SCS Global Services Report

Phase II Report for RFQQ 2217 AQP

Prepared for
State of Washington Department of Ecology

Report Title
CO_2 Removal Project Standards Analysis

Date
30 June 2023

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Executive Summary

Phase II built upon previous efforts from Phase I: Analytical Refinement & Protocol Scenarios. This report presents the results of Phase II, summarizing information about out-of-jurisdiction protocols, new and developing protocols, a meta-comparison of all protocols concerning their application in the State of Washington, and enhancements made upon past analyses drawn from additional research. We found that Washington has a high potential for carbon project development across all sinks, despite relatively few projects being developed in the state at the time of the analysis relative to other areas with a similar offering of carbon dioxide sinks.

Our conclusions are based upon evidence gathered from three primary data sources: extensive environmental datasets, stakeholder interviews, and the underlying standards that act as 'blueprints' for protocols across all carbon dioxide sinks. There is still high uncertainty related to the physical capacity of aquatic coastal (blue) and aquatic freshwater (teal) carbon dioxide sinks. However, this is also a problem for areas outside of Washington, given the low data availability globally for blue and teal carbon crediting.

To expand our understanding of Washington's terrestrial sink capacity, we conducted a similar modeling effort as we did with the Phase I forest carbon modeling but also included agricultural sinks. The results of this soil carbon modeling effort indicated southwest Washington has a high potential for agricultural offset projects.

Also, based upon our meta-analysis across all sinks, we identify seven protocols that are most suitable for Washington for each carbon dioxide sink: VM007 (blue and teal), VM0042 (agriculture), VM0026 (grasslands), the California Air Resources Board (CARB), Compliance Offset Protocol U.S. Forest Projects (improved forest management), the California Air Resources Board, Compliance Offset Protocol U.S. Forest Projects (afforestation, reforestation, revegetation), and City Forest Credits (urban forest).

From the Phase II meta-analysis, we identified components of highly suitable protocols for Washington that could further improve, uncovered additional data gaps, and made broad conclusions about the suitability, readiness, and robustness of carbon protocols for Washington, accounting for the evolving nature of the carbon market. One component to increase the suitability of protocols across most sinks is to improve the interpretability of how protocols are described and presented, which leads to more efficient project implementation and greater alignment in audit outcomes. Other components requiring improvement for specific 'winning' protocols are discussed in this report. Besides the general lack of data availability for blue and teal carbon storage change for Washington and aquatic areas similar to Washington, we find that data, such as emissions factors and common practice metrics, could be updated to represent conditions in areas across Washington better.

Identifying areas of improvement for existing protocols and broader data gaps is especially timely since broader adoption of blue, teal, and agricultural protocols is expected worldwide, and registries are expected to continue updating their standards. Furthermore, jurisdictional approaches to carbon offset programs are now being implemented globally, and lessons learned from this implementation could impact how Washington chooses to move forward with policies around carbon projects in the state. Under the compliance WA Cap-and-Invest Program, which commenced in January 2023, Washington formally adopted the following California Air Resources Board Offset Protocols: Livestock Projects Compliance Offset Protocol, U.S. Forest Projects Compliance Offset Protocol, Ozone Depleting Substances Compliance Offset Protocol, and Compliance Offset Protocol Urban Forest Projects as described in WAC 173-446-505. We have carefully analyzed these protocols and many others to inform the conclusions and recommendations found in this report.

All protocols can provide carbon offsets under either compliance or voluntary markets, perhaps with modifications. While this report focuses on the suitability, readiness, and robustness of carbon offset protocols to enable stakeholders to better understand and refine protocols for their selected carbon dioxide sink, the ultimate goal is the development of projects which provide long-term climate benefits. Carbon offsets are a market-based solution to address climate change, and quality and integrity must be paramount. Sound protocols, project development, implementation, qualified verifiers, and carbon registries are all required to achieve this end.

Lastly, SCS developed a cloud-based web application (‘CarboSink’ interface) that will be accessible to the Washington Department of Ecology. The dashboard interface of this interactive data repository of spatial information enables users to input data and rerun sensitivity analyses for the most suitable two protocols for each sink. Users may also view estimated forest carbon capacity (e.g., related to 100-year stand growth) and estimated soil carbon capacity at a county level across the state. This interface can serve as the foundation for the continued assessment of the suitability of carbon offset projects by Washington’s various stakeholders.

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List of Abbreviations

ACR	American Carbon Registry
ADD-AM	Demonstration Of Additionality of Tidal Wetland Restoration And Conservation Project Activities
AFOLU	Agriculture Forestry and Other Land Uses
ANAB	ANSI National Accreditation Board
ARR	Afforestation/Reforestation/Revegetation
CARB	California Air Resources Board
CAR	Climate Action Reserve
CCB	Climate Community and Biodiversity Standards
CDM	Clean Development Mechanism
CFI	Australia’s Carbon Farming Initiative
CIW	Avoiding Conversion to Open Water or Impounded Wetland
CORSIA	Carbon Offsetting and Reduction Scheme For International Aviation
DNR	Department of Natural Resources
FAO	Food and Agriculture Organization
FCPF	World Bank’s Forest Carbon Partnership Facility
FullCAM	Full Carbon Accounting Model
GAP	Greenhouse Gas Assessment for Projects
GFOI	Global Forest Observations Initiative
GGIT	Greenhouse Gas Implementation Tool
GHG	Greenhouse Gas
IAF	International Accreditation Forum
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
ISFL	World Bank’s Initiative for Sustainable Forest Landscapes
ISO	International Organization for Standardization
JCM	Japan-Cambodia Joint Crediting Mechanism

MRV	Monitoring Reporting and Verification
NLCD	United States Geological Survey's National Land Coverage Dataset
NPS	National Park Service
NRTs	Nori Carbon Removal Tonnes
OOJ	Out-Of-Jurisdiction
PRISM	Parameter-Elevation Relationships on Independent Slopes Model
REDD+	Reduced Emissions from Deforestation and Forest Degradation
REM	Climate Forward - Reduced Emissions from Megafires Forecast Methodology
RM	Climate Forward Reforestation Forecast Methodology
RWE	Tidal Wetland Restoration Without Vegetation Establishment
SEPA	State Environmental Policy Act
SCS	SCS Global Services
SEP	Soil Enrichment Protocol
SOC	Soil Organic Carbon
SSURGO	United States Department of Agriculture's Soil Survey Geographic Database
VCS	Verified Carbon Standard
VVB	Validation and Verification Body
WRC	Wetlands Restoration and Conservation

1 Introduction

1.1 Objective and Scope of Phase II

The objective of the CO_2 Removal Project Standards Analysis (the Project), per the Request for Qualifications and Quotations (RFQQ 2217 AQP), is as follows:

> Develop and apply appropriate carbon protocols to map, categorize, and catalog the suitability, readiness, and robustness of Washington terrestrial and aquatic carbon dioxide sinks for potential use as carbon offset projects in regulatory and voluntary carbon markets. Project developers can use this to assess conformity with Washington's climate laws, rules, markets, and goals by applying existing, new, and modified carbon offset protocols for carbon dioxide removal projects.

The scope of Project Phase II: Analytical Refinement & Protocol Scenarios includes six tasks. Five Tasks guide the project's investigation and inform Task 10 of this report:

- Task 5: Expand standards to include out-of-jurisdiction protocols (Section 2)
- Task 6: Expand standards to include developing protocols (Section 3)
- Task 7: Sensitivity analysis for existing protocols (Section 4)
- Task 8: Re-assess Task 3 for the final report (Section 5)
- Task 9: Cataloging & Mapping New Standards to Carbon Dioxide Sinks (Section 6)

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As stated in the RFQQ, much of the work involved in Phase II relied heavily on the expert judgment of both the project team and stakeholders involved in project development or carbon markets.

During Phase II, SCS built upon work from the previous Phase I. Objectives we addressed during Phase I included:

Task 1 Assessment Process: We identified five broad carbon dioxide sinks, including terrestrial sinks: green (forests, rangelands: shrublands and grasslands, agriculture: pastures and cropland) and aquatic sinks: blue (marine and coastal) and teal (freshwater ecosystems). Based upon data availability, SCS modeled forest growth 100 years into the future at inventory plots across the state and mapped out forest carbon capacity across the state at a combined land ownership and county level. Blue, teal, and soil carbon capacities were indirectly estimated based on available sediment and gridded soil data. The northwest forests could be expected to provide the greatest carbon storage, while the southwestern agricultural areas showed higher capacity based on mapped soil data. The database and web interface underlying 'CarboSink', an interactive data repository of spatial information, was initially developed for this task.

Task 2 Categorization of Standards: SCS devised a set of standards for comparing the suitability of different protocols (i.e., 'methodologies) relative to Washington. Determining the eligibility of the protocol to Washington was the first step. Among eligible projects for Washington, the next step was to more specifically assess components of these protocols concerning the readiness, robustness, and suitability of their implementation across Washington. SCS assessed suitability in the same approach as 'barrier analysis' that some protocols and registry standards require projects to assess their overall additionality for a proposed area, and the overall capacity to remove carbon with respect to 'common practice' was also estimated as part of this assessment. Phase I results indicated that a wide variety of protocols were eligible across Washington for each sink and that barriers to effective implementation vary across sink types.

Task 3 Cataloging and Mapping Standards to Carbon Dioxide Sinks: SCS applied a quantitative approach to map standards, particularly the capacity to remove carbon above and beyond 'common practice.' Capacity for forest carbon was estimated for each forest ownership category within each county by projecting stand growth 100 years in the future for all available forest inventory plots. Carbon dioxide equivalents resulting from the 100-year growth projection were subtracted by the California Air Resources Board (CARB) common practice metrics, which are developed for different assessment areas at a regional scale, and the result was mapped for Washington. Areas with 100-year growth less than common practice were not deemed as suitable as those with higher carbon dioxide removal beyond common practice. The capacity of other sinks was inferred from available data, but a quantifiable common practice metric could not be applied to blue, teal, agriculture and grassland sinks.

Please note: Additional protocols have been added to the analysis since Phase I, additional terrestrial carbon capacity has been added for agricultural soil carbon stocks, and a standardized sensitivity analysis was conducted to score and assess protocol suitability for each sink and project type. We define 'project type' as the differentiation between forest carbon protocol approaches: improved forest management (IFM), afforestation/reforestation/revegetation (ARR), and urban forestry. The other terrestrial sinks (grassland and agriculture) and the blue and teal sinks did not have such 'project type' differentiations. One additional note is that Phase I initially classified rangeland as a separate sink, including grasslands and shrublands. Shrublands are not as much of a focus as grasslands in offset protocols, so, therefore, we focus on the grassland 'sink', rather than all rangelands.

Lastly, Terrestrial carbon dioxide sinks are divided into Forest, Agriculture and Grasslands, while Aquatic carbon dioxide sinks are divided into Blue and Teal Carbon.

Task 4: Phase I Interim Project Report: SCS developed a report with the results of Tasks 1-3 on 30 June 2022.

1.2 Background

Washington has a history of utilizing carbon dioxide removal projects, beginning with one of the first programs in the country requiring mitigation of greenhouse gas emissions from power plants (RCW 80.70) with the option of using carbon dioxide removal projects and putting a framework in place for the geological sequestration of carbon dioxide (RCW 80.80). There has also been an increasing interest in using carbon dioxide removal projects as mitigation for the State Environmental Policy Act (SEPA) and formalizing the role of these projects in SEPA mitigation has been proposed as part of the Greenhouse Gas Assessment for Projects (GAP) rule that is still ongoing at ECOLOGY. Voluntary markets demand for carbon removal offset projects has also increased in recent years, especially for large corporate buyers (including prominent Washington firms like Amazon and Microsoft). Finally, the passage of the Climate Commitment Act in 2021 led to the development of Washington's cap-and-invest program in January 2023. In concert with other laws and action, cap-and-invest will help Washington achieve the following greenhouse gas emissions reductions codified by law: 45% below 1990 levels by 2030, 70% below 1990 levels by 2040, and 95% below 1990 levels and net-zero carbon emissions by 2050.

1.3 Methods

Phase II methods are primarily borrowed from Phase I, including the standardized sensitivity analysis for Task 7. SCS reviewed more than 50 protocols including 30 reviewed during Phase I to provide for Task 5 (Appendix A) and Task 6 (Appendix B). The sensitivity analysis was standardized across all carbon dioxide sinks and project types, which we discuss in more detail in Task 7. SCS reached out to stakeholders to discuss the results of the sensitivity analysis as well as applied expert judgment from their extensive experience with carbon offset projects (see Section 1.3.2). Upon reassessing Task 3, SCS included an estimate of soil organic carbon capacity at a county level, described in Task 8. Finally, we updated our previous categorization standards for each carbon dioxide sink in Section 6.

1.3.1 Stakeholders

The following list of stakeholders are among those who were interviewed to obtain additional information for this assessment. Stakeholder input informed our understanding of new and developing protocols, our initial sensitivity analysis, and about data gaps related to the blue and teal carbon dioxide sinks. These interviews, combined with our expert judgment helped to inform the analysis of this Project.

Stakeholder Name	Title	Organization	Related Sink
Dan Kane	Sr. Manager	TerraCarbon	Agriculture
McKenzie Smith	Analytical Team Manager	Climate Action Reserve	Agriculture
Chloe Ney	Analytical Associate	Climate Action Reserve	Agriculture
Elizabeth Guinessey	Manager	Verra	Blue and Teal
Steven Deverel	President	Hydrofocus	Blue and Teal
David Mendoza	Director of Public Advocacy and Engagement	The Nature Conservancy	All
Liz Johnston	Director	City Forest Credits	Forest

As further described in Section 1.4, SCS has been an internationally accredited validation and verification body since 2009 and has extensive experience in carbon offset projects. As such, SCS has either verified or communicated with stakeholders (landowners, technical consultants, sovereign entities, agencies) associated with the carbon offset projects below:

Project Name	Methodology / Protocol
Finite Carbon - Colville IFM	CARB Compliance Offset Protocol: U.S. Forest Projects
Winston Creek Forest Carbon Project	ACR Improved Forest Management on Non-Federal U.S. Forestlands
Puget Sound Energy Baker-White River Forest Carbon Project	ACR Improved Forest Management on Non-Federal U.S. Forestlands
The Nature Conservancy Washington Rainforest Renewal Project	ACR Improved Forest Management on Non-Federal U.S. Forestlands
Ashford III	CARB Compliance Offset Protocol: U.S. Forest Projects
King County Rural Forest Carbon Project	VCS, VM0012: Improved Forest Management in Temperate and Boreal Forests version 1.2

1.3.1.1 Overburdened Communities

Few protocols are specifically designed to address the challenges faced by overburdened communities. The US Environmental Protection Agency has defined an overburdened community as follows:

Minority, low-income, tribal, or indigenous populations or geographic locations in the United States can potentially experience disproportionate environmental harms and risks. This disproportionality can result from greater vulnerability to environmental hazards, lack of opportunity for public participation, or other factors. The increased vulnerability may be attributable to an accumulation of negative or lack of favorable environmental, health, economic, or social conditions within these populations or places. The term describes situations where multiple factors, including environmental and socio-economic stressors, may act cumulatively to affect health and the environment and contribute to persistent environmental health disparities.

Some standards, such as the Verified Carbon Standard (VCS) and the Climate, Community, and Biodiversity Standards (CCB), incorporate community engagement and biodiversity elements into projects. These projects require engagement with stakeholders, including the local communities, in the carbon sequestration project design and implementation phases. The goal is to enhance the permanence of carbon with this local engagement and with the CCB Standards, benefits to communities. It accomplishes this by requiring that the project proponents describe the socio-economic and biodiversity conditions and impacts of the project site and make projections about how these conditions will change with and without the influence of the project. These projects must show benefits beyond a without-project scenario, considering risks that could detrimentally impact the project over its lifetime.

The standard incorporates the International Association for Impact Assessment (IAIA 2003) defines social impacts and social impact assessment as changes to one or more of the following:

- People's way of life – how they live, work, play, and interact daily;
- Their culture – their shared beliefs, customs, values, and language or dialect;
- Their community – its cohesion, stability, character, services, and facilities;
- Their political systems – the extent to which people participate in decisions that affect their lives, the level of democratization that is taking place, and the resources provided for this;

- Their environment – the quality of the air and water people use; the availability and quality of the food they eat; the level of hazard or risk, dust, and the noise they are exposed to; the adequacy of sanitation, their physical safety, and their access to and control over resources;
- Their health and wellbeing – health is a state of complete physical, mental, social, and spiritual wellbeing, and not merely the absence of disease or infirmity;
- Their personal and property rights – particularly whether people are economically affected or experience personal disadvantages which may include a violation of their civil liberties;
- Their fears and aspirations – their perceptions about their safety, their fears about the future of their community, and their aspirations for their future and their children's future.

The standard recognizes the difficulty of showing a cause and effect between the social and biodiversity standards.

- It is difficult to prove cause and effect – this is the challenge of showing attribution.
- Social and biodiversity impacts tend to be long-term phenomena – it is hard and unrealistic to identify them in the short- term.
- Social and biodiversity impacts may be subtle and are not easily measured; for example, social impacts are often indirect (or "side-effects") and related to contested social and political values.
- Social and biodiversity impacts are often unexpected, especially negative ones.
- It can be challenging to distinguish between impacts and outcomes.
- There has been a lack of research data on land-based carbon projects' social and biodiversity effects.
- The diversity of project types means there is no "one-size-fits-all" approach to SBIA.
- There has been a lack of user-friendly guidance for project proponents.

Finally, to support and uphold social and environmental safeguards alongside the carbon accounting requirements, VCS and CCB projects have a 30-day public comment period. The public comment period allows stakeholders to comment on specific projects. In contrast, scheme-specific public fora afford stakeholders to comment on larger context topics such as the schemes and protocols themselves. Each scheme offers stakeholders the ability to provide feedback as well as express grievances. Individual schemes should be contacted directly for more information.

These community requirements can be overlayed on all the standards described in our analysis to reduce harm and substantively increase benefits from carbon offset projects to overburdened communities.

1.3.2 Technical Aspects

SCS's understanding of carbon project protocol components (e.g., 'aspects') fueled our Phase II assessment. To standardize the sensitivity analysis across all protocols and sinks, the following components were assessed (more details in Section 6):

- Barrier analysis: if required, a project must provide evidence of technical, cultural, institutional, or investment barriers to prevent implementing carbon-removing practices across an area. This analysis summarizes how 'suitable' a project may be for being an 'additional' carbon removal project. It is connected to how effectively a project can remove carbon dioxide beyond business-as-usual conditions.
- Leakage: if required, a project must identify and account for shifts in 'business as usual'-related behavior to areas outside of the project as a result of project activity.
- Robustness of carbon projects may be indirectly related to the frequency in which it is verified. Protocols that require smaller intervals of verification assessments reduce uncertainty around the authenticity of carbon dioxide reductions or removals over time, the project's risk assessment is updated more often, and any systematic quality issues can be more likely identified.
- Project adoption is also indirectly related to robustness, as a greater number of registered projects generally indicates that it is possible to implement a protocol. Protocols with more projects tend to have older projects associated with them, which indicates projects using that protocol have stood a measurable test of time. It also factors into readiness and suitability, as a larger number of adopted projects in an area similar to Washington would indicate that a given protocol is more likely ready to be implemented in Washington.
- Interpretability is not a measurable quantity, or a 'presence/absence' criterion as listed above. The ease at which a protocol may be interpreted, which includes quantification, monitoring guidelines, eligibility criteria, how well uncertainty can be assessed for each parameter, and the inclusion of examples, among other things, was first judged by SCS in our capacity as verifiers for many types of carbon offset projects. However, SCS interviewed stakeholders, including project developers, to get their perspectives on SCS' assessment. This information, in turn, could update SCS's overall assessment of interpretability. Robustness and readiness are related to the ease of a protocol's interpretability.

1.3.3 International Best Practices

As an International Accreditation Forum (IAF)-accredited Validation and Verification Body (see Section 1.4), SCS has extensive knowledge of the various carbon accounting criteria and best practices. The following international best practices provided the lens through which SCS conducted this Project:

- The following normative references of the International Organization for Standardization (ISO):
  - ISO 14065:2013, Greenhouse gases — Requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition
  - IAF Mandatory Document 6: 2014 —Application of ISO 14065: 2013
  - ISO 14064-3:2006, Greenhouse gases — Part 3: Specification with guidance for the validation and verification of greenhouse gas assertions
  - ISO 14064-3:2019, Greenhouse gases — Part 3: Specification with guidance for the verification and validation of greenhouse gas statements
  - ISO 14066:2011, Greenhouse gases — Competence requirements for greenhouse gas validation teams and verification teams
- IAF Mandatory Document for the Application of ISO 14065:2013
- 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories ("the IPCC 2006 Guidelines")
- 2019 refinement to the 2006 IPCC Guidelines
- Global Forest Observations Initiative (GFOI) 2020, Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative, Edition 3.0, Food and Agriculture Organization, Rome ("GFOI")

Global Forest Observations Initiative (GFOI) 2020, Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative, Edition 3.0, Food and Agriculture Organization, Rome ("GFOI")

1.4 Experience and Expertise of SCS Global Services

SCS Global Services (SCS) is a global leader in third-party verification, certification, auditing, testing services, and standards. Established as an independent third-party certification firm in 1984, we aim to recognize the highest performance levels in environmental protection and social responsibility in the private and public sectors and to stimulate continuous improvement in sustainable development. In 2012, Scientific Certification Systems, Inc. began doing business as SCS Global Services, communicating its global position with offices and representatives in over 20 countries.

SCS' Greenhouse Gas (GHG) Verification Program has verified carbon offsets since 2008. It has verified about 300 million tonnes of CO_2e in nearly 30 countries providing GHG verification services to various industries, including manufacturing, transportation, municipalities, and non-profit organizations. The GHG Verification Program draws upon SCS's established expertise to serve the global carbon market. It has been voted a Best Verification Body by its peers in the carbon market through Environmental Finance magazine for several years.

