to the NLCD data being automatically defined at a resolution of thirty-meter, while i-Tree Canopy data is user defined as specific points.

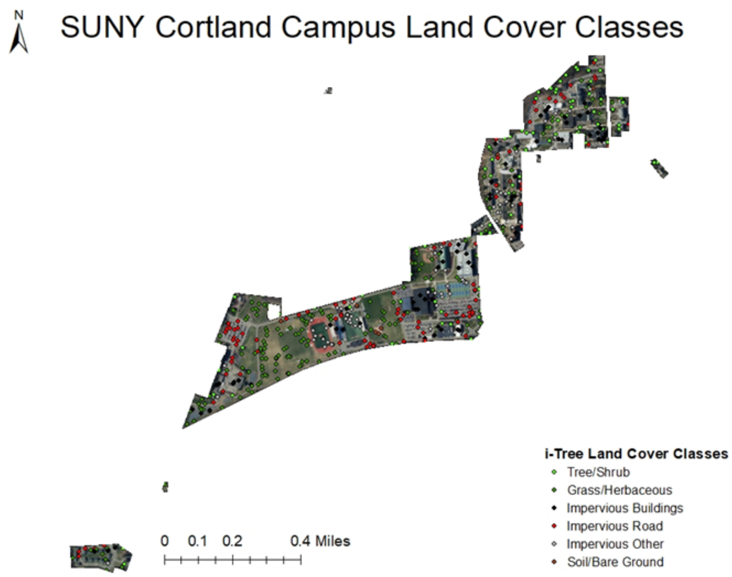


Figure 4: i-Tree Canopy Land Cover Points for SUNY Cortland, New York.

In i-Tree Canopy each point was defined as a certain land cover class, which the tool then used to calculate statistics on the data. For tree canopy the region with the highest percentage was SUNY Cortland Hoxie Gorge and with the least was SUNY Cortland. The region with the greatest area was Cortland County, while the least was again SUNY Cortland. Even though SUNY Cortland Hoxie Gorge had the greatest percentage of trees, it is one of the smallest locations. A similar pattern is seen when the percentage and area of impervious surfaces were compared. The site with the highest percentage of impervious surfaces was SUNY Cortland and with the least was SUNY Cortland Hoxie Gorge. The location with the greatest area was Cortland County and with the least was again SUNY Cortland Hoxie Gorge (Figures 5 and 6).

Next, the percentage of tree canopy cover was contrasted to the percentage of impervious surfaces. Here it is seen that the list of areas with the highest to lowest percentage is the opposite of one another (Figure 5). This is to be expected as the locations with the highest percentage of trees would be the same places with the lowest percentage of impervious surfaces. Finally, to verify the difference in the accuracy of the land cover classification, Cortland County was compared to both the county with the Town of Homer, Cortlandville and the City of Cortland removed and as all the smaller municipalities combined. For Cortland compared to the county with regions removed the percent difference average across the different land classes was 42.06, while the average for the county compared to the smaller areas combined was 13.89 percent.

The carbon sequestration estimates were then compared to each other and to the area of tree canopy in each locale. When compared to each other it was seen that the number of tons of carbon sequestered yearly, CO_2 equivalent sequestered yearly, carbon stored, and CO_2 equivalent stored for the different areas highest to lowest were the same. The location with the highest amount of carbon sequestration and storage was Cortland County, while the lowest was SUNY Cortland. Then the amount of area of tree canopy cover from highest to lowest was compared to the amount of carbon sequestration and storage. These lists displayed the locations in the same order (Figures 6-8). This is logical as the greater number of trees there are, the more tons of carbon that can and will be taken out of the atmosphere. Lastly, the difference in carbon sequestration and storage estimation was determined by comparing Cortland County to the county with areas removed and Cortland County to the county created by combining municipalities. The percent difference averages across the different carbon estimates were 16.16 and 0.28, respectively.

