FINAL

Biological Carbon Sequestration Study

Comox Valley Regional District, British Columbia

Prepared for:

The Comox Valley Regional District
770 Harmston Avenue
Courtenay, BC V9N 0G8

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EXECUTIVE SUMMARY

The Comox Valley Regional District (CVRD) in British Columbia (BC) retained Pinchin Ltd. (Pinchin) to conduct this Biological Carbon Sequestration Study (the Project) under project number CVED-24-031.Comox Valley Regional District, British Columbia Pinchin assessed carbon sequestration potential across various land and water types within CVRD jurisdiction (Figure 1). The Project was part of the CVRD's Corporate Energy and Emissions Plan and intended to support decision-making in enhancing and protecting existing regional biological carbon sequestration in order to offset corporate emissions and support community climate action.

Biological carbon sequestration is the process by which atmospheric carbon dioxide (CO_2) is absorbed by plants, soils, and aquatic systems, and stored as carbon in biomass, such as trees, other plants, animals, and fungi, and in soils and sediments. Those natural processes help reduce and regulate overall concentration of CO_2 in the atmosphere, with our understanding of them thereby contributing to the global effort to combat climate change.

In this study, we categorized the region into different land types or ecosystems. We assessed the baseline carbon sequestration rates, looked at ways to improve carbon sequestration within those land types, modelled the amount of carbon being sequestered annually and the amount that could be sequestered if certain strategic actions were taken, and assessed how much carbon is currently embodied in each land type.

Results of the modelling output indicated that biological carbon sequestration rates are four times higher than the annual 2021 CVRD community-wide greenhouse gas (GHG) emissions inventory, when logging is not considered. Results also show that the embodied carbon within CVRD ecosystems equals over 700 years of CVRD community-wide emissions at 2021 levels. As such, biological carbon sequestration plays an important role in the carbon cycle of the region.

Protecting existing forests and promoting reforestation and afforestation initiatives will be essential in maximizing the sequestration potential of habitats in the CVRD. Protecting and restoring salt marshes will also play a role. Numerous strategies have been suggested including to do with agriculture and water

quality management. The key strategies to enhance carbon biosequestration in the region are outlined below:

1. **Forest Preservation**: Protecting existing forests, especially larger forest stands from development or permanent removal is the number one priority for the CVRD to retain existing stored carbon and enhance biosequestration:
   a. **Better Environmental Data and Planning:** Better lidar data in the CVRD or other forest tree size data sets would be valuable in making more informed decisions. Creating a more holistic Environmental Plan for the region, that considers ecological, hydrogeological, watershed, community needs, as well as carbon considerations would be beneficial prior to making land management decisions based solely on carbon sequestration alone.
   b. **Forest Land Protection:** Forests, particularly larger tree stands, should be protected in order to retain larger stores of carbon and ensure continued sequestration. This may be accomplished through land acquisition or other means of more permanent conservation.
   c. **Forest Lands Policy Development:** Practical policy and legislative changes to promote afforestation and dissuade or restrict permanent tree removal and forest soil removal should be considered. Many municipalities restrict forest canopy removal using tree cutting bylaws and soil movements with soil bylaws. While the CVRD does not have the authority to implement a tree cutting bylaw, other planning tools may be useful in protecting these valuable carbon sinks, e.g., through the creation of a Development Permit Area.
2. **Salt Marsh Preservation and Restoration:** Approximately 70% of salt marsh areas have been lost, presenting a significant opportunity for restoration and protection of existing salt marshes. Seen as they have a high carbon sequestration potential per hectare, and there are already initiatives underway, supporting salt marsh restoration and ensuring protection of salt marsh areas is important for carbon sequestration.

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KEY DEFINITIONS

- Embodied Carbon: In the context of ecosystems, this refers to the carbon stored in long-lived biomass such as trees and soils.
- Sequestered Carbon: Carbon that has been captured from the atmosphere and stored in a stable form within vegetation, soils, sediments, or aquatic systems over a long period. This process reduces the concentration of CO_2 in the atmosphere and contributes to climate change mitigation.
- Emissions: The release of greenhouse gases, particularly carbon dioxide (CO_2), into the atmosphere from natural processes (e.g., respiration, decomposition) and human activities (e.g., fossil fuel combustion, land use change).
- Coastal Squeeze: A process where coastal habitats such as salt marshes and mudflats are trapped between rising sea levels and fixed human infrastructure (e.g., seawalls, urban development), preventing their natural inland migration and leading to habitat loss.
- Green Infrastructure: A network of natural and semi-natural systems—such as wetlands, forests, green roofs, and riparian buffers—that provide ecosystem services including stormwater management, air and water purification, and carbon sequestration, while supporting biodiversity and climate resilience.

1.0 INTRODUCTION

The Comox Valley Regional District (Client) in British Columbia (BC) retained Pinchin Ltd. (Pinchin) to conduct this Biological Carbon Sequestration Study (the Project) under project number CVRD-24-031. Pinchin assessed the CVRD's carbon sequestration potential across various land and water types within CVRD jurisdiction (Figure 1) as a part of CVRD's Corporate Energy and Emissions Plan intended to support decision-making in enhancing and protecting existing regional biological carbon sequestration.

The CVRD's Corporate Energy and Emissions Plan (CEEP), adopted in 2023, sets a baseline for corporate greenhouse gas (GHG) emissions, and aims to reduce emissions to net zero by 2050, meaning a 90% reduction from 2019 GHG emissions levels, with the remainder offset or neutralized. Given the urgent need to address global GHG emissions, the plan highlights the benefits of protecting local natural areas that offer significant carbon sequestration benefits. The CVRD has developed a Strategic Plan for its Regional Parks and Trails Service and intends to develop a Land Acquisition Strategy to direct decision making on land acquisitions for regional parks and trails, which could be a useful tool to protect valuable forest lands from logging or development through the purchase of parkland. In addition to the strategies outlined in this study, the regional district's ongoing initiatives—such as the Agriculture Plan and Planning and Development Services' efforts to protect sensitive ecosystems—should be recognized and leveraged as complementary pathways for enhancing carbon sequestration across the region. With biological carbon storage identified as a decision-making criterion, this Project aims to better understand the baseline information and factors that affect carbon sequestration in various ecosystems and identify regional opportunities to enhance the benefits of carbon sequestration, protect natural areas, and contribute to the overall reduction of greenhouse gas emissions.

2.0 WHAT IS BIOLOGICAL CARBON SEQUESTRATION?

Biological carbon sequestration is the process by which atmospheric carbon dioxide (CO_2) is absorbed by plants, soils, and aquatic systems, and stored as carbon in biomass, such vegetation, animals, and fungi, and in soils and sediments. These natural processes help reduce and regulate the overall concentration of CO_2 in the atmosphere, and our understanding of them can contribute to the global effort to ameliorate effects of climate change.

Carbon sequestration is dynamic. Within different land types and ecosystems, there is an interplay of both carbon sequestration into biomass and substrates and release due to decay and degradation, and that process varies seasonally and over time. At the ecosystem level annually, scientific data are available that make it possible to predict and quantify overall annual carbon sequestration rates and embodied carbon within different ecosystems in the CVRD.

It is important to distinguish between annual sequestration rates—the amount of carbon absorbed and stored by ecosystems each year—and embodied or sequestered carbon, which refers to the cumulative carbon stored over time in biomass and substrates. While annual sequestration contributes to the buildup of embodied carbon, this stored carbon remains vulnerable to release through human activities such as logging, land development, or disturbance. Therefore, the dual objective of carbon management is to increase the annual rate of sequestration and to protect existing embodied carbon stocks from loss or degradation.

Our understanding and quantifying of carbon cycles in natural biological systems can be used to better predict anticipated carbon emissions or sequestration rates related to land and water management changes, thus enabling climate-informed decisions in our communities.

Photo 1 - Agriculture stores substantial carbon in its soils.

3.0 PROJECT SCOPE

The study included assessment of current biological carbon sequestration within the CVRD and identification of opportunities for retaining or enhancing carbon sequestration. The primary objectives are to:

- **Identify and classify ecosystems** within the CVRD that have significant potential for carbon sequestration.
- **Analyze factors** influencing the biological carbon storage capacity of these ecosystems, including soil properties, vegetation types, human factors, and climatic conditions.
- **Identify management strategies** aimed at protecting embodied carbon and optimizing carbon sequestration while maintaining ecological health and resilience.
- **Quantify the carbon sequestration potential** of various management scenarios through advanced modelling techniques.
- **Engage CVRD staff** to provide different perspectives and input, encourage knowledge sharing and inform recommended strategies.

4.0 APPROACH

To achieve the objectives of this Project, Pinchin adopted a methodology encompassing five steps:

1. Ecological Mapping and Classification;
2. Analysis of Factors Affecting Biological Carbon Storage Capacity;
3. Identification of Land Management Strategies for Protecting and Optimizing Carbon Sequestration;
4. Quantification of Carbon Sequestration Potential and Scenario Modelling, and
5. Interest Holder Engagement.

Based on the above five steps, Pinchin developed insights and key recommendations.

4.1 Ecological Mapping and Classification

The first step involved high-level ecological mapping to identify and classify the different land and water types within the Comox Valley Regional District (CVRD). Using Geographic Information System (GIS) technology, we mapped the region to categorize areas into key land classifications: Agricultural Land, Aquatic Bodies, Developed Land, Forests, and Low Vegetative Cover. Each classification was further divided into sub-categories as needed, based on the data collected.

This mapping and classification provided a foundational understanding of the region's ecological landscape and its current carbon sequestration capacity. By assessing the ecological characteristics of each land type, we established a baseline that reflects current conditions and identifies areas with the highest potential for enhanced carbon storage. This foundational step set the stage for targeted management recommendations tailored to the unique characteristics of each ecosystem type.

4.2 Analysis of Factors Affecting Biological Carbon Storage Capacity

After mapping and classifying the land types, Pinchin conducted a detailed analysis to identify the factors that affect the biological carbon storage capacity of each ecosystem. This step involved understanding the mechanism through which the carbon is sequestered, and evaluating how various environmental, anthropogenic, and management factors influence carbon sequestration in each land classification. From an extensive list of factors, Pinchin prioritized those with the highest potential for actionable implementation and maximum biosequestration potential.

Key factors assessed included:

- **Land Cover**: Understanding how vegetation, fauna, soils, sediment, land cover, and land use practices influence carbon capture and sequestration rates in different ecosystems.

- **Habitat Health**: Analyzing conditions that affect carbon retention, including agricultural, riparian, forested, rivers and lakes, and marine areas. We compared the functions of degraded areas to restored areas to understand their influence on sequestration potential.
- **Aquatic Carbon Dynamics**: Evaluating freshwater, estuarine, and marine coastal systems to assess their carbon storage potential. Particular attention was given to seagrasses, salt marshes, and mudflats due to their high performance in carbon sequestration, while also assessing other aquatic and marine biota.
- **Climate Impacts**: Assessing the role of regional climate conditions, such as precipitation and temperature variations and predicted trends, on carbon sequestration rates and ecosystem types. We also considered how ocean rise (e.g., coastal squeeze) might affect future habitats within the CVRD in relation to carbon sequestration.
- **Human Activity and Development**: Considered the effect of urban development on carbon sequestration rates and identifying opportunities for green infrastructure.

This comprehensive analysis provided insights into the factors that influence carbon storage efficiency and helped inform the development of targeted land management strategies.

4.3 Development of Land Management Strategies for Optimizing Carbon Sequestration

Based on findings of our analysis, we developed land-management strategies tailored for each identified ecosystem type. This step involved defining best practices and recommended actions to optimize carbon sequestration across various land classifications. Pinchin focussed on best management practices and strategies that were based on scientific evidence and tailored to the specific ecological and management conditions of each land type within the CVRD.

Key components of this step included:

- **Forest Management**: Recommendations for sustainable forestry practices, reforestation, and forest conservation efforts to maximize carbon storage in forested areas and watersheds. Given the extensive forested land within the CVRD, this was an important consideration.
- **Carbon Storage Enhancement**: Strategies for protecting and restoring aquatic ecosystems, including freshwater and marine coastal areas, with a particular focus on tidal salt marshes, seagrass meadows, and mudflats, due to their high carbon storage rates. Pinchin also identified opportunities for enhancing carbon sequestration within mitigation strategies to adapt to coastal squeeze changes (e.g., green infrastructure).

- **Agricultural Best Practices**: Guidance on regenerative agriculture, soil conservation, and land-use changes aimed at increasing carbon storage in farming areas.
- **Urban and Hardscape Solutions**: Recommendations for integrating green infrastructure and urban reforestation to mitigate the adverse effects of developed areas on carbon sequestration.

4.4 Quantification of Carbon Sequestration Potential and Scenario Modelling

Pinchin conducted modelling at a high-level using available data and known or literature value sequestration rates, to quantify the current and potential carbon sequestration capacity of each land classification under both existing and recommended management practices. If literature values were not congruent with understanding or conceptual model, they were adjusted for parity with other known values. Pinchin referred to an extensive range of documentation and existing peer-reviewed studies to derive factors, fine-tuned some site-specific variables, and provided possible combination of factors that provided maximum carbon sequestration retention or gains in relation to efforts. This step involved calculating the typical carbon sequestration rates for each ecosystem type and modeling the impact of applying optimized management strategies across the region.

The calculations included three main categories:

- **Baseline Carbon Sequestered per Land Type**: Estimates of annual carbon storage rates per hectare for each land classification under current management practices.
- **Land Management Carbon Sequestration Optimization**: Total potential additional carbon sequestration rate, assuming recommended strategies are applied across all relevant land types within the CVRD.
- **Embodied Carbon per Land and Water Type**: Estimated existing storage of carbon in each land type were provided.

4.5 Interest-Holder Engagement

The results of the technical analysis will serve as the foundation for engaging with CVRD interest holders to discuss potential land acquisitions, management strategies, and policy recommendations. Pinchin will present the findings in a clear, actionable format, highlighting the key insights of the work as well as the most promising opportunities for the CVRD to enhance biological carbon sequestration. This information will build awareness and inform and allow for alignment of this work with existing initiatives within the CVRD.

Photo 2 - Salt Marsh has the second highest carbon sequestration rate in the CVRD, with forests ranking first.
(Photo by Tim J. Clermont, Guardians of Our Salish Estuaries Society)

5.0 RESULTS

5.1 Ecological Mapping and Classification

Pinchin mapped out the high-level land types or ecosystems within the CVRD (See Appendix I – Figure 3). The map detailed the region's ecological landscape, categorizing it into key classifications such as Agricultural, Aquatic, Asphalt, Building, Forest, Forest Regeneration (less than 5 years), Alpine Meadows, and Subalpine and Montane Grasslands. This map served as a critical tool for identifying areas with the highest potential for enhanced carbon storage and highest actionability for strategies. Based on the identification of the highest carbon sequestration land types (forest and aquatic), additional maps breaking down these land types into sub-ecosystems were created (see Appendix I – Figures 4 and 5). As part of the deliverables for this project, a georeferenced electronic map output with associated meta-data of both the baseline sequestration rate and embodied carbon amount per hectare will be provided to the CVRD.

5.2 Analysis of Factors Affecting Biological Carbon Storage Capacity

To help identify the best possible ways to sequester carbon using land management techniques, a long list of potential land management techniques was identified and considered that could help sequester carbon. The results of this analysis were compiled into a comprehensive Table of Factors Affecting Carbon Biosequestration (see Appendix II) for each land classification identified in the previous step. This table detailed the factor type, its description, the mechanism through which carbon is sequestered, the bio-sequestration potential within that factor, and its actionability for the CVRD, and how climate change may affect the land class. This deliverable provided critical insights into the key drivers of carbon storage capacity, enabling targeted strategies for enhancing biological carbon sequestration across the CVRD in the next step.

5.3 Land Management Strategies for Optimizing Carbon Sequestration

Based on the factors significantly influencing carbon sequestration for land classifications identified in Step 2 and their high actionability, this section expands on the mechanism through which carbon sequestration is affected, and sets forth strategies tailored to optimize carbon sequestration by focussing on best practices, recommended actions, and policy considerations.

The five land classifications addressed in this section are:

1. **Agricultural Land**: Carbon sequestration in agricultural soils through sustainable farming practices;
2. **Aquatic**: Carbon storage in aquatic plants, algae, and sediments of freshwater, coastal, and marine ecosystems;
3. **Developed Land**: Urban and hardscape land class focussing on urban forestry, green infrastructure, and sustainable urban planning;
4. **Forests**: Preservation and management of forests for carbon storage, classified into three categories: older than 250 years, between 5 and 250 years, and having trees less than 5 years old; and
5. **Low Vegetative Cover**: Enhancing carbon sequestration through restoration and sustainable grazing practices across grasslands and shrubs.

More detailed options and actions for optimizing carbon sequestration across these land classifications are provided in Appendix II. It includes defining best practices, recommended actions, factors that most affect carbon sequestration, steps to improve considering these factors, the influence of best practices, identifying gaps in understanding, and exploring policy partnership advocacy, volunteering, grant funding, and land purchases to influence carbon sequestration.

By implementing the strategies and actions outlined in this document, we can enhance carbon sequestration, contribute to mitigating climate change, and promote sustainable land management practices across various ecosystems. This approach will not only help reduce atmospheric CO_2 levels but also improve ecosystem health, biodiversity, and resilience across the CVRD.

5.4 Carbon Sequestration and Storage

Pinchin developed a high-level model using mapping land type areas, known and customized baseline sequestration rates, fine-tuned with sequestration rate factors, to quantify the current and potential carbon sequestration capacity of each land classification. The results included estimations of carbon storage rates per hectare for each land classification under current and proposed management practices, and evaluations of different land management strategy scenarios to identify the most effective approaches for enhancing carbon storage. The model also estimates embodied carbon within each land type, to provide context and comparisons for sequestration rates to total sequestered carbon within ecosystems (see Appendix III). Keep in mind that the model output and factors used in this report are static representations of a dynamic system over varied land types. While they will not match all areas within a land type, they are considered order of magnitude representative of the land category for the purpose of the CVRD making carbon sequestration informed land management decisions. For future projects or land acquisitions, more detailed, site-specific carbon assessments should be undertaken to ensure that carbon sequestration opportunities are fully understood and integrated; project proponents are encouraged to evaluate the carbon implications of their initiatives by applying localized data, ecosystem-specific modeling, and management strategies aligned with regional carbon goals or objectives.