As an internationally recognized verification body, SCS is currently accredited to ISO 14065:2 for Greenhouse Gas Validation and Verification by the ANSI National Accreditation Board (ANAB) under the auspices of the International Accreditation Forum and includes accreditation for ISO 14064-2, specifically for Land Use and Forestry, which can be confirmed on the ANAB directory of accredited entities[1]. Our accreditation validates and verifies assertions related to GHG emissions reductions and removals at the project level. We also have the scope for verification of GHG emissions reductions and removals at the organizational level for Agriculture, Forestry, and Other Land Uses (AFOLU) as well as GHG emissions under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Through this accreditation, SCS offers verification of carbon offset projects in the voluntary market under the Verified Carbon Standard, American Carbon Registry (ACR), Plan Vivo, Climate Action Reserve (CAR), and the Climate, Community, and Biodiversity standards.

In the compliance market, SCS is accredited through the California Air Resources Board (CARB) to verify projects under their Cap-and-Trade Program for US Forests, Urban Forests, Ozone Depleting Substances, Mine Methane Capture, and Livestock projects. SCS provides evaluation services for a wide array of carbon offset projects, including forestry, energy efficiency, industrial processes, agriculture, and transportation.

SCS also recently became accredited to the Japan-Cambodia Joint Crediting Mechanism (JCM) and performs assessments as a third-party assessor under the World Bank's Initiative for Sustainable Forest Landscapes (ISFL) and the World Bank's Forest Carbon Partnership Facility (FCPF).

SCS has been a leader in providing validation and verification services for many project types. Our background in project auditing is complemented by our validation assessments of many

[1] https://www.ansi.org/Accreditation/environmental/greenhouse-gas-validation-verification/AllDirectoryDetails?&prgID=200&OrgId=33&statusID=4

new offset project-type protocols (e.g., sustainable agricultural management, soil carbon, mangrove restoration, etc.). Our protocol assessments demonstrate our fluency with the complexity of both terrestrial and aquatic project types, having addressed project design and emissions reductions calculations issues in different forest types, soils and grasslands, peatlands, and wetlands, and beyond.

SCS' experience with the first assessments of voluntary improved forest management (IFM) projects in California under the Climate Action Reserve allowed us to be well-prepared for implementing the California Air Resources Board's Compliance Offset Program. Since 2012, we have been verifying projects under that regulatory system and learned many lessons not just through verifying forestry, agricultural, and wetland projects but through the whole process: from the development of the offset program and associated project-type protocols to the comment process, public reactions, and subsequent government responses. Consequently, we can bring so much insight to assess the suitability, readiness, and robustness of carbon offset projects for the diverse number of carbon dioxide sinks in the State of Washington.

2 Task 5: Expand standards to include out-of-jurisdiction protocols

2.1 Task Objective

The objective of Task 5 expanded upon the protocols developed in Task 2 to include out-of-jurisdiction (OOJ) protocols that can be adapted for use in the State of Washington with modified geographic and data requirement criteria. Since some protocols have been developed since the Phase I report was issued in June 2022, we included protocols not previously available during the Phase I assessment. We also considered various out-of-jurisdiction protocols from other countries or sub-national governments that are currently not applicable in Washington State which translated to various schemes such as Verified Carbon Standard (VCS), American Carbon Registry (ACR), Climate Action Reserve (CAR), Government of Alberta, Canada, Federal Government of Canada, and the Federal Government of Australia. The deliverables for Task 5 are tabular listings of standards categorized similarly to Task 2, along with the background and information used for the selection process, as part of the final project report. The tabular listing includes the information gathered from these out-of-jurisdiction standards to inform each carbon dioxide sink's technical, cultural, and administrative feasibility.

2.2 Standards and Protocol Review

2.2.1 Forest

We identified one relevant OOJ forest protocol: VM0034 Canadian Forest Carbon Offset Methodology.

VM0034 – Canadian Forest Carbon Offset Methodology version 2.0

VM0034 is a VCS forest carbon offset protocol applicable to lands within Canada; therefore out-of-jurisdiction and not applicable to the State of Washington. Unlike some of the other forestry protocols, which only apply to single project activities, VM0034 includes several project activities, including Reduced Impact Logging, Logging to Protected Forest, Extended Rotation Age/Cutting Cycle, Low Productive to High Productive Forests, and Avoiding Planned Deforestation. The crediting period under VM0034 is 30 years. Additionality is determined using the CDM Tool 02 – "Combined tool to identify the baseline scenario and demonstrate additionality." Monitoring, reporting, and verification follow the requirements of the Verified Carbon Standard.

2.2.2 Agriculture

We identified two OOJ agricultural land management protocols: the Enhanced Soil Organic Carbon protocol, which is still in development by the Federal Government of Canada, and the Government of Australia's Carbon Farming Initiative. Nothing specific may be reported for Canada's Enhanced Soil Organic Carbon protocol, as it is still in development with an unknown release date. Although the adoption rate for Australia's Carbon Farming Initiative is unknown, we found specific information related to the protocol.

Federal Government of Australia – Carbon Farming Initiative (Estimating Sequestration of Carbon in Soil Using Default Values)

Australia's Carbon Farming Initiative (CFI) relies heavily upon the FullCAM model ('Full Carbon Accounting Model')[2] for quantifying soil organic carbon change resulting from farm management practice changes. Only areas within FullCAM model coverage in mainland Australia and Tasmania may be eligible. There is a five-year historic lookback period to assess prior farm management before this protocol's application starts. Farm management data is drawn mainly from nutrient and stubble management plans. FullCAM modeled soil organic carbon for various practice changes, and default factors are used to estimate emissions reductions from nitrous oxide and methane following management changes. Stratification is required for FullCAM model implementation. The latest version of the Carbon Farming Initiative was released in July 2015, but it is still being determined how many credits have been generated for farms following this protocol.

2.2.3 Grasslands

Canadian Grassland Offset Protocol

We only found one OOJ protocol for Grasslands. The CAR developed the Canadian Grassland Offset Protocol which is only applicable to Canadian Grasslands. It creates additionality through the establishment of measures to protect the ecological functions of the grasslands and the avoidance of conversion to croplands that result in additional carbon being primarily stored as soil carbon. The protocol requires land conservation and a project implementation agreement to promote permanence.

2.2.4 Blue Carbon

Only one out of jurisdiction protocol was identified for Blue Carbon which is from ACR.

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[2] https://www.dcceew.gov.au/climate-change/publications/full-carbon-accounting-model-fullcam

ACR - Restoration of California Deltaic and Coastal Wetlands version 1.1

This ACR protocol, released in April 2017, applies to both blue and teal carbon depending on the applicability conditions and type of wetlands (coastal vs. freshwater). For blue carbon, this protocol only applies to coastal wetlands of the Sacramento-San Joaquin Delta and San Francisco Bay Estuary of California, as the protocol was developed, envisioning most projects occurring in these geographic areas. Hence, it is not applicable in the state of Washington. This protocol includes several project activities, including converting agricultural fields, seasonal wetlands, and open water to permanent coastal wetlands. This protocol is a framework of several modules to determine baseline and project scenarios (e.g., BL-Ag agricultural lands, BL-OW open water, BL-SW seasonal wetlands, PS-TW tidal wetlands). Carbon reservoirs, including aboveground and belowground woody biomass, shrubs and herbaceous biomass, litter, and soil organic carbon, are included in this protocol. Baseline conditions must be determined using the baseline modules (BL-Ag agricultural lands, BL-SW seasonal wetlands, BL-OW open water) and additionality is determined through legal requirements, performance standard evaluation, and practice-based performance standards. The projects must meet the applicability conditions and demonstrate regulatory surplus to be considered additional. This protocol's project crediting period is 40 years per ACR standard, and these projects can occur on all land ownership classes (private, county, state, federal, and tribal). Currently, one project is registered, and one is in process, and both are in California.

2.2.5 Teal Carbon

Four out of jurisdiction protocols were identified for Teal carbon. Two protocols are from ACR and two from VCS.

VCS - VM0004: Methodology for Avoided Planned Land Use Conversion in Peat Swamp Forests version 2.0

The latest version, 2.0 of this VCS protocol (VM0004), was released in October 2022. This protocol only applies to tropical peat swamp forests of Southeast Asia and, therefore, is not applicable in the state of Washington. Project activities only include avoided planned land use conversion on undrained tropical peat swamp forests, and previously drained peatlands are not eligible. Only land use changes that would be caused by corporate or governmental entities (plantation companies, national or provincial forestry departments, etc.) are included. Land use changes from community groups, community-based organizations, individuals, or households are excluded. Carbon reservoirs included in this protocol are standing live aboveground biomass, shrubs, herbaceous, non-woody aboveground biomass, and peat (soil organic matter). This protocol uses the project method to determine additionality. Baseline scenarios and additionality are demonstrated using the latest version of the “Tool for the

Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities.” All project activities eligible for this protocol must avoid planned wetland degradation activities. Further, when establishing the baseline scenario, the project proponent must present verifiable evidence to demonstrate that the project area was intended to be converted to a different land use or land cover class. Project and jurisdictional proponents must demonstrate that they have the legal right to control and operate project or program activities as per VSC standards. Only one project in Southeast Asia is registered under this protocol.

ACR - Restoration of California Deltaic and Coastal Wetlands version 1.1

This ACR protocol, released in April 2017, applies to both blue and teal carbon depending on the conditions and type of wetlands (coastal vs freshwater). For teal carbon, this protocol is only applicable to managed wetlands of the Sacramento-San Joaquin Delta and San Francisco Bay Estuary of California. Hence, it is not applicable in the state of Washington. This protocol includes project activities including conversion of agricultural fields, and seasonal wetlands to permanently managed wetlands. This protocol is a framework of several modules to determine baseline and project scenarios (e.g., BL-Ag agricultural lands, BL-SW seasonal wetlands, PS-MW managed wetlands). Carbon reservoirs including aboveground and belowground woody biomass, shrubs and herbaceous biomass, litter, and soil organic carbon are included in this protocol. Baseline conditions must be determined using the baseline modules (BL-Ag agricultural lands, BL-SW seasonal wetlands). The legal requirement for additionality is determined by performance evaluation and practice-based performance standards. The projects must meet the applicability conditions and demonstrate regulatory surplus to be considered additional. The crediting period of projects of this protocol is 40 years per ACR standard, and these projects can occur on all land ownership classes (private, county, state, federal, and tribal) as per ACR standard. To date, there is one project registered and one project in process and both projects are in California.

VCS - VM0027: Methodology for Rewetting Drained Tropical Peatlands version 1.0

This VCS protocol was released in July 2014. This protocol applies to tropical peatlands of Southeast Asia and is not applicable in Washington. Project activities include rewetting the drained tropical peatlands through the permanent or temporary construction of structures (e.g., dams) that hold back water in drainage waterways. The project area must exist at an elevation less than 100m above sea level, and the mean annual water level below the peat surface within the project area for the baseline and project scenarios cannot be greater than one meter in depth. This protocol is only applicable where the most plausible baseline scenario is where the project area has been drained due to human-induced drainage activities and would remain drained in the absence of the project. Aboveground biomass and soil organic matter carbon reservoirs are included in this protocol. The latest version of the VCS Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry, and Other Land Use Project Activities must be used to identify the potential alternative baseline land use scenarios and to demonstrate additionality in the project area. The project must demonstrate a significant difference in the net GHG benefit between the baseline and project scenarios for at least 100 years. Project and jurisdictional proponents must demonstrate that they have the legal right to control and operate project or program activities as per VCS standards. No projects are registered or under development for this protocol.

ACR - Methodology for the Restoration of Pocosin Wetlands version 1.0

This ACR protocol was released in October 2017 and is limited to freshwater wetlands of the coastal plain of southeast Virginia, North Carolina, South Carolina, or Georgia that are seasonally saturated primarily through precipitation. Hence, it is not applicable in Washington State. Project activities include re-wetting previously drained pocosin wetlands by raising the average annual water table elevation in the drained wetland by partially or entirely reversing the pre-existing drained state. The project area must be free of any land use that could be displaced outside the area (e.g., agriculture) for five or more years before the project start date. Any areas of soil disturbance associated with the implementation of the project activity must be less than 3% of the project area. The project activity must only increase GHG emissions within the area via hydrological connectivity. Carbon reservoirs, including aboveground & belowground woody biomass, shrubs and herbaceous biomass, and soil organic carbon, are included in this protocol. Legal requirements, beyond standard practice and barrier (financial, technological, or institutional) analysis, determine additionality. The project crediting period under this protocol is 40 years per ACR standard. The projects for this protocol apply to all land ownership classes (private, county, state, federal, and tribal) per ACR standard. To date, only one project is listed, which is in North Carolina.

2.3 Task 5 Findings

2.3.1 Forest

VM0034 is similar to the CARB Forest Offset Protocol in that multiple project activities are included. VM0034 allows for five specific project activities, which are aimed at forest conservation, improved forest management, and avoided deforestation, whereas the CARB Forest Offset Protocol activities are improved forest management, reforestation, and urban forestry.

2.3.2 Agriculture

We are limited to broad statements about Australia's Carbon Farming Initiative – Estimating Sequestration of Carbon in Soil Using Default Values outside of jurisdictional regenerative agriculture-based protocols. Still, nothing is known about Canada's agricultural carbon offset protocol or any other active out-of-jurisdiction agricultural carbon offset protocol. Australia's Carbon Farming Initiative protocol is based around a regionally specific model, and this framework stands in contrast to generally more complex protocols in the voluntary market that are also more flexible in eligibility and implementation. However, an advantage to Australia's jurisdictional approach is the efficiency in project implementation and crediting. The use of IPCC default emissions factors is conservative, and the FullCAM model is not applicable to the State of Washington. However, developing a regionally specific model for the agricultural sector in Washington may save development time if a jurisdictional approach similar to Australia's Carbon Farming Initiative was ever adopted.

Two more protocols were identified as out of jurisdiction but are currently inactive. It includes Australia's Carbon Farming Initiative – Measurement of Soil Carbon Sequestration in Agricultural Systems and the Government of Alberta, Canada's Quantification Protocol for Conservation Cropping. Given the lack of information about Canada's developing Enhanced Soil Organic Carbon protocol, we cannot make inferences about how Alberta's now-inactive protocol differs from one in development. It is also unknown why Australia ceased crediting for their Measurement of Soil Carbon Sequestration protocol.

2.3.3 Grasslands

The grassland standards allow a variety of methods; VM0026 and the CAR Grassland Protocol are used to measure changes in soil carbon as the primary way to reduce atmospheric carbon. Thus, alternative practices are used as a predominant resource to increase and store carbon in this ecosystem. These methods require a conservation easement to support the permanence of the withdraws. The data gap in most systems is the reliance on models to estimate soil carbon. Thus, the uncertainty combines the sampling and the use of the models.

2.3.4 Blue and Teal Carbon

SCS reviewed various out-of-jurisdiction protocols for blue and teal carbon, including protocols from VCS and ACR that are currently not applicable in Washington State. The Climate Action Reserve currently has no protocols for blue and teal carbon, but other out-of-jurisdiction protocols were developed for regional areas to meet the unique regional conditions and availability of calibrated models and data. For example, the ACR protocol - *Restoration of California Deltaic and Coastal Wetlands version 1.1* only applies in the Sacramento-San Joaquin

Delta and San Francisco Bay Estuary of California. This protocol focuses on these areas of California where the available data demonstrate high GHG emissions and the potential for net GHG emissions reductions. This protocol requires the use of an approved biogeochemical model, published measurement data, or published method applicable to the site to estimate baseline and project emissions and carbon stock changes. Peer-reviewed models such as SUBCALC, PEPRMT, and WARMER, calibrated and validated for the wetlands of California, can be used for the ex-ante and ex-post estimation of GHG removals and emissions. This protocol may be modified for the wetlands of Washington State if these models can be calibrated using appropriate peer-reviewed or other quality-controlled. Alternatively, some other models can be used for the wetlands of Washington State. However, they must be documented in peer-reviewed literature, calibrated, and validated for the soils and biogeochemical conditions of the wetlands using quality-controlled parameters and data, able to effectively simulate carbon stocks and GHG emissions for baseline and project conditions and conservative in estimating GHG emissions reductions. Furthermore, some other alternative measurement methods, such as estimates of GHG fluxes using Eddy Covariance towers and chamber measurements, subsidence measurements, soil cores, and remote sensing methods, can be utilized to estimate baseline and project emissions.

Moreover, VCS protocols VM0004 and VM0027 only apply in tropical peatlands of Southeast Asia. However, the wetlands/peatlands prevalent in Washington State are temperate peatlands. and their growth, development, and biogeochemistry would differ from the tropical peatlands of Southeast Asia. Thus, the lack of available data might hinder the potential application of these protocols.

Lastly, the ACR Protocol - *Restoration of Pocosin Wetlands version 1.0* is limited to previously drained freshwater wetlands of the coastal plain of southeast Virginia, North Carolina, South Carolina, or Georgia that are seasonally saturated primarily through precipitation.

2.3.5 Summary Tables

The technical, cultural, and administrative feasibility tables for the out-of-jurisdiction protocols for each carbon dioxide sink are listed in the following pages.

Table 2.1: Summary of the technical feasibility of out-of-jurisdiction standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Technical Feasibility			
	Data Availability	GHG Removal Potential (Low, Medium, High)		
	Unknowable, Developing, or Well Understood	CO_2	N_2O	CH_4
Forest	Well Understood	Removal: High Reduction: High Emissions: Low	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: None
Agriculture	Developing and Unknown	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: None
Grasslands	Developing	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low
Blue Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Low
Teal Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Medium

Table 2.2: Summary of cultural feasibility of out-of-jurisdiction standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	Land Ownership
	(Requirements Included in Protocol?)	(Requirements Included in Protocol?)
Forest	Included: Local Stakeholder Consultation + Public Comment Period per VCS Standard	No exclusions within the protocol's jurisdiction: project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Agriculture	Included: Local Stakeholder Consultation	No exclusions within the protocol's jurisdiction: project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Grasslands	Stakeholders are sought when developing the standards.	There are no exclusions per the ACR and VCS standards. All lands are eligible for these projects. However, the Canadian grasslands is limited to Canada
Blue Carbon	Included: Stakeholder consultation and community impact assessment required per ACR standard.	No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities. No exclusions per ACR Standard. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard.
Teal Carbon	Included: Local Stakeholder	No exclusions specified per VCS Standard:

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	**Land Ownership**
	(Requirements Included in Protocol?)	**(Requirements Included in Protocol?)**
	Consultation and Public Comment Period per VCS Standard Included: Environmental and community impact assessment required per ACR standard.	Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities. No exclusions per ACR standard. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard.

Table 2.3: Summary of administrative feasibility of out-of-jurisdiction standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Administrative Feasibility		
	Applicability	# Projects Registered	# Projects in Process
Forest	Limited to lands within Canada, not applicable to WA.	1 in Canada, none in the US	6 in Canada, none in the US
Agriculture	Limited to Canada (when protocol is released) and Australia	None in registration	None in registration
Grasslands	Property must exist on Canadian Grassland	Climate actions reserve does not list any projects	None as registry is not published.
Blue Carbon	Not applicable in WA as of now. Active under ACR (Restoration of California Deltaic and Coastal Wetlands version 1.1)	1 registered, but none in WA or adjacent states.	1 listed, but none in WA or adjacent states.
Teal Carbon	Not applicable in WA as of now. Active under ACR (Restoration of California Deltaic and Coastal Wetlands version 1.1, Methodology for the restoration of Pocosin Wetlands V1.0) and VCS (VM0004, VM0027)	2 registered, but none in WA or adjacent states.	2, but none in WA or adjacent states.

3 Task 6: Expand standards to include new and developing protocols

3.1 Task Objective

The objective of Task 6 was to expand the protocols developed in Task 2 to identify and include any new or developing protocols since the Phase I report. This task aimed to ensure that most recent information on protocols was available. SCS made significant progress in identifying and including new and developing protocols, which include protocols in the draft stage, undergoing peer review, etc. We focused on protocols related to teal and blue carbon dioxide sinks that are still maturing in carbon markets. The deliverables for task 6 are a tabular listing of standards categorized similarly to Task 5 as part of this final project report. The tabular listing includes the information gathered from these new and developing standards to inform each carbon dioxide sink's technical, cultural, and administrative feasibility.

3.2 Standards and Protocol Review

3.2.1 Forest

Four “new and developing” forestry protocols were identified: two from the Climate Forward registry and two from VCS. Climate Forward is a relatively new registry under the Climate Action Reserve that focus on ex-ante crediting for immediate restoration activities. Of the two VCS protocols identified, one applies to improved forest management activities using a dynamic baseline approach, and the other is applicable to ARR activities.

Climate Forward – Reforestation Forecast Methodology version 2.0

The *Climate Forward Reforestation Forecast Methodology* (RM) version 1.0 and version 2.0 were released in May 2020 and in April 2022, respectively. To date, nine RM projects are listed on the Climate Forward registry with zero credits registered to date. Of these nine listed projects, three are in the State of Washington, with another in Oregon, Idaho, and California. Ex-ante credits are generated with the RM by replanting areas following a disturbance that would otherwise not naturally regenerate, often following wildfire. The use of growth and yield models quantifies this. Two accounting options are available under the RM: tone-year (fewer credits) and tone-tone (more credits) accounting. To be eligible for tone-tone accounting, long-term conservation easements must be incorporated into the project, which follows specific guidelines described in the RM.

Climate Forward - Reduced Emissions from Megafires Forecast Methodology version 1.0

The Climate Forward *Reduced Emissions from Megafires Forecast Methodology* (REM) version 1.0 was released in March 2023. Like the Climate Forward RM, REM credits projects on an ex-ante basis based on model simulations. Where RM is based purely on growth and yield projections, REM also uses wildfire behavior models to quantify the reduction in expected emissions from wildfire following fuel management treatments designed to reduce wildfire severity. Currently, there are no REM projects listed on the registry. However, several are in various stages of development across the western US.

VM0045 – Improved Forest Management Methodology Using Dynamic Matched Baselines for National Forest Inventories version 1.0

VM0045 was approved in October 2022. Where most improved forest management protocols take a “static baseline” approach, i.e., a baseline scenario is identified at the time of project development and is held constant as the basis for crediting throughout the crediting period, VM0045 takes a “dynamic baseline” approach. This dynamic baseline is generated using a series of permanent measurement plots outside the project area, defining a “business as usual” scenario using empirical measurements. As the permanent plots are remeasured, the baseline values may shift, reflecting potential changes to business as usual in the region as the project matures. To date, no projects listed with this protocol on the VCS registry.

