Carbon and Carbon Dioxide Sequestration Estimates at Selected Trees for Canterbury Planting Sites

By

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GEOG309 Research for Resilient Environments and Communities

Research Project Report

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Executive summary

The growing urgency for climate change action and Aotearoa New Zealand’s (NZ) commitment to carbon

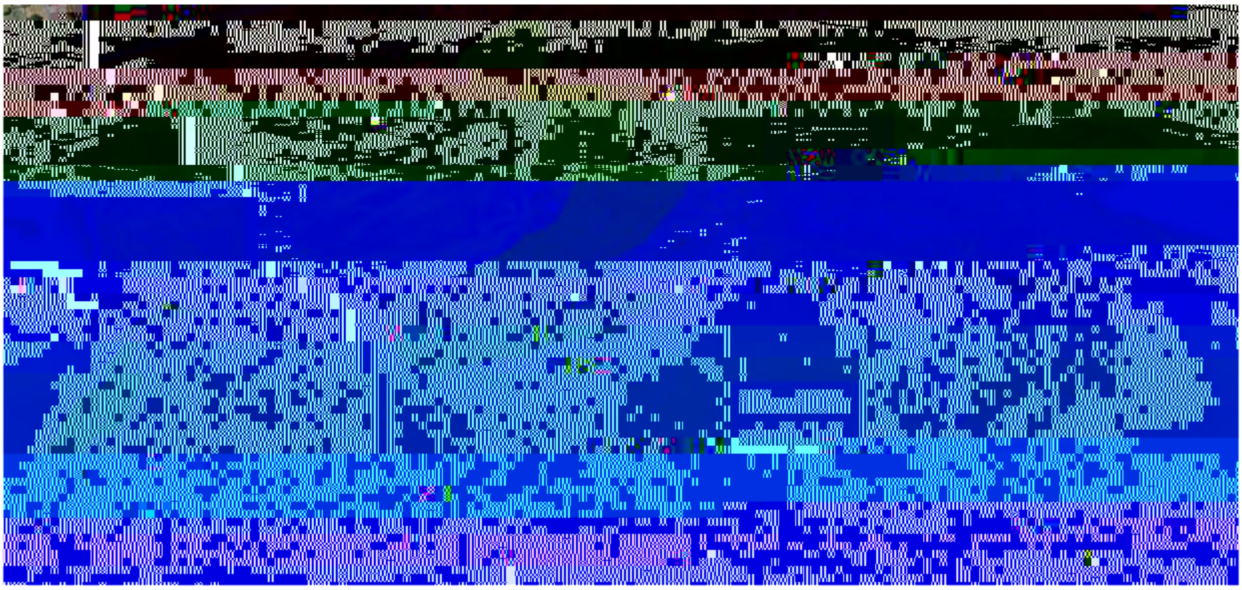

Figure 1. This image illustrates how the planting sites were divided up. The 10 x 10m sampling plot was where all samples and measurements were acquired. There were three sampling plots within SMR. These sampling plots are situated within a planting area.

Figure 7. TWR sampling plot 4, with randomly generated points.

3.2. Field work

The pre-recorded points were located in the field. The points were obtained within an estimated 1-2m error. However, due to the proximity of the points to each other and the dense overhead vegetation, up to a 5m error may be associated with each point. Once each point was located, the top 30cm of soil was sampled using an auger. This was completed for all five points within the sample plot. On occasion, issues were encountered with accessing the randomly selected sample points. At SMR there were occasions where only the first 15cm of the soil was obtainable as a result of obstructing stones. In some cases, the sampling point was completely inaccessible due to dense vegetation. A similar issue arose at CR, where vegetation was obscuring the soil at the sampling point location. In the case of these occurrences, an accessibility sampling method was utilised (Jensen & Shumway, 2010). However, four sampling points were not collected as they were completely unobtainable. This occurred at OR and TWR, where sampling points were located on a paved surface.

Soil samples were also obtained at each of the planting sites on unvegetated ground. This proved to be difficult given in most locations ground void of trees was scarce. Due to the locations also being available for public use, a large portion of unvegetated ground was paved over. At

