Institute for Sustainable Food Systems

Research Brief

From the Okanagan Bioregion Food System Project 2021

Impacts of Agricultural Production on Carbon Stocks in the Okanagan Bioregion

Authors:

Anna Rallings[1]
Kent Mullinix[2]*

[1]University of California-Merced, Merced, CA

[2] Institute for Sustainable Food Systems, Kwantlen Polytechnic University, Richmond, BC

*corresponding author:
kent.mullinix@kpu.ca

Abstract

The natural resources of the Okanagan bioregion include extensive areas of forest, shrub land and mixed grassland which provide valuable ecosystem services. Among these, carbon sequestration (stocks) on natural lands in the bioregion equates to 3.69MT, the equivalent of over 2.9 million vehicles driving in one year. The majority (72%) of these stocks are within woodlands, often on the hillsides and in the northern regions of the bioregion where forest cover is dense. The location, character and importance of these stocks should motivate regional land managers to strategically protect the most valuable areas of carbon stocks, particularly those within the reaches of agricultural development. The large lot acquisitions proposed in the Biodiversity Strategy are one such strategic program. Additionally, landowners can offset as much as 65% of carbon potentially lost to future land conversion to irrigated farmlands by establishing woody, perennial buffers such as hedgerows and riparian buffers. The Okanagan bioregion has an opportunity to implement climate smart planning around its agricultural lands and protect this vital, climate change mitigating resource.

Background

What are Carbon Stocks?

An ecosystem service is an ecological process that occurs naturally and benefits our communities and economy. Carbon storage is a valuable ecosystem service plants provide by pulling carbon from the atmosphere through the process of photosynthesis and storing it in their tissues (Chapin et al. 1990). Some carbon is stored above-ground in trunks, branches, and leaves, while others are stored below-ground in roots or in soil when the plant decomposes. The amount of carbon stored and how long it is stored depends on the species and its lifecycle, the characteristics of the soil it grows in, and land management. Woody perennial plants which survive and grow year after year can hold onto carbon for decades or even centuries, longer than many other forms of carbon storage (Morgan et al. 2010). This attribute of woody perennial plants makes trees and shrubs an invaluable sink for atmospheric carbon. This is referred to as carbon stocks (Chapin et al. 1990).

When land is converted from carbon-storing plants to farmland or urban development, the carbon stored in the wood is re-released into the atmosphere. The expansion of farmland poses a risk to forests and has the potential to cause the release of large quantities of carbon in many regions of the world (Chaplin-Kramer et al. 2015). The United Nations has initiated several programs, such as REDD+, to help countries collect data on their valuable carbon stocks and prevent deforestation due to human activity (Strassburg et al. 2010). Planting and maintaining non-production perennial vegetation (NPPV), such as hedgerows and riparian buffers on farmlands can help reduce the diminution of carbon stocks from agriculture while still allowing food to be produced (Schroeder, 1994). However, the protection of large, contiguous stands of forest are often key to preserving critical climate-mitigating carbon stocks (Rallings et al. 2019).

Carbon stock assessments measure the climate change mitigation potential of perennial vegetation as well as estimates the potential value of protecting land from conversion. Landscape-scale assessments of carbon stocks should be used as approximations due to the great variability of how carbon can be stored year to year. However, such estimates can provide insight into this undervalued service provided by natural lands and on-farm vegetation.

The Okanagan bioregion landscape is comprised of extensive interior Douglas fir and ponderosa pine forests, and unique valley-bottom mixed grassland habitats and riparian forests. Urban settlements occupy portions of the lowland. Much of the forest resources are dedicated to timber harvest and rangeland. Land conversion in highly arable areas of the Okanagan have resulted in the conversion of the mixed forest of these lowland areas, however, forests and mixed grasslands remain an extensive landscape element of Okanagan farmlands. In the future, urban expansion and agricultural production pressures will increasingly incentivize the conversion of natural lands to accommodate an expanding population and economy (OCCP & SOSCP, 2014). The extensive NPPV carbon stocks currently stored within the Okanagan's agricultural lands provide a valuable opportunity to preserve stored carbon and mitigate CO_2 emissions. Landowners and regional managers of protected agricultural lands (e.g the ALR) are in a unique position to preserve these critical stocks. The Grassland Conservation Council has taken some early steps in developing plans for grassland carbon and potential ecosystem service payments with future work to be done in mapping carbon and consulting with ranchers and farmers on how to best implement their management (Harrower 2014).