VCS - Methodology for Afforestation, Reforestation, and Revegetation Projects

The VCS “*Methodology for Afforestation, Reforestation, and Revegetation Projects*” (ARR) is currently under development. It would act as a “VCS native” alternative to the CDM protocol “AR-ACR003”, commonly used for ARR projects with the VCS registry in North America and internationally. The proposed VCS ARR protocol uses the same Clean Development Mechanism (CDM) principles and tools as AR-ACR003. The critical difference is that the ARR protocol will be an official VCS protocol, as opposed to the CDM protocol AR-ACR003 registered on the VCS registry.

3.2.2 Agriculture

A group of new and developing agricultural land management protocols not associated with out-of-jurisdiction protocols has been identified. These include VCS VM0042 version 2, Nori Pilot Croplands Methodology, Gold Standard Soil Organic Carbon Framework Methodology, Food and Agriculture Organization (FAO) GSOC Monitoring, Reporting and Verification (MRV) Protocol, and Baker Institute for Public Policy BCarbon Standard. These protocols are deemed ‘new’ if they have been recently (e.g., ~3 years) released without a clear understanding of the length of the development process or if they represent a substantial update to a previous protocol (e.g., VM0042 version 1.0). Protocols are 'developing' if they have not been released for project implementation.

VCS – VM0042 version 2.0

SCS conducted a protocol revision assessment for VM0042 version 2.0, and is therefore familiar with its development. This version was released in May 2023, and the process involved reviewing over 200 public comments from various stakeholders connected to VM0042. Protocol components that underwent extensive revisions include soil sampling requirements, uncertainty calculations, and the inclusion of a measure and remeasure approach to quantifying soil organic carbon change over time. Further, exceptions for eligibility conditions were added where it is possible for a project to undergo a one-time land conversion from grassland to cropland and vice versa if it can be demonstrated that the land is degraded or that the converted land is part of a long-term integrated crop-livestock system.

Nori - Pilot Croplands Methodology

Nori focuses on hosting the sale of Nori Carbon Removal Tonnes (NRTs), where one NRT translates to one t CO_2 equivalent removal from the atmosphere, just like credits from other offset schemes. This protocol went into effect in December 2021, and at the time of writing, 16 projects have sold NRTs under this protocol, none of which are based in Washington. The protocol's additionality is based on the change in SOC resulting from farm practice changes and does not factor in regional common practice. The soil carbon quantification is based heavily on the Greenhouse Gas Implementation Tool (GGIT) developed by Colorado State University staff and students.

Gold Standard – Soil Organic Carbon Framework Methodology

Version 1.0 of this protocol was published in January 2020, and it is unclear whether any projects have been registered under this protocol. This protocol is similar to the Soil Enrichment Protocol (SEP) and VM0042. However, fewer specifics are offered regarding soil organic carbon (SOC) modeling and measurement guidelines. It is noted that the VCS module VMD0021 is referenced for the measure and re-measure quantification approach. The protocol does allow for quantification of SOC using IPCC 2019 default factors if historic baseline data is unavailable. The uncertainty calculations are based on a standard error calculation and borrows from the inactive VCS protocol VM0017. Additionality is assessed relative to Gold Standard's Additionality Template, which provides an approach using Clean Development Mechanism tools, an activity penetration test, and a regulatory surplus test if the project is in a country with a UNDP Human Development Indicator below or equal to 0.7.

Food and Agriculture Organization - GSOC MRV Protocol

The FAO's protocol was released in September 2020, and whether any projects have been registered under this protocol is unclear. The quantification approach is based on RothC modeling by default and measurements every four years. The protocol is quite detailed, but it is difficult to determine strict requirements versus recommendations. For instance, the additionality assessment is vague. Appendix 4 contains detailed yet unclear information on soil sampling approaches, since "carbon stocks must be expressed in units of equivalent mass" (Wendt and Hauser 2013), which does not require bulk density. However, bulk density measurements are also discussed in the same appendix, which appears contradictory when expressing what soil sampling approach is allowed under the protocol. Overall, the protocol provides technical guidance adopted by VM0042 version 2.0 and shares components with SEP and VM0042.

Baker Institute for Public Policy – Bcarbon

The Bcarbon protocol is under development and SCS did not have access to any preliminary documentation about this protocol.

3.2.3 Blue Carbon

Two new protocols were identified for blue carbon which are applicable to the state of Washington. One protocol is from ACR and one from VCS.

VCS – VM0007 Reduced Emissions from Deforestation and Forest Degradation (REDD)+Methodology Framework (REDD+ MF) version 1.6

This VCS protocol (VM0007) version 1.6 was released in September 2020 and is the most current. This protocol applies to both blue and teal carbon depending on the applicability conditions and type of wetlands (coastal vs. freshwater). It is a REDD+ Methodology Framework with a compilation of modules and tools that define the project activity and necessary methodological steps. Hence, a project-specific protocol can be constructed for blue carbon (coastal wetlands) by choosing the appropriate modules. This protocol framework includes several project activities, including coastal wetland restoration combined with conversion to a forest, or revegetation (RWE+ARR), coastal wetland restoration without vegetation establishment (RWE), avoiding conversion to open water or impounded wetland (CIW), and avoiding drainage or wetland degradation combined with avoiding deforestation/forest degradation (CIW+REDD). Carbon reservoirs are determined based on the use of different modules for specific types of project activities. For each of the included project activities, the most plausible baseline scenario must be determined using the VCS tool T-ADD.

It is noted that the baseline must be revised and reassessed every ten years. Additionality of tidal wetland conversion and restoration project activities is demonstrated by using an activity method and the module ADD-AM (*Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities*), which includes regulatory surplus. Project and jurisdictional proponents must demonstrate that they have the legal right to control and operate project or program activities as per VCS standard. Two projects are registered and nine are under development, but no project is registered or listed in Washington or the United States.

ACR - Afforestation and Reforestation of Degraded Land Version 1.2

This ACR protocol *Afforestation and Reforestation of Degraded Land*, version 1.2, was released in May 2017. It applies to both blue and teal carbon depending on the applicability conditions and type of wetlands (coastal vs. freshwater). This protocol applies to afforestation and reforestation project activities implemented on degraded lands, including coastal wetlands. Project activities include Increasing and restoring vegetative cover through planting, sowing, or human-assisted natural regeneration of woody vegetation in degraded coastal wetlands. Intentional water table manipulation is not allowed when project activities are implemented on coastal wetlands. The latest version of the "Tool identifies degraded or degrading lands for consideration in implementing CDM A/R project activities" shall be applied to demonstrate that lands are degraded or degrading. Carbon reservoirs included in this protocol are aboveground and belowground biomass and harvested wood products, but soil organic matter pool is excluded for coastal wetlands. The CDM Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities is used to demonstrate additionality and baseline scenarios. The projects for this protocol apply to all land ownership classes (private, county, state, federal, and tribal) as per ACR standards. To date, only one project is registered outside of the United States. Two projects are canceled, and two are inactive per the ACR registry.

3.2.4 Teal Carbon

Two new protocols were identified for teal carbon which are applicable to the state of Washington. One protocol is from ACR and one from VCS.

VCS – VM0007 REDD+ Methodology Framework (REDD+ MF) version 1.6

This VCS protocol (VM0007) version 1.6 was released in September 2020 and is the most current. This protocol applies to both blue and teal carbon depending on the applicability conditions and type of wetlands (coastal vs. freshwater). It is a REDD+ Methodology Framework with a compilation of modules and tools that define the project activity and necessary methodological steps together. Hence, a project-specific protocol can be constructed for teal carbon (freshwater wetlands) by choosing the appropriate modules. This protocol framework includes several project activities, including peatland rewetting combined with conversion to a forest or revegetation (RWE+ARR), freshwater wetland restoration without vegetation establishment (RWE), peatland rewetting and avoiding deforestation/ forest degradation and avoiding deforestation/forest degradation (RWE+REDD), avoiding degradation (CIW), avoiding drainage or freshwater wetland degradation combined with avoiding deforestation/forest degradation (CIW+REDD). Carbon reservoirs are determined based on the use of different modules for specific types of project activities. For each of the included project activities, the most plausible baseline scenario must be determined using the VCS tool T-ADD. It is noted that the baseline must be revised and reassessed every ten years. Additionality of freshwater wetland conversion and restoration project activities is demonstrated by using an activity method and the VCS tool T-ADD to identify credible alternative land use scenarios, evaluate the alternatives and proposed project scenarios. Project and jurisdictional proponents must demonstrate that they have the legal right to control and operate project or program activities as per VCS standards. To date, two projects are registered, one is under development, and one is on hold as per the VCS registry. No project is registered or listed in Washington or the United States.

ACR - Afforestation and reforestation of degraded land version 1.2

This ACR protocol *Afforestation and Reforestation of Degraded Land*, version 1.2 was released in May 2017. It applies to both blue and teal carbon depending on the applicability conditions and type of wetlands (coastal vs. freshwater). This protocol is applicable to afforestation and reforestation project activities implemented on degraded lands, including freshwater wetlands. Project activities include increasing and restoring vegetative cover through planting, sowing, or human-assisted natural regeneration of woody vegetation in degraded freshwater wetlands. Intentional water table manipulation is not allowed when project activities are implemented on freshwater wetlands. The latest version of the "*Tool for the identification of degraded or degrading lands for consideration in implementing CDM A/R project activities*" shall be applied to demonstrate that wetlands are degraded or degrading. Carbon reservoirs included in this protocol are aboveground and belowground biomass, litter, and harvested wood products. Soil organic matter pool is excluded for freshwater wetlands. The CDM Combined tool identifies the baseline scenario and demonstrates additionality in A/R CDM project activities are used to demonstrate additionality and baseline scenarios. The projects for this protocol apply to all land ownership classes (private, county, state, federal, and tribal) as per ACR standards. Currently, only one project is registered outside of the United States. Two projects are canceled, and two are inactive per the ACR registry.

3.3 Task 6 Findings

3.3.1 Forest

There is increasing interest and scrutiny in the forest carbon offset market, and new and developing protocols reflect much of this interest and concern. VM0045 addresses a common criticism in forestry offset projects, namely the identification of the baseline. By introducing the dynamic baseline, VM0045 may result in more robust crediting under shifting regional forest management regimes. However, one risk with a dynamic baseline is that it may result in higher uncertainty for landowners and project developers, which could reduce the supply and turn developers to alternative protocols.

Both Climate Forward protocols are based on ex-ante crediting and projected emission reductions or removal, as opposed to the more common ex-post crediting based on measured past performance. Ex-ante crediting can provide upfront capital to fund restoration projects that would otherwise not be financially viable. However, this may also come with a greater risk of impermanence, although conservative crediting generally acts as a mitigation effort.

3.3.2 Agriculture

The revision process for VM0042 version 2.0 involved a large group of stakeholders invested in agricultural offset credit project development. The version update is an overall advancement of agricultural land management protocols, given the extensive stakeholder involvement and adoption of version 1.0 among many projects which will soon update to version 2.0. Further, the new version 2.0 drew upon other protocols discussed as ‘new.’ In an interview with the Climate Action Reserve, SCS became aware of planned revisions for the Soil Enrichment Protocol (SEP), which is similar to VM0042 with a focus on flexibility increased for integrated crop-livestock systems and may be complete by the end of the year 2023.

The other new protocols also include components that VM0042 or SEP contain. Still, their guidance could be more comprehensive in a number of different project aspects (e.g., additionality, leakage, baseline/project quantification, monitoring). For example, the Pilot Croplands Methodology does not require standard practice tests for additionality unlike VM0042 and SEP. Further, the Gold Standard Soil Organic Carbon Framework is more comprehensive than other new protocols besides VM0042 version 2.0 and provides more guidance about quantifying nitrous oxide and methane emissions reductions, but it encompasses fewer parameters and lacks overt guidance on best-practice soil sampling approaches. Lastly, the FAO GSOC MRV protocol provides a framework around using RothC for soil carbon modeling, including an approach for parameterizing RothC to different areas worldwide. This general approach may be helpful across protocols as RothC requires fewer parameters and it meets requirements outlined in VCS module VMD0053 for soil organic carbon modeling.

The Baker Institute ‘Bcarbon’ protocol is under development at the time of this writing and the release date is unknown. There is not enough information about this protocol to compare with others mentioned previously.

3.3.3 Grasslands

The new standards are very similar to the existing ones, allowing for alternative grassland management practices that potentially increase soil carbon and including conservation easement to support the permeance of the removals. These standards rely on models to estimate soil carbon.

3.3.4 Blue and Teal Carbon

SCS reviewed two new protocols for blue and teal carbon, which should have been included during phase I of the report. One protocol is from VCS, and the second is from ACR, both applicable in Washington State. VCS protocol VM0007 REDD+ Methodology Framework is a compilation of modules and tools that define the project activity and necessary methodological steps. It includes a decision tree to clearly indicate likely baseline type and applicability. The relevant baseline modules must be applied with relevant applicability conditions and criteria. Projects may be standalone Wetlands Restoration and Conservation (WRC) or combined with REDD or ARR. While developing WRC baselines, the project must reference at least ten years to model a spatial trend in drainage, and it must consider long-term (20-year) average climate variables. For monitoring GHG emissions from freshwater or coastal wetlands, the monitoring plan must use the methods given in Module M-PEAT or M-TW, respectively, and use appropriate leakage modules based on project activities. Also, projects must use Module X-UNC to combine uncertainty information and conservative estimates and produce an overall uncertainty estimate of the total net GHG emission reductions.

Furthermore, ACR protocol- Afforestation and reforestation of degraded land version 1.2 can be implemented on degraded wetlands, which are expected to remain degraded or degrade in the project's absence. This protocol mandates the use of regeneration monitoring areas to ensure that the natural (without planting) regeneration rates assumed in the baseline scenarios remain valid over the crediting period. Each regeneration area must be re-assessed at intervals for at least ten years for the crediting period. Leakage due to agricultural activity displacement must be accounted for.

3.3.5 Summary Tables

The technical, cultural, and administrative feasibility tables for the new and developing protocols for each carbon dioxide sink are listed in the following pages.

Table 3.1: Summary of the technical feasibility of new and developing standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	**Technical Feasibility**			
	Data Availability	**GHG Removal Potential (Low, Medium, High)**		
	Unknowable, Developing, or Well Understood	**CO_2**	**N_2O**	**CH_4**
Forest	Well understood	Removal: High Reduction: High Emissions: Low	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: None
Agriculture	Developing and Unknown	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Low
Grasslands	Developing	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low
Blue Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Low
Teal Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Medium

Table 3.2: Summary of cultural feasibility of new and developing standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	Land Ownership
	(Requirements Included in Protocol?)	(Requirements Included in Protocol?)
Forest	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: for communal ownership, must obtain "free and prior consent".	Must demonstrate ownership. No exclusions.
Agriculture	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard	No exclusions: project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Grasslands	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: Stakeholder consultation and community impact assessment required per ACR standard.	No exclusions. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard.
Blue Carbon	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: Stakeholder consultation and community impact assessment required per ACR standard.	No exclusions. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard. No exclusions specified per VCS Standard:

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	Land Ownership
	(Requirements Included in Protocol?)	(Requirements Included in Protocol?)
		Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Teal Carbon	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: Environmental and community impact assessment required per ACR standard.	No exclusions per ACR standard. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard. No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.

Table 3.3: Summary of administrative feasibility of new and developing standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Administrative Feasibility		
	Applicability	**# Projects Registered**	**# Projects in Process**
Forest	All are applicable to Washington State	Climate Forward RM: 0 Climate Forward REM: 0 VM0045: 0 VCS ARR: 0	Climate Forward RM: 9 Climate Forward REM: 0 VM0045: 0 VCS ARR: 0
Agriculture	All are applicable to Washington State	None currently known in Washington	None currently known in Washington
Grasslands	VM0026 is applicable to Washington State.	VM0026 has no projects registered	VM0026 has 22 projects in various stages on its public registry.
Blue Carbon	Applicable in WA. Active under ACR (Afforestation and Reforestation of Degraded Land) and VCS (VM0007)	3 registered, but none in WA or adjacent states.	13, but none in WA or adjacent states.
Teal Carbon	Applicable in WA. Active under ACR (Afforestation and Reforestation of Degraded Land) and VCS (VM0007)	3 registered, but none in WA or adjacent states.	11, but none in WA or adjacent states.

4 Task 7: Sensitivity analysis for existing protocols

4.1 Task Objective

The objective of Task 7 was to select one existing or adapted protocol for each major carbon dioxide removal project type relevant to Washington State, such as reforestation, wetland restoration, agriculture, grasslands, urban forest, etc. The selected protocols represent the best available use in Washington State's projects. The goal of this exercise is to demonstrate how changes to protocols may change their applicability and thereby increase or decrease potential supply, or otherwise impact how a carbon dioxide sink translates into a carbon dioxide removal project.

4.2 Methods

SCS followed a rigorous selection process that included three steps to select the best protocol for each project type relevant to Washington State. The first step involved analyzing all major protocols from various registries (VCS, ACR, CAR, CARB, etc.) available for a particular project type. The second step was to confirm their applicability for the state of Washington. For the third step, we compared two selected applicable protocols (for Washington State) based on five aspects: (1) whether a barrier analysis is included in the additionality assessment, (2) the maximum length of time a project can go without verification, (3) whether or not leakage is considered, (4) the relative ease of interpretability, and (5) the protocol adoption rate, preferably within the United States. Each aspect was assigned a weighted score, and the winning protocol was selected based on the highest weighted score. Additionally, we also gathered feedback from different stakeholders relevant to each project type after sharing our results of the protocol comparison.

The five aspects can be informed directly from protocol documentation or registry databases and are used to gauge how effective associated carbon offset projects may be for enhancing and protecting carbon dioxide sinks when implemented in Washington.

The barrier analysis relates to a project's additionality: Does a protocol require a project to explain and defend investment, cultural, institutional, or technological impediments that prevent certain project activities from being commonplace across a specific area? Also included in the barrier analysis is a demonstration of regulatory surplus: Does the protocol require carbon projects to conduct activities not mandated by law?

The verification cycle length relates to rigor in monitoring: protocols that allow a project to conduct activities without being verified for extended time period reduce the effectiveness of verification, such as interviewing stakeholders about what transpired early in the verification period and increase the chance that systematic problems with quality control persist as the project collects data.

Leakage is important to account for when baseline activities from spill into other areas, which may be driven by the marketplace or other pressures. Generally, leakage is accounted for with a deduction related to some form of production or yield loss after a project starts.

Interpretation is subjective, but SCS as an auditing body has experience in reviewing many different protocols and project implementations, which provides a holistic perspective on how sound guidance is written and presented to project developers and verifiers. Stakeholders, such as protocol developers, were asked about our interpretability assessment of their associated protocol compared to others during stakeholder interviews for this project.

Finally, the adoption rate, or active projects ready for validation, for a given protocol can be taken from registry databases. We focused on project adoption within the United States, as this would be relevant to Washington state, while not narrowing the focus of the count too much to limit inferences from the metric. Project adoption is also tied to ease of implementation, as interpretability is, but it also indirectly ties to the longevity, or permanence, of projects that follow a given protocol. One may infer less risk for projects failing under a specific protocol if a substantial number have been implemented.

A major objective in devising the five aspects for the protocol scoring and sensitivity analysis is to ensure the scoring process can be standardized across all project types. All five are general enough to be recorded and assessed across all project types. Specific guidance must be considered, such as carbon dioxide sink quantification and monitoring methods. Still, we aim to ensure this analysis may be interpreted similarly across all sinks. Scoring for each aspect operates the same way across all project types.

Collecting data for all five aspects is relatively straightforward, besides interpretability, which does require knowledge of how protocols are written across a particular project type. When scoring protocols, the barrier analysis is zero or one (if provided in the protocol, zero if not). The same approach applies to leakage. The verification cycle length can typically be taken from a protocol’s monitoring or verification section or a protocol’s registry’s standard. The protocol with the shortest verification cycle length is deemed a winner for that aspect and is awarded a score of one, while other protocols with a longer cycle length get zero. The easiest interpretation protocol is awarded one, while all others are zero. Project adoption scores one to the protocol with the most active projects seeking validation or that have been validated.

The final score determines the winning protocol for a project type, and this is a weighted average of scores across all five aspects:

$$Score_{Final} = \sum_{i=1}^{5} Score_i \cdot Weight_i$$

where i is one of five aspects, Score is the score (zero to one) for a particular aspect, Weight is that aspect's weight, and ScoreFinal is the final weighted score for a protocol.

Weights are assigned to each aspect to reflect an importance measure one may impose on that aspect of the overall score. For instance, certain aspects, such as interpretability, may not be as important as the barrier analysis. Preferences may also vary across different project types. SCS also adopted a weighted averaging approach to test how weights affect the final score. The data underlying each score would be relatively static. Still, if the winning protocol changes after weights are adjusted, the winner is decided mainly upon the perceived importance of different aspects rather than the underlying data.

The sensitivity analysis itself is made up of two main steps: 1) produce a weighted score based on actual data (currently available) and SCS-assigned weights for eligible protocols, and 2) adjust weights and data to better understand how 'stable' a winner is across different aspect preferences and to see how changing aspect data may change which protocol 'wins.' SCS managed subjectivity in the final scoring process and learned why protocols may be better suited for Washington versus others based on the protocols' characteristics. Also, by adjusting data in the sensitivity, SCS essentially create 'hybrid' hypothetical protocols that simulate what a stable 'winner' would look like for Washington for each carbon dioxide sink. In summary, SCS conduct the following for Task 7 for each carbon dioxide sink:

1) Remove protocols ineligible for Washington.
2) Score remaining protocols and choose the top two.
3) Adjust weights to gauge how perceived aspect importance impacts the final scoring outcome. Weights must add up to one.
4) Adjust data to understand better how the second place (or tied) protocol may become the winner.

Table 4.2.1: Aspects along with their description used for selecting favored protocols for different sinks.