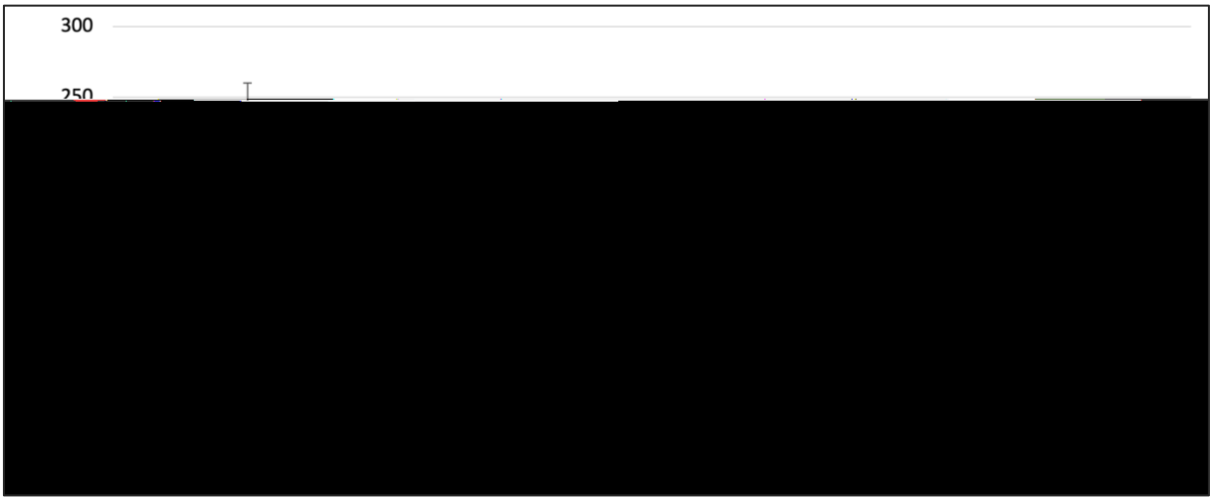

Figure 8. The soil C tonnage per hectare (t C/ha^{-1}) for each planting site. CR has the greatest C stock on a per hectare basis, followed by TWR, SMR and ŌR.

Figure 9 shows the tree biomass (AGB/BGB) C stocks per ha at each planting site. TWR and SMR had almost identical tree biomass C stocks of 19 and 18 t $C/ha^{-}1$, respectively. CR had the smallest tree biomass C stock of 8 t C/ha^{-1}.

4.2. Differences in carbon stocks between unvegetated areas

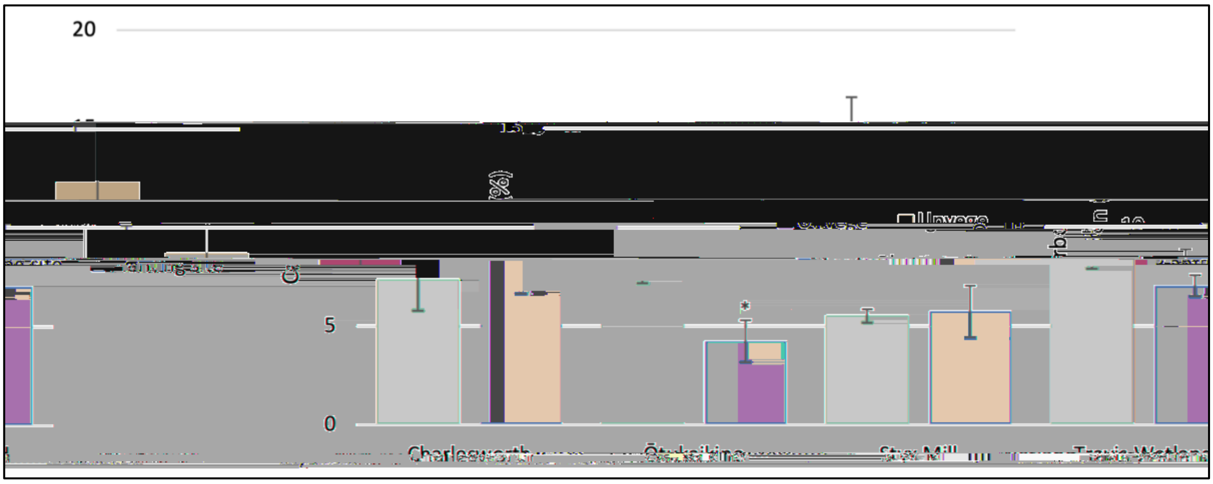

*Figure 10. Comparison between the SOC (%) measured between the four planting sites (green) and the nearby unvegetated areas (brown). * statistically significant difference at ŌR.*

4.3. Total C stocks and CO_2 sequestration estimates at the four planting sites

Table 1 shows the total C and CO_2 stocks at each planting site, as well as the size of each site. A clear trend in the data shows C and CO_2 stocks increase with increasing planting site size.

5. Discussion

The results showed variation in the total C stocks at the four selected TFC planting sites (Table 1). These variations were exp.025 140.05 71e31)

plantings is accounted for within the measurements. This means not all the C measured in the soil can be attributed to the plantings.