The objective of this indicator was to produce a snapshot of aboveground carbon storage for Okanagan bioregion farm and ranch lands, achieved through the fusion of several rich data sources. There have not been studies focused on landscape-wide carbon storage in this region and a better understanding of this ecosystem resource can support Okanagan-specific strategies to prevent deforestation and lead to integration of farm and ranch land carbon into future carbon management planning.

Measuring Carbon Stocks

Measures the amount of carbon stored in aboveground woody, non-production perennial vegetation such as trees and shrubs. This represents carbon that was previously in the atmosphere that is now stored in vegetation (biomass). Carbon stored in the soil and belowground portions of perennial vegetation is not accounted for in this project. Agricultural land and pasture can also store carbon in soil through sustainable practices, however, this complex dynamic is not included in the calculated carbon stocks for this project.

Methods

The study focused on the NPPV located on lands agriculture within the 2017 Agricultural Land Use Inventory (ALUI) and Agricultural Land Reserve (ALR) boundaries. Although extensive rangeland leases exist in addition to the surveyed ALUI/ALR area, the management and tenure of operators on these lands differs significantly from those within the ALUI/ALR and thus were not included in this estimate.

The 2017 Vegetation Resource Inventory (VRI, BC Ministry of Forests Lands and Natural Resource Operations 2017) was used as the basis for aboveground biomass estimates aligned with the 2017 ALUI/ALR. The carbon storage of each treed parcel within the VRI was calculated:

$$C = [\text{Primary Treed Species Biomass (all)}] \times [\% \text{ cover}] \times f$$

Where the dominant NPPV species biomass is converted using a factor (f) of 0.55 to account for the average percentage of carbon constituting plant biomass (Ponce-Hernandez, et al. 2004). The character of VRI stands was determined by mapping each parcel to the ALUI classification for each surveyed natural parcel.

To explore the impact of future land use scenarios, the study focused on the following agriculture futures (modeled scenarios):

1. **Baseline** - 2016 land cover with 2017 ALUI natural vegetation.
2. **Expand Land** - conversion of natural lands that are farmable and with access to irrigation water to agriculture.
3. **Mitigate Impacts** - conversion of natural lands that are farmable and with access to irrigation water to agriculture (same as above), with the addition of on-farm habitat enhancements through hedgerow and riparian buffer plantings where possible and retention of existing critical habitats.

VRI parcels were summarized by ALUI natural land cover class and Agricultural Land Capability (Kenk 1983; Agriculture and Agri-Food Canada 1998) and Conservation Ranks (Caslys Consulting Ltd. 2011) for analysis. On-farm enhancements (hedgerows and riparian buffers) for the Mitigate Impacts scenario were added to land cover maps, to replace cultivated land. Replacement mitigation covers were assigned a carbon value based on biogeoclimatic zone, wherein the average carbon value of natural land parcels of equivalent zones were used for the area of enhancement. In the case of Hedgerows, this carbon value was reduced by 30% to reflect the higher degree of management (e.g. pruning, thinning) that typically occurs with typical on-farm hedgerows (Czerepowicz et al. 2012).

Results and Discussion

In 2017, the Okanagan bioregion ALUI contained an estimated 3.69MT of carbon (MT C), equivalent to over 2.9 million cars driving for one year (Greenhouse Gas Equivalencies Calculator). The great majority of these stocks were located within the extensive forest parcels and patches (86%) (Figure 1). The mixed grassland regions were also a substantial component (13%) of the region's carbon stocks. The distribution of these stocks was moderated by the types of forest and grasslands located throughout the bioregion, with the density of carbon increasing towards the higher moisture northern areas of the region, and with increasing elevation. Interior Douglas fir (IDF) forests accounted for 43.5% of all carbon stocks. The North Okanagan, dominated by IDF forests, was a hotspot of carbon stocks, however, hillside parcels surrounding the Okanagan Valley typically exhibited higher carbon density (Figure 2).