Aspects	Description
Baseline and additionality	Rigor in the model's use of additionality. The ability of the standard to only allow true additionality
Monitoring and Data Requirements	Monitoring requirement and data used in monitoring
Leakage	Method used to adjust the carbon storage due to losses attributed to leakage
General interpretability	Complexity and ease of implementation
Adoption	Adoptability of the standard

The CarboSink interface provides the tools to input data, adjust weights for each aspect, and compare the top two protocols for each sink. Tables showing the data inputs and weighted scoring outcomes are provided in the interface. Figure 4.1 shows two outcomes from an analysis of the agriculture protocols. A demonstration of the agriculture analysis is presented as a case study of the process below. Appendix C also contains sensitivity analysis results for the various carbon dioxide sinks.

a) b)

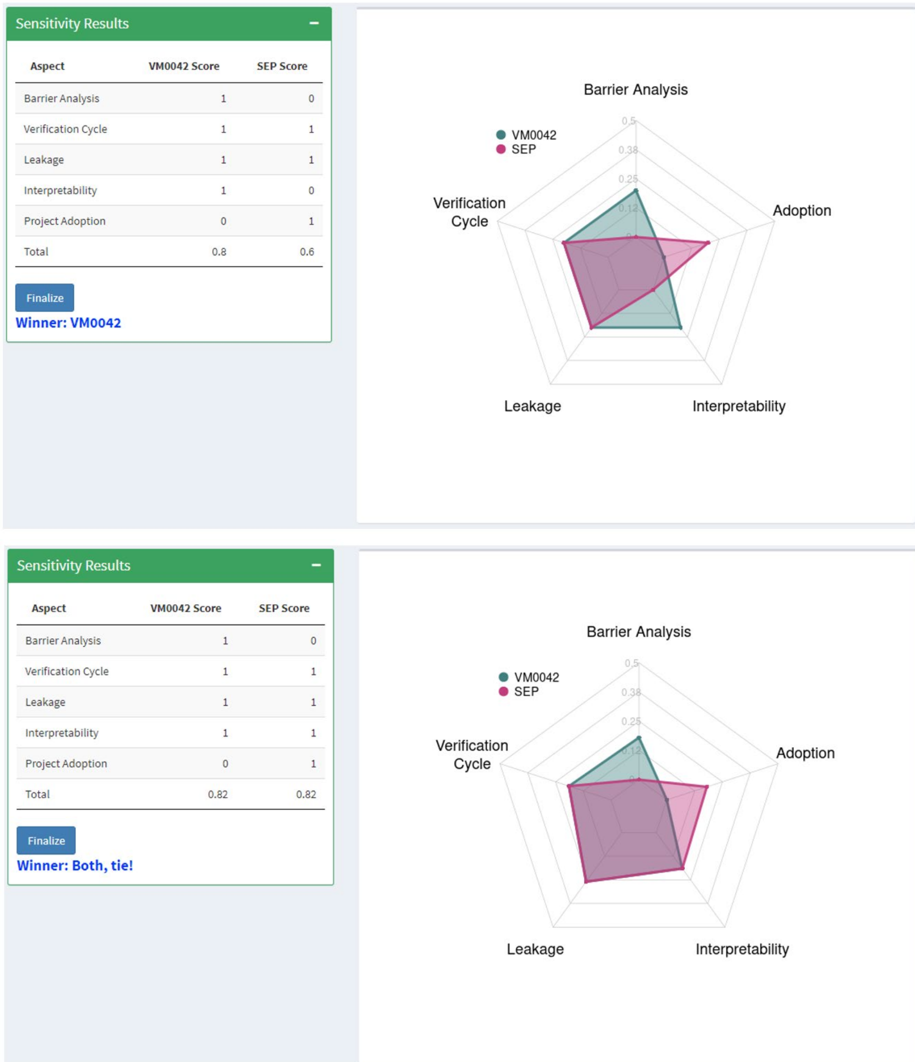


Figure 4.1: Output from CarboSink showing a) the result of scoring VM0042 and SEP based upon SCS's original scoring and weights (not shown) all equal, and b) result if SEP's interpretability becomes 1 and aspect weights (not shown) were randomly adjusted, resulting in a tie in this case.

4.3 Selected Protocols

4.3.1 Forest

The State of Washington has elected to adopt the California Air Resources Board (CARB)–Forest Offset Protocol. Advantages of the CARB Forest Offset Protocol include that it encompasses three relevant project types: Improved Forest Management, Reforestation, and Urban Forestry, and has robust systems in place for quantification, project monitoring, reporting, and verification. Disadvantages include that some requirements can be cumbersome to navigate, potentially resulting in higher development costs or lower implementation rates. Reforestation projects are credited on an ex-post basis, so there may be some lost opportunity in developing projects that rely on ex-ante crediting to fund project activities. Monitoring, reporting, and verification processes for Urban Forest projects may be one barrier to entry resulting in these projects not being implemented under the CARB Forest Offset Protocol. City Forest Credits has a more active urban forestry protocol than the CARB Forest Offset Protocol, which may serve as inspiration for a more useable urban forest protocol. The Climate Forward REM is the only protocol the authors are aware of, which aims to fund wildland fuel reduction treatments to reduce future emissions due to wildfire. Additionally, incorporating a dynamic baseline in improved forest management projects may help improve additionality in regions where forestry practices may be shifting over time.

Improved Forest Management

Based on the sensitivity analysis described above, the CARB Forest Offset Protocol is the most applicable improved forest management protocol currently available. The American Carbon Registry IFM Methodology version 2.0 (ACR-IFM) is also applicable and robust in Washington. The ACR-IFM protocol is rated slightly lower than CARB-IFM because CARB-IFM can be perceived to have a generally more robust baseline barrier analysis and higher project adoption rate. See Appendix C for a demonstration of using CarboSink to conduct a sensitivity analysis of the IFM protocols.

Afforestation, Reforestation, Revegetation

Afforestation, Reforestation, Revegetation protocols that are currently most applicable to Washington are CARB-ARR and ACR-ARR. These two protocols are similar and primarily vary in their respective adoption rates. Hence, CARB-ARR appears to be the most applicable for immediate use in Washington due to its higher adoption rate. See Appendix C for a demonstration of using CarboSink to conduct a sensitivity analysis of the ARR protocols.

Urban Forests

The urban forest sensitivity analysis considered the CARB Urban Forest Protocol alongside City Forest Credits. SCS recommend City Forest Credits primarily because of a much higher adoption rate. SCS is unaware of any registered projects under the CARB Urban Forest Protocol. See Appendix C to demonstrate using CarboSink to conduct a sensitivity analysis of the Urban Forest protocols.

4.3.2 Agriculture

The VM0042 version 2.0 and SEP protocols are the only known agricultural land management protocols with ongoing projects in the United States: SEP has three projects (two of which have been validated), and VM0042 has two at the time of writing, with more being listed soon. The OOJ protocols are not eligible for the state of Washington, however, several new protocols are considered in this analysis alongside those considered in Phase I. Nori's protocol did show that credits have been sold for 16 farms. Still, whether these are ongoing projects is unclear, and Nori's Croplands Methodology does not seem to account for leakage. VM0017 and VM0021 are older agricultural land management protocols made inactive by VCS. Any projects following these protocols must adopt another protocol (e.g., VM0042) by the next baseline reassessment. VM0042 version 1.0 will be inactive for projects that do not pass validation within six months of the release of version 2.0. Moreover, version 2.0 itself is more accessible for interpretation than version 1.0. Therefore, the top two initial scoring and analysis protocols include VM0042 version 2.0 and SEP.

VM0042 version 2.0 has a higher weighted score of 0.8 versus SEP's 0.6. Based on an interview with the Climate Action Reserve, SEP will undergo revisions this year. If these revisions result in a more straightforward protocol interpretation over VM0042, then the scores will equal 0.8 for both, resulting in a tie. We randomly adjusted weights (adjusted from 0.2 for each of the five aspects). If the interpretability for SEP is '1' as weights are randomly adjusted, the winner flips back and forth, sometimes resulting in a tie. Further, it indicates that if SEP can improve interpretability, then the 'winner' between VM0042 and SEP depends upon the perception of importance for each aspect (see Appendix D for a demonstration of the analysis described above).

4.3.3 Grasslands

The available grassland protocols were reviewed relevant to grassland carbon dioxide sinks. This include ACR, CAR and VCS protocols and standard for grassland. VCS protocol VM0026 was compared with CAR U.S. Grassland protocol for the final step. See Appendix C to demonstrate using CarboSink to conduct a sensitivity analysis of the Urban Forest protocols.

4.3.4 Blue Carbon

SCS reviewed all available protocols relevant to the blue carbon dioxide sink for this task and included three ACR protocols, Restoration of Degraded Deltaic Wetlands of the Mississippi Delta, Restoration of California Deltaic and Coastal Wetlands, and Afforestation and Reforestation of Degraded Land, and three VCS protocols VM0007, VM0024, and VM0033. Two ACR protocols, Restoration of Degraded Deltaic Wetlands of the Mississippi Delta and

Restoration of California Deltaic and Coastal Wetlands, were eliminated as they are out of the jurisdiction and currently not applicable in Washington State. Further, protocols were reviewed based on baseline/project activities relevant to the coastal wetlands of Washington State. For e.g., the ACR protocol Afforestation and Reforestation of Degraded Land was eliminated because the project activities only included woody vegetation and did not include marshes and seagrass. Moreover, the soil organic pool is not included in projects implemented on coastal wetlands or organic soils. VCS protocol VM0024 was also eliminated because it applies to open-water wetlands only, which are less prevalent in Washington State. Therefore, based on applicability, project activities, baseline conditions, and additionality, VCS protocols VM0007 and VM0033 were chosen for final evaluation. Figure C4 in Appendix C summarizes the data for each aspect used in the final comparison of VM0007 and VM0033 protocols.

Both VM0007 and VM0033 are applicable for coastal wetlands of Washington state and include project activities on coastal forests, marshes, and seagrass meadows. Further, both protocols have strict historical baseline data requirements and include barrier analysis to demonstrate additionality. Also, both protocols have a maximum of ten years for a verification cycle and baseline re-assessment period. However, VM0033 does not include leakage if the applicability conditions are met. Moreover, while VM0033 is easier to interpret compared to VM0007, more projects have been registered under VM0007 as it allows for more flexibility in using different modules for relevant applicability conditions and criteria and for the inclusion of REDD and ARR project activities along with WRC project activities. Based on the weighted scores, VM0007 is the winner for blue carbon dioxide sinks.

4.3.5 Teal Carbon

For this task, SCS reviewed all available protocols relevant to the teal carbon dioxide sink and included four ACR protocols Restoration of Degraded Deltaic Wetlands of the Mississippi Delta, Restoration of California Deltaic and Coastal Wetlands, Afforestation and Reforestation of Degraded Land, and Methodology for the Restoration of Pocosin Wetlands, and four VCS protocols VM0007, VM0004, VM0027, and VM0036. Three ACR protocols, Restoration of Degraded Deltaic Wetlands of the Mississippi Delta, Restoration of California Deltaic and Coastal Wetlands, and Methodology for the Restoration of Pocosin Wetlands and two VCS protocols VM0004 and VM0027 were eliminated as they are out of the jurisdiction and currently not applicable in Washington State. Further, protocols were reviewed based on baseline/project activities relevant to the freshwater wetlands of Washington State. For e.g., the ACR protocol, Afforestation and Reforestation of Degraded Land, was eliminated because the soil organic pool is not included for projects implemented on freshwater wetlands or organic soils. Therefore, based on applicability, project activities, baseline conditions, and additionality, VCS protocols VM0007 and VM0036 were chosen for final evaluation. Figure 5C in Appendix C summarizes the data for each aspect used in the final comparison of VM0007 and VM0036 protocols.

Both VM0007 and VM0036 are applicable for freshwater wetlands of Washington state and have strict historical baseline data requirements and include barrier analysis to demonstrate additionality. Further, both protocols have a maximum of ten years for a verification cycle and baseline re-assessment period. However, VM0036 does not include leakage if the applicability conditions are met. Moreover, while VM0036 is easier to interpret compared to VM0007, more projects have been registered under VM0007 as it allows for more flexibility in using different modules for relevant applicability conditions and criteria and for the inclusion of REDD and ARR project activities along with WRC project activities. Based on the weighted scores, VM0007 is the winner for teal carbon dioxide sinks.

4.4 Task 7 Findings

4.4.1 Forest

The sensitivity analysis above yielded the following results:

- CARB-IFM is preferred over ACR-IFM for improved forest management project types. This is largely driven by higher adoption rates of CARB-IFM and higher perceived robustness of the baseline barrier analysis.
- CARB-ARR is preferred over ACR-ARR for Afforestation, Reforestation, and Revegetation project types. These two protocols were found to be exceedingly similar, in fact both protocols follow the principles of the Clean Development Mechanism–approved consolidated afforestation and reforestation baseline and monitoring methodology AR-ACM0001. CARB-ARR is preferred largely due to the higher current adoption rates.
- City Forest is preferred over CARB-Urban Forest for urban forestry project types largely because City Forest is, while a newer registry and protocol, much more active than CARB Urban Forestry in both Washington and throughout the United States. We are unaware of any registered projects under the CARB Urban Forest protocol.

4.4.2 Agriculture

Based upon the agricultural sensitivity analysis, we have the following take-aways:

- Currently, VM0042 version 2 is the ‘winner’ for Washington, however its adoption rate in the United States is not as high as SEP.

- SEP may improve the overall ease of interpretation after upcoming revisions, thereby making it just as suited as VM0042 version 2.0 for Washington. These improvements could include clearer modeling guidance and support (e.g., VM0042 requires independent modeling expertise to review modeling approach), less overall text, more examples for implementing different components, and a clearer pathway for the inclusion of integrated crop-livestock systems.
- SEP does not involve an in-depth barrier analysis, but VM0042 requires projects to demonstrate additionality through the VCS barrier analysis.
- SEP does have a longevity requirement. We did not factor overall longevity requirements as an aspect for analysis, but it is noted that this requirement is absent in VM0042.

4.4.3 Grasslands

The available grassland protocols were reviewed relevant to grassland carbon dioxide sink. This include ACR, CAR and VCS protocols for grassland. VCS protocol VM0026 is a flexible standard that allows multiple pathways for estimating the amount of atmospheric carbon dioxide removed from the grasslands. This is similar to the CAR - U.S. Grassland protocols, version 2.1 and the CAR Canadian grassland protocols, version 1.0, which is unavailable for Washington projects. One includes direct measurements and the other allows for validated models. A conservation easement is required that contains the management practices to maintain the carbon dioxide sink. This promotes the permanence of the carbon storage.

4.4.4 Blue Carbon

- Currently, VM0007 is the winner for blue carbon dioxide sink. However, it has not yet been adopted within the United States yet. All projects registered (2) or under development (9) with this protocol are outside of the United States.
- The effectiveness and applicability of coastal wetland restoration projects under both VM0007 and VM0033 protocols can be improved by modifying or expanding the range of acceptable techniques, such as by including fisheries areas and incorporating species with higher carbon sequestration capacities.
- Coastal wetlands provide multiple ecosystem services in addition to carbon sequestration, such as flood protection and biodiversity conservation. Modifying these protocols to consider the integration of these ecosystem services and their co-benefits can enhance their applicability and help promote holistic wetland management.
- Modifying the approach for estimating baseline emissions by incorporating more accurate data sources or accounting for local/regional factors can improve the applicability of these protocols to the specific wetland areas.

- Enhancing the monitoring requirements, such as including site-specific parameters or remote sensing technologies and accounting for wetland-specific characteristics, such as the presence of fluctuating water levels or diverse vegetation types can also improve the applicability of these protocols to coastal wetlands.
- The applicability of these protocols to coastal wetlands can further be improved by developing and using hydrological and biogeochemical models by incorporating long-term average climate variables and using local/regional published data.

4.4.5 Teal Carbon

- Currently, VM0007 is the winner for teal carbon dioxide sink. However, it has not yet been adopted within the United States yet. All of projects registered (2), under development (1) or on hold (1) under this protocol are outside the United States.
- The applicability of both VM0007 and VM0036 protocols for freshwater wetlands can be improved by modifying and improving data collection methods, obtaining more accurate and comprehensive data on carbon stocks, and GHG emissions.
- The applicability of these protocol to freshwater wetlands can be further enhanced by improving project planning strategies, such as incorporating more measurement plots, optimizing stratification approaches, or conducting additional work to diminish uncertainty.
- Modifying the methods used to estimate carbon stock changes, such as employing alternative measurement techniques, adjusting sampling protocols, or incorporating more detailed data on carbon pools specific to freshwater peatlands and wetlands, could affect the accuracy and applicability of the protocol.
- Modifying the equations or parameters used in calculations, based on improved understanding or specific characteristics of freshwater peatlands and wetlands, may also improve the applicability of these protocols.

5 Task 8: Re-assess Task 3 for final report

5.1 Task Objective

The objective of Task 8 was to reassess the initial standards mapping to the carbon dioxide sinks analysis completed in Task 3. Phase II has been expanded to include the new and developing protocols in Tasks 5 and 6. SCS used a systematic approach to review and refine the categorization applied to the carbon dioxide sinks. The previous analysis considered the potential carbon offset projects in Washington State. The revised analysis improves the understanding of carbon dioxide sinks in Washington State, reflecting additional knowledge that SCS uncovered during Phase II. This addresses data gaps identified in Phase I and highlights additional data gaps which may impact the utilization of carbon offset protocols in the state.

5.2 Methods

5.2.1 Forest Growth Capacity and CarboSink

The forest growth and yield modeling has not been updated since Phase I, but the results are now integrated into the CarboSink database and interface. See Appendix E for a demonstration of how to view forest carbon capacity across Washington, and growth curves underlying these results.

5.2.2 Soil Organic Carbon Modeling

The results of this work can be seen in the CarboSink interface. Based on the findings from Task 3 of the Phase I report, SCS undertook the soil sequestration modeling for agricultural areas of Washington State, which was one of the identified data gaps in Phase I. For this Task, SCS showed estimates of soil organic carbon capacity across different counties of Washington State based upon a simple simulation of increased carbon inputs. We take this as simulating less tillage or other farm management adjustments. We parameterized and ran the RothC soil organic carbon model to estimate soil organic carbon capacity at a county level across Washington. This modeling effort aimed to improve our understanding of soil organic carbon capacity in agricultural sinks beyond current estimates of soil organic carbon storage based on available soil data.

SCS estimated potential soil organic carbon (SOC) changes under an increase in carbon inputs to simulate changes in SOC at a county level. This approach differs somewhat from the forestry-related analysis since the general SOC modeling approach differs from forest growth and yield modeling in typical carbon projects. Soil carbon models acceptable for use under SEP and VM0042/VMD0053 requirements are partly driven by weather data. They are structured as a system of differential equations that simulate SOC dynamics and exchanges across separate 'pools' with differing decomposition rates. The model must be initialized and 'spun up' or run to an equilibrium state after starting with initial conditions the RothC model is a relatively simple SOC process model that can be used to simulate SOC changes under a baseline and project scenario.

Following general protocol requirements, we model SOC under simplified assumptions of 'business as usual' at a county level and under conditions where carbon inputs are increased slightly to simulate the effect of chanced practices, such as conversion to no-till agriculture. The model is run for both cropland and pastureland for each county, and necessary inputs, such as temperature, precipitation, evapotranspiration, and soil properties, were averaged at the county level. Soil properties were averaged for cropland and pastureland separately, and the national land coverage dataset (NLCD; Dewitz & USGS, 2021) was used to identify areas of pastureland and cropland. It can be noted that pasturelands in this context are designated as agriculture, separate from the 'grasslands' sink, composed mainly of perennial grasslands with little or no management inputs. Soil data (e.g., clay content) was taken from 100 m resolution gridded datasets (Ramcharan et al., 2018) that were derived from SSURGO data. We assumed a depth of 30 cm for the SOC stock estimation. Initial SOC stocks were taken as an average of values from the FAO GSOC map (FAO, 2018) for pasture and cropland in each county. Weather data from 2000 - 2020 from the PRISM (Temperature, Precipitation; PRISM Climate Group, 2020) and TerraClimate (Evapotranspiration; Abatzoglou et al., 2018) was averaged for each month of the year for each county and land use (e.g., pasture and cropland).

To calculate SOC for a baseline scenario, the RothC model (Coleman & Jenkinson, 1996) was run to equilibrium or to the point where SOC stocks at the year's end closely resemble the average GSOC value for each county and land use. We adjusted monthly carbon inputs during the equilibrium runs until RothC nearly replicated the relevant averaged GSOC value. We used a gradient-based optimization algorithm (Byrd et al., 1995) and automated the original RothC model to achieve acceptable results efficiently. Then, we cross-checked calibrated annual C inputs in 12 high wheat-producing counties (Adams, Asotin, Benton, Columbia, Douglas, Franklin, Garfield, Grant, Lincoln, Spokane, Walla Walla, and Whitman), which were identified as such by high concentrations of spring and summer wheat shown by the USDA's crop type map (USDA, 2020) across these counties compared to the rest of the state. Wang et al. (2016) provided a mean C input estimate for wheat in the USA at 2.6 tC ha^{-1} with a standard deviation of 1.4 tC ha^{-1}, and we checked if the optimal C inputs did not exceed and were relatively close to this value. After optimal C inputs were estimated, RothC was run to equilibrium, and the initial C stocks for each of the five soil carbon pools based upon the equilibrium run begin a regular RothC run over 30 years to simulate a potential crediting period timespan.

Project scenario simulations were designed to be conservative and followed FAO guidance (FAO 2020, Section 6.5.2). A 'low' C increase is deemed conservative, and FAO (2020) suggested an adjustment of C inputs into RothC by 5% to simulate such a project scenario. Therefore, we increased the optimal C input estimates by 5% for each county and land use type and ran RothC with these new inputs for 30 years.

Lastly, we calculated SOC capacity for each county and land use (cropland and pasture) by subtracting the project scenario SOC stock projected by RothC with its associated baseline SOC stock at the end of the same period. A greater difference between baseline and project scenario indicated a higher degree of potential SOC sequestration by a given county's crediting period. All SOC stocks are in units tC ha^{-1}.

5.3 Task 8 Findings

5.3.1 Agriculture

The optimization procedure discussed in section 5.3 produced optimal estimates of annual C inputs less than Wang et al., (2016)'s 2.6 tC ha^{-1} value (Table 5.1). The C inputs were 1.05 tC ha^{-1} on average, which is relatively close to 2.6, especially given Wang et al. (2016)'s standard deviation of 1.4 tC ha^{-1}. As the C inputs were reasonable and would likely not lead to SOC over-estimation at the county level, we used the optimal C input estimates for each county to run baseline scenarios. We then added 5% to the C inputs and ran a project scenario for each county.