Modelling results for the key habitat types with respect to carbon sequestration and potential strategies are shown in the pictogram image below. Where sequestration rates are show as a small pink semi circle representing carbon dioxide equivalent, per hectare per year and actual carbon stored per hectare is show as a larger red semi-circle. From this pictogram it is clear that forests and salt marsh have both the highest sequestration rates as well as the highest volumes of stored carbon on a per hectare basis.

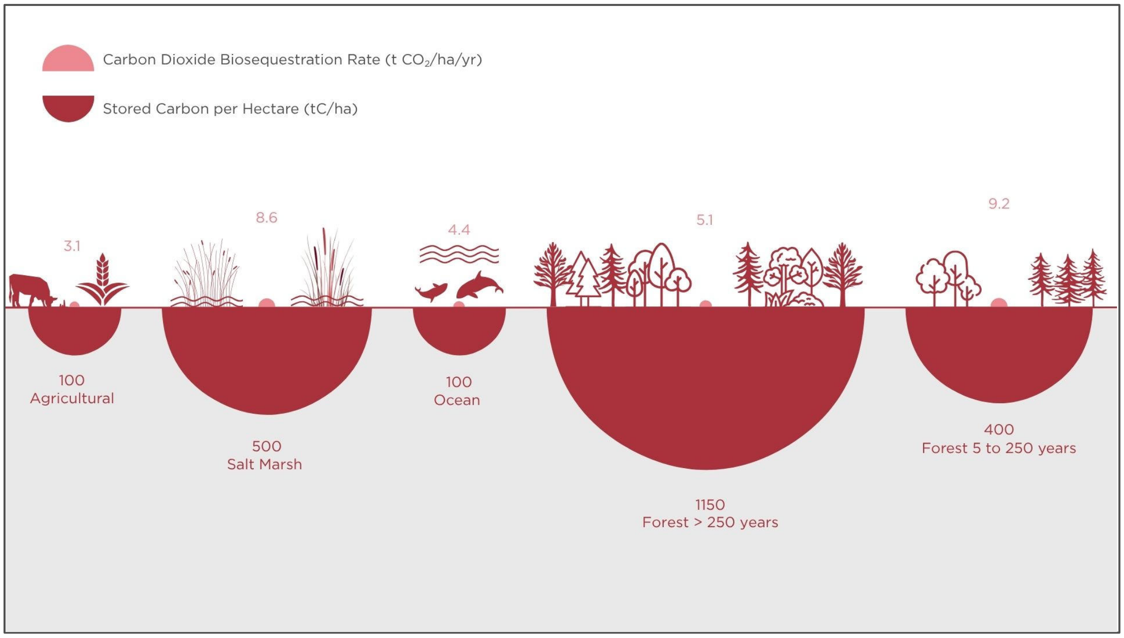

Figure 1 - Carbon sequestration and storage are dependent on soil type, vegetation, and climate. Wetter and colder conditions enhance retention, while disturbances such as deforestation and fires release carbon back into the atmosphere. This figure highlights the importance of stored carbon compared to the annual sequestration rate.

The next section will analyze the results in a few different ways to help clarify key recommendations where efforts can realize the most amount of carbon sequestration and storage.

6.0 DISCUSSION AND INSIGHTS

Modelling work highlighted the relative sequestration rates of the various land types within the CVRD. It identified the potential magnitude of actions related to optimization of carbon sequestration through implementation of different high potential strategies. It also identified the estimated embodied carbon stored in the different land types within the CVRD.

Modelling enabled us to provide context for the importance of biosequestration in the CVRD. Two key contextual findings include:

1. Biological carbon sequestration rates are approximately four times greater than the annual 2021 CVRD emissions inventory[1].
2. Embodied carbon within CVRD ecosystems is approximately equal to over 700 years of CVRD emissions (at 2021 levels, based off 2021 Emissions Inventory).

These findings underscore the important role of carbon sequestration in local climate action. While these ecosystems have long existed and historically contributed significantly to carbon storage, their continued

[1] Note that 2021 CVRD emissions inventory did not consider emissions associated with the logging industry within the CVRD.

protection and enhancement remain essential. However, it is equally important to recognize that stored carbon is vulnerable to release through human activities such as logging and land changes such as development. Therefore, while biological sequestration supports climate mitigation, it must be pursued in tandem with broad-based fossil fuel emission reductions to meet community-wide climate goals.

As such, optimizing carbon sequestration will be a combination of enhancing sequestration rates through carefully considered management techniques and incentives and protecting embodied carbon. Actions to enhance and protect ecological health and carbon sequestration are often synergistic.

It is helpful to look at the biosequestration in a few different ways:

- Annual biosequestration rate per unit of land area (per hectare in this report);
- Annual overall biosequestration rate per habitat type;
- Carbon storage per unit of land area (per hectare); and
- Overall carbon stored per habitat type.

The above information will provide context for how much carbon is being sequestered in the CVRD. Later in this section, we will look at how different strategies enhance carbon sequestration within each habitat type.

The annual biosequestration rate per unit of land area is shown in figure 2 below. Forests aged 5–250 years and salt marshes have the highest annual carbon sequestration rates—between 9.2 and 8.6 tonnes CO_2 equivalents per hectare. Other habitats sequester 3.1–5.1 tonnes per hectare per year. Developed land is assumed to have zero sequestration and is excluded from these charts.

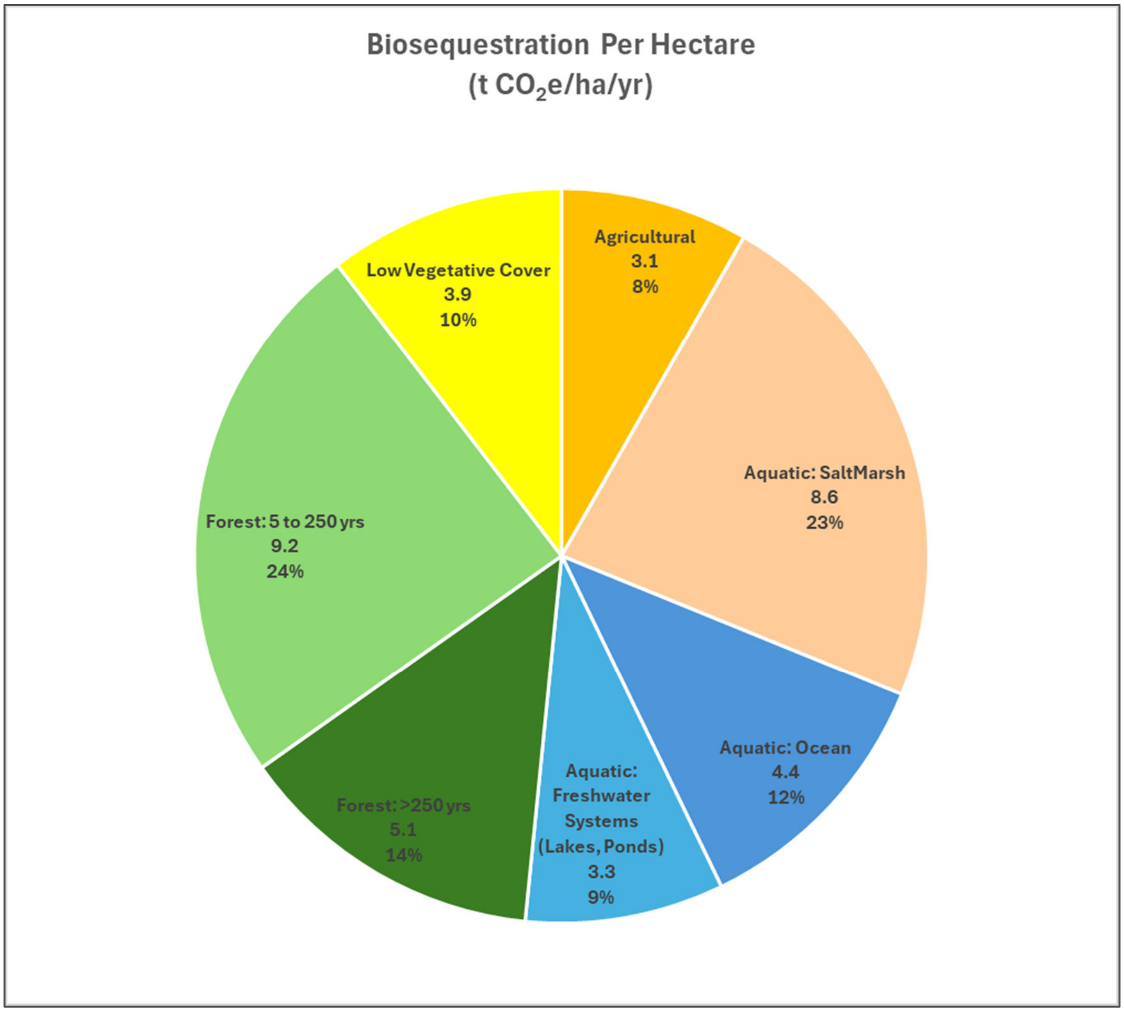

Figure 2 - The annual biosequestration rate per unit of land area for each habitat type in the CVRD. Note that forests less than 5 years are not shown in this chart as they have a net negative sequestration rate (due to soil loss).

The annual overall biosequestration rate per habitat type is shown in figure 3. Forests aged 5–250 years are by far the greatest overall at 64% of overall sequestration, due to the large land mass of this habitat type at 45% of land cover. Similarly, the ocean comes in second at 12% overall sequestration, with a land type at 29% of land cover. The remaining 24% of sequestration comes from the other land types.

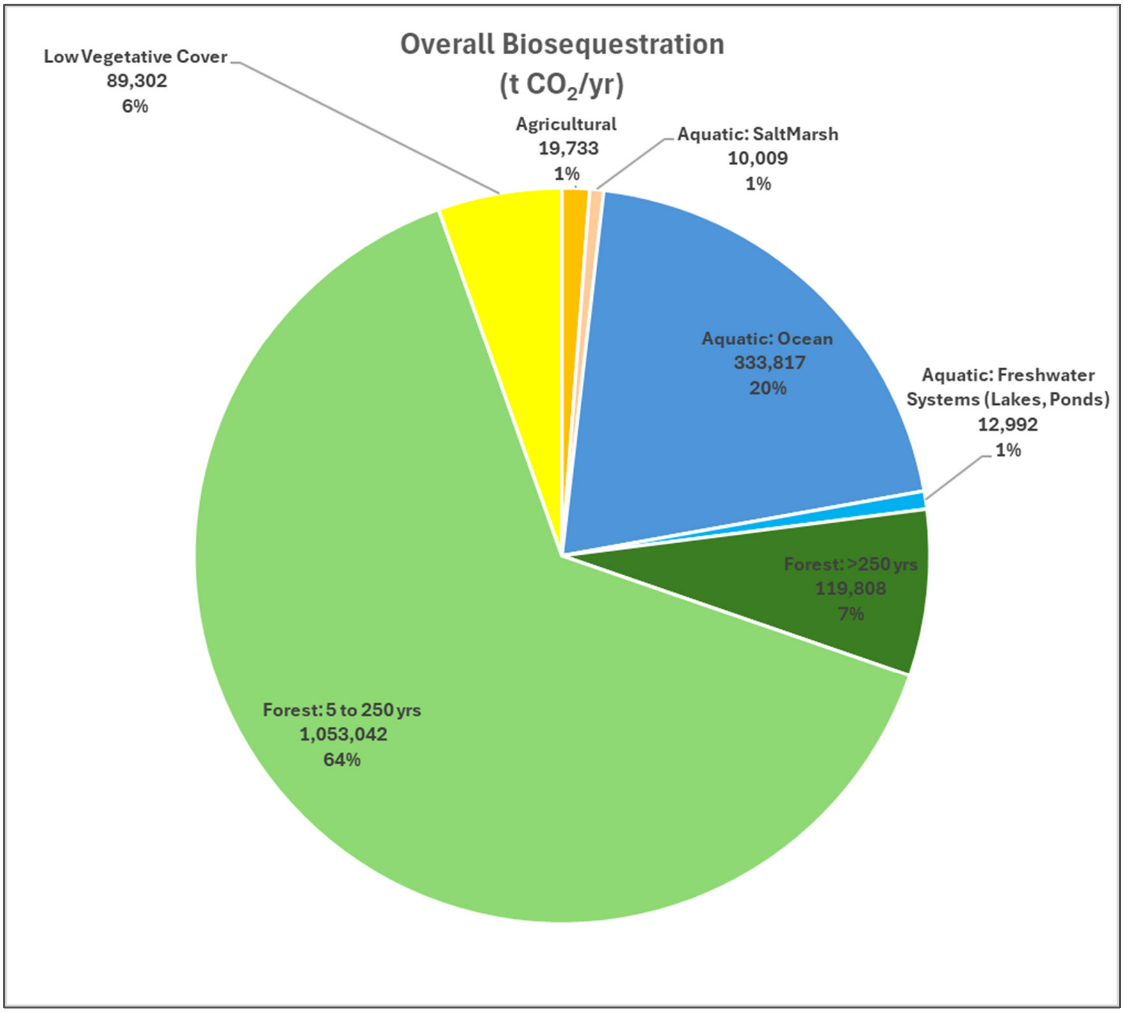

Figure 3 - The overall annual biosequestration rate for each habitat type in the CVRD.

Carbon stored per unit of land area (per hectare) is shown in figure 4. Forests greater than 250 years old have over twice the stored carbon per unit area of any other land type at 1150 tonnes of carbon per hectare, followed by Salt Marsh at 500, forests 5 to 250 years old at 400, and the rest of the land types between 50 and 100 tonnes of carbon per hectare.

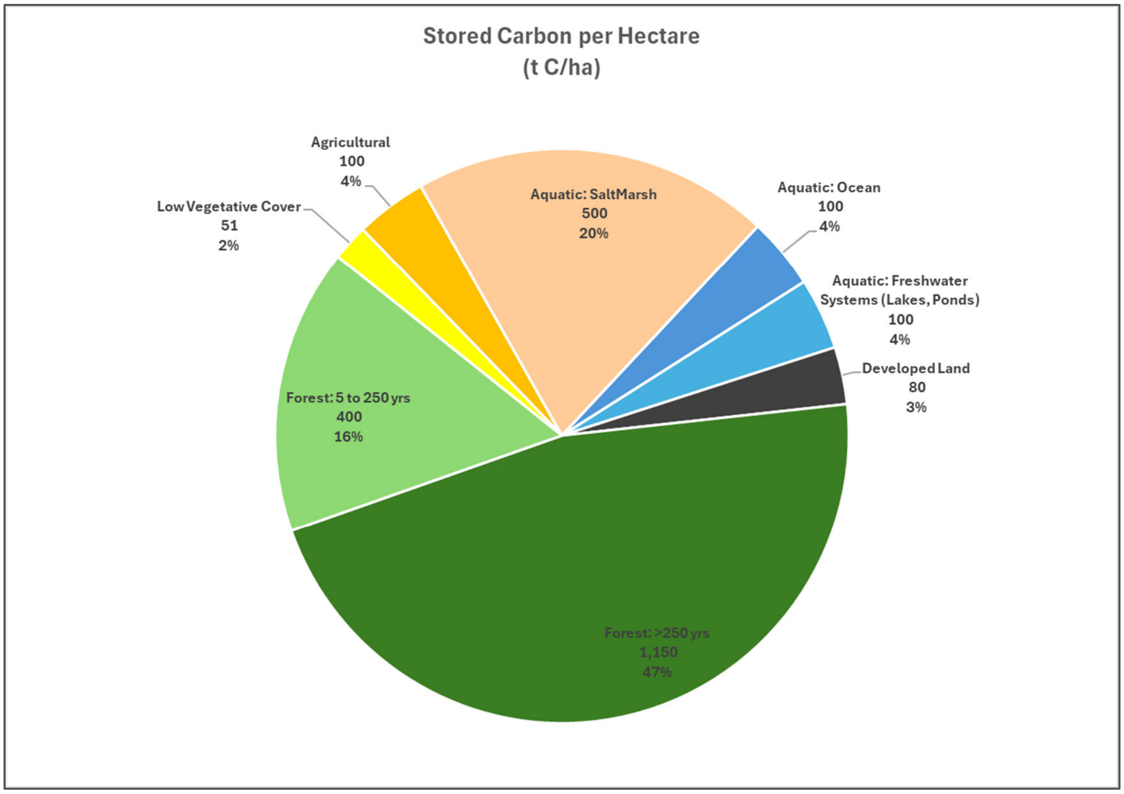

Figure 4 - Stored carbon per hectare for each habitat type in the CVRD.

The overall carbon stored per habitat type is shown in figure 5. Forests clearly store the most carbon of any other land type in the CVRD, with 56% stored as forest between 5 and 250 years old, and 33% stored as forest over 250 years old. Most of the > 250 year old forest carbon exists in Strathcona Park. Due to the larger land mass, the ocean stores 9% of the regions carbon and the other habitat types store 2% or less each.