Future deforestation of ALUI parcels poses a risk to approximately 13% of carbon stocks in the region- primarily due to the co-location of carbon with potentially arable land. The greatest component of that change is from the loss of woodlands and shrub lands (0.47MT C at risk from conversion). However, the carbon stock near wetlands and waterbodies are converted at the highest rate (76% and 26% at risk to conversion, respectively). In the Expand Land scenario, the expansion of agricultural production is limited due to the availability of irrigation water sources, however, the CO_2 emissions produced by the land conversion should be considered when planning for agriculture's growth in the bioregion. The character of critical carbon stock locations could aid in planning policy around land conversion.

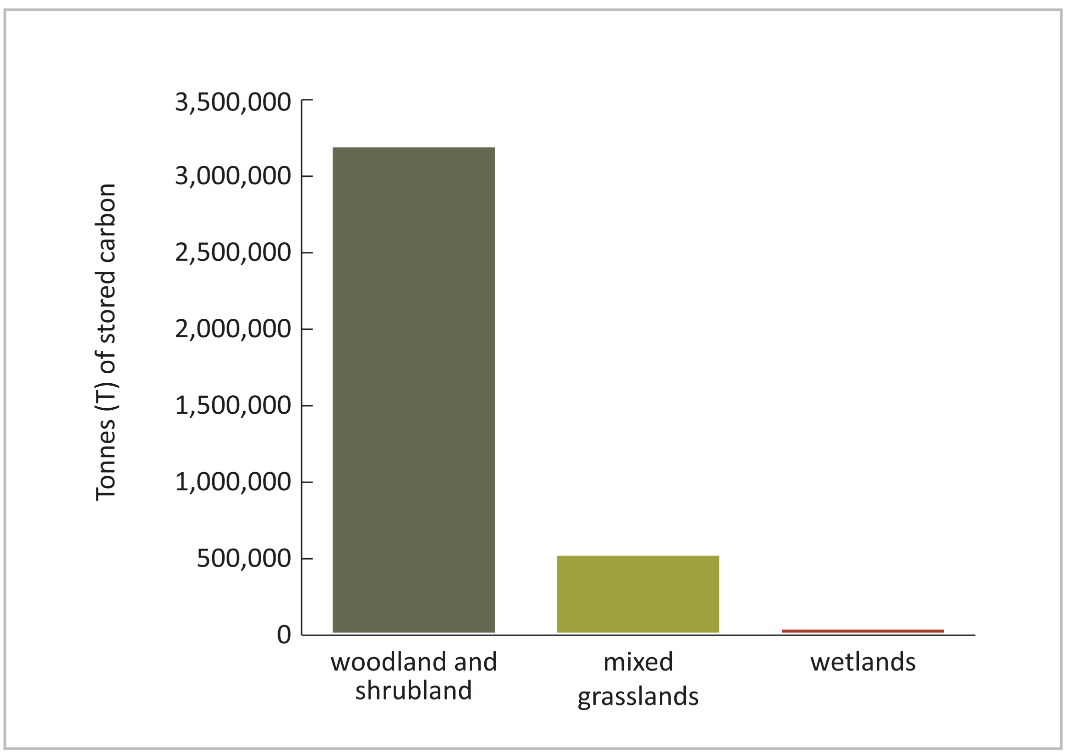

Figure 1: Tonnes of stored carbon in perennial vegetation in the Okanagan bioregion in baseline year 2016.

In the bioregion, 72% of the carbon stocks are in class 4-6 agricultural lands, with the majority (49%) in forests, and often on large, underdeveloped hillside parcels. In the bioregion, 69% of areas of high carbon value were concomitantly High and Very High Conservation Rank areas, and these critical hillside habitat parcels often border undeveloped natural and protected lands. Large carbon stocks are often co-located with other ecosystem services and robust ecosystems, making the protection of these large forests a multi-benefit investment. The Okanagan Biodiversity Strategy has proffered the purchase and protection of large tracts a potentially effective method of preventing deforestation and land conversion in these important contiguous forest parcels.