Table 5.3.1: Optimal C inputs for each county for RothC initialization.

County	Annual C input [tC ha^{-1}]
Adams	0.71
Asotin	1.20
Benton	0.70
Columbia	1.65
Douglas	0.68
Franklin	0.60
Garfield	1.37
Grant	0.51
Lincoln	0.89
Spokane	1.33

County	Annual C input [tC ha^{-1}]
Walla Walla	1.21
Whitman	1.69
Mean	1.05
95 CI	0.82 - 1.28

The potential SOC capacity for agricultural projects in cropland is lower in the central portion of Washington. This is the case for SOC projections in pastures. Capacity is highest in the state's southwestern region for both, especially in Pacific County.

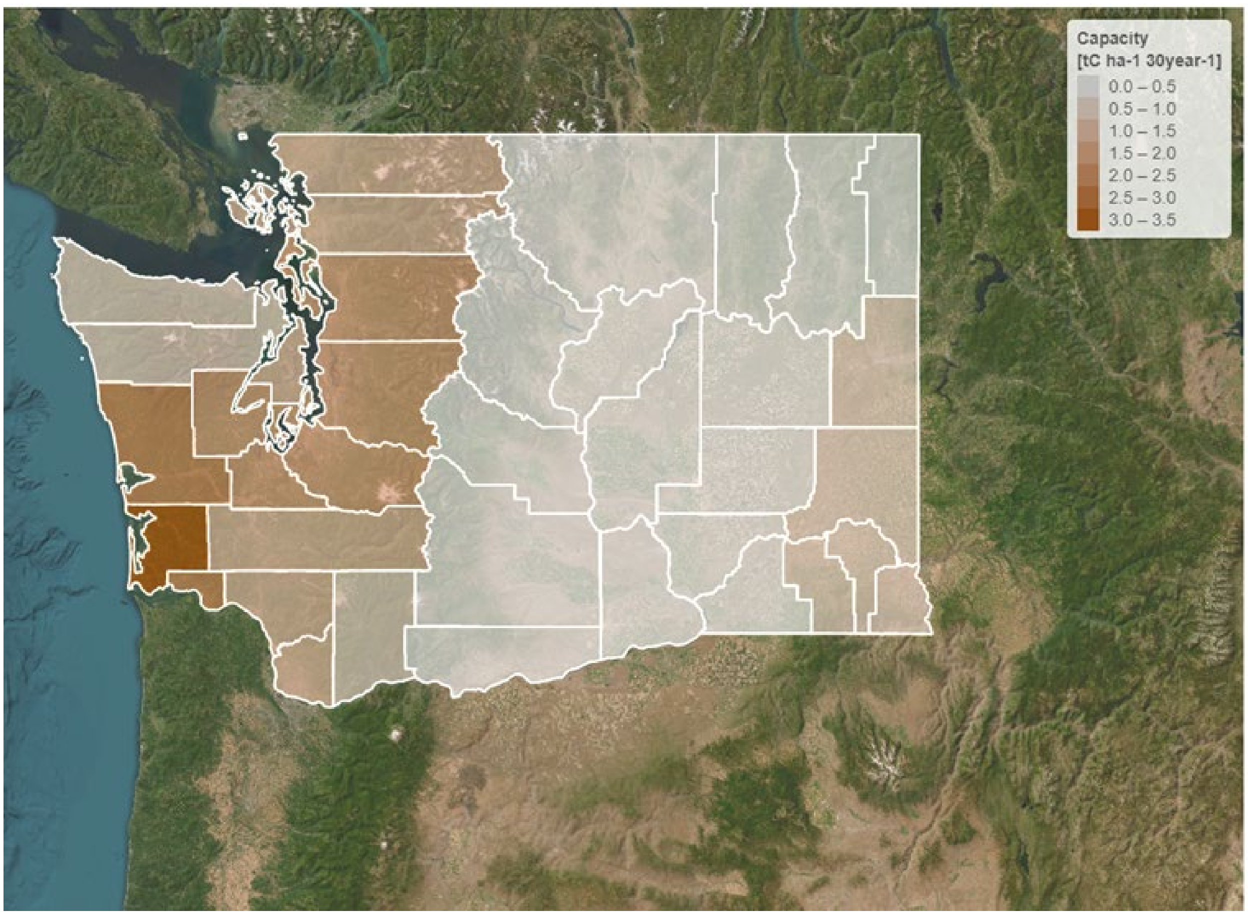


Figure 5.3.1: Modeled cropland soil carbon capacity, defined as the difference between baseline and project scenarios for cropland in each county after 30 years.

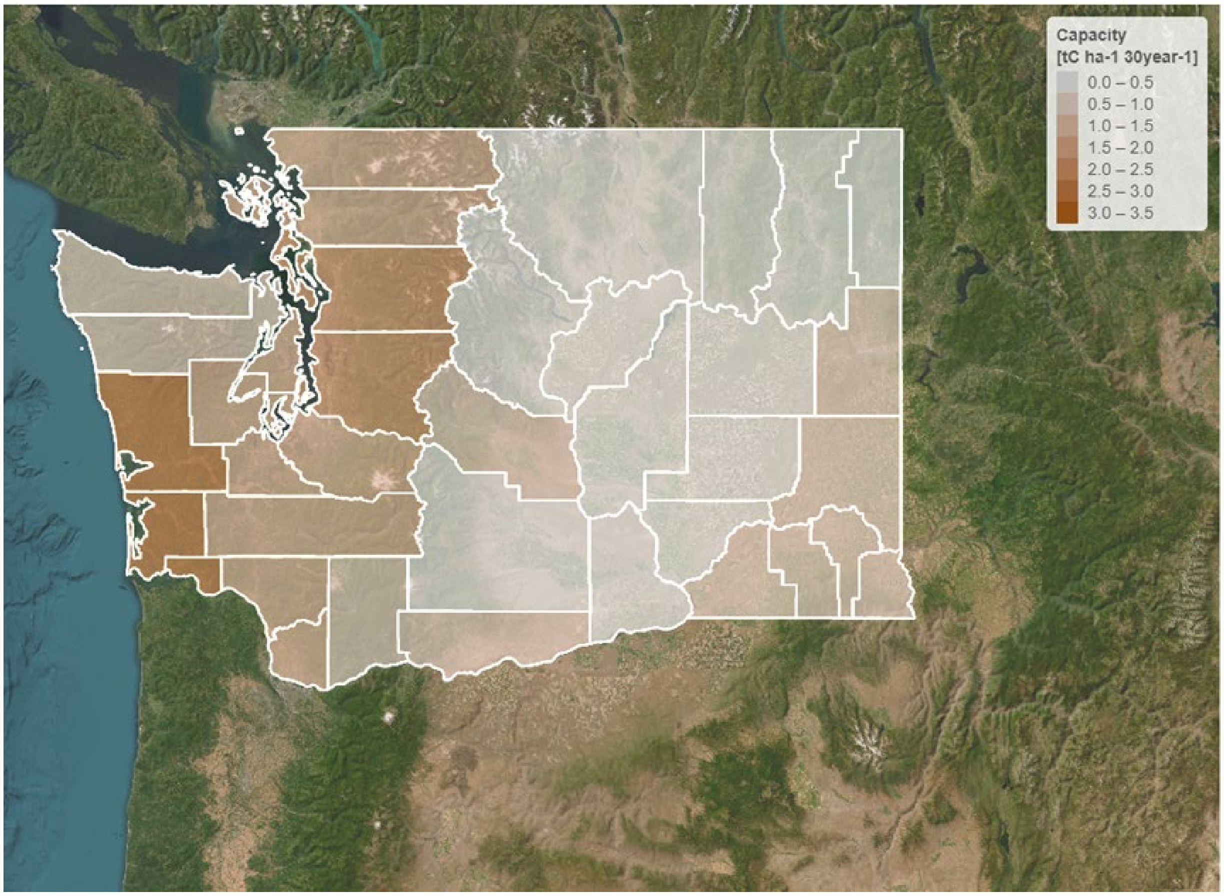


Figure 5.3.2: Modeled pastureland soil carbon capacity, defined as the difference between baseline and project scenarios for pastureland in each county after 30 years.

These patterns may be explained by clay content and climate variables. Clay content is generally higher in counties west of the Cascade Mountains, and soils with higher clay content generally have a higher area of exposed particle surfaces, which provides a greater surface for accumulated SOC to adhere to. Furthermore, the west's high precipitation inputs lead to less soil moisture deficits. The rate at which residue inputs are decomposed and sequestered in the soil matrix decreases under soil moisture deficit conditions. The following are RothC outputs and climate graphs for Pacific County, which has the highest SOC capacity for cropland (clay content = 14% on average; SOC capacity = 3.25 tC ha^{-1} $30year^{-1}$). These environmental conditions may be contrasted with Franklin County, which has a relatively low SOC capacity for cropland (clay content = 7% on average; SOC capacity = 0.28 tC tC ha^{-1} $30year^{-1}$). Figure 5.3.3 shows these two counties' soil carbon modeling outputs and average monthly precipitation and temperature patterns.

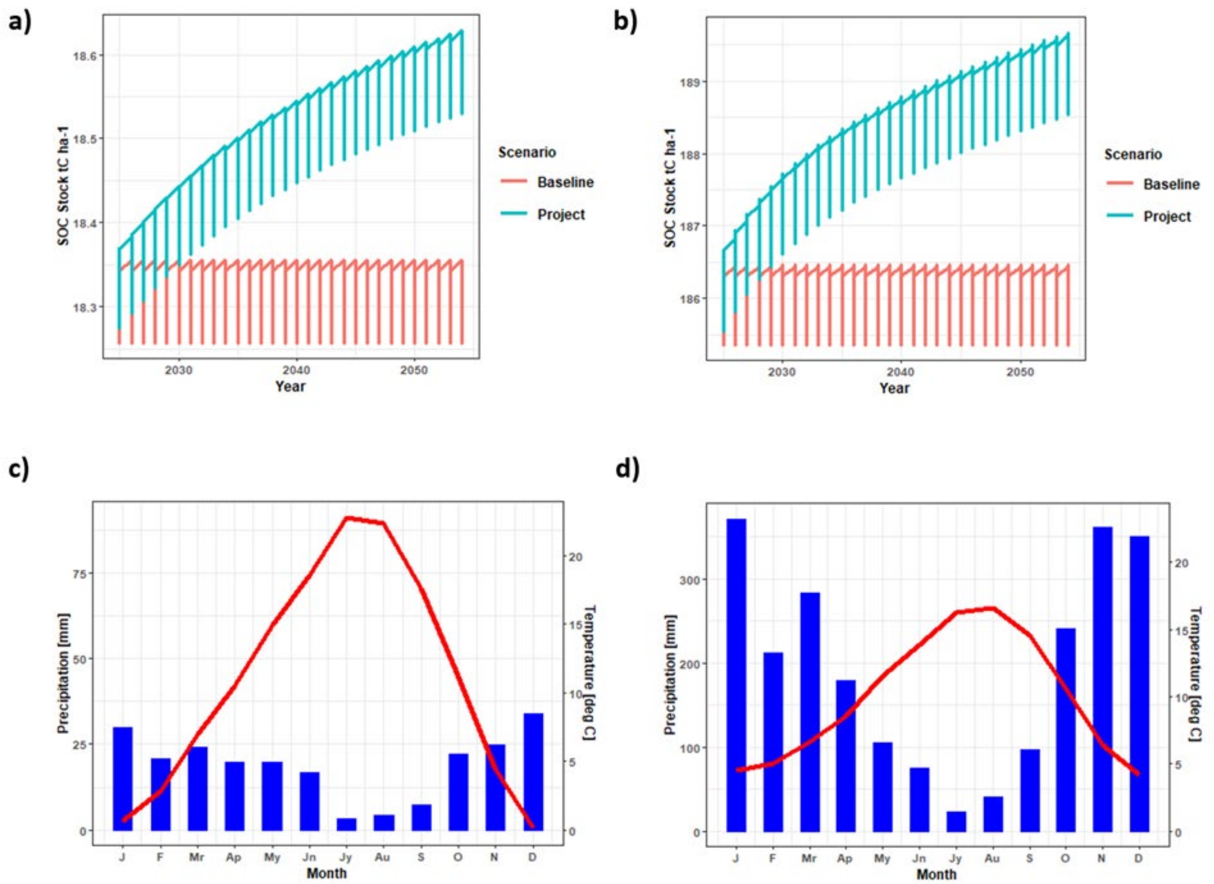


Figure 5.3.3: Carbon modeling output, showing monthly SOC stocks (tC ha^{-1}) for baseline and project scenarios for a) Franklin County and b) Pacific County. Climate graphs showing average monthly precipitation (mm) as blue bars and temperature (deg C) as red lines for c) Franklin County and d) Pacific County.

Finally, we show adoption rates for multiple practice changes based on data from the Soil Enrichment Protocol (SEP) for assessing common practice. In an interview with a developer that worked on VM0042 version 2 revisions, SCS learned that SEP's approach to assessing common practice and their data is also in line with VM0042's assessment criteria. Figures 5.3.4 – 5.3.7 show county-level adoption rates for all counties in Washington for four relevant practice changes: conversion to no-till, conversion to reduced till, integration of cover crops, and shifts in crop rotation and grazing intensity that enhance soil carbon sequestration. The threshold adoption rate for a practice deemed non-additional for VM0042 is 20% and 50% for SEP. It can be noted that both protocols allow for stacking and averaging adoption rates across practices to argue that a project as a whole is additional.

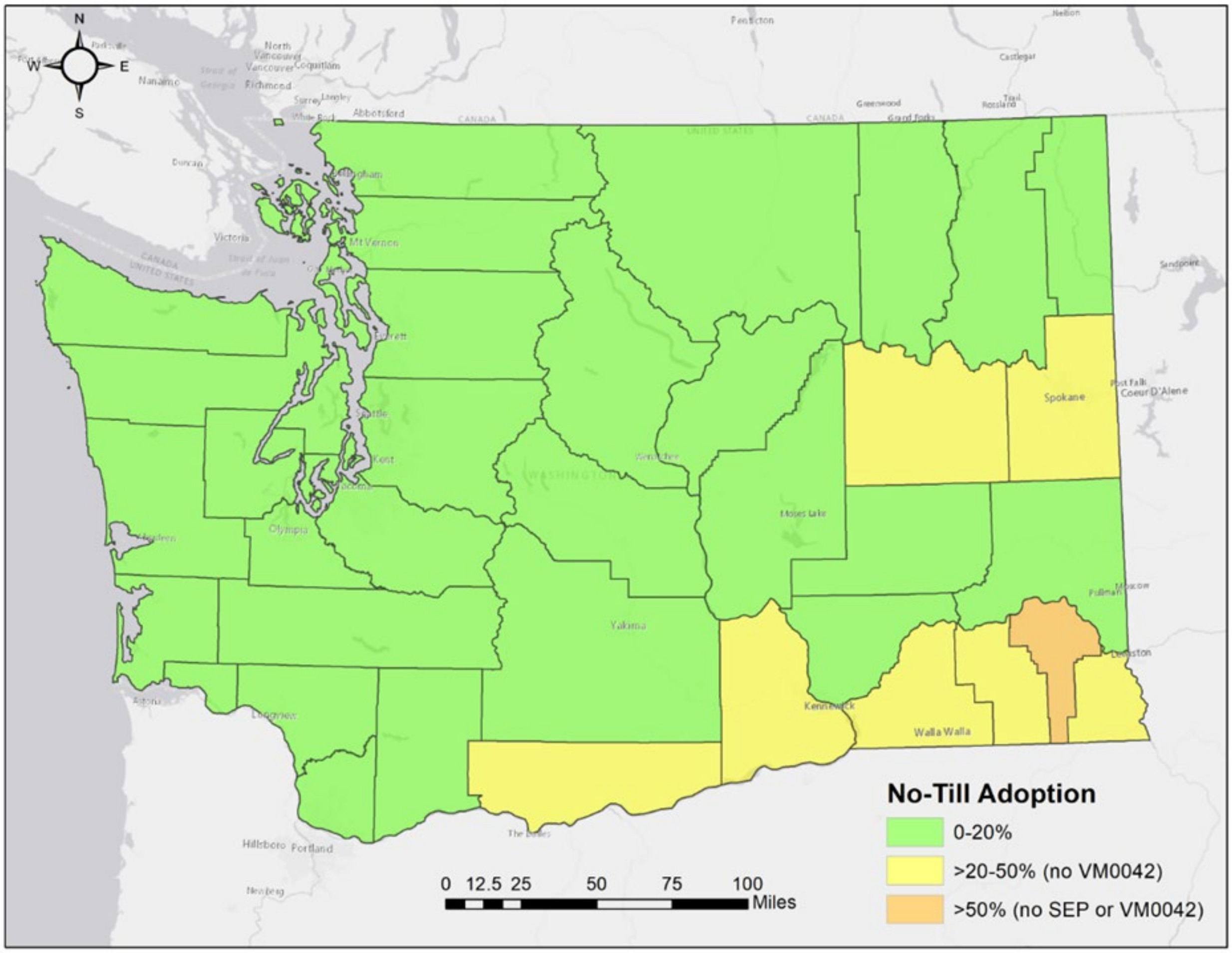


Figure 5.3.4: Adoption rates (% operations adopting practice) for the no-till practice at the county-level across Washington. Yellow indicates counties with percent adoption between 20-50% and orange indicates counties with adoption greater than 50%.

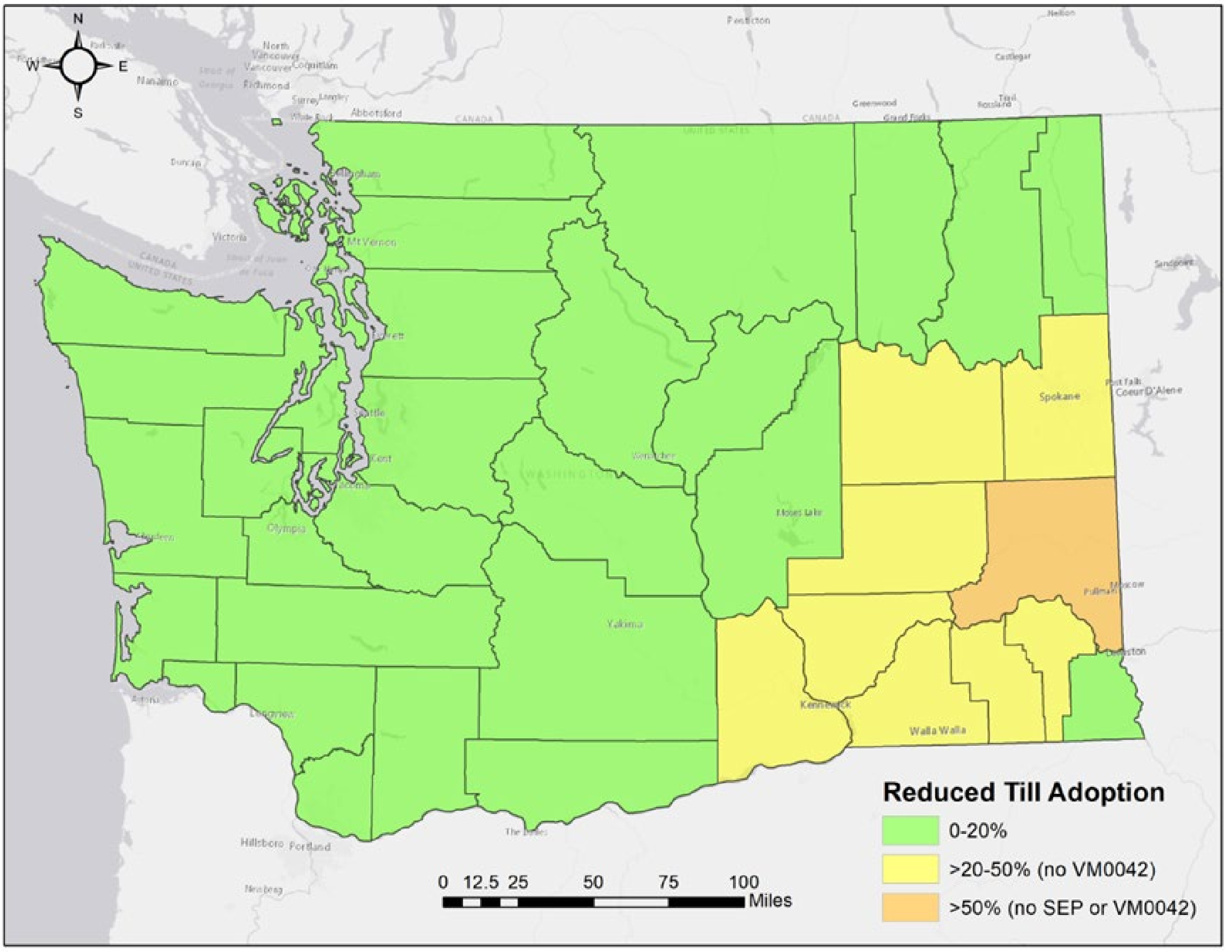


Figure 5.3.5: Adoption rates (% operations adopting practice) for the reduced-till practice at the county-level across Washington. Yellow indicates counties with percent adoption between 20-50% and orange indicates counties with adoption greater than 50%.