The use of secondary data from the Downie et al. (2019) was a key limitation for this project. This was particularly prevalent for the calculation of the BGB. Due to the simplicity of the parameters included in the authors' allometric equation, a more detailed analysis on the BGB could not be completed. The accessibility issues faced by the previous group also meant a portion of data could not be calculated within this project.

Furthermore, the results are based on a small number of samples when compared to the size of the TFC plantings. This may have introduced inaccuracies as broad assumptions were made based on the degree of representability the samples had for the entire planting site.

6. Conclusion

A total of 4,360 t C is stored across the four planting sites, which equates to a total of 15,987 t CO_2. The estimation of C stocks per ha at each site returned slightly higher values than many reported in the literature. This could be a consequence of aforementioned limitations, such as the small sample size or the SOM to SOC factor. However, at two of the four sites, nearby unvegetated areas exhibited a higher C stock than that of the planting sites. The literature deems this not uncommon due to the history of NZ's grasslands and the disruption of soil C catalysed by afforestation and reforestation.

Future recurring C stock measurements should be taken at the four TFC planting sites to track C sequestration rates as the sites age. The literature suggests the sites' C stocks could surpass neighbouring unvegetated areas once tree stands are older than 30 years. With the growing cruciality of native forests as sinks for rising C emissions, quantifying their impact is invaluable.

TFC have planted and donated over one million trees, with a goal of two million and beyond. The results of this research capture their impact at this moment in time, but the impact they are having toward NZ's C neutrality goal will continue to grow.

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References

Allen, D. E., Pringle, M. J., Page, K. L., & Dalal, R. C. (2010). A review of sampling designs for the measurement of soil organic carbon in Australian grazing lands. *The Rangeland Journal*, *32*(2), 227–246. DOI: 10.1071/RJ09043

Ausseil, A. E., Jamali, H., Clarkson, B. R., & Golubiewski, N. E. (2015). Soil carbon stocks in wetlands of New Zealand and impact of land conversion since European settlement. *Wetlands Ecology and Management*, *23*(5), 947–961. doi:10.1007/s11273-015-9432-4

Beets, P. N., Kimberley, M. O., Oliver, G. R., Pearce, S. H., Graham, J. D., & Brandon, A. (2012). Allometric equations for estimating carbon stocks in natural forest in New Zealand. *Forests, 3,* 818–839. doi: 10.3390/f3030818

Beets, P. N., Kimberley, M. O., Paul, T., Oliver, G., Pearce, S., & Buswell, J. (2014). The inventory of carbon stocks in New Zealand's post-1989 natural forest for reporting under the Kyoto protocol. *Forests*, *5*(9), 2230

Dean, W. E. (1974). Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. *Journal of Sedimentary Petrology*, *44*(1), 242–248.

Downie, R., Faris, J., Lam, H., & Shirley, L. (2019). *Estimation of carbon sequestration levels in Trees for Canterbury plantings.* Retrieved July 20, 2020, from https://canterbury.ac.nz/science/schools-and-departments/geog/community-engagement/

Jensen, R. R. & Shumway, J. M. (2010). Sampling our world. In B. Gomez & J. P. Jones (Eds.), *Research methods in geography: a critical introduction* (pp. 77–90). Wiley-Blackwell.

Li, Q., Jia, Z., Feng, L., He, L., & Yang, K. (2018). Dynamics of biomass and carbon sequestration across a chronosequence of Caragana intermedia plantations on alpine sandy land. *Scientific Reports, 8*(1). doi:10.1038/s41598-018-30595-3

MacDicken, K. G. (1997). *A guide to monitoring carbon storage in forestry and agroforestry projects.* USA: Winrock International Institute for Agricultural Development.

Manaaki Whenua. (2020, February 18). *Maps and Tools*. S-Map Online. https://smap.landcareresearch.co.nz/maps-and-tools/app/

Manning, P., de Vries, F. T., Tallowin, J. R. B., Smith, R., Mortimer, S. R., Pilgrim, E. S., Harrison, K. A., Wright, D. G., Quirk, H., Benson, J., Shipley, B., Cornelissen, J. H. C., Kattge, J., Bönisch, G., Wirth, C., & Bardgett, R. D. (2015). Simple measures of climate, soil properties and plant traits predict national-scale grassland soil carbon stocks. *The Journal of Applied Ecology, 52*(5), 1188–1196. doi:10.1111/1365-2664.12478

McLaren, R. G. & Cameron, K. C. (1996). *Soil Science*. Oxford University Press.

Minasny, B., Malone, B. P., McBratney, A. B., Angers, D. A., Arrouays, D.,