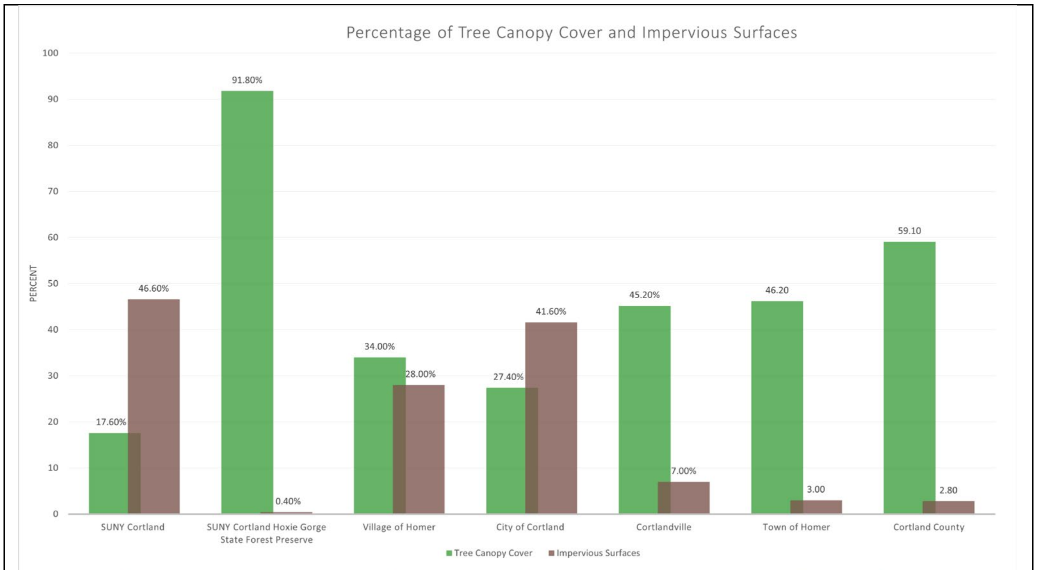


Figure 5: Percentage of Tree Canopy Cover and Impervious Surfaces.

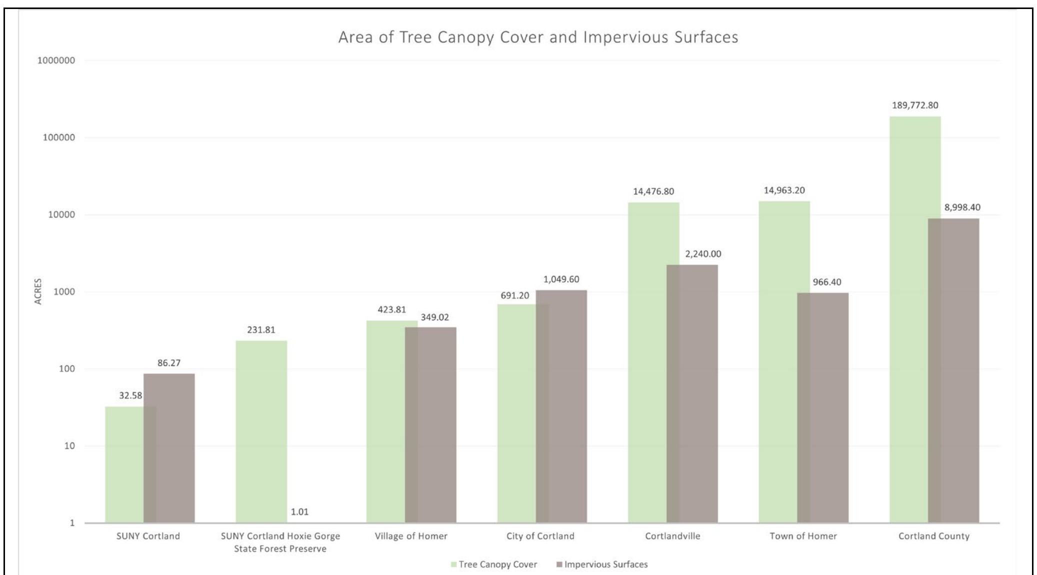


Figure 6: Area of Tree Canopy Cover and Impervious Surfaces.