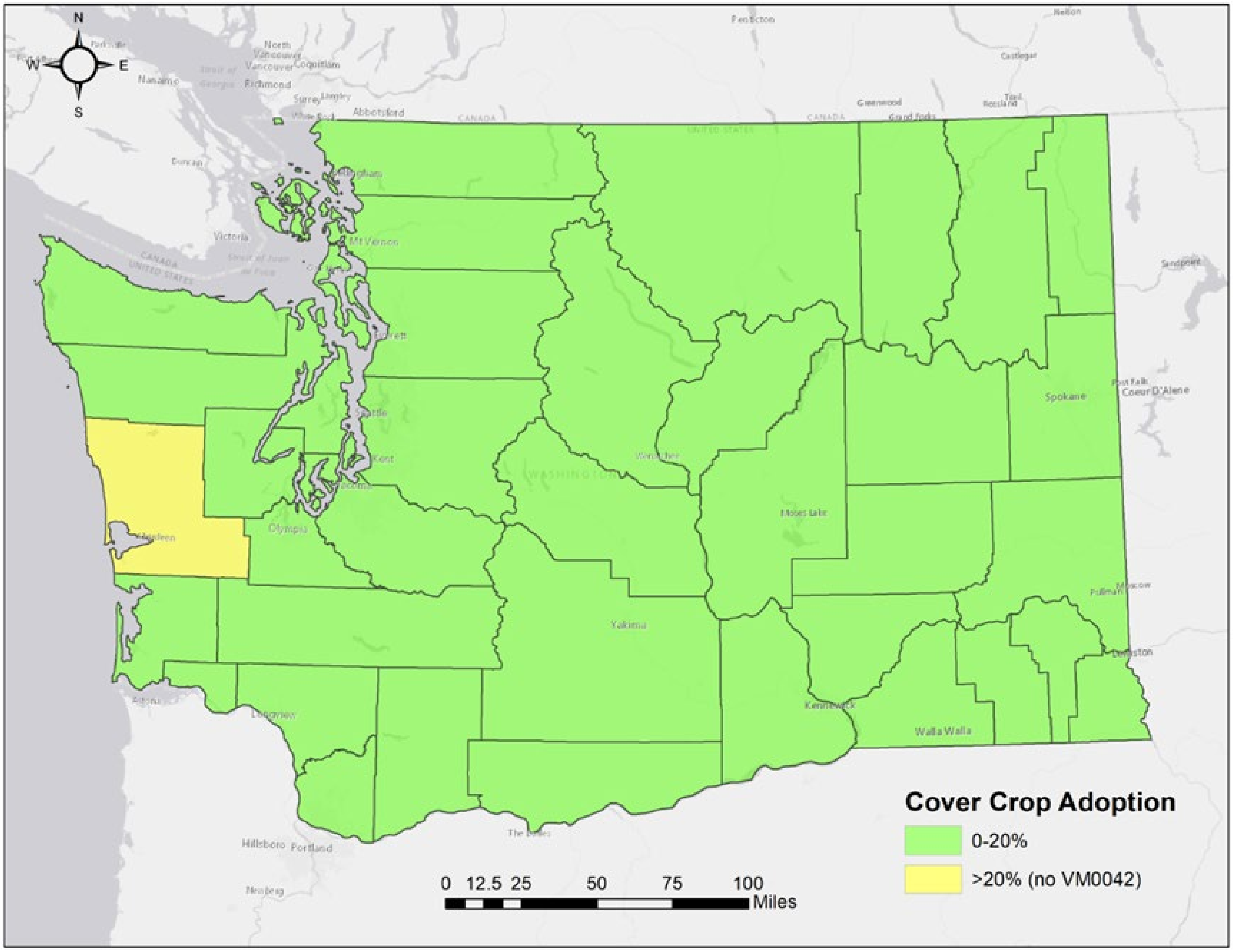


Figure 5.3.6: Adoption rates (% operations adopting practice) for the cover crop practice at the county-level across Washington. Yellow indicates counties with percent adoption between 20-50% and orange indicates counties with adoption greater than 50%.

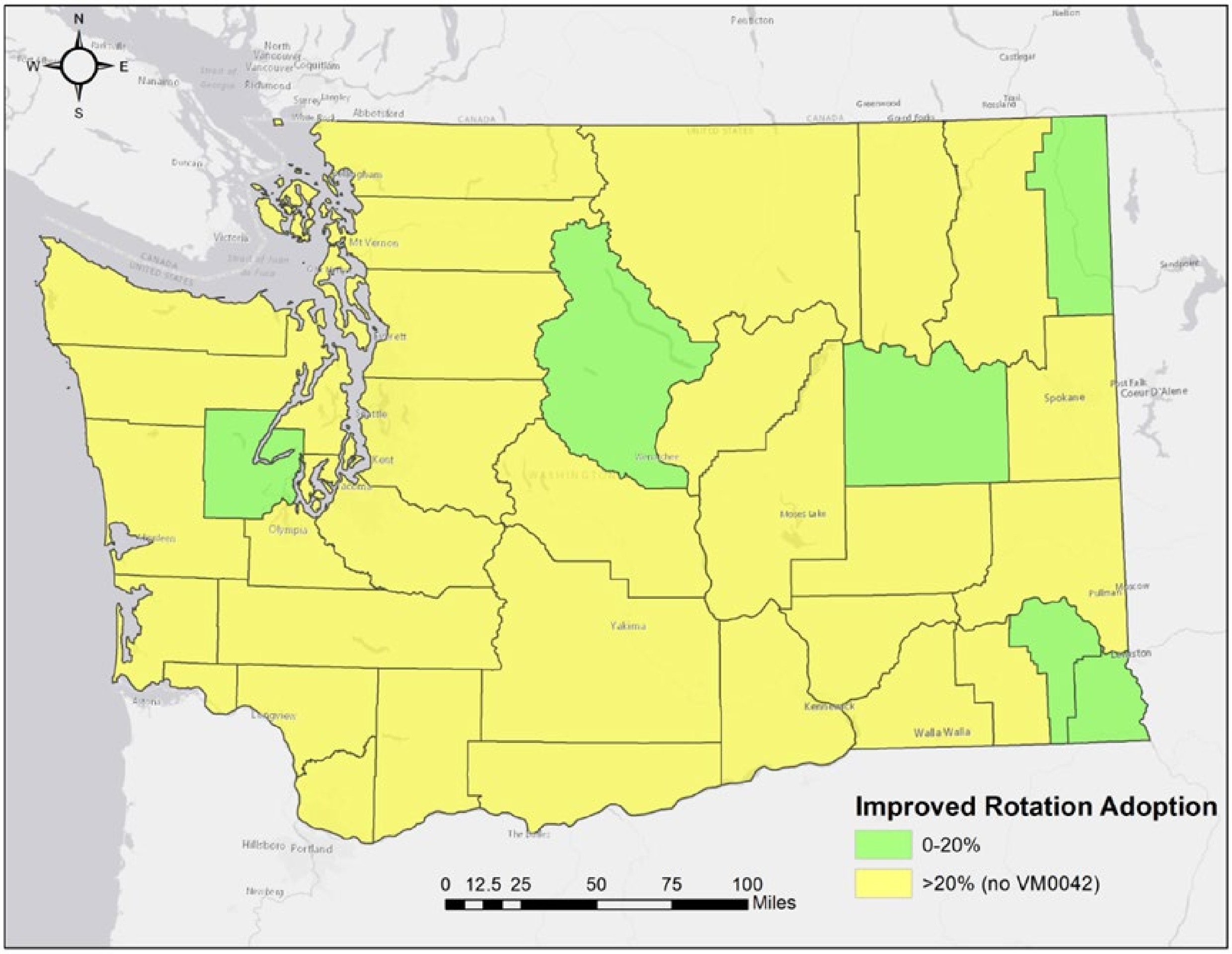


Figure 5.3.7: Adoption rates (% operations adopting practice) for the improved rotation and reduced intensive grazing practice at the county-level across Washington. Yellow indicates counties with percent adoption between 20-50% and orange indicates counties with adoption greater than 50%.

The following statements assume that projects are focused on singular practice adoption rates (i.e., no project-level stacking or weighted averaging to demonstrate additionality) for four practices with available data (Figures 5.4-7). The patterns of adoption rates generally exclude VM0042 from the southeastern portion of the state for projects with reduced tillage. The allowable coverage for no-till is broader for both protocols, besides counties on the southeastern boundary of Washington. Cover cropping is broadly additional for Washington. Improved crop rotation and grazing practices are broadly non-additional by itself for VM0042.

When considering results from the soil carbon modeling and adoption rates, the most straightforward and potentially highest net greenhouse gas removal benefit appears to be in the southwest region of Washington for both SEP and VM0042. There are still opportunities for developing effective and high net-removal projects in the southeastern agricultural area of Washington for both protocols; however, at a broad level, stacking practice changes to show additionality may be required for more areas. Also, this analysis is partly driven by county-level data model inputs, so there are likely pockets of high net-removal potential via soil carbon sequestration across the southeastern portion of the state.

6 Task 9: Cataloging & Mapping New Standards to Carbon Dioxide Sinks

6.1 Task Objective

The objective of Task 9 was to create a crosswalk between carbon dioxide sinks established in Task 1, and the new categorization standards established in Tasks 5, and 6 with those identified in Task 2. This crosswalk was combined with updated information from Task 8 so that all standards evaluated in this project were used to create a final and comprehensive assessment in this task. The deliverables for this task are included as data tables below.

6.1.1 Summary Tables

The technical, cultural, and administrative feasibility tables for all of the protocols for each carbon dioxide sink are listed in the following pages.

Table 6.1: Summary of the technical feasibility of new categorization standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Technical Feasibility			
	Data Availability	GHG Removal Potential (Low, Medium, High)		
	Unknowable, Developing, or Well Understood	CO_2	N_2O	CH_4
Forest	Well Understood	Removal: High Reduction: High Emissions: Low	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: None
Agriculture	Developing and Unknown	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Low

Carbon Dioxide Sink	Technical Feasibility			
	Data Availability	GHG Removal Potential (Low, Medium, High)		
Grasslands	Developing	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low	Removal: Developing Reduction: Low Emissions: Low
Blue Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Low
Teal Carbon	Developing	Removal: Medium Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: Low Emissions: Medium

Table 6.2: Summary of cultural feasibility of new categorization standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	Land Ownership
	(Requirements Included in Protocol?)	(Requirements Included in Protocol?)
Forest	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: for communal ownership, must obtain "free and prior consent".	Must demonstrate ownership.
Agriculture	Stakeholder comments during the standard development and revisions are common among VCS protocols in particular, such as VM0042 version 2.0.	There are no exclusions among stakeholders or ownership class in these standards.
Grasslands	Stakeholder comments during the standard development and revisions are common among the protocols.	There are no exclusions among stakeholders or ownership class in these standards.
Blue Carbon	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: Stakeholder consultation and community impact assessment required per ACR standard.	No exclusions. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard. No exclusions specified per VCS Standard: Project and jurisdictional proponents shall

Carbon Dioxide Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	**Land Ownership**
	(Requirements Included in Protocol?)	**(Requirements Included in Protocol?)**
		demonstrate that they have the legal right to control and operate project or program activities.
Teal Carbon	Included: Local Stakeholder Consultation and Public Comment Period per VCS Standard Included: Environmental and community impact assessment required per ACR standard.	No exclusions per ACR standard. ACR accepts projects on all land ownership types (private, county, state, federal and tribal) provided the project proponent demonstrate that the land is eligible, documents clear land title and offsets title, the offsets contract is enforceable, and the project activity is additional and meets all other requirements of the ACR standard. No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.

Table 6.3: Summary of administrative feasibility of existing, new, and out of jurisdiction categorization standards and protocols applied to the carbon dioxide sinks across the State of Washington.

Carbon Dioxide Sink	Administrative Feasibility		
	Applicability	# Projects Registered	# Projects in Process
Forest	Canadian protocols limited to Canada. Active under ARB, CAR, and some smaller registries such as City Forest Credits.	12	15
Agriculture	Limited to Canada (when protocol is released) and Australia. Active under VCS (VM0042, VM0017, VM0022).	4	19
Grasslands	The Canadian Grassland conversion avoidance requires the property be in Canada. ACR must have a conservation easement. Active under VCS (VM0042, VM0017, VM0022, VM0032, VM0026).	6	45
Blue Carbon	Restoration of California Deltaic and Coastal Wetlands version 1.1 is not applicable in WA as of now. Active under ACR. VM0007, VM0024, and VM0033 are applicable in WA and is active under VCS.	7	18
Teal Carbon	Restoration of California Deltaic and Coastal Wetlands version 1.1 is not applicable in WA as of now. Active under ACR. VM0007 is applicable in WA and is active under VCS. VM0036 is applicable in WA and is active under VCS.	5	5

7 Conclusions and Key Takeaways

All the terrestrial and aquatic sinks in the State of Washington have great potential for carbon offset projects in both the regulatory and voluntary carbon markets. This Project categorized, cataloged, and mapped carbon dioxide sinks' suitability, readiness, and robustness in the context of Washington's climate laws, rules, markets, and goals. This Project is well-timed, given the interest and application of offset projects within the State of Washington and internationally. The results provided herein can be utilized to catalyze the next development phase across the various sinks or through a deeper exploration into the sink or project type of the interested stakeholders.

In the compliance market, the Washington Cap-and-Invest Program will focus on businesses that exceed emissions of 25,000 tonnes of CO_2e per year, and carbon offsets may be used by emitters regulated under the program to cover up to 5% of their emissions. An additional 3% may be covered if these credits are generated over Tribal lands. The program's objective is to ensure Washington achieves its emissions reduction goals by 2050, and penalties for businesses that do not comply with emissions reduction regulations will be enacted at multiple stages in the future. As of the writing of this report, Washington Ecology recognizes four types of protocols that may be utilized for offset credits in the program: U.S. forestry, urban forestry, livestock projects, and Ozone-Depleting Substance (ODS) projects. Two of these four correspond to carbon dioxide sink-related protocols we have cataloged and analyzed in this report: U.S. forestry and urban forestry. Adopted by Cap-and-Invest, the CARB Forest Offset Protocol would be the best choice for an IFM, ARR, and urban forest project under the compliance system.

Based on the analyses conducted by SCS, irrespective of whether a protocol was developed for compliance or voluntary market, the most suitable protocols are CARB-IFM (IFM), CARB-ARR, ACR-ARR for ARR, and City Forest for urban forestry. The CARB-IFM protocol is more widely adopted and requires an intensive barrier analysis, which is the deciding factor in its highest suitability. The ARR protocols show CARB-ARR and ACR-ARR as essentially tied for the highest suitability, the reasons for which are discussed in Task 7. Finally, City Forest accounts for leakage is the most interpretable and has a higher project adoption than other protocols.

Forests in Washington represent a significant carbon sink with a history of developed carbon offset projects (11 at the time of this Report) and ample opportunity for additional development. Historically there has been a focus on improved forest management project types. It appears there is space and demand for ex-ante-based crediting schemes to fund immediate restoration projects which would not otherwise be financially feasible, specifically post-wildfire rehabilitation. This area should be the topic of future research. Similarly, using ex-ante crediting to fund fuel reduction treatments which are likely to reduce the fire severity and thus CO_2 emissions in the event of a wildfire, is an innovative solution that addresses the significant forestry management challenge which faces much of the forested portions of eastern Washington – the accumulation of wildland fuels and corresponding stand structure resulting in high risk of catastrophic wildfire. It should be noted that wildfire is also an important consideration when evaluating the permanence and robustness of a forestry project. Fuels treatments and buffer pool contributions help to account for project risks from natural disturbances and other factors such as managerial and political risks. These aspects of a forestry project and the protocol selected are two areas of refinement when determining long-term results and integrity.

Utilizing a dynamic baseline in improved forest management projects may be an effective way to improve additionally throughout the crediting periods, especially in areas where "business as usual" forest management practices may be shifting. The use of a dynamic baseline; however, it may create an unacceptable increase in uncertainty for landowners and project developers.

Urban forestry projects are exciting in many communities, partly because of the clear co-benefits to those urban areas. Identifying barriers to entry for urban forest projects and increasing the pace and scale of these projects could greatly benefit the people of Washington.

Blue and teal carbon protocols have gained significant attention for carbon offset projects due to their potential for mitigating climate change and conserving aquatic ecosystems. The VCS and ACR protocols are a platform for validating and verifying such projects. However, despite their potential, most of these protocols need to be region-specific due to data gaps and limitations hindering their wider adoption. One of the significant challenges in blue and teal carbon protocols is our limited understanding of the complex interactions and processes involved in carbon sequestration and storage within coastal and freshwater wetlands. The scientific knowledge regarding these ecosystems is still evolving, making it difficult to quantify and verify the carbon sequestration potential accurately. Another major challenge is the availability of quality data. Obtaining reliable data about aquatic ecosystems can be challenging due to remote and inaccessible locations and the high data collection costs.

Inconsistent data quality and variability across different regions also pose challenges in accurately estimating carbon stocks and emissions. Furthermore, establishing robust and consistent baselines for blue and teal carbon projects is challenging due to natural variability and changes in carbon stocks over time due to the dynamic nature of coastal and freshwater wetlands. Potential improvements in existing blue and teal carbon protocols are related to enhanced data collection and monitoring. Investing in advanced technologies, such as remote sensing, satellite imagery, and drones, can improve data collection efficiency and accuracy. Therefore, continued research and innovation are essential for addressing the data gaps and limitations in blue and teal carbon protocols, as studies on aquatic ecosystem dynamics, carbon fluxes, and long-term monitoring can improve the accuracy and reliability of carbon storage.

For all carbon offset projects, and for blue and teal projects, in particular, stakeholder engagement by involving local communities, indigenous peoples, and other stakeholders in the design, implementation, and monitoring of carbon projects is crucial for these projects' success and long-term sustainability. Furthermore, these protocols can be improved by incorporating co-benefits beyond carbon sequestration, such as habitat restoration, biodiversity conservation, and coastal protection, for a comprehensive assessment of wetland projects' overall value and impact.

Given the diversity of Washington's ecosystems which could support blue and teal projects, along with opportunities within its agricultural sector, we conclude that these carbon dioxide sinks have the suitability for adoption to Washington's Cap-and-Invest Program, should that be of interest. As data uncertainties and projects on 'untapped' sinks in Washington become established, the long-term robustness of blue, teal, agricultural, and grassland projects will become more apparent. Additionally, more protocols will need to be refined or adopted for use in Washington to increase readiness. For now, the following protocols achieve the highest score for suitability, readiness, and robustness for the relatively 'untapped' sinks: VM0007 for blue, VM0007 for teal, VM0042 version 2.0 for agriculture (with an honorable mention to the Soil Enrichment Protocol following its revision), and VM0026 for grasslands.

The following are broader comments about the suitability, readiness, and robustness of the sinks analyzed throughout Phases I-II of this Project concerning their associated carbon dioxide sinks:

Suitability

Suitability is defined as the appropriateness of a carbon offset project in the selected carbon dioxide sink. It can be defined through feasibility (financial and legal) and natural environmental conditions such as climate, soil type, land cover, and land use potential. For the latter group, data, as viewed in CarboSink, allows the user to better understand the suitability for a carbon offset project, often through the specific requirements of a protocol. The CarboSink interface was developed for a closer interaction with the data underlying our analyses, enabling us to conduct the sensitivity analysis (Task 7) and identify county-level patterns of carbon capacity for forest and agriculture carbon dioxide sinks.

In the State of Washington, broad geographic areas will high suitability for carbon offset projects were identified:

- Northwest Washington shows high forest carbon capacity, which generally extends above 'common practice' metrics developed by CARB.
- Forests in northwest Washington, owned by the National Park Service (NPS), Department of Natural Resources (DNR), and the US Forest Service, show the highest capacity for storing carbon after 100 years of uninterrupted growth.
- Private forests throughout the state still show high capacity beyond CARB's common practice statistics, especially in the westernmost counties bordering the Pacific Ocean.
- Southwest Washington shows areas with high cropland and pasture-land soil capacity, which would suit agricultural protocols. At a county level, higher clay content and increased precipitation drive the high soil capacity estimates. Note: given the uncertainty in the gridded soil clay and soil organic carbon content data, and our model application at the county level, we acknowledge that there may be pockets of relatively high soil carbon capacity in the southeast part of the state.
- Agricultural projects using VM0042 version 2.0 and SEP may need to gather common practice adoption rates in a localized area within the county of interest or conduct a 'stacking' approach when demonstrating the additionality of their project's combined practice changes, as some practice changes indicate a widespread of at least 20% adoption, which is the threshold for VM0042.
- At this point, it is not possible to include further information on blue, teal, and grassland carbon capacities beyond what was already reported in the Phase I report.

On a larger scale, jurisdictional-based approaches have been developed to go beyond the project scale and can be developed based on a watershed, region, or state. Jurisdiction approaches are becoming more common worldwide as governments are beginning to adopt carbon offset programs with a baseline suitable for jurisdiction. Carbon offset projects may be nested within this jurisdiction, offering greater feasibility, and addressing leakage.

One key takeaway from the jurisdictional approaches is that they rely on more localized data and models. Examples are projects using the more regionally specific Tier 2 and Tier 3 level emissions factors and other parameters required for carbon accounting. Australia's soil modeling platform underlies its agricultural carbon offset program.

Robustness

Verification frequency, adoption rates, and interpretability all factor into a protocol's robustness. The top-scoring protocols generally have a verification cycle of five years, which corresponds to the maximum allowable time that a project may go without measuring key variables, such as soil carbon or tree measurements required for biomass estimation. An exception is among protocols associated with blue and teal carbon dioxide sinks, where the cycle lasts a maximum of ten years. Project adoption for agricultural protocols will be essential to track among VM0042 version 2.0 and SEP, as both protocols appear close in their adoption rates in the United States. As protocols become older, adoption rates may shift downwards as some projects become inactive and have their registration status changed, potentially because of the loss of a large carbon stock from the project. Interpretability boosted some protocols that scored closely with another top-scoring protocol during Task 7. Through SCS's experience conducting protocol assessments, it has been observed that tracking publicly available stakeholder comments and reactions to protocol development is essential to understanding the carbon community's overall understanding and any challenges faced in implementing protocols.

Data availability is also critical for project developers during project planning, influencing robustness. Greater data availability and accessibility generally lead to higher confidence when project developers begin estimating how carbon stocks could increase over time and when they assess risks to future carbon stocks. SCS found that federal and state data collection and repository efforts, such as the Forest Inventory and Analysis program (FIA), Washington State's inventory data, the USDA's Soil Survey Geographic Database (SSURGO), the USGS's National Land Coverage Dataset (NLCD), and gridded climate data from the Parameter-elevation Relationships on Independent Slopes Model (PRISM), among others, informed our broad-scale assessments of carbon dioxide sink capacities across Washington. These data repositories afford a robust, consistent, and comprehensive data set that can be used for baseline and project analyses. This is critical for a practical feasibility and risk assessment before project development. Any additional data to help delineate eligible areas for blue and teal carbon projects or estimate sink capacity would aid project development within these sinks immensely.