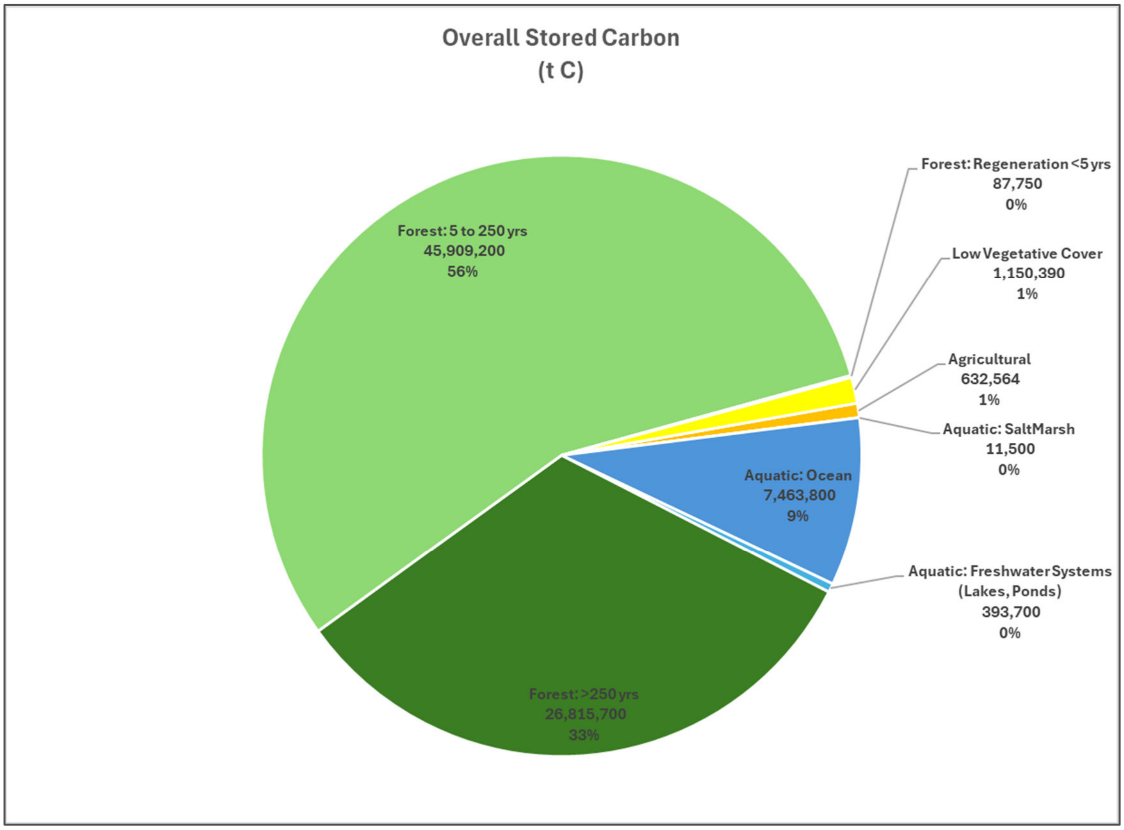

Figure 5 - Overall stored carbon for each habitat type in the CVRD.

As much of the forested area in the region is regulated by the *Private Managed Forest Land Act*, and emissions data relating to land use change was noted as inconsistent and lacking in sufficient granularity in the 2021 CVRD Emissions Report. There are some relevant insights gained from the model that relate to release of stored carbon from logging and forest clearing for development. The literature suggests that logging of temperate coastal forests is expected to result in the long-term release of between 40% and 65% of embodied carbon. Similarly, when forested sites are cleared for development, a greater amount of embodied carbon loss is expected due to additional carbon lost from soils. Furthermore, if wood waste or soil cleared from sites ends up deeply buried, such as in a landfill-type environment, carbon could be released as methane, which is a significantly more potent greenhouse gas than carbon dioxide—approximately 84 times more effective at trapping heat over a 20-year period. As such, high carbon value soils and plant material should be carefully managed to preserve sequestered carbon where possible and mitigate the conversion of carbon to methane.

Strategy scenarios to prevent the loss of stored carbon, and enhance the sequestration capacity of habitat types was modelled and the results are detailed in Appendix III, tables 3, 5, 8 and 10. The 100 yr strategy scenarios that yield the greatest sequestration per hectare are shown below.

Strategy Scenario	Annual Average Impact ($t\ CO_2e/ha/yr$)
Protection of > 250 yr forest from development	47
Protection of 5-250 yr forest from development	24
Protection of > 250 yr forest from logging	21
Protection of 5-250 yr forest from logging	9.5
Stable 5-250 yrs Forest: Extend rotation, harvest after 80 years instead of 40	7.3
Salt marsh restoration	7.1

Inset Table 1: Key Strategy Scenarios with the Greatest Sequestration Result

From the inset Table 1, protecting forests from development has the greatest carbon sequestration result per hectare, out of any of the strategies modelled in this report. Protecting forests from logging (where it is assumed that soils remain, and new trees grow immediately) also has a relatively high impact on carbon sequestration, in the development scenario it is assumed that the soils are lost and a new forest is not regrown.

In the scenario where larger trees are protected (either from development or logging), there is a greater carbon sequestration result. Extending the forest logging or harvest cycle from 40 to 80 years can result in additional carbon sequestration levels, though that would be less than those achieved through full protection of the same forest over a 100-year period. The extension of the harvesting rotation strategy is important if wood is to be harvested on lands under CVRD jurisdiction for the purposes of creating lumber or useful materials.

Salt marsh restoration had a relatively high impact potential and there appear to be unique opportunities within the CVRD to restore salt marsh habitat. Salt marsh sequestration impacts are comparable to land afforestation[2]. Afforestation sequestration rates range from 4 to 9 t CO_2e/ha/yr depending on the forest growth rate, using average forest sequestration values from the model.

Exceptions of strategies with higher carbon impacts that were not included in the table below include protection of peatlands and freshwater marsh areas. These were excluded as substantial unprotected peatlands were not identified in the CVRD during this study, and freshwater protected marshland should already be protected by provincial regulations.

Based on the above, protecting and careful management of existing forests and promoting reforestation and afforestation initiatives will be essential in maximizing their sequestration potential. The health of forest systems is complex and interconnected. Consideration should be given to ecological connections,

[2] Afforestation is planting of a forest in an area where there was none previously.

including ecological connection corridors, to ensure the stability and sustenance of these forests. Additionally, the hydrogeology of these stands should be considered to ensure they remain sufficiently wet and are not drained or dewatered if development occurs around them, particularly in upgradient areas. Maintaining proper hydrological conditions is essential for the continued health and carbon sequestration capabilities of these forests.

Photo 3 - Forest land type, which represents both the highest sequestration rate and largest store of embodied carbon in the CVRD.

7.0 RECOMMENDATIONS

To achieve the CVRD's goal of net zero corporate emissions by 2050, it is important to focus on enhancing and protecting regional biological carbon sequestration. This effort could involve compounding benefits from various natural land areas, including aquatic systems, forests, and agricultural and urban soils, to maximize carbon storage and sequestration. Protecting existing forests and promoting reforestation and afforestation initiatives will be essential in maximizing the sequestration potential of habitats in the CVRD. Protecting and restoring salt marshes will also play a role. Based on our findings from this study, and further to the strategies outlined in Appendix II, the quantified impacts of strategies in Appendix III, and the analysis and insights above, the following key recommendations are provided.

7.1 Key Recommendations

1. **Forest Preservation**: Protecting existing forests, especially larger forest stands from development or permanent removal is the number one priority for the CVRD to retain existing stored carbon and enhance biosequestration:
    a. **Better Environmental Data and Planning:** Better lidar data in the CVRD or other forest tree size data sets would be valuable in making more informed decisions. Creating a more holistic Environmental Plan for the region, that considers ecological, hydrogeological, watershed, community needs, as well as carbon considerations would be beneficial prior to making land management decisions based solely on carbon sequestration alone.
    b. **Forest Land Protection:** Forests, particularly larger tree stands, should be protected in order to retain larger stores of carbon and ensure continued sequestration. This may be accomplished through land acquisition or other means of more permanent conservation.
    c. **Forest Lands Policy Development:** Practical policy and legislative changes to promote afforestation and dissuade or restrict permanent tree removal and forest soil removal should be considered. Many municipalities restrict forest canopy removal using tree cutting bylaws and soil movements with soil bylaws. While the CVRD does not have the authority to implement a tree cutting bylaw, other planning tools may be useful in protecting these valuable carbon sinks, for example through the creation of a Development Permit Area.
2. **Salt Marsh Preservation and Restoration:** Approximately 70% of salt marsh areas have been lost, presenting a significant opportunity for restoration. Seen as they have a high carbon sequestration potential per hectare, and there are already initiatives underway, supporting salt marsh restoration and ensuring protection of salt marsh areas is important for carbon sequestration.

7.2 Secondary Recommendations

All other strategies outlined in Appendix II and Appendix III, Tables 3, 5, 8 and 10 are considered secondary recommendations. These include incorporating the agricultural practices into the Agricultural Plan for the region and incorporating water quality considerations into engineering design, operations and planning of stormwater infrastructure.

8.0 TERMS AND LIMITATIONS

This work was performed subject to the Terms and Limitations presented or referenced in the proposal for this project.

Information provided by Pinchin is intended for Client use only. Pinchin will not provide results or information to any party unless disclosure by Pinchin is required by law. Any use by a third party of reports or documents authored by Pinchin or any reliance by a third party on or decisions made by a third party based on the findings described in said documents, is the sole responsibility of such third parties. Pinchin accepts no responsibility for damages suffered by any third party as a result of decisions made or actions conducted. No other warranties are implied or expressed.

9.0 CLOSURE

Pinchin sincerely appreciates the opportunity to complete this study. Please contact Pinchin if you have any questions, comments or require further information.

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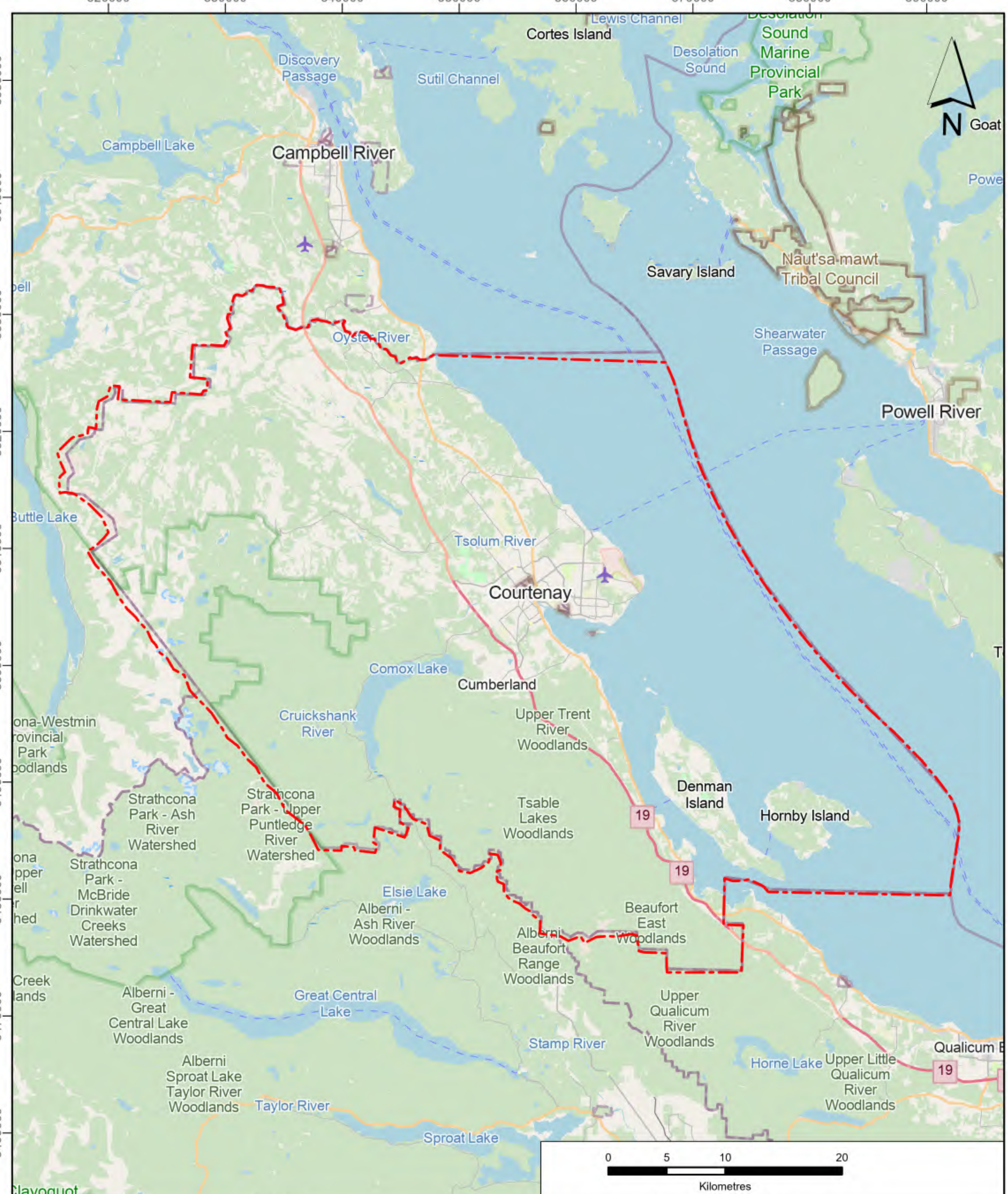
Template: Master Environmental Assessment Report, ENS, June 6, 2022

FIGURES



PINCHIN

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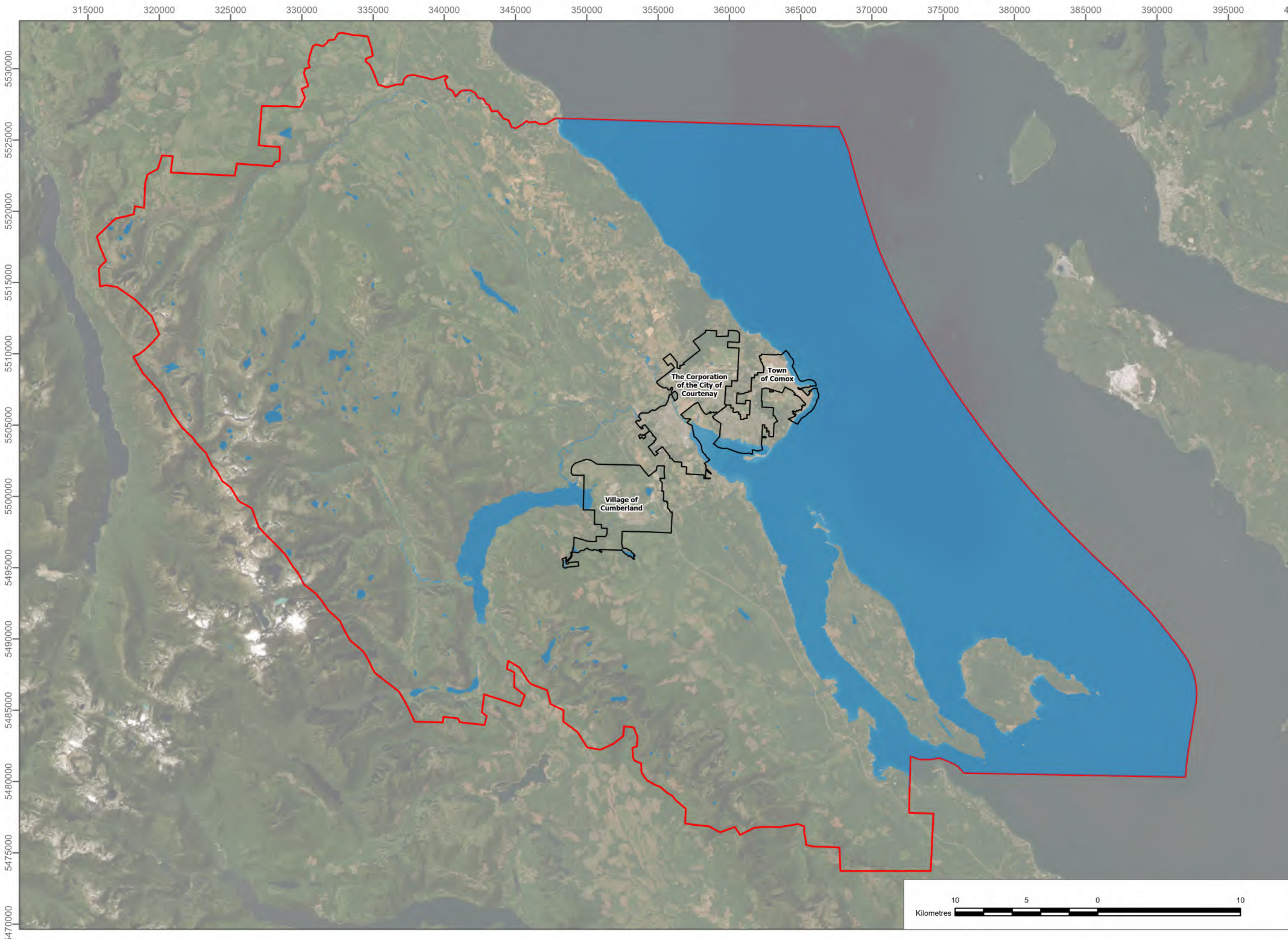
CLIENT NAME:	COMOX VALLEY REGIONAL DISTRICT
PROJECT LOCATION:	COMOX VALLEY, COMOX, BC, CANADA
FIGURE NAME:	KEY MAP
FIGURE NUMBER:	1
PROJECT NUMBER:	347023
SCALE:	AS SHOWN
DRAWN BY:	CF
REVIEWED BY:	BA
DATE:	DECEMBER 2024



N

LEGEND

- WATERBODY
- MUNICIPALITY
- COMOX VALLEY REGIONAL DISTRICT

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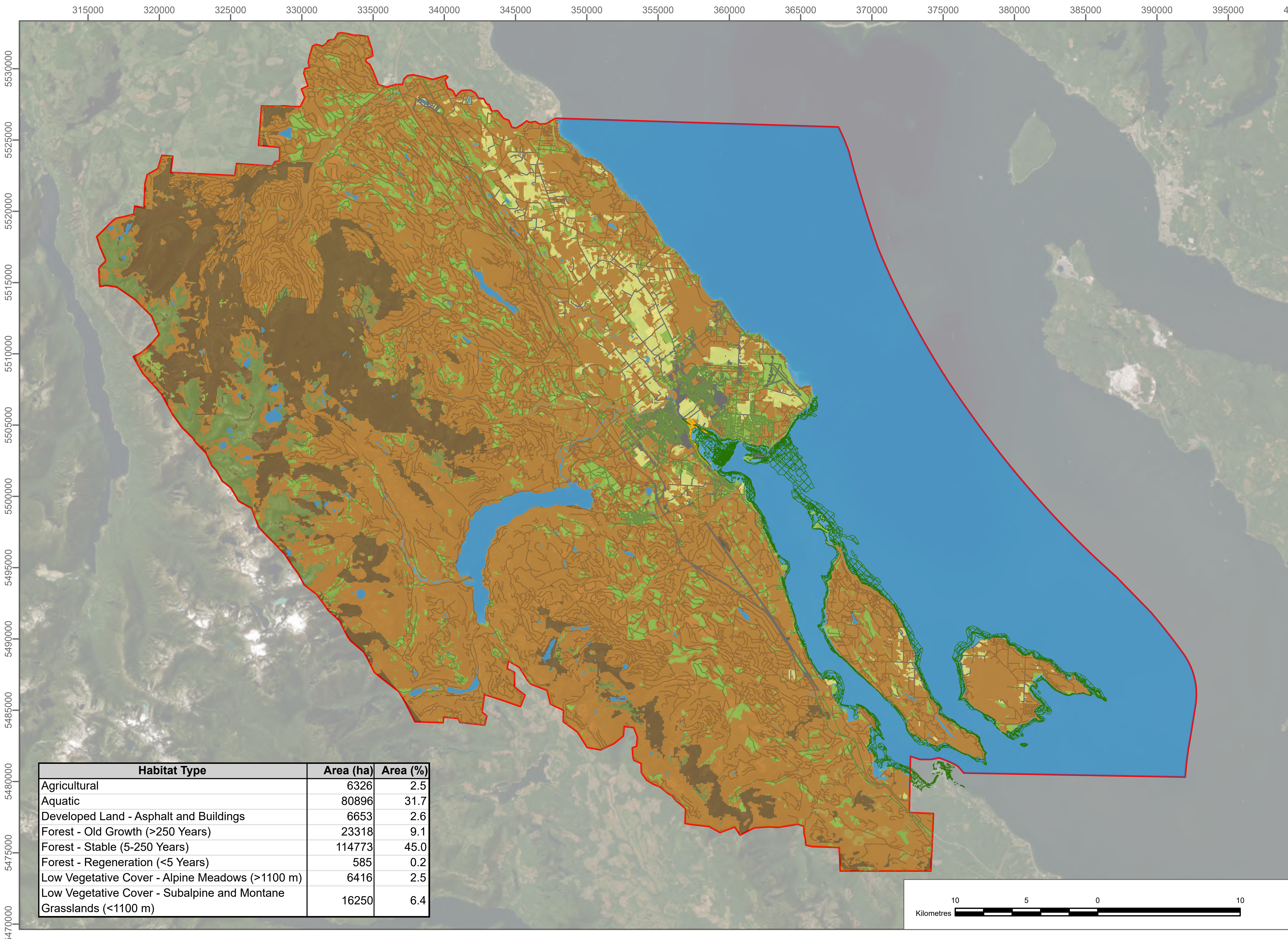
PINCHIN