In addition to large tract conservation, on-farm enhancements can be integrated as a strategy to increase carbon, adding to their ecosystem services value. Hedgerows and Riparian Buffers increased farmland carbon by 5-6% in both the Baseline and Expand Land scenarios. Although this seems a small increase, the on-farm enhancements mitigated 8.5% of carbon loss due to conversion in the Expand Land scenario. Although large contiguous parcels of NPPV provide the greatest carbon storage potential, the carbon stored in on-farm enhancements are in addition to other services, such as wind breaks, water retention, and wildlife corridors (Bentrup 2008). Through existing programs, such as the Environmental Farm Plan, consideration for plantings which maximize carbon storage along with other functions would greatly benefit the Okanagan bioregion.

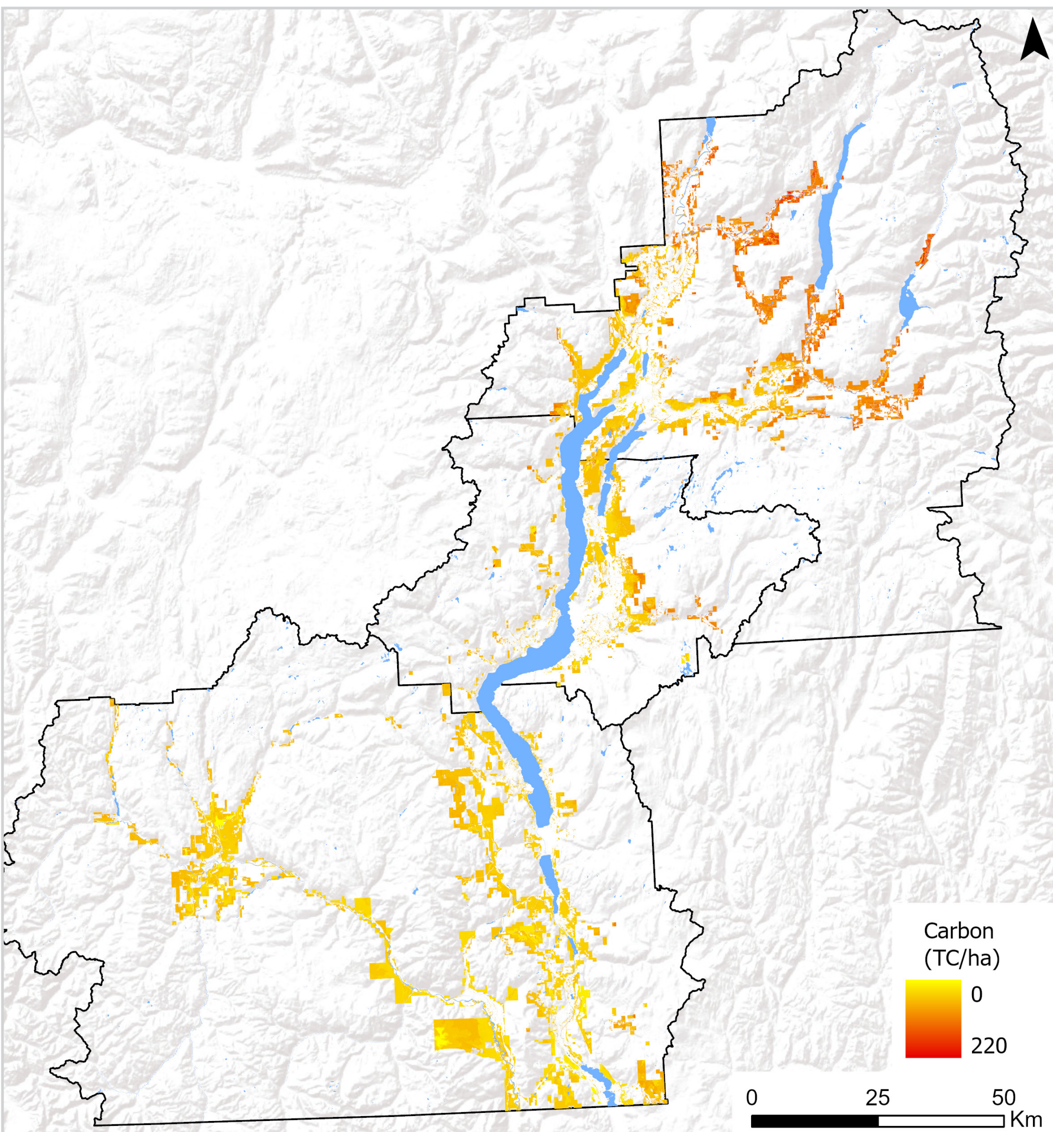

Figure 2: Distribution of mean carbon stocks per hectare on natural lands of the ALUI. The mean carbon increases along the north-south axis with greater forest density.