Monitoring, reporting, and verification (MRV) are also essential to ensure robustness and long-term climate benefits, with environmental and social safeguards. Project monitoring, through protocol requirements and competent implementation, is required to ensure that valuable data are collected over the life of a project. Accurate reporting and verification by an IAF-accredited validation and verification body (VVB) (or a similar rigor accreditation by another entity such as the California Air Resources Board) at a sufficient frequency, without conflict of interest, is also paramount. A competent VVB, in concert with oversight by the protocol's registry, is needed to ensure integrity and long-term quality. Each protocol has a different process, so it is essential to understand where robustness may be compromised when MRV, in any one of the components of monitoring, reporting and verification, is less rigorous.

Readiness

Readiness can be related to suitability (discussed above), interpretability, and adoption rate. Some sinks and project types have had greater usage than others. Forestry projects, particularly those in the Improved Forest Management category, have many protocols and applications across the United States and the State of Washington. They are also commonly implemented throughout the United States. Thus, a greater capacity exists to develop, implement, and verify this project type. This capacity, while uneven, crosses the ownership groups of public, tribal, and private (spanning family to large industrial). Readiness through the capacity building has been galvanized practically through new technology (both remotely and in the field) and intellectually through sharing information through conferences, scientific papers, and working groups. The same methods could be applied to other project types and carbon dioxide sinks. The challenge is that being the pioneer in a new project type or protocol requires a great deal of quality control and testing to ensure long-term desired results and patience to test new protocols and work with verifiers and registries to assess the novel project accurately. As such, case studies and close coordination with the protocol developer and registry facilitate readiness and robustness when suitability exists.

Projects that can leverage available data also have the advantage of readiness. Though the scale or detail of the work may lead to further data collection efforts to develop a carbon offset project, these data may help assess financial and legal feasibility. Localized data about standard practice metrics and practice change adoption rates would be a helpful addition to project planning and feasibility, and these metrics are tied to a protocol's readiness. The super sections[3] and corresponding assessment area common practice metrics used in CARB forestry protocols correspond to large areas across Washington, which may be too course of a scale to assess common practice at a typical forestry project-level properly. For example, CarboSink utilizes publicly available data, yielding that one area may not be as "suitable" for a forest carbon project. However, a CARB IFM project has been successfully registered in that area

[3] https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/us-forest-projects/2015

because more site-specific information was gathered and verified. CarboSink could yield more accurate results should data, including more localized data, be added over time.

The Climate Action Reserve's compilation of county-level adoption rates of different agricultural practice changes relevant to SEP is a great help for assessing standard practices for SEP and VM0042 projects. Updating such common practice metrics over time for Washington would also provide a benefit for assessing project robustness as more projects are developed over time across the state.

The takeaway for the grassland initiatives is that they primarily focus on improving grassland management by introducing improved grazing practices and control of grazing intensity. The second element many standards have in common is the avoidance of conversion of grasslands to primarily other agricultural uses such as row crops. The protocols typically used quantitative models to estimate the soil carbon as the actual measurement is often too heterogenous to measure precisely with small sample sizes.

Washington is host to a diverse array of ecosystems and climates. To date, the opportunity for new carbon project development is high, given the relatively low number of existing projects for each sink and the opportunity for many carbon offset projects of the various project types across the state. Eligible protocols exist for each sink in Washington with varying degrees of suitability, readiness, and robustness. Understanding that these three factors are interrelated and may change as the carbon market grows is essential. With the increasing price of carbon, the economics of project development change and will likely allow projects to be smaller in land area and in areas of lower suitability.

Above all, stakeholder engagement is key to ensuring continued robustness and readiness as protocols are updated and developed. Furthermore, modifications to protocols through the registry specific review processes is important to promote improves as protocols continue to be road-tested, new data becomes available, technology advances, and lessons are learned.

Opportunities exist for Washington Ecology to develop state-specific common practice metrics and quantitative parameters protocols used for demonstrating additionality and quantifying carbon offsets to support the development of carbon projects. As Washington's Cap-and-Invest program advances and evolves, we see potential in including additional protocols in this compliance market. Similarly, mechanisms exist for the state to provide data and tools to promote existing, new, and future carbon offset protocols within the voluntary market. Carbon offsets provide a market-based mechanism for a climate change solution to Washington stakeholders and beyond. When considering technical, cultural, and administrative feasibility, the potential for carbon offset projects across many carbon dioxide sinks in the State of

Washington is vast. CarboSink can be used a tool to better understand feasibility for a carbon offset project where additional data, capacity, and management can lead to carbon offsets with long-term quality and integrity.

Appendix A: Task 5: Cataloging & Mapping Out-of-Jurisdiction Standards to Carbon Dioxide Sinks

Forestry

- VM0034 Canadian Forest Carbon Offset Methodology, version 2.0

Agriculture

- Federal Government of Canada - Enhanced Soil Organic Carbon protocol (still in development)
- Federal Government of Australia – Carbon Farming Initiative (Estimating Sequestration of Carbon in Soil Using Default Values)

Grasslands

- Canadian Grassland Offset Protocol version 1.0

Blue Carbon

- ACR - Restoration of California Deltaic and Coastal Wetlands version 1.1

Teal Carbon

- VM0004: Methodology for Avoided Planned Land Use Conversion in Peat Swamp Forests version 2.0
- ACR - Restoration of California Deltaic and Coastal Wetlands version 1.1
- VCS - VM0027: Methodology for Rewetting Drained Tropical Peatlands version 1.0
- ACR - Methodology for the Restoration of Pocosin Wetlands version 1.0

Appendix B: Task 6: Expand Standards to Include Developing Protocols

Forestry

- New: Climate Forward – Reforestation Forecast Methodology version 2.0
- New: Climate Forward - Reduced Emissions from Megafires Forecast Methodology version 1.0
- New: VM0045 – Improved Forest Management Methodology Using Dynamic Matched Baselines for National Forest Inventories version 1.0
- Developing: VCS - Methodology for Afforestation, Reforestation, and Revegetation Projects

Agriculture

- New: VCS – VM0042 version 2.0
- New: Nori - Pilot Croplands Methodology version 1.3
- New: Gold Standard – Soil Organic Carbon Framework Methodology version 1.0
- New: Food and Agriculture Organization - GSOC MRV Protocol, September 2020
- Developing: Baker Institute for Public Policy – Bcarbon

Blue Carbon

- New: VCS – VM0007 Reduced Emissions from Deforestation and Forest Degradation (REDD)+Methodology Framework (REDD+ MF) version 1.6
- New: ACR - Afforestation and Reforestation of Degraded Land version 1.2

Teal Carbon

- New: VCS – VM0007 Reduced Emissions from Deforestation and Forest Degradation (REDD)+Methodology Framework (REDD+ MF) version 1.6
- New: ACR - Afforestation and Reforestation of Degraded Land version 1.2

Appendix C: Task 7: Sensitivity analysis for existing protocols

We provide a summary of the sensitivity analysis for each sink. The figures and tables are pulled directly from the CarboSink interface.

C1 Forestry

The sections below are examples of sensitivity analyses for the three forestry project types considered: Improved Forest Management (IFM), Afforestation, Reforestation, Revegetation (ARR), and Urban Forestry.

C1.1. Improved Forest Management

The following summarizes the data for each aspect in the comparison of the IFM protocols CARB-IFM and ACR-IFM. By default, the scores are set to SCS's analysis for Phase II, and the weights favor baseline barrier analysis and verification cycle length.

Data Entry

	ARB-IFM	ACR-IFM	Weights
Baseline barrier analysis (1 = included)	0.75	0.25	0.3
Verification cycle length (max years)	5	5	0.3
Leakage (1 = included)	1	1	0.2
Interpretability (1 = easiest)	0	1	0.1
Project adoption (count)	161	73	0.1

Sum of Weights: 1

Scramble Weights | Reset

Figure C1.1.1: An example of input data in CarboSink when comparing CARB and ACR IFM protocols using CarboSink.

Sensitivity Results

Aspect	ARB-IFM Score	ACR-IFM Score
Barrier Analysis	1	0
Verification Cycle	1	1
Leakage	0	1
Interpretability	0	1
Project Adoption	1	0
Total	0.63	0.57

Finalize

Winner: ARB-IFM

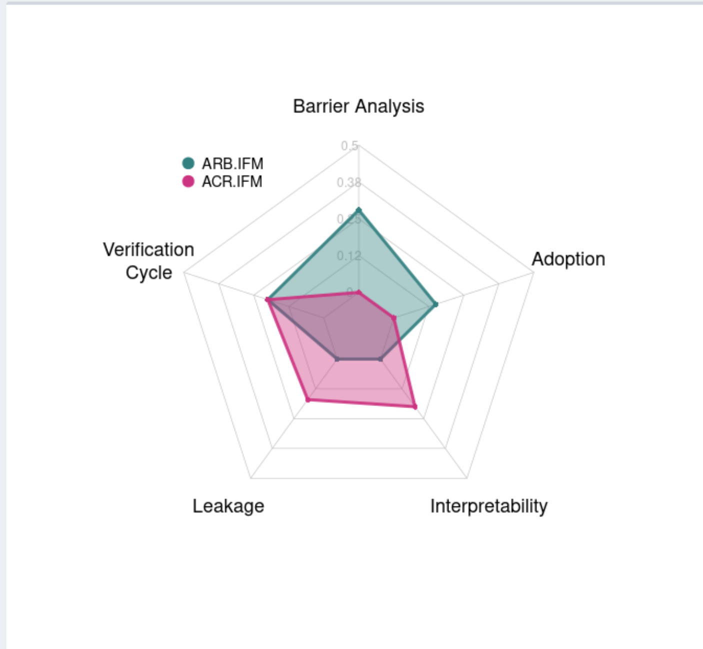


Figure C1.1.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C1.1.1) and a spider plot related to each protocol's scores across Aspects.

C1.2. Afforestation, Reforestation, Revegetation

Below is the summary of the CarboSink sensitivity analysis for the two selected ARR protocols.

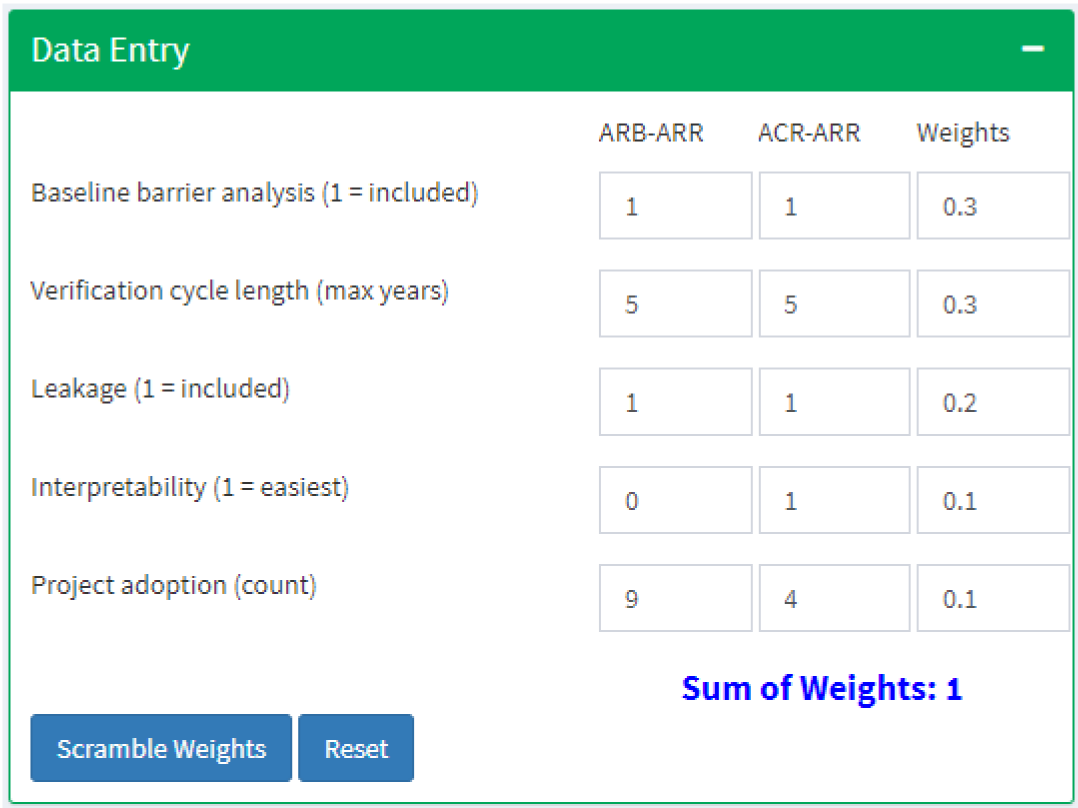


Figure C1.2.1: Example input data for the ARR protocol sensitivity analysis.

Sensitivity Results

Aspect	ARB-ARR Score	ACR-ARR Score
Barrier Analysis	1	0
Verification Cycle	1	1
Leakage	1	1
Interpretability	0	1
Project Adoption	1	0
Total	0.9	0.6

Finalize

Winner: ARB-ARR

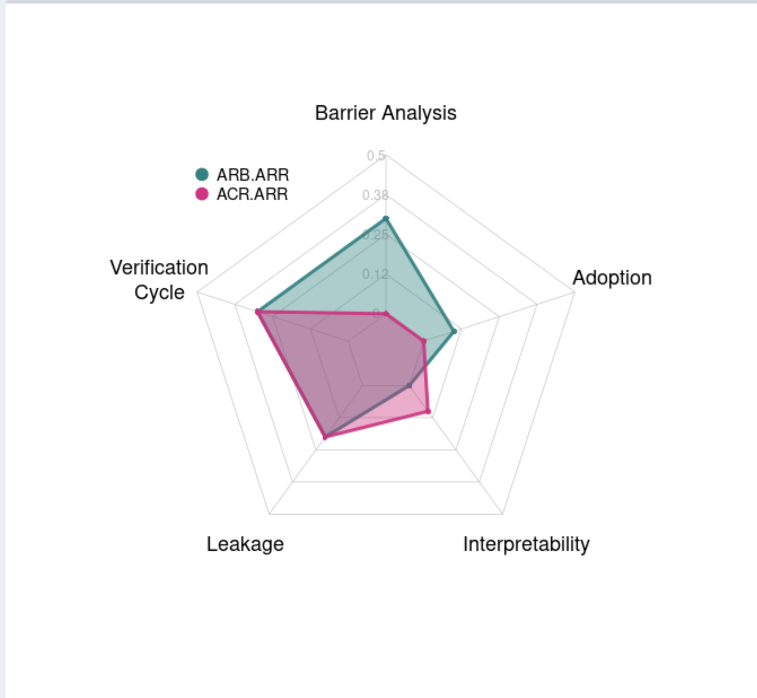


Figure D1.2.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C1.2.1) and a spider plot related to each protocol's scores across Aspects.

C1.3. Urban Forestry

Sensitivity analysis for Urban Forestry protocols are summarized below.

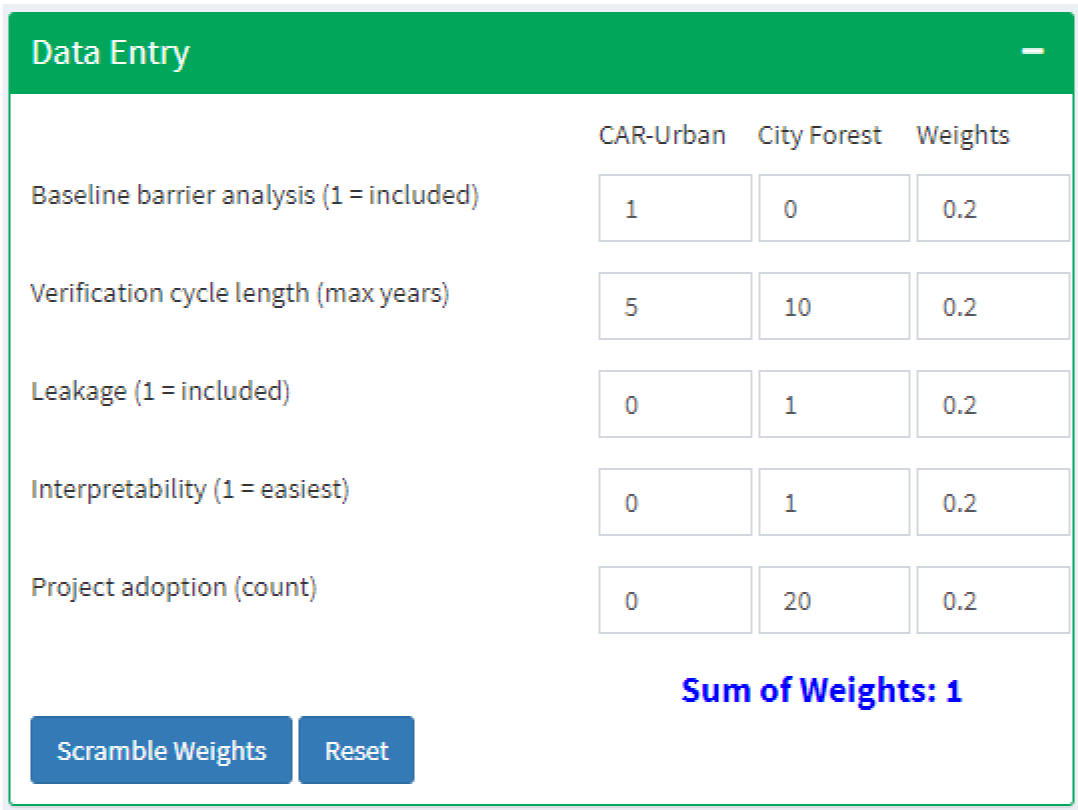


Figure C1.3.1: Input data for an Urban Forestry protocol sensitivity analysis.

Sensitivity Results

Aspect	CAR-Urban Score	City Forest Score
Barrier Analysis	1	0
Verification Cycle	1	0
Leakage	0	1
Interpretability	0	1
Project Adoption	0	1
Total	0.4	0.6

Finalize

Winner: City Forest

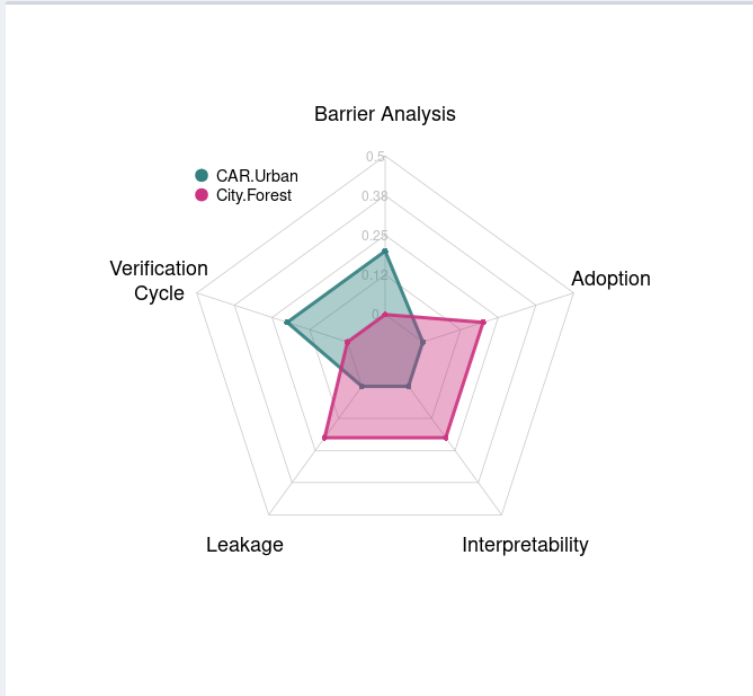


Figure C1.3.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C1.3.1) and a spider plot related to each protocol's scores across Aspects.

C2 Agriculture

The following summarizes the data for each aspect in the comparison of VM0042 and SEP. By default, the scores are set to SCS's analysis for Phase II, and the weights are all equal to 0.2.

Data Entry

	VM0042	SEP	Weights
Baseline barrier analysis (1 = included)	1	0	0.2
Verification cycle length (max years)	5	5	0.2
Leakage (1 = included)	1	1	0.2
Interpretability (1 = easiest)	1	0	0.2
Project adoption (count)	2	3	0.2

Sum of Weights: 1

Scramble Weights | Reset

Figure C2.1: Table from CarboSink summarizing data inputs for each aspect and importance weights for each. This is based upon SCS's analysis of agricultural protocols for Phase II.

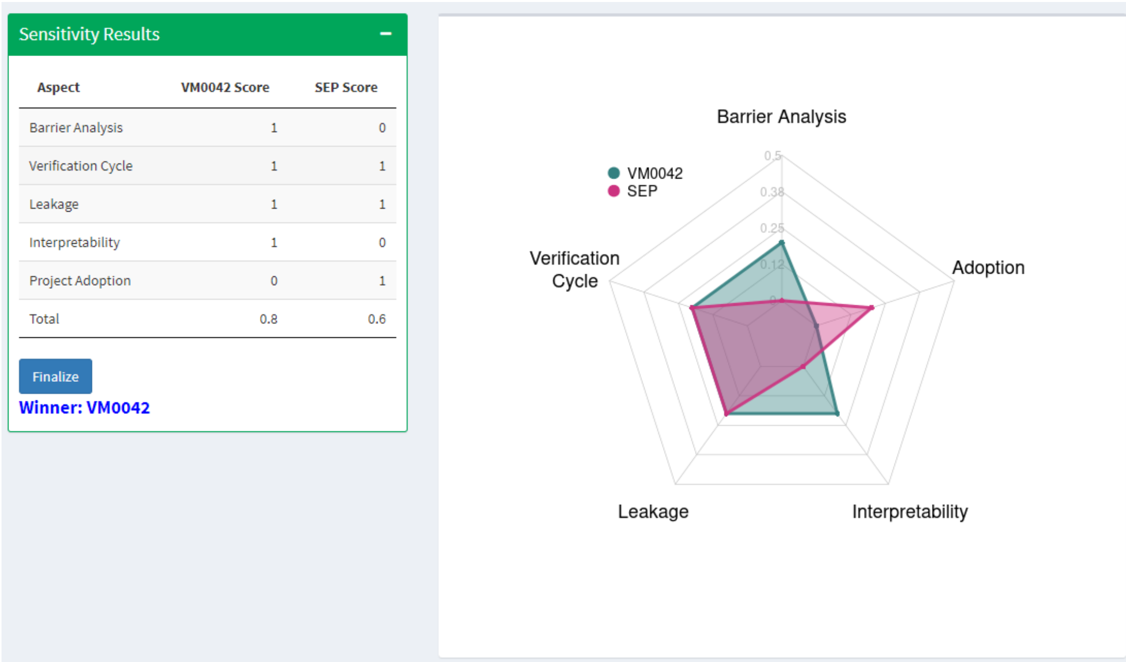


Figure C2.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C2.1) and a spider plot related to each protocol's scores across Aspects.