PROJECT NAME	BIOLOGICAL CARBON SEQUESTRATION STUDY
CLIENT NAME	COMOX VALLEY REGIONAL DISTRICT
PROJECT LOCATION	COMOX VALLEY, COMOX, BC, CANADA
FIGURE NAME	SITE PLAN
PROJECT NUMBER: 347023	SCALE AS SHOWN
DRAWN BY CF	REVIEWED BY BA
DATE DECEMBER 2024	FIGURE NUMBER 2



Habitat Type	Area (ha)	Area (%)
Agricultural	6326	2.5
Aquatic	80896	31.7
Developed Land - Asphalt and Buildings	6653	2.6
Forest - Old Growth (>250 Years)	23318	9.1
Forest - Stable (5-250 Years)	114773	45.0
Forest - Regeneration (<5 Years)	585	0.2
Low Vegetative Cover - Alpine Meadows (>1100 m)	6416	2.5
Low Vegetative Cover - Subalpine and Montane Grasslands (<1100 m)	16250	6.4

N

LEGEND

- COMOX VALLEY REGIONAL DISTRICT
- AGRICULTURAL
- AQUATIC
- AQUATIC - SEAGRASS
- AQUATIC - SALT MARSH
- DEVELOPED LAND - ASPHALT AND BUILDINGS
- FOREST - OLD GROWTH (>250 YEARS)
- FOREST - STABLE (5-250 YEARS)
- FOREST - REGENERATION (<5 YEARS)
- LOW VEGETATIVE COVER - ALPINE MEADOWS (>1100 M)
- LOW VEGETATIVE COVER - SUBALPINE AND MONTANE GRASSLANDS (<1100 M)

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c) Project Watershed - K'ómoks Estuary - Ecology & Restoration Map
d) Towards a regional plan for climate change adaptation, mitigation and biodiversity conservation in Indigenous, rural, and urban landscapes of the Comox Valley, August 2022

PINCHIN

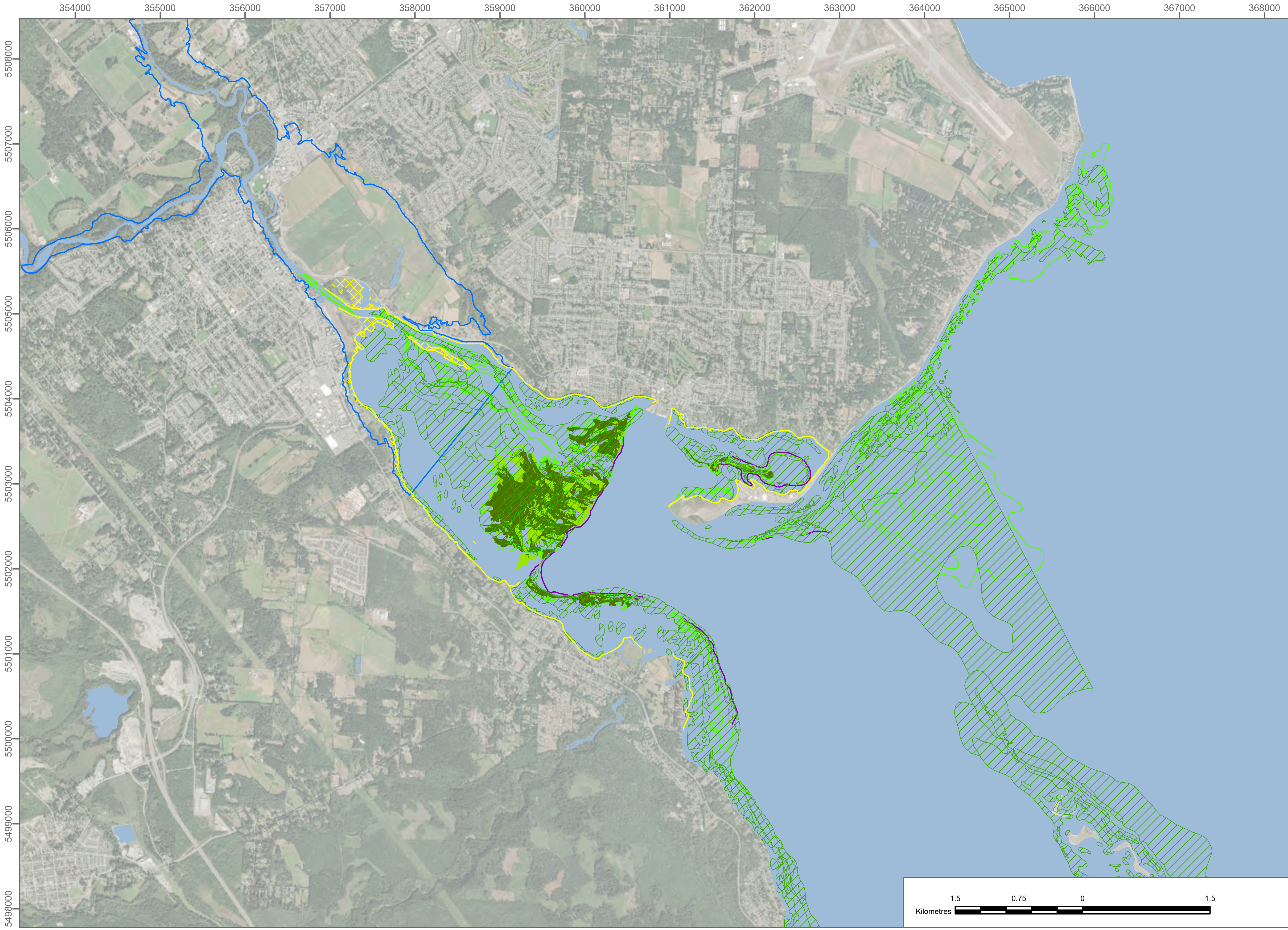
PROJECT NAME
BIOLOGICAL CARBON SEQUESTRATION STUDY

CLIENT NAME
COMOX VALLEY REGIONAL DISTRICT

PROJECT LOCATION
COMOX VALLEY, COMOX, BC, CANADA

FIGURE NAME
HABITAT TYPE

PROJECT NUMBER: 347023	SCALE AS SHOWN
DRAWN BY CF	REVIEWED BY BA
DATE MAY 2025	FIGURE NUMBER 3



LEGEND

- COMOX VALLEY REGIONAL DISTRICT
- WATERBODY
- FLOODPLAIN
- SENSITIVE ECOSYSTEM INVENTORY - EELGRASS
- EELGRASS - DENSE (2014)
- EELGRASS - SPARSE (2014)
- EELGRASS - ESTIMATE (2007)
- EELGRASS - MAXIMUM POTENTIAL ZONES (2013)
- SALT MARSH - ESTIMATE (2007)
- SALT MARSH POTENTIAL RESTORATION (2013)

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c) Project Watershed - K'ómoks Estuary - Ecology & Restoration Map

PINCHIN

PROJECT NAME: BIOLOGICAL CARBON SEQUESTRATION STUDY	
CLIENT NAME: COMOX VALLEY REGIONAL DISTRICT	
PROJECT LOCATION: COMOX VALLEY, COMOX, BC, CANADA	
FIGURE NAME: AQUATIC (EELGRASS, SALT MARSH)	
PROJECT NUMBER: 347023	SCALE: AS SHOWN
DRAWN BY: CF	REVIEWED BY: BA
DATE: MAY 2025	FIGURE NUMBER: 4

APPENDIX I
Table of Factors Report

PINCHIN

FINAL Analysis of Factors Affecting Biological Carbon Sequestration and Emissions in Comox, British Columbia, Canada: Interim Table of Factors

LIST OF ACRONYMS USED

AGB = Above ground biomass
AGC = Above ground carbon
BCE = Blue carbon ecosystems
C = Carbon
CC = Climate change
GHG = Green house gas
H = High
IC = Inorganic carbon
L = Low
OC = Organic carbon
OM = Organic matter
SLR = Sea level rise
SOC = Soil/sediment organic carbon
SOM = Soil/sediment organic matter

1.0 AGRICULTURAL

Table 1. Interim Table of Factors Affecting Agricultural Carbon Bio-Sequestration

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Crop type and rotation[1]	Improves SOM and C storage; chronic monocropping depletes long-term sequestration potential	H	Management practices (e.g., no-till, decreasing summer fallow increasing perennial crops into rotations, restoring degraded lands) may provide gains in SOC in Canadian land used for agriculture ranging from 0.1 to 0.5 t C ha per year	H	Switching from annual to perennial crops, Deep roots that stay in ground
Tillage practices[2]	No-till/reduced-till practices preserve SOC by reducing disturbance; conventional tillage accelerates C loss through oxidation	H	Management practices (e.g., no-till, decreasing summer fallow increasing perennial crops into rotations, restoring degraded lands) may provide gains in SOC in Canadian land used for agriculture ranging from 0.1 to 0.5 t C ha per year	H	Switch to low or no-till practices where applicable
Agroforestry[3]	Integrating trees/crops/pastures enhances AGC/SOC sequestration, increases biodiversity, improves resilience to climate extremes	H	Agroforestry can improve bio-sequestration and reduce emissions from livestock	H	Possible options to promote
Organic farming and soil amendments[4, 5]	Organic practices (e.g., biochar, compost, manure, cover cropping)	H	Enhance SOC and microbial activity, improves soil structure, increases nutrient availability	H	Composting and amendments are common practice

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Soil Erosion and Water management[6]	Efficient irrigation and on-site wetland restoration can reduce soil erosion, improve water retention, and enhance C storage in agricultural lands	H	Drainage designs to promote plant growth and limit erosion have a high potential to promote and retain SOC in combination with other factors	H	Reducing erosional soil loss in waterways commonly regulated
Fertilizer use[7]	Altering fertilizer application method and type can improve plant growth and residues thus helping build SOC	L	Precision fertilizer applications, using slow release including organic fertilizers can increase SOC storage	H	Modifying Fertilizer is implementable from a management standpoint
Restoration potential[8]	Converting degraded/abandoned agricultural land to regenerative practices, reforestation, or agroforestry improves SOC	L	Fallow/naturalizing lands are likely to stabilize over time and may naturally regenerate with decent SoC regeneration	H	
Increase Biodiversity[9]	Promotes C storage, nutrient cycling, ecosystem stability	L	Part of SOC building, requires other factors to increase potential	H	
Organic Pest and disease control[10]	Reduces reliance on chemical pesticides, mitigating their negative effects on soil microbes and carbon cycling	L	Part of overall erosional loss and SOC building	H	
Climate Change					
Greenhouse gas emissions[11]	Livestock systems CH_4 and N_2O; Mitigation strategies (e.g., diet management, alternate wetting and drying) reduce emissions	H	Animal emissions can be significant depending on practices	L	May be challenging for CVRD to regulate what type of farming or what practices are used to control agriculturally based emissions that are more operationally related

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Climate resilience[12]	Adaptive practices (e.g., drought-resistant crops, crop diversification) reduce vulnerability to extreme weather events, ensuring C storage continuity	L	Failing crops are likely a self-correcting issue	L	CVRD unlikely to regulate operational practices that are not results or land based

2.0 AQUATIC

Table 2. Interim Table of Factors Affecting Aquatic Carbon Bio-Sequestration

Factor	Description/Mechanism	Bio-Sequestration Potential		Actionability	
Blue Carbon: Oceans and Coastal Ecosystems (seagrass, salt marsh, mudflats)					
Conservation and restoration[13]	Coastal/estuarine systems store significant AGC/SOC; vulnerable to climate change and land-use changes	H	Very high C storage potential; many secondary benefits	H	Conservation and restoration efforts already underway in Comox
Coastal squeeze[14, 15]	SLR and development restrict landward migration of coastal habitats	H	Loss of BCE result in significant C losses	H	Long term planning under CVRD scope
Sedimentation rates[13]	SOM/SOC depend on sediment availability, tidal patterns, watershed management upstream	H	Critical for long-term carbon storage in aquatic systems	L	Difficult to directly manage oceanic and fluvial inputs, erosion etc.
Hydrodynamics[16]	Influence C deposition/retention. Strong hydrodynamic events can remove SOC from system	H	Localized role in C deposition, varying effects depending on site-specific tidal and wave conditions	L	Limited control over hydrodynamics without water divergence structures
Change in biota[17]	Shifts in plant and animal communities due to climate change or invasive species can alter C sequestration	L	Mixed effects: loss of high C-sequestering native species but some invasives enhance sequestration	L	Important for secondary ecosystem services, but role in C-sequestration unclear
Carbonate production[18]	Sequester IC through calcification processes, though can release CO_2	L	Minor and uncertain role in regional carbon dynamics compared to SOC/AGC	L	Difficult to manage calcification and IC import

Factor	Description/Mechanism	Bio-Sequestration Potential		Actionability	
Biological pump[19]	Transport of OC from surface waters to the deep ocean	L	Underpins global long-term sequestration; effects more relevant at broader scales than regional in Comox	L	Difficult to manage and monitor seafloor
Freshwater Systems: Lakes, Ponds, Rivers, Wetlands, Riparian					
Lakes and Ponds: Water Quality and GHG Emissions[20]	Eutrophication, pollution, nutrient loads impact health of aquatic vegetation and their C storage; decomposition of blooms release GHG	H	Potentially high emissions in large Comox Lake	H	Management of freshwater essential
Riparian vegetation[21]	AGB/SOM in riparian zones influences adjacent aquatic systems	H	Crucial role in stabilizing aquatic systems and enhancing carbon sequestration in connected habitats	H	Conservation and restoration
Wetland connections[22]	Wetlands adjacent to lakes and rivers act as sinks for organic carbon	H	Critical carbon sinks	H	Conservation and restoration
Lakes and Ponds: Organic Input[23]	Organic matter input from watershed runoff	L	Lake C-sequestration low compared to forests/blue carbon	L	Managed by upstream agricultural and forestry practices
Climate Change					
Sea-level rise[24]	Alters tidal zones, reduces coastal habitat areas, affects sedimentation patterns	H	Directly impacts C sequestration in coastal systems	L	Minimal direct control over SLR
Temperature changes[25]	Mixed effects: increase metabolic rates of aquatic organisms, decomposition rates, and vegetation growth; may increase productivity	H	Exacerbate decomposition and emissions	L	Minimal direct control over Temperature
Storm intensity and frequency[15]	Disrupts coastal sedimentation and can lead to habitat erosion	H	Significantly reduce region's C storage capacity	L	Minimal direct control over weather though can focus on erosional protection where practical

Factor	Description/Mechanism	Bio-Sequestration Potential		Actionability	
Precipitation changes[26]	Alters freshwater input to estuaries and coastal systems (salinity and sediment transport)	L	Moderate effects compared to habitat loss or temperature impacts but still influence sedimentation and salinity gradients	L	Minimal direct control over precipitation
Ocean acidification[27]	Increased CO_2 levels many reduce carbonate availability, impacting calcifying organisms, but also may enhance C sequestration	L	Indirectly affects C storage via ecosystem balance but not manageable regionally	L	Minimal direct control over ocean acidification

3.0 DEVELOPED LAND

Table 3. Interim Table of Factors Affecting Carbon Bio-Sequestration of Developed Lands

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Urban forestry and green infrastructure[28]	Increasing tree canopy cover in urban areas, green roofs, bioswales, urban green spaces, reduce impervious surfaces	H	Significant potential for long-term carbon storage	H	Can be incorporated into city planning
Soil Health and Amendments[29]	Compaction and sealing reduce soil organic carbon storage; restoration is possible. Biochar, compost, and mulch increase soil carbon storage in urban landscapes	H	Potential restoration through mitigation efforts	H	Can be incorporated into city planning, encouraged at municipal-level
Urban Planning[30]	Designing green corridors that connect ecosystems promotes ecological health, and natural area spaces promote carbon sequestration in urban areas	H	Long-term sequestration potential	H	Needed for any bio-sequestration on developed land

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Climate Change					
Resilience to climate change[31]	Adaptive designs (e.g., flood-resistant, heat-tolerant materials) enhance resilience to climate change impacts, urban forest cover decreases extreme heat events though shade, natural areas protection may help mitigate flood events	L	Benefits to climate change resilience, not bio-sequestration	H	Important for long-term climate-resilience low-impact on bio-sequestration