DISCUSSION

The population data in this study was used as a proxy measure to show development in Cortland County. It displayed that the areas being focused on are more urbanized, which usually means the least amount of vegetation. It also demonstrated that due to land use two square miles in the Village of Homer are not the same as two square miles in another municipality. Additionally, when determining carbon sequestration and storage amounts land cover, especially tree canopy cover, is the most significant measure.

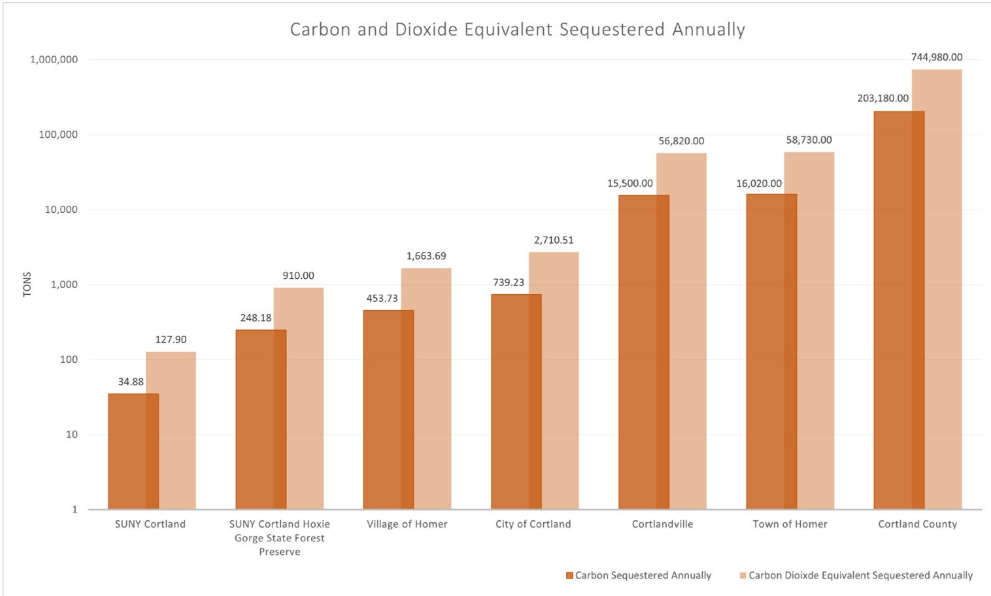


Figure 7: Amount of Carbon and CO_2 Equivalent Absorbed from the Atmosphere Annually.

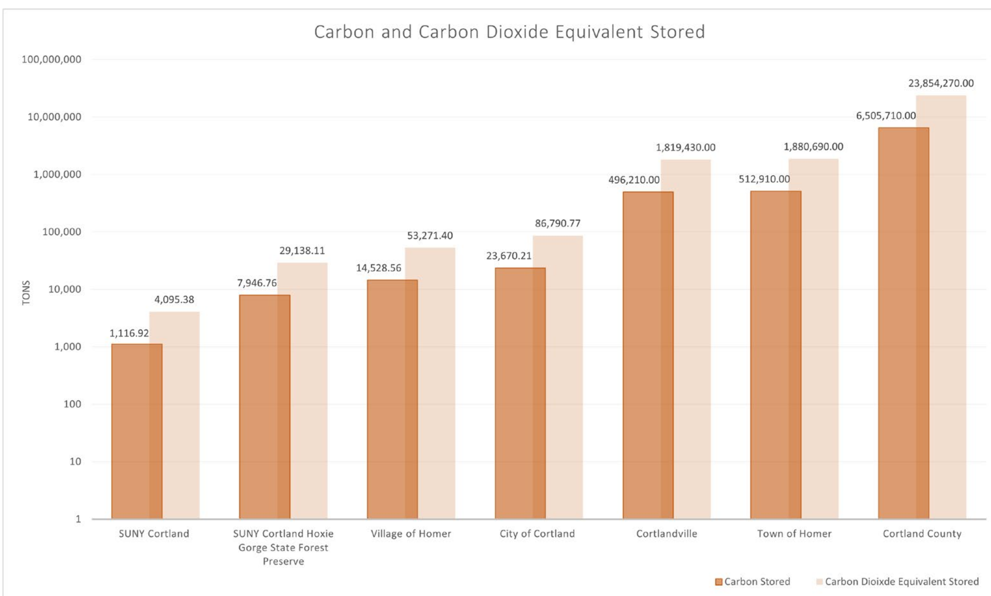


Figure 8: Total Amount of Carbon and CO_2 Equivalent Removed from the Atmosphere.