Although this assessment highlights the importance of uncultivated woody perennial stands for carbon storage (stocks), the contribution of soil carbon should not be discounted. Globally, it is estimated that soil retained carbon accounts for 34% of the earth's carbon stocks and grassland vegetation is particularly adept at retaining soil carbon, storing on average 100-300 TC/ha (Wilson 2009). These estimates are comparable with medium to high carbon densities in woody perennial NPPV in the bioregion. However, the analysis of this carbon sink poses a significant challenge due to the influence of many site-specific factors, both natural and human-influenced, such as farmland management and crop production practices. Although soil carbon can be measured directly through sampling, landscape-scale estimates require datasets not currently available for the bioregion. There have been strides to measure soil carbon in other regions (e.g. Paul et al. 2020), and future research should be conducted to fill this important gap.

Conclusion

The Okanagan bioregion contains highly productive and important agricultural and natural lands. In the future if farmlands expand, land conversion from forests and grasslands will be an inevitable consequence. With thoughtful, informed planning accounting for the numerous critical services provided by natural lands, the region can strategically implement policies and practices to protect the most valuable parcels within the ALUI/ALR to mitigate carbon emissions as well as preserve the myriad other benefits provided by natural lands. Based on the assessment reported herein, specific large lot land acquisitions, such as those proposed in the Biodiversity Strategy, alongside on-farm enhancements to mitigate carbon loss from expanding farmlands, will preserve the robust natural resources of the Okanagan. The economic and environmental valuation of carbon stocks in land use planning can result in tangible benefit to landowners, communities, and local governments. With increased data and analysis, the Okanagan bioregion can concurrently identify similar strategies for soil carbon stock preservation and enhancement on its farm and ranch lands.

Suggested Citation

Rallings, A., K. & Mullinix. (2021). Impacts of Agricultural Production on Carbon Stocks in the Okanagan Bioregion. Research Brief from the Okanagan Bioregion Food System Design Project. Richmond, British Columbia: Institute for Sustainable Food Systems, Kwantlen Polytechnic University.

References

Agriculture and Agri-Food Canada. 1998. "Canada Land Inventory, National Soil Database." Ottawa, Ontario. http://sis.agr.gc.ca/cansis/nsdb/cli/index.html.

BC Ministry of Forests Lands and Natural Resource Operations. 2017. "Vegetation Resource Inventory 2017." https://catalogue.data.gov.bc.ca/dataset/02dba161-fdb7-48ae-a4bb-bd6ef017c36d.

Bentrup, G. 2008. "Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways." General Technical Report SRS-109. Lincoln, NE.

Caslys Consulting Ltd. 2011. "Keeping Nature in Our Future: Volume 1 - A Biodiversity Conservation Analysis for the South Okanagan-Similkameen Region."

Chapin, F . Stuart III, Ernst-Detlef Schulze, and Harold A Mooney. 1990. "The Ecology and Economics of Storage in Plants." Annual Review of Ecology and Systematics 21: 423–47.

Chaplin-Kramer, Rebecca, Richard P. Sharp, Lisa Mandle, Sarah Sim, Justin Johnson, Isabela Butnar, Llorenç Milà i Canals, et al. 2015. "Spatial Patterns of Agricultural Expansion Determine Impacts on Biodiversity and Carbon Storage." Proceedings of the National Academy of Sciences 112 (24): 7403–7. doi:10.1073/pnas.1406485112.

Czerepowicz, L., B.S. Case, and C. Doscher. 2012. "Using Satellite Image Data to Estimate Aboveground Shelterbelt Carbon Stocks across an Agricultural Landscape." Agriculture, Ecosystems & Environment 156 (August). Elsevier B.V.: 142–50. doi:10.1016/j.agee.2012.05.014.