4.0 FORESTS

Table 4. Interim Table of Factors Affecting Forest Carbon Bio-Sequestration

Factor	Description / Mechanism	Bio-Sequestration Potential		Actionability	
Established Forests (Secondary Growth, Old Growth Late Successional Forests)					
Vegetation age and type[32]	Old-growth forests store large quantities of carbon in biomass and soil. Different tree species have varied growth rates, lifespans, and wood densities	H	Old-growth most significant long-term C sink	H	Some Old-growth forests in B.C. set for permanent protections
Soil health, decomposition and microbial activity[33, 34]	Long-term C reservoirs (centuries or millennia) especially in cool, wet, conditions and undisturbed areas	H	SOC critical in temperate regions like Comox	H	BC's Long-Term Soil Productivity program (LTSP)
Biodiversity[35]	Diverse forests can sequester more C due to niche complementarity among species	H	Long term C storage: effect less immediate compared to factors like disturbances; however, diverse forests are more resilient to disturbances	L	More under provincial jurisdiction
Disturbances[36]	Fire, pests, logging result in immediate carbon release to the atmosphere	H	Major threat can release significant amounts of carbon	L	More a provincial responsibility

Factor	Description / Mechanism	Bio-Sequestration Potential		Actionability	
Human management[37]	Selective logging, reforestation, afforestation can influence carbon dynamics significantly	H	Management practices have a substantial impact on regional carbon budgets	L	CVRD lower influence and jurisdiction on forestry practices
Edge effects[38]	Fragmented forest patches by agriculture or development experience changes in microclimates and species composition, often reducing carbon storage potential but increasing in some cases	L	Fragmentation may be regionally important but secondary to larger-scale factors like disturbances and management	H	Minimizing edge effects incorporated into sustainable forestry practices
Forest Regeneration (<5 years)					
Growth rates[39]	Young forests initially sequester C rapidly through high rates of photosynthesis, then store less C overall compared to mature forests due to smaller biomass and undeveloped root systems	H	Forest regeneration represents only 0.2% of the total land cover in Comox. Need to assess rate of sequestration	L	Limited control overgrowth rates during replanting
Management practices[35]	Species selection, replanting density, fertilization, weed control silviculture techniques (e.g., selective logging, shelterwood systems, continuous cover forestry)	H	Critical to optimizing the C sequestration potential of regenerating forests	L	Management practices key to enhancing all factors though under provincial jurisdiction
Soil carbon restoration[40]	Disturbed soils recover slowly after deforestation or replanting - microbial activity, OM inputs, nutrient cycling stabilize over time. Early SOC gains depend on inputs from leaf litter and root exudates	L	Old growth forests usually have higher total soil carbon; but Important in regenerating forests for long-term soil SOC	L	Prevent further degradation for soil recovery
Disturbance recovery[41]	Degree of prior disturbance (e.g., clear-cutting, fire) influences the regeneration success. Residual OM, soil quality, and seed availability determine the speed and efficiency of carbon recovery	L	Small area of regenerating forests in Comox limits its significance at landscape level	L	Prevent further degradation for soil recovery

Factor	Description / Mechanism	Bio-Sequestration Potential		Actionability	
Climate change					
Climate sensitivity[42]	Temperature and precipitation regulate tree growth, photosynthesis, and organic matter decomposition, young forests highly responsive to environmental conditions like temperature, precipitation, and extreme weather. Droughts or frosts during early growth stages can limit survival and carbon uptake	H	Important but less immediately controllable than management practices or disturbance mitigation	L	Limited control over climate; must incorporate into climate-resilient management practices

5.0 LOW VEGETATIVE COVER

Table 5. Interim Table of Factors Affecting Carbon Bio-Sequestration of Low Vegetative Cover

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Disturbance (pest susceptibility, fires)[43, 44]	Often have lower biodiversity, making them more vulnerable to pest outbreaks	H	Localized impacts, but overall effect on Comox C storage is moderate given lower biomass	H	Increasing/preserving plant diversity and wildfire prevention
Restoration potential[45]	Restoration efforts (e.g., planting drought-tolerant or fast-growing species) enhance AGC storage and SOC, improving resilience to future climate extremes	H	Restoring degraded areas high potential for improving C sequestration and resilience	H	Replanting, land reclamation
Vegetation type[46, 47, 48]	Sparse vegetation (grasses, shrubs) stores less C but stabilizes SOM	H	Lacks the AGC/SOC density of forests or blue C, has role in stabilizing soil and preventing erosion	L	Impractical to change species composition of natural grasses/shrubs

Factor	Description/Mechanism	Bio-sequestration Potential		Actionability	
Soil organic matter[49, 48]	Sparse vegetation contributes fewer organic inputs, reducing SOC and microbial activity; but resilient species (e.g., drought-tolerant grasses) can gradually improve soil carbon through root exudates and OM deposition	H	SOM levels lower in these areas, but with 10.3% of the Comox gives them some importance; therefore, restoration could enhance C storage but remains secondary to the high-sequestration potential of forests/aquatic	L	SOM will develop with undisturbed low vegetative cover
Climate Change					
Climate change impacts	Rising temperatures and altered precipitation patterns increase the vulnerability of low vegetative cover areas to desertification, reduced water availability, and heat stress. Resilience to climate extremes depends on ability to withstand drought, floods, or temperature fluctuations variable between species. E.g., perennial grasses with deep roots more drought resistant. Restoration should prioritize climate-resilient species	H	Susceptibility to climate extremes has broad implications for regional C balance and ecosystem health	L	Enhancing resilience in low vegetation areas with climate-adapted species is key to maintaining SOC where possible

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APPENDIX II

Land Management Strategies for Optimizing Carbon Sequestration

1.1 Agricultural Land

Biological carbon sequestration occurs in agricultural land through the process of photosynthesis, where crops and cover plants uptake atmospheric CO_2 and convert it into organic matter. This carbon is then stored in the soil through plant residues, root exudates, and the decomposition of organic materials, eventually contributing to soil formation over the long term.

1.1.1 Factors Affecting Carbon Sequestration

1. **Crop Type and Rotation**: The type of crops grown and the crop rotation patterns can influence carbon sequestration. Deep-rooted crops, such as perennial grasses and legumes, contribute more to soil carbon storage by transferring organic matter deeper into the soil profile. Crop rotation, which involves alternating different crops on the same land, can improve soil structure, reduce erosion, and support beneficial microbial activity (e.g., promoting fungal networks and microbial byproducts that enhance soil aggregation), all of which contribute to soil organic matter accumulation and carbon sequestration;
2. **Tillage Practices**: Tillage practices may influence the amount of carbon stored in agricultural soils. Conventional tillage involves turning over the soil, which disrupts soil structure, accelerates organic matter oxidation and microbial decomposition, and releases stored carbon back into the atmosphere. In contrast, conservation tillage practices, such as no-till or reduced tillage, minimize soil disturbance, maintain soil structure, and helps maintain lower oxygen conditions in deeper soil layers, slowing decomposition and promoting long-term carbon retention;
3. **Agroforestry**: Agroforestry integrates trees and shrubs into crops and pastures, providing multiple benefits for carbon sequestration. Trees assimilate CO_2 through photosynthesis and store it in their biomass, while also contributing organic matter to the soil through leaf litter, other biomass deposition, root turnover, and root exudates. The presence of trees improves soil structure, mitigates erosion, strengthens the area's resilience to climate extremes, offsets livestock emissions, and increases biodiversity – all of which contribute to long-term carbon storage in both biomass and soil;
4. **Organic Farming and Soil Amendments**: Organic farming practices, which avoid synthetic fertilizers and pesticides, can enhance soil health and carbon sequestration. Organic amendments such as biochar, compost, manure, and cover crops introduce carbon-rich material into the soil, increasing soil organic matter, stimulating microbial activity, and enhancing soil structure, ultimately promoting long-term carbon

sequestration. Organic farming practices support local biodiversity and ecosystem resilience by providing habitats for pollinators and other organisms within the food chain. While these practices primarily enhance ecological stability, they can also contribute to soil health and carbon sequestration by promoting diverse plant and microbial communities; and

5. **Soil Erosion and Water Management**: Effective soil erosion and water management practices can help maintain and enhance carbon sequestration in agricultural land Erosion reduces soil depth and organic matter content, leading to a loss of stored carbon. Implementing erosion control measures, such as contour plowing, terracing, and maintaining ground cover, can help retain soil and carbon. Proper water management practices, including efficient irrigation and drainage systems, support healthy plant growth and soil structure, enhancing carbon sequestration. Efficient irrigation and on-site wetland restoration can reduce soil erosion, improve water retention, and enhance carbon storage in agricultural lands.

1.1.2 Best Practices and Recommended Actions

1. **Conservation Tillage**: Implement practices that minimize soil disturbance to retain organic matter and carbon in the soil. By reducing tillage, farmers can prevent the release of stored carbon, improve soil structure, and promote soil health;
2. **Cover Cropping**: Use cover crops, such as legumes and grasses, to fix CO_2 during photosynthesis and add organic matter to the soil when plowed under. Cover crops can enhance soil fertility, prevent erosion, and increase soil carbon storage;
3. **Crop Rotation**: Diversify plant species to improve soil structure, enhance soil health, and increase carbon storage. Rotating crops helps maintain soil fertility and reduces the risk of pests and diseases, contributing to long-term carbon sequestration;
4. **Agroforestry**: Integrate trees into agricultural landscapes to increase carbon sequestration in both biomass and soil. Agroforestry practices can provide additional benefits such as improved biodiversity, soil fertility, and microclimate regulation;
5. **Enhance Soil Organic Matter**: Use organic amendments, such as biochar, compost, and manure, to increase soil organic matter content and enhance carbon storage. Organic amendments improve soil structure, water retention, and nutrient availability;
6. **Promote Sustainable Farming Techniques**: Adopt conservation tillage, cover cropping, and crop rotation to improve soil health and carbon storage. Sustainable farming practices contribute to the overall resilience and productivity of agricultural systems;

7. **Retention of Organic Matter In-Field**: Retain and allow the decomposition of additional organic matter from crop yields (such as husks or shells) within the agricultural field before transporting the harvested crops to processing facilities; and
8. **Role of Policy, Partnership, and Funding**: Develop policies and government programs that encourage sustainable farming practices, such as conservation tillage, cover cropping, and agroforestry, to incentivize farmers to adopt these techniques. Collaborate with agricultural organizations to promote best practices and provide support to farmers. Partnerships can facilitate knowledge exchange, technical assistance, and access to resources. Seek funding opportunities to implement and expand sustainable agricultural practices. Grants can help cover the costs of adopting new practices and technologies that enhance carbon sequestration.

1.2 Aquatic

In aquatic ecosystems, including freshwater (lakes, rivers, wetlands), coastal (estuaries, seagrass meadows, salt marshes), and marine (open ocean, continental shelf) environments, biological carbon sequestration occurs as aquatic plants, macroalgae (e.g., seaweeds), and microalgae (e.g., phytoplankton) take up atmospheric and dissolved CO_2 through photosynthesis. The carbon fixed by these organisms is then transferred to sediments and organic material, where it can be stored long-term. Coastal blue-carbon habitats, such as salt marshes and seagrass meadows, are effective at sequestering carbon due to their high organic matter input from plant production, slow decomposition rates in waterlogged and anoxic sediments, and efficient trapping of suspended carbon-rich particles. Furthermore, marshes in particular may allow for enhanced vertical carbon storage as sea levels rise. These conditions allow large amounts of carbon to accumulate in sediments over centuries to millennia. Additionally, rivers transport significant amounts of organic carbon and sediments to coastal areas, where deposition and burial further enhance long-term carbon storage in estuarine and marine environments.

1.2.1 Factors Affecting Carbon Sequestration

1. **Restoration and Conservation**: The ability of aquatic ecosystems to store carbon depends on the conservation and restoration of plant-dominated habitats, which have been and continue to be subject to extensive degradation. Habitat loss, pollution, and land-use change have reduced the capacity of wetlands, seagrass meadows, and other coastal ecosystems to sequester and store carbon. Degraded habitats store less carbon due to reduced plant productivity, organic matter loss, and sediment disturbance, while restored and well-protected habitats can enhance carbon storage by promoting biomass accumulation and stable carbon burial. Restoration projects and conservation efforts,

such as wetland protection, seagrass replanting, salt marsh restoration, and coastal habitat preservation, are essential for maintaining and improving carbon sequestration in aquatic ecosystems. The health and extent of aquatic habitats significantly influence their carbon sequestration capacity. Degraded habitats store comparatively less carbon, while restored and well-conserved habitats can have enhanced carbon storage. Restoration projects and conservation efforts, including protecting wetlands and coastal areas, are essential for maintaining and improving carbon sequestration in aquatic ecosystems;

2. **Coastal Squeeze**: The combined effects of sea-level rise and coastal development often restrict the landward migration of coastal habitats, a phenomenon known as coastal squeeze. This can lead to a reduction in the area available for carbon sequestration in coastal and estuarine ecosystems, as primary producers in these ecosystems thrive within a very narrow range of suitable water depth. To mitigate this, it is important to implement policies and long-term planning that allow for the natural migration of these habitats inland and to protect undeveloped land adjacent to coastal areas. This can help maintain and enhance the carbon sequestration potential of coastal ecosystems, despite changing environmental conditions;
3. **Lakes and Ponds, Water Quality**: The carbon sequestration potential of lakes, ponds and the ocean depends on water quality and biological productivity, which regulate the balance between carbon fixation, deposition, and long-term storage in sediments. Clear, well-oxygenated waters with diverse aquatic vegetation and phytoplankton communities support higher rates of carbon uptake and deposition, while low-oxygen (anoxic) conditions in sediments help slow decomposition, preserving stored carbon over time. However, excessive nutrient inputs (eutrophication) can disrupt this balance by triggering algal blooms, leading to oxygen depletion (hypoxia) in the water column. Hypoxic conditions accelerate microbial breakdown of organic matter before it settles into sediments, reducing the overall amount of carbon that gets buried and increasing the release of CO_2 and methane back into the atmosphere. Maintaining high water quality through nutrient management, pollution reduction, and wetland buffers enhances the ability of lakes and ponds to sequester carbon effectively while also reducing greenhouse gas emissions associated with excessive organic matter decomposition;
4. **Riparian Vegetation**: The above-ground biomass and soil organic matter in riparian zones (areas adjacent to rivers and streams) influence the carbon sequestration capacity of adjacent aquatic systems. Healthy riparian vegetation stabilizes stream banks, reduces erosion, and contributes organic matter to the soil, enhancing carbon storage. Protecting

and restoring riparian zones by planting native vegetation and managing land use can improve carbon sequestration in connected aquatic ecosystems; and

5. **Wetland Connections**: Wetlands adjacent to lakes and rivers can act as major organic carbon sinks. These wetlands capture and store organic carbon through sedimentation and the accumulation of plant material. Maintaining and enhancing the connections between wetlands and their adjacent aquatic systems is necessary for optimizing carbon sequestration. By protecting and restoring wetlands and their connections to aquatic systems, we can ensure that they continue to function as effective carbon sinks and support overall ecosystem health.

1.2.2 Best Practices and Recommended Actions

1. **Habitat Restoration**: Restore and conserve blue carbon habitats such as saltmarshes and seagrass beds (eelgrass is a type of seagrass) to maintain and enhance their carbon storage capacity. Restoration efforts can involve replanting vegetation, removing invasive species, and improving hydrological conditions such as through structural modifications to landforms. These actions help increase carbon storage, enhance biodiversity, and improve ecosystem health;
2. **Conservation of Freshwater Wetlands**: Protect and restore freshwater wetlands, particularly those connected with lakes and rivers, which play a significant role in carbon sequestration through sedimentation and organic matter accumulation. Conservation practices include creating buffer zones, regulating water levels, and preventing pollution. Healthy wetlands contribute to long-term carbon storage and support diverse plant and animal species;
3. **Water Quality Management**: Implement measures to improve water quality, such as reducing nutrient runoff and controlling pollution, to support healthy aquatic ecosystems and optimize carbon sequestration. Promoting sustainable agricultural and urban practices including green infrastructure for stormwater management can reduce the impact of pollutants on water bodies, enhancing the ability of aquatic plants, algae, plankton and other life forms to sequester and store carbon;
4. **Monitor and Manage Sedimentation**: Ensure that sedimentation rates are optimal for carbon storage by managing upstream land use and preventing excessive soil erosion. Implementing soil conservation techniques, such as contour plowing and reforestation, can reduce sediment runoff and enhance sedimentation processes in aquatic habitats;
5. **Promote Sustainable Land Use**: Encourage practices that reduce nutrient runoff and pollution, which negatively impact aquatic ecosystems. Sustainable land use practices,

such as maintaining riparian buffers and reducing fertilizer application, help protect water quality and support carbon sequestration; and

6. **Role of Policy, Partnership, and Funding**: Partner with environmental organizations and agencies to promote the conservation and restoration of aquatic ecosystems. Collaboration can lead to the development and implementation of effective conservation strategies, as well as access to technical expertise and resources. Seek grants and funding opportunities to support habitat restoration and conservation efforts. Funding can help cover the costs of restoration activities, monitoring, and maintenance, ensuring the long-term success of conservation projects. Work with policymakers to implement and enforce regulations that protect aquatic ecosystems from degradation and pollution. Advocating for policies that support habitat restoration, water quality improvement, and sustainable land use can enhance carbon sequestration efforts.

1.3 Developed Land

Biological carbon sequestration in developed urban areas occurs through green infrastructure, such as urban forests, parks, green roofs, and living walls. Trees and vegetation in these spaces fix atmospheric CO_2 during photosynthesis and store it in their biomass and soils. In addition to direct sequestration by plants, permeable surfaces and green spaces contribute to carbon storage by enhancing soil health and reducing the urban heat island effect.