College campuses are becoming increasingly interested in sustainability and being environmentally conscious. This study included SUNY Cortland which when compared to the county caused only a slight impact, since the region is rural. If this was done for a City University of New York College (CUNY) or a campus in another highly urbanized area, the college would have a greater impact. However, low carbon sequestration and storage numbers can be modified by planting additional trees both on and off-campus. Many campuses own other properties where trees can be planted to decrease carbon emissions, and aid in becoming carbon neutral. This is a viable strategy since if there is carbon being emitted on this land it would be the college's responsibility. So, if carbon sequestration and storage is occurring at these other properties it would be the college's concern, therefore it could be added to that occurring at the main campus. For SUNY Cortland this approach may be feasible as the college already owns a portion of Hoxie Gorge State Forest Preserve, Raquette Lake Campsite, and Brauer Field Station. These other properties are all mostly forested and could aid in the college's goal of becoming carbon neutral.

Although, it should be noted that planting trees is not the only way campuses should be combatting carbon emissions. In addition, other strategies can be implemented, including switching to renewable energy, reducing transportation or building emissions, recycling, and sourcing sustainable suppliers. The sampling from the i-Tree Canopy program was found to be reliable and consistent for every location. This was concluded since the estimates for the aggregate of the county, or the combination of the municipalities, compared to Cortland County as a whole, were almost equal. This is useful because when smaller areas are done separately there is more detail available. Yet, if it was needed, areas can be merged to produce an accurate result. The standard errors for all estimates were low as well, meaning there was not much variance in the measures of the areas being studied. According to the standard error calculations, the number of data of points used appears to optimize at 300 (Figure 1), which is a bit less than the recommended minimum of 500 for iTree Canopy (iTree 2023). However, this may be due to the rural setting in this study rather than urban forests iTree Canopy is most often used to study.

CONCLUSIONS

Carbon sequestration is a vital topic when it comes to the discussion of sustainability. This is the natural absorption of CO_2 from the atmosphere. Being able to establish an estimate of natural carbon sequestration can be extremely helpful to communities, towns, college campuses, cities, and states. By using the tool i-Tree Canopy this can be accomplished with accuracy no matter the geographic setting or scale. Once carbon sequestration estimates are calculated they can be combined with carbon emission levels to determine a community's impact in the climate crisis. It was seen, as presumed, that the places with the smallest area of trees had the smallest carbon and CO_2 equivalent sequestration and storage estimates. When the estimates were then compared based on which locations had the highest to the lowest storage it was the same for all carbon estimates, showing the reliability of the tool. Furthermore, another piece of evidence that proves the consistency, was the high percent difference between Cortland County compared to the county with locations removed, meaning there was a large error between the estimates. The same was done for Cortland County compared to the municipalities combined and this percent difference was less than one. This demonstrates that if an area is completed as a whole or as small areas merged, the estimates will be almost equal.

Despite the tool's limitations due to Google Map imagery, calculation of carbon estimates, and being based on only United States, United Kingdom, and Sweden data, there are many advantages to using it. Further research using this tool for SUNY Cortland has been planned for Spring 2023. This future project will calculate the carbon sequestration for the other SUNY Cortland properties and then compare this to the campus's carbon emissions. SUNY Cortland does have a plan in place to become carbon neutral, though, it does not incorporate carbon sequestration. This is not currently incorporated in the calculation of emissions or as a way to reduce them. The purpose of this future research will be to determine the amount of CO_2 emissions being offset by the carbon sequestration naturally occurring at all four of SUNY Cortland's properties.

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