Harrower, William. 2014. "Examining Monitoring Strategies and Synergies for Grassland Soil Carbon and Rangeland Forage Production in British Columbia: First Steps In Establishing A Payment For Ecosystem Services Program For Soil Carbon."

Kenk, Evert. 1983. Land Capability Classification for Agriculture in British Columbia. Kelowna, BC. http://www.env.gov.bc.ca/wld/documents/techpub/moe1/moem1.pdf.

Morgan, J. A., R. F. Follett, L. H. Allen, S. Del Grosso, J. D. Derner, F. Dijkstra, A. Franzluebbers, R. Fry, K. Paustian, and M. M. Schoeneberger. 2010. "Carbon Sequestration in Agricultural Lands of the United States." Journal of Soil and Water Conservation 65 (1): 6A-13A. doi:10.2489/jswc.65.1.6A.

Okanagan Collaborative Conservation Program, and South Okanagan Similkameen Conservation Program. 2014. "Keeping Nature in Our Future: A Biodiversity Conservation Strategy for the Okanagan Region," 1–69. http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=42389.

Paul, S S, L Dowell, N C Coops, M S Johnson, M Krzic, D Geesing, and S M Smukler. 2020. "Tracking Changes in Soil Organic Carbon across the Heterogeneous Agricultural Landscape of the Lower Fraser Valley of British Columbia." Science of The Total Environment 732: 138994. doi:https://doi.org/10.1016/j.scitotenv.2020.138994.

Ponce-Hernandez, Raul, Parviz Koohafkan, and Jacques Antoine. 2004. "Assessing Carbon Stocks and Modelling Win-Win Scenarios of Carbon Sequestration through Land-Use Changes." Rome, Italy.

Rallings, A.M., S.M. Smukler, S.E. Gergel, and K. Mullinix. 2019. "Towards Multifunctional Land Use in an Agricultural Landscape: A Trade-off and Synergy Analysis in the Lower Fraser Valley, Canada." Landscape and Urban Planning 184. doi:10.1016/j.landurbplan.2018.12.013.

Strassburg, Bernardo B.N., Annabel Kelly, Andrew Balmford, Richard G. Davies, Holly K. Gibbs, Andrew Lovett, Lera Miles, et al. 2010. "Global Congruence of Carbon Storage and Biodiversity in Terrestrial Ecosystems." Conservation Letters 3 (2): 98–105. doi:10.1111/j.1755-263X.2009.00092.x.

Wilson, SJ. 2009. "The Value of BC's Grasslands: Exploring Ecosystem Values and Incentives for Conservation. Grasslands Conservation Council of British Columbia." https://bcgrasslands.org/wp-content/uploads/2017/06/bc_grasslands_value_wilson_21aug09.pdf.

About the Institute for Sustainable Food Systems

The Institute for Sustainable Food Systems (ISFS) is an applied research and extension unit at Kwantlen Polytechnic University that investigates and supports sustainable agriculture and regional food systems as key elements of sustainable communities. We focus predominantly on British Columbia but also extend our programming to other regions.

Our applied research focuses on the potential of regional food systems in terms of agriculture and food, economics, community health, policy, and environmental integrity. Our extension programming provides information and support for farmers, communities, business, policy makers, and others. Community collaboration is central to our approach.

About the Okanagan Bioregion Food System Project

Communities and governments are increasingly looking to strengthen regional food systems as a way to address many complex agriculture and food challenges. The Okanagan Bioregion Food System Project explores the social, economic, and ecological outcomes of a regional food system in the Okanagan. This multidisciplinary research project, initiated by ISFS and regional partners, can guide conversations among communities and decision-makers seeking to advance their regional food system.

The Okanagan Bioregion Food System Project considers and builds upon existing food system planning and other related work to support local and regional food systems in the bioregion.

For the full report and more research briefs visit: www.kpu.ca/isfs/okanagan-bioregion

Project Funders

real estate foundation BRITISH COLUMBIA

REGIONAL DISTRICT RDOS OKANAGAN-SIMILKAMEEN

CENTRAL OKANAGAN FOUNDATION empowering generations to give.

Interior Health Every person matters

Canada Green Corps | Brigade verte du Canada

REGIONAL DISTRICT NORTH OKANAGAN

KPU