1.3.1 Factors Affecting Carbon Sequestration

1. **Urban Forestry and Green Infrastructure**: The extent and quality of green spaces in urban areas directly influence carbon sequestration potential. Different plant species have varying abilities to sequester carbon, with trees generally providing the highest sequestration capacity. Native species, which are well-adapted to local environmental conditions, are often more resilient and effective in storing carbon. Parks, urban forests, and community gardens provide opportunities for trees and vegetation to assimilate CO_2 and store carbon in biomass and soils. Increasing tree canopy cover in urban areas through urban forestry and green infrastructure practices, such as green roofs and bioswales, significantly enhances carbon sequestration. Reducing impervious surfaces and increasing the availability of green spaces allow for more natural areas to sequester carbon and provide additional environmental benefits, such as improved air quality and reduced urban heat island effect;
2. **Soil Health and Amendments**: Soil compaction and sealing in urban areas reduce soil organic carbon storage. Restoring soil health through decompaction and the application

of soil amendments, such as biochar, compost, and mulch, can enhance carbon sequestration. Biochar, made from organic materials, increases soil carbon storage by providing stable carbon that persists in the soil for long periods. Compost and mulch add organic matter to the soil, improving soil structure, water retention, and nutrient availability, which supports healthy vegetation growth and enhances carbon storage; and

3. **Urban Planning**: Policies and regulations that promote incorporating of green infrastructure and sustainable development practices can significantly impact carbon storage in urban areas. Sustainable urban design principles, such as compact development, mixed land use, and efficient public transportation, reduce the overall carbon footprint of urban areas. These principles promote the creation and maintenance of green spaces, reduce the need for extensive land development, and support the integration of green infrastructure into city planning. Sustainable urban design contributes to long-term carbon sequestration and improved quality of life for residents. Designing green corridors that connect ecosystems and promote ecological health is essential for maximizing carbon sequestration in urban areas. Green corridors allow for the movement of wildlife, support biodiversity, and enhance the resilience of urban ecosystems. Incorporating natural area spaces into urban planning promotes carbon sequestration by providing areas where vegetation can thrive and fix CO_2. If organic soil from green infrastructure is displaced due to construction or landscaping activities and is transported to dump sites, it can result in release of stored CO_2 during the handling, transportation, and initial exposure at dump sites due to microbial action. Anaerobic conditions (e.g., deeply buried in landfills) can produce methane (CH_4) instead of CO_2 which is a much more potent greenhouse gas. Organic soil in its natural state, particularly in urban green spaces, continues to sequester carbon from the atmosphere over time. When it's displaced and effectively removed from this active carbon cycle, that potential for ongoing sequestration is lost. Sustainable urban planning practices, such as creating parks, community gardens, and green infrastructure, support long-term carbon storage and create healthier, more livable cities. Supportive policies can also incentivize private property owners to adopt green infrastructure practices.

1.3.2 Best Practices and Recommended Actions

1. **Urban Forestry**: Plant and maintain trees in urban areas to fix CO_2, improve air quality, and provide shade. Focus on selecting native species that are well-adapted to the local environment. Urban forestry programs can enhance carbon storage, reduce the urban heat island effect, and provide recreational and aesthetic benefits;

2. **Sustainable Urban Planning**: Incorporate green spaces, permeable surfaces, and green infrastructure into urban development plans to promote carbon sequestration and improve urban resilience. Sustainable urban planning practices create healthier, more livable cities and support long-term carbon storage;
3. **Enhance Soil Organic Matter**: Use organic amendments, such as compost and mulch, in urban green spaces to increase soil organic matter content and enhance carbon storage. Healthy soils support plant growth and improve the overall carbon sequestration potential of urban vegetation;
4. **Promote Sustainable Construction Practices**: Encourage the use of sustainable building materials and practices that reduce the carbon footprint of urban development. Sustainable construction practices can include the use of recycled materials, energy-efficient designs, and the integration of green infrastructure into building projects. Implement modern, science-based smart building designs and layouts to optimize heat retention and natural cooling, thereby reducing associated greenhouse gas emissions. Soil reuse and redistribution within urban areas should be explored still be a preferable option to maximize the carbon-sequestering benefits; and
5. **Role of Policy, Partnership, and Funding**: Engage with municipal authorities to promote the integration of green infrastructure into urban planning and development. Supportive policies and incentives can facilitate the adoption of best practices and enhance carbon sequestration efforts. Identify grants and funding opportunities to support the implementation and maintenance of urban greening initiatives. Funding can help cover the costs of tree planting and other green infrastructure projects. Encourage community participation in urban greening projects through volunteering, education, and awareness programs. Engaging the community fosters a sense of ownership and responsibility, ensuring the success and sustainability of urban greening initiatives.

1.4 Forests

Forests play a critical role in biological carbon sequestration, with both old-growth and new-growth forests contributing to carbon uptake and long-term storage. In old-growth forests, mature trees and carbon-rich soils store large amounts of carbon, accumulated over centuries. These forests act as major carbon sinks, assimilating CO_2 through photosynthesis and sequestering it in biomass and soil organic matter. Recently cleared forests have a negative carbon sequestration rate (net release of carbon) due to the erosion and decomposition of soils and debris, until the trees and vegetation are large and dense enough to counteract this effect which happens at about 5 years of age. In younger forests older than 5 years, trees rapidly take up CO_2 as they grow and develop, with high photosynthetic rates leading to increased carbon storage in their biomass. However, young forests are more vulnerable to disturbances such as fire, storms, and pest outbreaks, which can cause tree mortality and accelerate the decomposition of fallen biomass, releasing stored carbon back into the atmosphere. As the forest matures, the carbon accumulated in both the trees and soil contributes to long-term sequestration, provided major disturbances are limited.

1.4.1 Factors Affecting Carbon Sequestration

1. **Vegetation Age and Type**: The carbon uptake and storage capacities of a forest depend on its age. Old-growth forests, with their mature trees and developed soils, store large amounts of carbon in biomass and soil organic matter. In contrast, new-growth forests sequester carbon at a faster rate due to the rapid growth of young trees, which have a high rate of photosynthesis and carbon uptake. Both forest age classes are important for overall carbon storage, with old-growth forests providing stable long-term storage and new-growth forests contributing to dynamic carbon uptake. Different tree species have varying abilities to sequester carbon, with some species being more efficient at carbon storage than others. Fast-growing species, such as Douglas-fir, red alder, and bigleaf maple, sequester carbon quickly due to their rapid biomass accumulation. However, slow-growing species like western hemlock, although slower in carbon uptake, store carbon for longer periods and contribute to stable long-term sequestration. Selecting a diverse mix of tree species can optimize carbon storage and enhance forest resilience; and
2. **Soil Health**: Healthy forest soils, rich in organic matter and nutrients, play a key role in carbon sequestration. Soil health is influenced by factors such as soil composition, moisture levels, and microbial activity. Practices that enhance soil health, such as minimizing soil disturbance, preserving leaf litter, and promoting natural decomposition

processes, can increase soil carbon storage. Protecting forest soils from erosion and degradation is essential for maintaining their carbon sequestration capacity.

1.4.2 *Best Practices and Recommended Actions*

1. **Preservation of Old-Growth Forests**: Protect existing old-growth forests and their fringe buffers from deforestation to maintain their high carbon storage capacity and biodiversity. Policies and regulations that prevent logging and land conversion in old-growth forests are essential for preserving these critical carbon sinks;
2. **Reforestation and Afforestation**: Plant trees on previously deforested or non-forested land to increase carbon sequestration. Focus on using native species that are well-adapted to the local environment. Reforestation and afforestation efforts can offset carbon emissions, enhance biodiversity, and restore degraded landscapes;
3. **Sustainable Forest Management**: Implement practices such as selective logging, controlled burns, and maintaining biodiversity to enhance long-term carbon storage in forest ecosystems. Sustainable management practices promote healthy forest growth, reduce the risk of severe wildfires, and support ecosystem resilience;
4. **Enhance Soil Health**: Protect and improve forest soil health by minimizing soil disturbance, preserving leaf litter, and promoting natural decomposition processes. Healthy soils support tree growth and increase soil carbon storage, contributing to overall forest carbon sequestration;
5. **Support Forest Recovery**: Implement practices that support forest recovery and resilience after disturbances, such as reforestation, controlled burns, and sustainable harvesting. Supporting forest recovery ensures that forests can continue to sequester carbon effectively and maintain their ecological functions; and
6. **Role of Policy, Partnership and Funding**: Partner with forestry organizations and agencies to promote sustainable forest management practices and support reforestation efforts. Collaboration can lead to the development and implementation of effective forest conservation strategies. Seek grants and funding opportunities to support reforestation and afforestation projects. Funding can help cover the costs of planting, monitoring, and maintaining new forests, ensuring their long-term success. Work with policymakers to implement and enforce regulations that protect forests from deforestation and degradation. Advocating for policies that support forest preservation and sustainable management can enhance carbon sequestration efforts.

1.5 Low Vegetative Cover

In areas with low vegetative cover, such as shrublands and grasslands, biological carbon sequestration occurs through the assimilation of atmospheric CO_2 by plants during photosynthesis. The carbon is stored both in plant biomass and, critically, in the soil, which serves as the primary long-term carbon reservoir in these ecosystems. Grasslands, in particular, can have deep root systems that contribute substantially to soil organic carbon storage. Although aboveground biomass is relatively low compared to forests, the extensive root networks transfer organic matter deep into the soil, where it is less susceptible to decomposition and loss. In the Comox Valley, about a third of the low vegetation cover is characterized by alpine meadows. These meadows experience shorter growing seasons, reasonable carbon storage due to a cooler climate, and are sensitive to disturbances.

Sustainable land management practices, such as rotational grazing, avoiding overgrazing, and promoting native vegetation, can optimize carbon sequestration in lower altitude low vegetation ecosystems. Additionally, restoration projects that reintroduce native plant species and improve soil health further enhance carbon storage by increasing belowground carbon inputs and stabilizing organic matter.

1.5.1 Factors Affecting Carbon Sequestration

1. **Disturbance (Pest Susceptibility and Fires)**: Alpine meadows in the Comox Valley store carbon at a slower rate due to their limited vegetation cover and short growing seasons. While fires are less prevalent in CVRD, disturbances such as introduction of pests, human activity, and climate change can impact carbon sequestration. Pests can reduce vegetation cover and biomass, while any fires, though rare, could release stored carbon back into the atmosphere. Some fire-adapted ecosystems may rely on periodic fires to maintain health and biodiversity. Implementing fire management practices, such as controlled burns, and monitoring pest populations can help maintain vegetation cover, promote regrowth, and enhance carbon storage. Sustainable land management practices that increase resilience to pests and fires are essential for optimizing carbon sequestration in these areas; and
2. **Restoration Potential**: Restoration efforts, such as planting drought-tolerant or fast-growing species, can enhance above-ground carbon storage and soil organic carbon in shrublands and grasslands. These restoration activities improve ecosystem health, increase vegetation cover, and enhance the soil's capacity to store carbon. By selecting species that are well-adapted to local conditions and resilient to future climate extremes, restoration efforts can support long-term carbon sequestration and ecosystem resilience. Restoration projects that focus on improving soil health and promoting diverse native vegetation contribute to enhanced carbon storage and overall ecosystem stability.

1.5.2 Best Practices and Recommended Actions

1. **Vegetation Restoration**: Reintroduce native plant species, especially those that are drought-tolerant or fast-growing, to enhance carbon sequestration and improve ecosystem health. Restoration efforts should focus on selecting diverse, deep-rooted species that contribute to long-term soil carbon storage. Replanting native vegetation can increase biodiversity and resilience, supporting the overall health of grasslands and shrublands;
2. **Sustainable Grazing Practices**: Implement rotational grazing and avoid overgrazing to maintain healthy grasslands and optimize carbon storage. Sustainable grazing practices help maintain vegetation cover, improve soil health, and ensure the long-term productivity of grasslands. Educating landowners and ranchers on sustainable grazing techniques can promote widespread adoption and success;
3. **Enhance Soil Organic Matter**: Use organic amendments, such as compost and manure, to increase soil organic matter content and enhance carbon storage. Organic amendments improve soil structure, water retention, and nutrient availability, supporting healthy plant growth and increasing soil carbon storage. Minimizing soil disturbance and protecting soil from erosion are also essential for maintaining soil health;
4. **Fire Management**: Implement controlled burns and other fire management practices to maintain ecosystem health and promote regrowth. Controlled burns can reduce the risk of severe wildfires, promote nutrient cycling, and support fire-adapted plant species. Fire management practices should be carefully planned and monitored to maximize ecological benefits and minimize carbon emissions;
5. **Pest Management**: Implement integrated pest management (IPM) practices to reduce the impact of pests on vegetation cover and carbon sequestration. IPM combines biological, cultural, mechanical, and chemical controls to manage pest populations while minimizing harm to the environment. Enhancing habitat for natural predators, using pest-resistant plant varieties, and monitoring pest populations can help maintain healthy vegetation and optimize carbon storage; and,
6. **Promote Sustainable Land Management**: Encourage landowners and managers to adopt sustainable land management practices that enhance carbon sequestration. Practices such is cies can improve the health and resilience of grasslands and shrublands. Sustainable land management practices support long-term carbon storage and ecosystem health.

7. **Role of Policy, Partnership and Funding**: Partner with conservation organizations and agencies to promote the restoration and conservation of low vegetative cover areas. Collaboration can lead to the development and implementation of effective restoration strategies, as well as access to technical expertise and resources. Identify grants and funding opportunities to support the implementation and maintenance of restoration projects. Funding can help cover the costs of replanting native vegetation, monitoring, and maintaining restored areas, ensuring their long-term success. Work with policymakers to implement and enforce regulations that protect shrublands and grasslands from degradation and land conversion. Advocating for policies that support restoration, sustainable grazing, and fire management can enhance carbon sequestration efforts.

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Template: Master Environmental Assessment Report, ENS, June 6, 2022

APPENDIX III

Carbon Biosequestration Model Output

Habitat Type	Area[1] (ha)	Area (%)	Baseline Biosequestration Rate[2] (t CO_2e/ha/yr)	Baseline Biosequestration Rate (t C/ha/yr)[4]	Source and Comments for Normal Sequestration Rate	Total Biosequestration Rate (t CO_2e/yr)	Total Biosequestration Rate[3] (t C/yr)	% of Total Biosequestration	Stored Carbon per Hectare (t C/ha)	Stored Carbon (t C)
Agricultural	6,326	2.5%	3.1	0.85	Modelled Sequestration Rate, see Agricultural Tab	19,733	5,377	1.2%	100	632,564
Aquatic: Coastal Ecosystems (Seagrass, Salt marsh, Mudflats)	2,321	0.9%	1.5	0.40	Modelled Sequestration Rate, see Aquatic Tab	3,440	937	0.2%	105	243,000
Aquatic: Ocean	74,638	29.2%	4.4	1.20	Modelled Sequestration Rate, see Aquatic Tab	328,706	89,566	20.3%	100	7,463,800
Aquatic: Freshwater Systems (Lakes, Ponds)	3,937	1.5%	3.3	0.90	Modelled Sequestration Rate, see Aquatic Tab	12,992	3,540	0.8%	100	393,700
Developed Land	6,653	2.6%	0	0	Assumes urban environment currently zero.	0	0	0.0%	80	532,240
Forest - Old > 250 yrs	23,318	9.1%	5.1	1.40	Modelled Sequestration Rate, see Forest Tab	119,808	32,645	7.4%	1,150	26,815,700
Forest - Stable 5 to 250 yrs	114,773	45.0%	9.2	2.50	Modelled Sequestration Rate, see Forest Tab	1,053,042	286,933	65.2%	400	45,909,200
Forest - Regeneration <5 yrs	585	0.2%	-18.4	-5.00	Modelled Sequestration Rate, see Forest Tab	-10,735	-2,925	-0.7%	150	87,750
Low Vegetative Cover	22,666	8.9%	3.9	1.07	Modelled Sequestration Rate, see Low Veg Tab	89,302	24,333	5.5%	51	1,150,390
Total	**255,217**	**100.0%**				**1,616,288**	**440,405**	**100.0%**	**326**	**83,228,344**

Note 1: Area (ha) provided from mapping documents - Figure 3 Habitats.
Note 2: Divided by 3.67 to convert from tCO_2e to tC. Conversion based on molecular weight calculation (44g/mol of CO_2/12g/mol of C).
Note 3: Emissions from 2021 CVRD GHG Emissions Inventory Report = 433,983 tCO_2/yr for comparison. However, not all carbon losses are accounted for such as logging and deforestation, only actual biosequestration of land type accounted for in this table.
Note 4: t C / ha / yr is metric tonnes of carbon per hectare per year.

Number	Factor	Factor sequestration rate (t C/ha/yr)			Baseline Rate	Land	Area integrated gains (t C/yr)			Reference	Stored Carbon (t C/ha)			Current Stored Carbon	Reference
		Min.	Max.	Mean	(t C/ha/yr)	Land (ha)	Min.	Max.	Mean		Min.	Max.	Mean	t C	
	General Agricultural Soils	0.2	1.5	0.85	0.85	6326				40	50	150	100	632,564	29
1	**Crop Type and Rotation**														
	Annual to perennial cropping	0.46	0.56	0.51	0.85	6326	2910	3542	3226	1					
	Crop-fallow to continuous cropping	0.15	0.33	0.24	0.85	6326	949	2087	1518	1					
	Cover crops	0.025	0.64	0.32	0.85	6326	158	4048	2024	2					
2	Tillage Practices (Conventional Tillage to No Tillage)	0.06	0.16	0.11	0.85	6326	380	1012	696	1					
3	**Agroforestry**														
	Tree-intercropping	0	3.91	0.87	0.85	6326	0	24733	5503	2					
	Silvopasture	0.1	1.48	0.79	0.85	6326	633	9362	4997	2					
4	**Organic Farming and Soil Amendments**														
	General organics (no biochar)	0.12	0.45	0.29	0.85	6326	759	2847	1834	3					
	Biochar	0.05	0.56	0.305	0.85	6326	316	3542	1929	4					
5	**Soil Erosion and Water Management**	1.05	2.5	1.775	0.85	6326	6642	15814	11228						
	Cropland water management *	0	0.77	0.31	0.85	6326	0	4871	1961	5a					
	Cropland set-aside and Land Use Change	0.32	1.34	0.83	0.85	6326	2024	8476	5250	5a,b					
	Degraded Land Restoration	0	1.98	0.94	0.85	6326	0	12525	5946	5a,b					

*Broken down into the soil and water management value used to calculate the previous value for transparency.

Number	Land Type	Strategy	Annual Average Impact (t CO_2e/ha/yr)
1	**Agriculture**	**Crop Type and Rotation**	
1.1	Agriculture	Annual to perennial cropping	1.9
1.2	Agriculture	Crop-fallow to continuous cropping	0.9
1.3	Agriculture	Cover crops	1.2
1.4	Agriculture	Tillage Practices (Conventional Tillage to No Tillage)	0.4
1.2	**Agriculture**	**Agroforestry**	
1.21	Agriculture	Tree-intercropping	3.2
1.22	Agriculture	Silvopasture	2.9
1.3	**Agriculture**	**Organic Farming and Soil Amendments**	
1.31	Agriculture	General organics (no biochar)	1.1
1.32	Agriculture	Biochar	1.1
1.4	**Agriculture**	**Soil Erosion and Water Management**	
1.41	Agriculture	Cropland water management *	1.1
1.42	Agriculture	Cropland set-aside and Land Use Change	3.0
1.43	Agriculture	Degraded Land Restoration	3.4

Factor	Area**	Area for Potential Restoration	Baseline Sequestration Rate (t C/ha/yr)			Area integrated gains based on restoring ecosystems (t C /yr)***			Reference	Stored Carbon (t C/ha)			Stored Carbon
	(ha)	(ha)	Min.	Max.	Mean	Min.	Max.	Mean		Min.	Max.	Mean****	t C
Blue Carbon Coastal													
Salt Marsh *	23	77	0.2	4.5	2.35	15	345	180	6,7,8			500	11,500
Seagrass *	17	24	0.03	1.9	0.97	1	45	23.1	9			200	3,400
Unvegetated (mudflats)	2281	-	0.07	0.7	0.4	-	-	-	10	50	150	100	228,100
Reversing Coastal Squeeze ^	2321	1161	0.1	2.4	1.2	116	2739	1429	11b			100	
	CVRD Saltwater Coastal Average^^^^				0.4	CVRD Saltwater Coastal Total^^^^						104.7	243,000
Ocean													
Blue Carbon: Strait of Georgia basin - baseline ^^^	74638	-	1.1	3.9	1.2	0	1492.76	746.38	11a	50	150	100	7,463,800
Freshwater Systems													
Lakes	2954	-	0.022	1.08	0.55	-	-	-	13	50	150	100	295,400
Freshwater Ponds	983	-	0.26	2.16	1.2	-	-	-	12	50	150	100	98,300
											CVRD Saltwater Coastal Total^^^^	100.0	393,700

* For Salt Marsh and Sea Grass, range of possible rates for this habitat type. So instead of making healthier excosystems, we are expanding the type of ecosystem.

** Existing habitat type.

*** For Salt Marsh and Sea GrassAssumes 70% of salt marsh has been lost, so aims for restoration of an additional 70%. Coastal squeeze not included in summary table for potential due to o

**** Sea grass assumed 2 x mudflat, salt marsh assumed 5 x mudflat, reversing coastal mudflat assumed same as mudflat, lake and open ocean assumed similar to mudflat.

N/A = Not Applicable.

^ See notes for calculation approach. We could frame this as "coastal squeeze prevention and adaptation" and stick with on positive numbers, since they change sign in the finaly tally.

^^^ See notes for calculation approach. Mean from Spooner paper appeared high compared to similar ecosystems, so brought down value to more of an average at 1.2 given area in front of Comox not a high sedimentation configuration (e.g. not a Fjord). Assume a 1% increase due to improvements in water quality if runoff and marine vessel actions taken.

^^^^ Area integrated.

Number	Land Type	Strategy	Annual Average Impact (t CO_2e/ha/yr)
1	**Aquatic: Blue coastal carbon**	**Aquatic: Coastal regeneration**	
1.1	Aquatic: Salt Marsh	Salt marsh restoration	7.1
1.2	Aquatic: Seagrass	Sea grass replanting/restoration	2.1
2	**Aquatic: Coastal carbon**	**Aquatic: Coastal carbon protection**	
2.1	Aquatic: Coastal carbon	Reversing coastal squeeze	5.5
	Aquatic: Open Ocean		
3.1	Aquatic: Open Ocean	Improving Ocean Health	0.4
4	**Aquatic: Freshwater systems**		
4.1	Aquatic: Lakes	Conservation of freshwater lakes	2.0
4.2	Aquatic: Ponds	Conservation of freshwater ponds	4.4

CVRD BIOLOGICAL CARBON SEQUESTRATION STUDY
Table 6: Developed Land
Comox Valley, British Columbia

August 22, 2025
Pinchin File: 347023.000

Factor	Area*	Baseline Rate	Factor sequestration rate (t C/ha/yr)			Potential Change in Carbon Sequestered (t C /yr)****			Reference	Stored Carbon (tC/ha)			Current Stored Carbon tC	Reference
	(ha)	(t C/ha/yr)	Min.	Max.	Mean	Min.	Max.	Mean		Min.	Max.	Mean	tC	
Urban forests***	1996	2.075	1.4	6.9	2.1	40	197	59	14	100	350	225	449,078	35
Brownfield **	67	0	1.09	16.1	8.6	73	1072	572	17					
Turfgrass - baseline*****	1331	1.0	0.4	1.7	1.0	-	-	-	16a,b,c	25	100	62.5	83,163	33
Asphalt/paved*****	3260													
Total Developed Land	6,653	0.8	-	-	-	-	-	-	-	-	-	80.0	532,240	

* Typical values used for breakdown of area. 30% for urban forest, 25% for roofs, 20% for turfgrass, rest asphalt/no sequestration.

** Reconverting brownfields to forest ecologies. High short term conversion capacity. Assumed 0 or close to 0 for baseline. Assumes 1% of developed land.

*** Decreased to align with natural forests, divided by 2. Note that area is not well calculated here, as the mapping may have classified this as forest. Is shown for carbon sequestration comp

**** Potential Change equal to sum of mean values for all categories with a value.

*****Areas not accurate. Note that asphalt also includes gravel forest roads. Spread of developed land in this table shown for order of magnitude carbon calculations only.

Factor	Area*	Baseline Rate	Factor sequestration rate (t C/ha/yr)			Application	Area integrated gains (t C /yr)			Reference	Stored Carbon (t C/ha)			Current Stored Carbon	Reference
	(ha)	(t C/ha/yr)	Min.	Max.	Mean		Min.	Max.	Mean		Min.	Max.	Mean	tC	
Vegetation Age and Type															
Forest > 250 yrs: Ancient, Preservation, Deferral	23,318	1.4	0.4	2.400	1.4	100%	0	23318	32,645	18	1000	1300	1150	26,815,700	36
Forest 5 to 250 yrs: Preservation	114,773	2.5									200	600	400	45,909,200	37
Optimization Factors															
5-250 yrs Forest: Extend rotation, harvest after 80 years instead of 40	114,773	2.5	-	-	2	20%	-	-	45,909	19,20					
5-250 yrs Forest: thinning	114,773	2.5	-	-	1.06	100%	-	-	121,659	19					
5-250 yrs Forest: fertilization	114,773	2.5	-	-	0.71	100%	-	-	81,489	19					
0-5 yr Regen areas: Prompt Regeneration	585	-5.0	2.2	4.1	3.15	100%	1287	2399	1,843	19,21	100	200	150	87,750	
Disturbance															
Fire Reduction **	138,091	2.5	-	-	0.119	5%	-	-	16,433	22					
Pest Reduction **	138091	1.4	-	-	0.11	5%	-	-	15,190	22					

* Land classified based on BC Vegetation Resources Inventory. Modified to match total land area in map for project. Old growth from old growth technical advisory panel forest assessment land base layer.

** Fire and pest potential reductions leading to carbon sequestration gains may be non-existent to highly variable and hence are not included in roll up calculations on main tab.

Number	Land Type	Sub-Land Type	Strategy	Annual Average Impact (t CO_2e/ha/yr)
1	**Forest**	**Forest > 250 yrs**		
1.1	Forest	Forest > 250 yrs	Protection of > 250 yr forest from logging	21
1.2	Forest	Forest > 250 yrs	Protection of > 250 yr forest from development	47
2	**Forest**	**Forest 5-250 yrs**		
2.1	Forest	Forest 5-250 yrs	Protection of 5-250 yr forest from logging	9.5
2.2	Forest	Forest 5-250 yrs	Protection of 5-250 yr forest from development	24
2.3	Forest	Forest 5-250 yrs	5-250 yrs Forest: Extend rotation, harvest after 80 years instead of 40	7.3
2.4	Forest	Forest 5-250 yrs	5-250 yrs Forest: thinning	3.9
2.5	Forest	Forest 5-250 yrs	5-250 yrs Forest: fertilization	2.6

Note: Strategy modelled for 100 year scenario, based off of numbers and assumptions in previous modelling tables.

Number	Factor	Area***	Baseline Rate	Factor sequestration rate (tC/ha/yr)			Area integrated gains (t C /yr)			References	Stored Carbon (t C/ha)			Stored Carbon	Reference
		(ha)	(t C/ha/yr)	Min.	Max.	Mean	Min.	Max.	Mean		Min.	Max.	Mean	tC	
1	**Disturbance reduction (pest susceptibility, fires)**	16250	1.07	0.01	0.11	0.06	174	1745	959	23					
2	**Restoration Potential (sub-alpine, less then 1100 m)**														
	Restoration	16250	1.30	0.5	2.1	1.30	-	-	-	24	30	80	55	893,750	38
3	**Wetland Connections**														
	Riparian Enhancement **	1625	6.4	0.9	2.3	1.60	1463	3738	2600	26					
	Peatland resoration *	163	0.23	0.10	0.30	0.20	16	49	33	2,27					
	Peatland avoided conversion *	163	0.23	2.16	4.45	3.31	351	723	537	2,27					
	Freshwater marsh restoration **	1625	1.75	0.075	0.097	0.09	122	158	140	2,28					
	Freshwater marsh avoided conversion **	1625	1.75	1.7	3.10	2.40	2763	5038	3900	2,28					
	Alpine (above 1100m)	6416	0.5	0	1	0.50	0	6416	3208		20	60	40	256640	39
	Total	22666	1.07						4167			**Total**	51	1,150,390	

* Peatlands assume 1% of total low veg cover.

** Freshwater marsh land and ripariran assumed 10% of low vegetation cover.

*** High elevation alpine area above 1100m (8370 ha) excluded from land area.

Number	Land Type	Strategy	Annual Average Impact (t CO_2e/ha/yr)
	Low vegetative cover		
1	Low vegetative cover	Disturbance reduction (pest susceptibility, fires)	0.2
	Low vegetative cover	**Wetland Connections**	
2.1	Low vegetative cover: Riparian areas	Riparian Enhancement	5.9
2.2	Low vegetative cover: Peatland	Peatland resoration	0.7
2.3	Low vegetative cover: Peatland	Peatland avoided conversion	12.1
2.4	Low vegetative cover: Freshwater marsh	Freshwater marsh restoration	0.3
2.5	Low vegetative cover: Freshwater marsh	Freshwater marsh avoided conversion	8.8
	Low vegetative cover	**Restoration**	
3.1	Alpine meadows (above 1100m)	Restoration: Alpine (above 1100m)	3.9
3.2	Sub-alpine meadows (below 1100m)	Restoration: Sub-alpine (below 1100m)	4.8

Number	Factor	Factor reference	Baseline reference	Notes and calculations
1	Annual to perennial cropping, Crop-fallow to continuous cropping, Tillage Practices (Conventional Tillage to No Tillage)	VandenBygaart, A. J., McConkey, B. G., Angers, D. A., Smith, W., de Gooijer, H., Bentham, M., & Martin, T. (2008). Soil carbon change factors for the Canadian agriculture national greenhouse gas inventory. Canadian Journal of Soil Science, 88(5), 671–680. https://doi.org/10.4141/CJSS07015	Stantec Report, Table 24,Cropland	
2	Agricultural: Cover crops, Tree-intercropping, Silvopasture; Low veg cover: Peatland, freshwater marsh	Drever, C. R., Cook-Patton, S. C., Akhter, F., Badiou, P. H., Chmura, G. L., Davidson, S. J., Desjardins, R. L., Dyk, A., Fargione, J. E., Fellows, M., Filewod, B., Hessing-Lewis, M., Jayasundara, S., Keeton, W. S., Kroeger, T., Lark, T. J., Le, E., Leavitt, S. M., LeClerc, M., Kurz, W. A. (2021). Natural climate solutions for canada. Science Advances, 7(23). https://doi.org/10.1126/sciadv.abd6034	Agricultural: Stantec Report, Table 24,Cropland; Low Veg. Cover: see Numbers 26-28	
3	Organic farming	VandenBygaart, A. J., McConkey, B. G., Angers, D. A., Smith, W., de Gooijer, H., Bentham, M., & Martin, T. (2008). Soil carbon change factors for the Canadian agriculture national greenhouse gas inventory. Canadian Journal of Soil Science, 88(5), 671–680. https://doi.org/10.4141/CJSS07015	Stantec Report, Table 24,Cropland	VandenBygaart et al. (2008) reported that organic amendments (excluding biochar) increased soil carbon by 0.12–0.45 t C ha^{-1} yr^{-1}, with a mean of 0.29 t C ha^{-1} yr^{-1}.
4	Biochar	Woolf, D., Amonette, J. E., Street-Perrott, F. A., Lehmann, J., & Joseph, S. (2010). Sustainable biochar to mitigate global climate change. Nature Communications, 1(5), 56. https://doi.org/10.1038/ncomms1053	Stantec Report, Table 24,Cropland	Assuming 10 tonnes of biochar per hectare, assuming 50% carbon content
5a	Erosion and water management	Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., & Smith, J. (2008). Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1492), 789–813. https://doi.org/10.1098/rstb.2007.2184	Stantec Report, Table 24,Cropland	Sequestration factor ranges for water management and erosion control were derived from Smith et al. (2008, Table 2) for the cool–moist climate zone, and converted from CO_2e to elemental carbon (C) by dividing by 3.67. For erosion control, relevant categories included cropland set-aside and degraded land restoration. These choices are supported by Lal (2003), who cites carbon sequestration potentials >1 t C ha^{-1} yr^{-1} for erosion control on degraded soils.
5b	Erosion and water management	Lal, R. (2003). Soil erosion and the global carbon budget. Environment International, 29(4), 437–450. https://doi.org/10.1016/S0160-4120(02)00192-7	Stantec Report, Table 24,Cropland	
6	Saltmarsh	Gailis, M., Kohfeld, K. E., Pellatt, M. G., & Carlson, D. (2021). Quantifying blue carbon for the largest salt marsh in southern british columbia: Implications for regional coastal management. Coastal Engineering Journal, 63(3), 275-309. https://doi.org/10.1080/21664250.2021.1894815	-	Saltmarsh restored land calculated assuming 70% of saltmarsh area lost.
7	Saltmarsh	Chastain, S. G., Kohfeld, K. E., Pellatt, M. G., Olid, C., Gailis, M., & Sveriges lantbruksuniversitet. (2022). Quantification of blue carbon in salt marshes of the pacific coast of canada. Biogeosciences, 19(24), 5751-5777. https://doi.org/10.5194/bg-19-5751-2022	-	-
8	Saltmarsh	Beck, A., Dodge, B., Kelly, B., Kent, S., & McCarthy, A. (2023). Salt Marsh. In Coastal Blue Carbon in Canada: State of Knowledge. Retrieved from https://wwf.ca/wp-content/uploads/2023/06/BlueCarbon_StateofKnowledge_SaltMarsh.pdf	-	-
9	Eelgrass	Hodgson, C., & Spooner, A. (2016). The K'ómoks and Squamish Estuaries: A Blue Carbon Pilot Project. Comox Valley Project Watershed Society.		Seagrass restored land calculated assuming 29% of eelgrass area lost (Spooner, 2016). *Z. marina* area coverage of the K'ómoks Estuary has been mapped as roughly 1.3 km2 (1.28-1.68 from mapping)
10	Mudflat	Douglas, T. J., Schuerholz, G., & Juniper, S. K. (2022). Blue carbon storage in a northern temperate estuary subject to habitat loss and chronic habitat disturbance: Cowichan estuary, british columbia, canada. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2022.857586	Average of mudflat range	Komoks estuary is sandy, like Cowichan. Nearest estimate for northern termperate mudflat sequestration from study in Cowichan Estuary. Note this estuary has substantial fine-particulate export, which may be similar in Komoks.
11a	Strait of George Basin	Spooner, A. M. (2016). Blue carbon sequestration potential in Zostera marina eelgrass beds of the K'ómoks Estuary, British Columbia (Master's thesis). Royal Roads University. Retrieved from https://www.researchgate.net/publication/310640505_Blue_carbon_sequestration_potential_in_Zostera_marina_eelgrass_beds_of_the_K%27omoks_Estuary_British_Columbia	Average of SoG range	Carbon accumulation rates (Corg) for Strait of Georgia Deep Basin sediments were converted from g C cm^{-2} yr^{-1} to t C ha^{-1} yr^{-1} using the conversion 1 g C cm^{-2} yr^{-1} = 1 t C ha^{-1} yr^{-1}. Reported rates range from 1.1 to 3.9 t C ha^{-1} yr^{-1}, with a mean of 2.14 t C ha^{-1} yr^{-1}. Mean reported values assumed to be current baseline, and area integrated gains represent min to max of current capacity, calculated as: (max x area) - (mean - area). Min. gain value is negative an represents loss of seuqestration capacity, mean is 0 and represents no change, max is positive and represents optimal state (increased allochthenous/autochthenous production/import).
11b	Coastal squeese	Galbraith, H., Jones, R., Park, R., Clough, J., Herrod-Julius, S., Harrington, B., & Page, G. (2002). Global climate change and sea level rise: Potential losses of intertidal habitat for shorebirds. Waterbirds (De Leon Springs, Fla.), 25(2), 173-183. https://doi.org/10.1675/1524-4695(2002)025[0173:GCCASL]2.0.CO;2	Average of current eelgrass, salt marsh, mudflat	Assuming a conservative global warming scenario of 2°C within the next century, major intertidal habitat loss at four of the sites (Willapa Bay, Humboldt Bay, San Francisco Bay, and Delaware Bay). Projected losses range between 20% and 70% of current intertidal habitat. To estimate potential carbon losses from coastal squeeze, carbon sequestration rates for salt marsh, eelgrass, and mudflat habitats were summed, expressed as negative values to reflect loss, and multiplied by 50% of their current areal extent. This reflects a mid-range scenario within the projected global range of 20% to 70% intertidal habitat loss by 2100.
12	Ponds	Taylor, S., Gilbert, P. J., Cooke, D. A., Deary, M. E., & Jeffries, M. J. (2019). High carbon burial rates by small ponds in the landscape. Frontiers in Ecology and the Environment, 17(1), 25-31. https://doi.org/10.1002/fee.1988 and Holgerson, M. A., & Raymond, P. A. (2016). Large contribution to inland water CO_2 and CH_4 emissions from very small ponds. Limnology and Oceanography Letters, 1(1), 23–29. https://doi.org/10.1002/lol2.10027	Baseline from mean reported by Taylor et al., 2019	Mean reported values assumed to be current baseline, and area integrated gains represent min to max of current capacity, calculated as: (max x area) - (mean - area). Min. gain value is negative an represents loss of seuqestration capacity, mean is 0 and represents no change, max is positive and represents optimal state.
13	Lakes	Heathcote, A. J., Anderson, N. J., Prairie, Y. T., Engstrom, D. R., & del Giorgio, P. A. (2015). Large increases in carbon burial in northern lakes during the anthropocene. Nature Communications, 6(1), 10016-10016. https://doi.org/10.1038/ncomms10016	Baseline: mean from 1950-Present OC burial (g m^{-2} per year) in British Columbia (CA) = 3.5 +/- 1.3.	Lower range infered from standard deviation. Holgerson et al. (2023) have shown that carbon burial rates in ponds are double those in lakes and similar as for wetlands; therefore, upper range based on half carbon sequestration capacity of ponds.
14a	Urban forests	Steenberg, J. W. N., Ristow, M., Duinker, P. N., Lapointe-Elmrabti, L., MacDonald, J. D., Nowak, D. J., Pasher, J., Flemming, C., & Samson, C. (2023). A national assessment of urban forest carbon storage and sequestration in Canada. Carbon Balance and Management, 18(1), 11. https://doi.org/10.1186/s13021-023-00230-4	Baseline calculated as mean of urban forests	Urban forest area integrated gains calculated by multiplying factor rates by 0.1 (asuming 10% increase in canopy cover from 30% to 40% as to reach target described in 14b).
14b	Urban forests	Ferdous, J., Hepburn, M. H., Pashanejad, E., & Sutherland, I. (2022). Towards a regional plan for climate change adaptation, mitigation and biodiversity conservation in Indigenous, rural, and urban landscapes of the Comox Valley. UBC Sustainability Scholars Program. https://sustain.ubc.ca/sites/default/files/2022-005_Towards%20a%20regional%20plan%20for%20climate%20change_Ferdous_Hepburn_Pashanejad_Sutherland.pdf	Mean of urband forest factor rates	From report: "Town of Comox notes in their 2011 OCP that they are below the recommended 40% tree cover target for municipalities in the Pacific Northwest." Calculation assumes 30% canopy cover for urban forests and reports area-integrated sequestration gains for the additional 10% cover.
15	Green roofs	Shafique, M., Xue, X., & Luo, X. (2020). An overview of carbon sequestration of green roofs in urban areas. Urban Forestry & Urban Greening, 47, 126515. https://doi.org/10.1016/j.ufug.2019.126515	Stantec Report, Table 24, Roads = other; Table 24, High reflectance Settlement = Settlement; assumes no current green roofs	Excluded harvest (vegetables, herbs) and Luo et al. study from Chinese greenroofs. Area of roofs calculated as 25% or urban landscape: https://www.catalyticfinance.org/resources/a-practical-guide-to-cool-roofs-and-cool-pavements#:~:text=Studies%20of%20a%20city's%20%E2%80%9Curban%20fabric%E2%80%9D%20indicate,that%20contacts%20them%20and%20convert%20that%20solar
16a	Turfgrass	David Suzuki Foundation. (n.d.). LawnShare. https://davidsuzuki.org/take-action/act-locally/lawnshare/	Mean of turfgrass factor rates	General note: Turfgrass systems sequester the most carbon in the first decade after establishment, especially when planted on former cropland or developed land. Carbon accumulation is enhanced by moderate irrigation and fertilization, minimal soil disturbance, and avoiding forest-to-turf conversions. Sequestration rates decline with turf age, often plateauing after ~50 years.
16b	Turfgrass	Phillips, C. L., Wang, R., Mattox, C., Trammell, T. L. E., Young, J., & Kowalewski, A. (2023). High soil carbon sequestration rates persist several decades in turfgrass systems: A meta-analysis. The Science of the Total Environment, 858(Pt 3), 159974-159974. https://doi.org/10.1016/j.scitotenv.2022.159974	Mean of turfgrass factor rates	Upper value (Phillips et al, 2023) = 5.3 Mg CO_2/ha/yr = 1.45t C/ha/yr; lower value (Trémeau et al., 2024) = 157 g CO_2e/m^2/yr = 0.43 t C/ha/yr. Turfgrass cover for Comox was estimated at approximately 22.5% of the urban area based on data from comparable Canadian towns. The value is anchored to reported turfgrass coverage in municipalities of similar size and land use, such as Collingwood, Ontario (22.7%). This estimate reflects typical proportions of lawns, parks, and recreational grass areas in low-density communities (David Suzuki Foundation, n.d.). Mean reported values assumed to be current baseline, and area integrated gains represent min to max of current capacity, calculated as: (max x area) - (mean - area). Min. gain value is negative an represents loss of seuqestration capacity, mean is 0 and represents no change, max is positive and represents optimal state.
16c	Turfgrass (meadows)	Trémeau, J., Olascoaga, B., Backman, L., Karvinen, E., Vekuri, H., & Kulmala, L. (2024). Lawns and meadows in urban green space – a comparison from perspectives of greenhouse gases, drought resilience and plant functional types. Biogeosciences, 21(4), 949–972. https://doi.org/10.5194/bg-21-949-2024		While conversion of lawns to meadows has benefitial ecological impacts, current evidence indicates that lawns sequester more carbon.

Number	Factor	Factor reference	Baseline reference	Notes and calculations
17a	Brownfield	Jorat, M. E., Goddard, M. A., Manning, P., Lau, H. K., Ngeow, S., Sohi, S. P., & Manning, D. A. C. (2020). Passive CO_2 removal in urban soils: Evidence from brownfield sites. Science of The Total Environment, 703, 135573. https://doi.org/10.1016/j.scitotenv.2019.135573	Stantec Report, Table 24, Roads = other; Table 24, High reflectance Settlement = Settlement	Very high potentially of urban brownfield lands containing "Technosols" to remove CO2 through precipitation of inorganic carbon in the form of calcite (CaCO3). Technosols are defined by the presence of technogenic materials, or artefacts, which are substances made or strongly altered by human activities, like bricks, concrete, and steel mill sludge, or brought to the surface, like excavated bedrock (IUSS, 2014). May required some intervention, such as incorporating demolition waste or crushed basic rocks within the landscaping of new urban infrastructure developments. Area calculated as 20% of total developed land (de Sousa, 2006).
17b	Brownfield	DE SOUSA, C. A. (2006). Urban brownfields redevelopment in canada: The role of local government. The Canadian Geographer, 50(3), 392-407. https://doi.org/10.1111/j.1541-0064.2006.00148.x	Stantec Report, Table 24, Roads = other; Table 24, High reflectance Settlement = Settlement	
18a	Oldgrowth	Luyssaert, S., Schulze, E. -., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., Ciais, P., & Grace, J. (2008). Old-growth forests as global carbon sinks. Nature, 455(7210), 213-215. https://doi.org/10.1038/nature07276	Baseline calculated as mean of oldgrowth forest factor rate range	Minimum from Gunderseb et al., 2008 (number 18b), maximum from Luyssaert et al, 2008. Gunderseb et al. challenged the highly cited Luyssaert et al. and reported lower sequestration rates. The minimum value (0.4 tC/ha/yr) represents unmanaged old growth, while the maximum value of 2.4 factors in old growth management.
18b	Oldgrowth	Gundersen, P., Thybring, E. E., Nord-Larsen, T., Vesterdal, L., Nadelhoffer, K. J., & Johannsen, V. K. (2021). Old-growth forest carbon sinks overestimated. Nature, 591(7851), E21–E22. https://doi.org/10.1038/s41586-021-03266-z	Baseline calculated as mean of oldgrowth forest factor rate range	
19	Mature: Extend rotation, second growth thinning, second growth fertilization	Black, T. A., Jassal, R. S., & Fredeen, A. L. (2008). Carbon sequestration in British Columbia's forests and management options. Pacific Institute for Climate Solutions (PICS), University of Victoria. https://pics.uvic.ca/sites/default/files/uploads/publications/Carbon_Sequestration_in_BCs_Forests.pdf	Black, T. A., Jassal, R. S., & Fredeen, A. L. (2008). Carbon sequestration in British Columbia's forests and management options. Pacific Institute for Climate Solutions (PICS), University of Victoria. https://pics.uvic.ca/sites/default/files/uploads/publications/Carbon_Sequestration_in_BCs_Forests.pdf	
20	Mature: Extend rotation, harvest after 80 years instead of 40	Christensen, E. (2022, March 17). Yes, long rotations can yield real climate gains for Cascadia. Sightline Institute. https://www.sightline.org/2022/03/17/yes-long-rotations-can-yield-real-climate-gains-for-cascadia/	Black, T. A., Jassal, R. S., & Fredeen, A. L. (2008). Carbon sequestration in British Columbia's forests and management options. Pacific Institute for Climate Solutions (PICS), University of Victoria. https://pics.uvic.ca/sites/default/files/uploads/publications/Carbon_Sequestration_in_BCs_Forests.pdf	
21	Regenerating: prompt reforestation, Cut blocks	Government of British Columbia. (n.d.). Factsheet: Reforestation in B.C. https://news.gov.bc.ca/factsheets/factsheet-reforestation-in-bc	Estimated average sequestration from BC's Forests for Tomorrow program is 11.47 t CO_2/ha/yr × (12/44) = 3.13 t C/ha/yr, with a plausible range of ±30%, or approximately 2.2–4.1 t C/ha/yr.	
22	Fire, pests	STINSON, G., KURZ, W. A., SMYTH, C. E., NEILSON, E. T., DYMOND, C. C., METSARANTA, J. M., BOISVENUE, C., RAMPLEY, G. J., LI, Q., WHITE, T. M., & BLAIN, D. (2011). inventory-based analysis of canada's managed forest carbon dynamics, 1990 to 2008. Global Change Biology, 17(6), 2227-2244. https://doi.org/10.1111/j.1365-2486.2010.02369.x	Second growth baseline for fire; old growth baseline for pests	Assumes 100% prevention of fire and pests
23a	Low vegetation Disturbance reduction: Fire	Loehle, C. (2023). The problem of permanence for carbon sequestration in forests. Mitigation and Adaptation Strategies for Global Change, 28(8), 45-45. https://doi.org/10.1007/s11027-023-10079-0	Baseline calculated as average of all low veg. cover	Assumes fire affects 1-2% of landscape annually
23	Low vegetation Disturbance reduction: Pests	Hicke, J. A., Allen, C. D., Desai, A. R., Dietze, M. C., Hall, R. J., (Ted) Hogg, E. H., Kashian, D. M., Moore, D., Raffa, K. F., Sturrock, R. N., & Vogelmann, J. (2012). Effects of biotic disturbances on forest carbon cycling in the united states and canada. Global Change Biology, 18(1), 7-34. https://doi.org/10.1111/j.1365-2486.2011.02543.x	Baseline calculated as average of all low veg. cover	Insect and pathogen disturbances in grassland and shrubland systems are poorly quantified, particularly in BC. However, based on expert consensus from U.S. sources (e.g., USDA GRACEnet reports), these biotic disturbances are generally minor compared to forests and result in limited, short-term impacts on carbon sequestration. As a precautionary estimate, we assume a 1–10% reduction in baseline sequestration rates in affected areas to reflect potential losses.
24	Restoration and conversion to perennial shrublands	Wilson, S. J. (2009). The value of British Columbia's grasslands: Exploring ecosystem values and incentives for conservation. Grasslands Conservation Council of British Columbia. Retrieved from https://bcgrasslands.org/wp-content/uploads/2017/06/bc_grasslands_value_wilson_21aug09.pdf	Stantec Report, Table 24, Settlement or Cropland	Factor rates calculated from biomass + SOC in Greenbelt study.
25	Grazing, N-fertilization	Derner, J. D., Boutton, T. W., Briske, D. D., & Whitman, T. (2007). Grazing and ecosystem carbon storage in the North American Great Plains. Journal of Soil and Water Conservation, 62(2), 77–85. https://www.ars.usda.gov/ARSUserFiles/30180000/DernerPDF/32.JSWC62%282%29Derner.pdf	Stantec Report, Table 24, Settlement or Cropland	
26	Riparian	Li, H., Johnson, C. J., Rex, J. F., & Todd, M. (2024). Long-term riparian forest loss around streams, lakes, and wetlands in ecologically diverse managed and unmanaged landscapes. Forest Ecology and Management, 562, 121931. https://doi.org/10.1016/j.foreco.2024.121931	Ofosu, E. (2023). Carbon sequestration as influenced by diverse riparian buffer systems in Southern Ontario, Canada (Doctoral dissertation, University of Guelph). University of Guelph Atrium. https://hdl.handle.net/10214/27436	Basline from Southern Ontario natural forest buffers (3.14 Mg C ha-1y-1). Factors calculated from biomass + SOC 30 years after planting (Drever et al., 2021). Range infered from SD. Applied to estmmated range of habitat loss. Assume riparian represents 10% low vegetative cover.
27a	Peatlands	Maynard, D.E. (1988). Peatland Inventory of British Columbia. British Columbia Mineral Development Agreement 185-1990. Retrieved from: https://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/OpenFile/BCGS_OF1988-33.pdf	See 27b	Peatland area calcualted assuming 1% landcover.
27b	Peatlands	Swenson, M. M., Wu, J., Packalen, M. S., Finkelstein, S. A., Roulet, N. T., & Moore, T. R. (2023). Using the Canadian Model for Peatlands (CaMP) to examine greenhouse gas emissions and carbon sink strength in Canada's boreal and temperate peatlands. Science of the Total Environment, 870, 161941. https://doi.org/10.1016/j.scitotenv.2023.161941	Swenson et al. (2023) report modeled NECB values for undisturbed temperate bogs ranging from 0.15 to 0.30 tC/ha/yr, with a mean around 0.23 under baseline, steady-state hydrological conditions.. The most realistic baseline for Comox peatlands from the Swenson et al. (2023) paper is 0.23 tC/ha/yr, based on modeled long-term average net ecosystem carbon balance (NECB) for undisturbed temperate peatlands	Factor sequestration gain from Drever et al., 2021 (Reference Number 2)
28	Freshwater wetlands	Ducks Unlimited Canada. (2020). The importance of freshwater mineral asoil wetlands in the global carbon cycle. Alberta NAWMP Partnership. https://abnawmp.ca/wp-content/uploads/2020/09/The-Importance-of-Freshwater-Mineral-Soil-Wetlands-in-the-Global-Carbon-Cycle_FINAL_web.pdf	Baseline carbon sequestration for freshwater mineral soil wetlands was estimated as 1.75 tC/ha/yr, based on the midpoint of the reported range (1–2.5 tC/ha/yr) in Ducks Unlimited Canada (2020), which reflects the average long-term accumulation in undisturbed systems.	Factor sequestration gain from Drever et al., 2021 (Reference Number 2)
29	Agricultural Fields	Lal, R. (2004). "Soil carbon sequestration impacts on global climate change and food security." Science, 304(5677), 1623–1627	Embodied carbon 50-150 Mg C/ha	
30	Intertidal Mudflats	McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., & Silliman, B. R. (2011). A Blueprint for Blue Carbon: Toward an Improved Understanding of the Role of Vegetated Coastal Habitats in Sequestering CO_2. _Frontiers in Ecology and the Environment, 9 (10), 552–560.	Embodied carbon 50-150 Mg C/ha	

Number	Factor	Factor reference	Baseline reference	Notes and calculations
31	Lakes	McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., & Silliman, B. R. (2011). A Blueprint for Blue Carbon: Toward an Improved Understanding of the Role of Vegetated Coastal Habitats in Sequestering CO_2. _Frontiers in Ecology and the Environment, 9_(10), 552–560.	Embodied carbon 25-150 Mg C/ha	
32	Eelgrass	Poppe, K. L., & Rybczyk, J. M. (2018). Carbon Sequestration in a Pacific Northwest Eelgrass (Zostera marina) Meadow. Northwest Science, 92(2), 80-91. https://doi.org/10.3955/046.092.0202	0.45 to 1.90 MgC/ha/year	
33	Turfgrass	Qian, Y., Follett, R. (2012). Carbon Dynamics and Sequestration in Urban Turfgrass Ecosystems. In: Lal, R., Augustin, B. (eds) Carbon Sequestration in Urban Ecosystems. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-2366-5_8	Embodied carbon 25-100 MgC/ha	
34	Streams and Rivers	McLeod, E., Chmura, G. L., Bouillon, S., Salm, R., Björk, M., Duarte, C. M., & Silliman, B. R. (2011). A Blueprint for Blue Carbon: Toward an Improved Understanding of the Role of Vegetated Coastal Habitats in Sequestering CO_2. _Frontiers in Ecology and the Environment, 9_(10), 552–560.	Embodied carbon 5-20 MgC/ha	
35	Urban Forest	John M. Kimble, Rattan Lal, Richard Birdsey, Linda S. Heath (2002). The Potential of US Forest Soils to Sequester Carbon and Mitigate the Greenhouse Gas Effect, CRC Press		
36	Forests - Old Growth, Coastal Temperate Rainforest	Franklin, J. F., Berg, D. R., & DeLuca, T. B. (2000). Characteristics of Old-Growth Coastal Temperate Rainforests in the Pacific Northwest: Implications for Carbon Storage. Ecological Applications, 10_(1), 183–196	Embodied carbon 1000-1300 Mg C/ha	
37	Forests - Mature 2nd Growth	Thompson, W. L., & Kittredge, D. (2012). Carbon Sequestration Dynamics in Second-Growth Forests of the Pacific Northwest. _Forest Ecology and Management, 271_, 12–20.	Embodied carbon 200-600 Mg C/ha	
38	Low-Veg: Subalpine and montane grasslands	Körner, C. (2003). “Alpine Plant Life: Functional Plant Ecology of High Mountain Ecosystems.” Springer	Embodied carbon 30-80 Mg C/ha	
39	Low-Veg: Alpine Meadows	Körner, C. (2003). “Alpine Plant Life: Functional Plant Ecology of High Mountain Ecosystems.” Springer	Embodied carbon 20-60 Mg C/ha	
40	Agriculture	Wood-Bohm (2022). "Carbon Sequestration in Agricultural Soils…" CAPI, https://capi-icpa.ca/wp-content/uploads/2022/04/April-21-Carbon-Sequestration-Research-Report-Susan-Wood-Bohm-EN.pdf	Rate from 0.2 to 1.5 Mg C/ha/yr	