By randomly adjusting weights with the ‘Scramble Weights’ button and setting the Interpretability to be 1 for both, which assumes they are equally as interpretable, then either protocol wins or they show a tie.

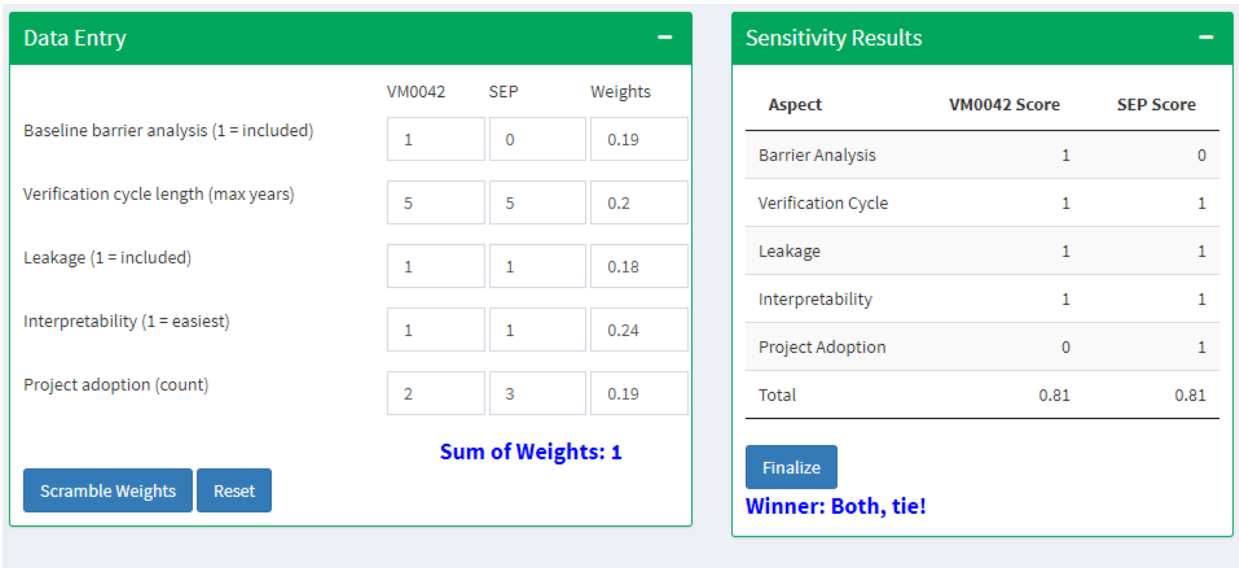


Figure C2.3: Results from CarboSink when setting both protocols’ Interpretability Aspect to 1 and randomly adjusting importance weights for each Aspect. The table to the left shows the input data and weights, while the table to the right shows the weighted score result.

C3. Grasslands

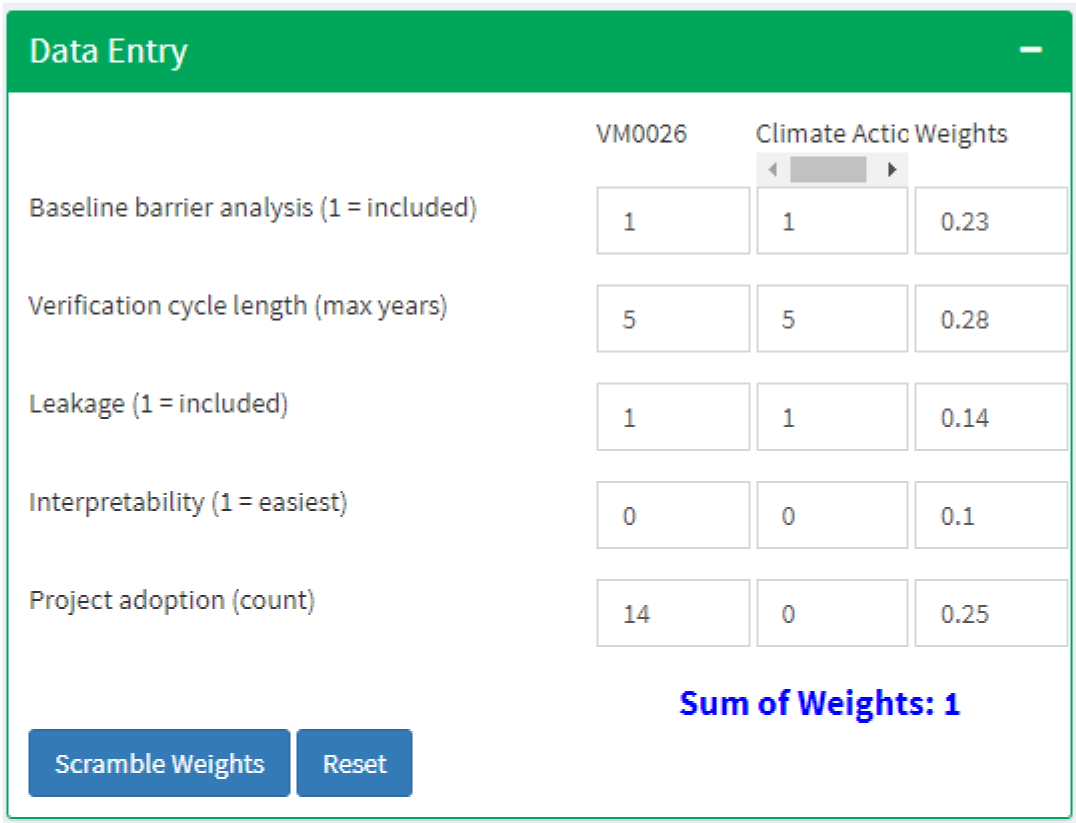


Figure C3.1: Default input data to CarboSink for Grasslands protocols Vm0026 and CAR- U.S. Grassland.

Sensitivity Results

Aspect	VM0026 Score	Climate Action Score
Barrier Analysis	1	1
Verification Cycle	1	1
Leakage	1	1
Interpretability	1	1
Project Adoption	1	0
Total	1	0.75

Finalize

Winner: VM0026

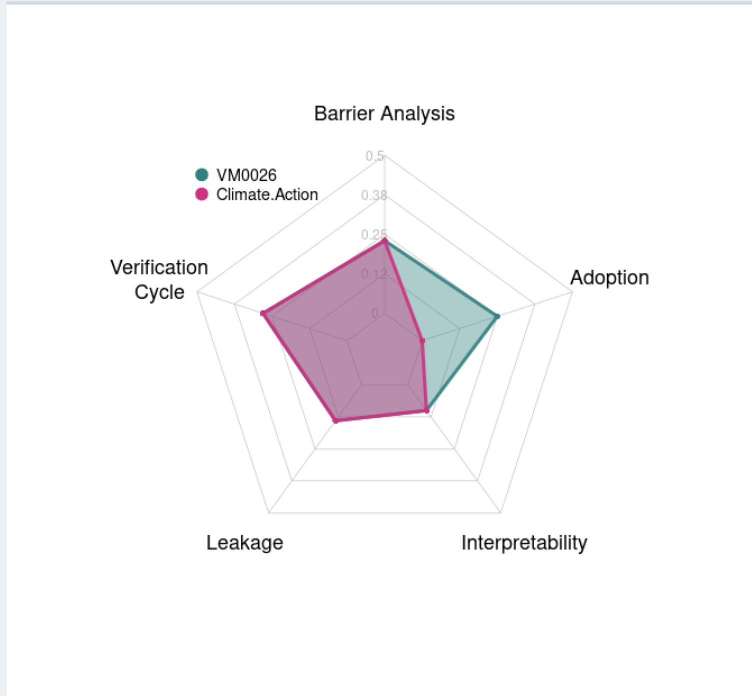


Figure C3.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C3.1) and a spider plot related to each protocol's scores across Aspects.

C4. Blue Carbon

Data Entry

	VM0007	VM0033	Weights
Baseline barrier analysis (1 = included)	1	1	0.23
Verification cycle length (max years)	10	10	0.28
Leakage (1 = included)	1	0	0.21
Interpretability (1 = easiest)	0	1	0.1
Project adoption (count)	13	9	0.18

Sum of Weights: 1

Scramble Weights | Reset

Figure C4.1: Table from CarboSink summarizing data inputs for each aspect and weights for VM0007 and VM0033 protocols for Blue carbon dioxide sinks. This is based upon SCS's analysis of Blue Carbon protocols for Phase II.

Sensitivity Results

Aspect	VM0007	VM0033
Barrier Analysis	1	1
Verification Cycle	1	1
Leakage	1	0
Interpretability	0	1
Project Adoption	1	0
Total	0.9	0.61

Finalize

Winner: VM0007

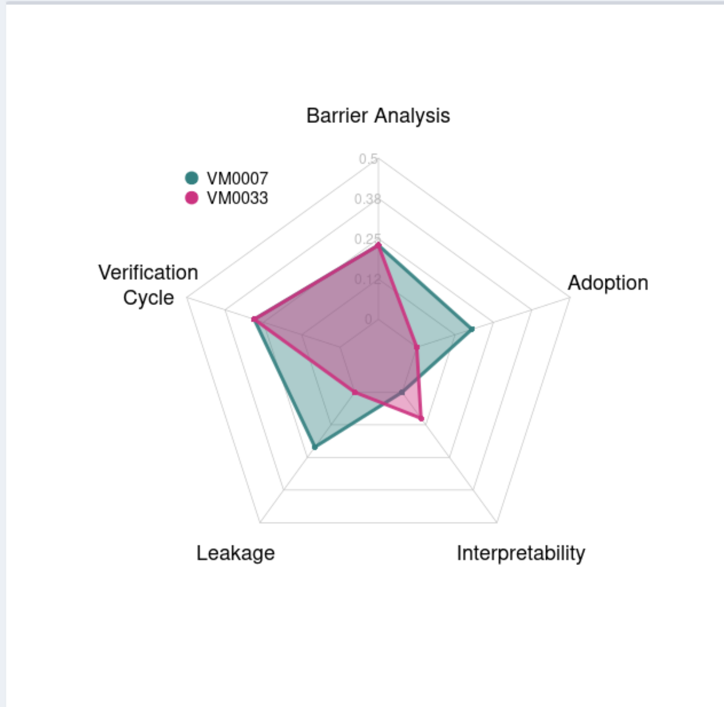


Figure C4.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C4.1) and a spider plot related to each protocol's scores across Aspects.

C5. Teal Carbon

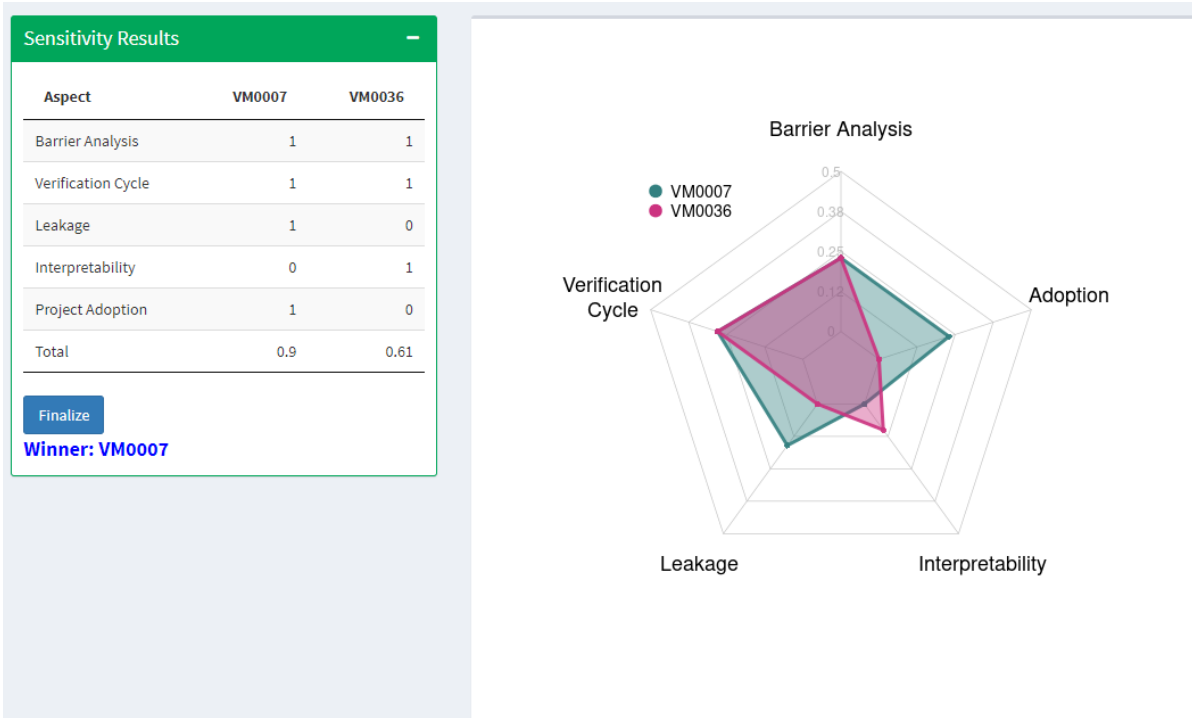
Data Entry

	VM0007	VM0036	Weights
Baseline barrier analysis (1 = included)	1	1	0.23
Verification cycle length (max years)	10	10	0.28
Leakage (1 = included)	1	0	0.16
Interpretability (1 = easiest)	0	1	0.1
Project adoption (count)	9	1	0.23

Sum of Weights: 1

Scramble Weights Reset

Figure C5: Table from CarboSink summarizing data inputs for each aspect and weights for VM0007 and VM0036 protocols for Teal Carbon dioxide sinks. This is based upon SCS's analysis of Teal carbon protocols for Phase II.



Sensitivity Results

Aspect	VM0007	VM0036
Barrier Analysis	1	1
Verification Cycle	1	1
Leakage	1	0
Interpretability	0	1
Project Adoption	1	0
Total	0.9	0.61

Figure C5.2: CarboSink output showing a table with the final weighted score (weights shown in Figure C5.1) and a spider plot related to each protocol's scores across Aspects.

Appendix D: Task 8: Re-assess Task 3 for final report

Table D1: Estimated difference between soil organic carbon (SOC) stocks in project versus baseline scenario across a 30 year period for each county and selected land use (cropland and pasture). Average percent clay content is also provided.

County	Cropland SOC Capacity [tC ha^{-1}]	Pasture SOC Capacity [tC ha^{-1}]	Cropland Clay Percentage [%]	Pasture Clay Percentage [%]
Stevens	0.43	0.43	15.5	15.5
Benton	0.29	0.29	8.1	8.8
Chelan	0.33	0.22	11.8	10.6
Clallam	0.82	0.89	14.1	13.5
Cowlitz	1.34	1.25	21.0	18.7
Grant	0.20	0.20	7.6	8.2
Jefferson	0.60	0.76	11.5	12.2
Kittitas	0.42	0.52	15.7	15.9
Lincoln	0.44	0.33	12.1	10.9
Okanogan	0.46	0.47	10.8	12.3
Pacific	3.25	2.41	14.3	27.5
Pierce	1.67	1.42	15.0	8.8
Snohomish	1.54	1.53	19.8	11.4
Walla Walla	0.46	0.56	12.3	16.5
Whatcom	1.42	1.34	9.9	10.2
Yakima	0.31	0.32	10.2	11.9
Clark	1.11	1.10	24.3	21.2
Mason	1.61	1.34	9.8	16.3
Grays Harbor	2.22	2.09	22.4	23.2
King	1.51	1.59	11.2	12.3
Skagit	1.18	1.20	20.4	12.3
Ferry	0.34	0.35	13.2	14.7
Whitman	0.71	0.70	17.2	13.5
Thurston	1.71	1.47	10.5	16.7
Franklin	0.28	0.19	7.3	8.2
San Juan	1.34	1.46	18.5	13.6
Pend Oreille	0.39	0.31	12.2	26.9
Skamania	0.52	0.81	16.4	22.1
Columbia	0.65	0.66	15.4	18.1
Island	1.70	1.72	16.7	11.3
Kitsap	1.35	1.21	8.5	8.1

County	Cropland SOC Capacity [tC ha^{-1}]	Pasture SOC Capacity [tC ha^{-1}]	Cropland Clay Percentage [%]	Pasture Clay Percentage [%]
Lewis	1.20	1.22	20.4	23.8
Klickitat	0.41	0.61	12.1	14.3
Adams	0.30	0.30	7.8	7.5
Spokane	0.65	0.64	17.8	17.1
Garfield	0.60	0.60	17.9	17.6
Asotin	0.51	0.62	18.6	19.9
Wahkiakum	2.08	2.30	22.8	24.0
Douglas	0.33	0.22	9.9	11.8

Appendix E: Demonstration of CarboSink for Forest Carbon Capacity

The forest carbon capacity modeled during Phase I has been uploaded to the CarboSink interface. We define forest carbon capacity as the maximum modeled growth for a stand 100 years into the future. Growth for the US Forest Service's Forest Inventory and Analysis plots is modeled 100 years into the future with the US Forest Service's Forest Vegetation Simulator, taking into account site index data and assuming no harvest. The FVS stand volume is converted to biomass using Air Resources Board required biomass equations. Biomass is then converted to tons of carbon dioxide equivalents (t CO_2e) per hectare. Results from all FIA plots are averaged to the county level for each ownership type: private, municipal, DNR, forest service, national park service, and tribal.

One may use CarboSink to view forest carbon capacity for each ownership class across all counties. Figure D1 shows forest carbon capacity for Washington Department of Natural Resources lands.

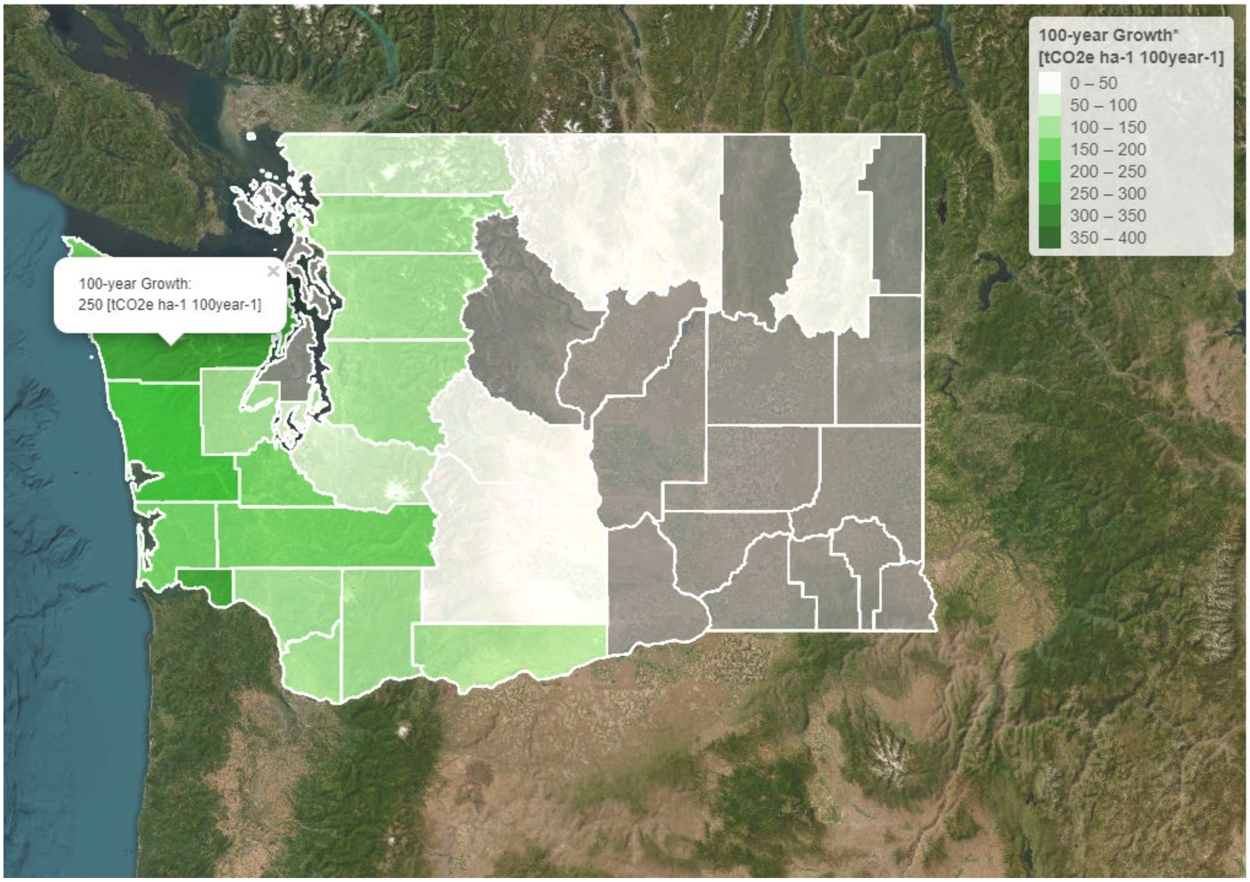


Figure E1: Forest carbon capacity for Department of Natural Resources lands, which is estimated based on 100-year stand growth at plots within each county and ownership type. The above was taken from the CarboSink interface. Counties without data are colored grey.

Figure E2 shows forest carbon capacity for Department United States Forest Service lands (USFS). The coloration (grey = no data; light green = low capacity; dark green = high capacity) is the same across all ownership types. From Figure D2, patterns of forest capacity are similar between the DNR and USFS lands.

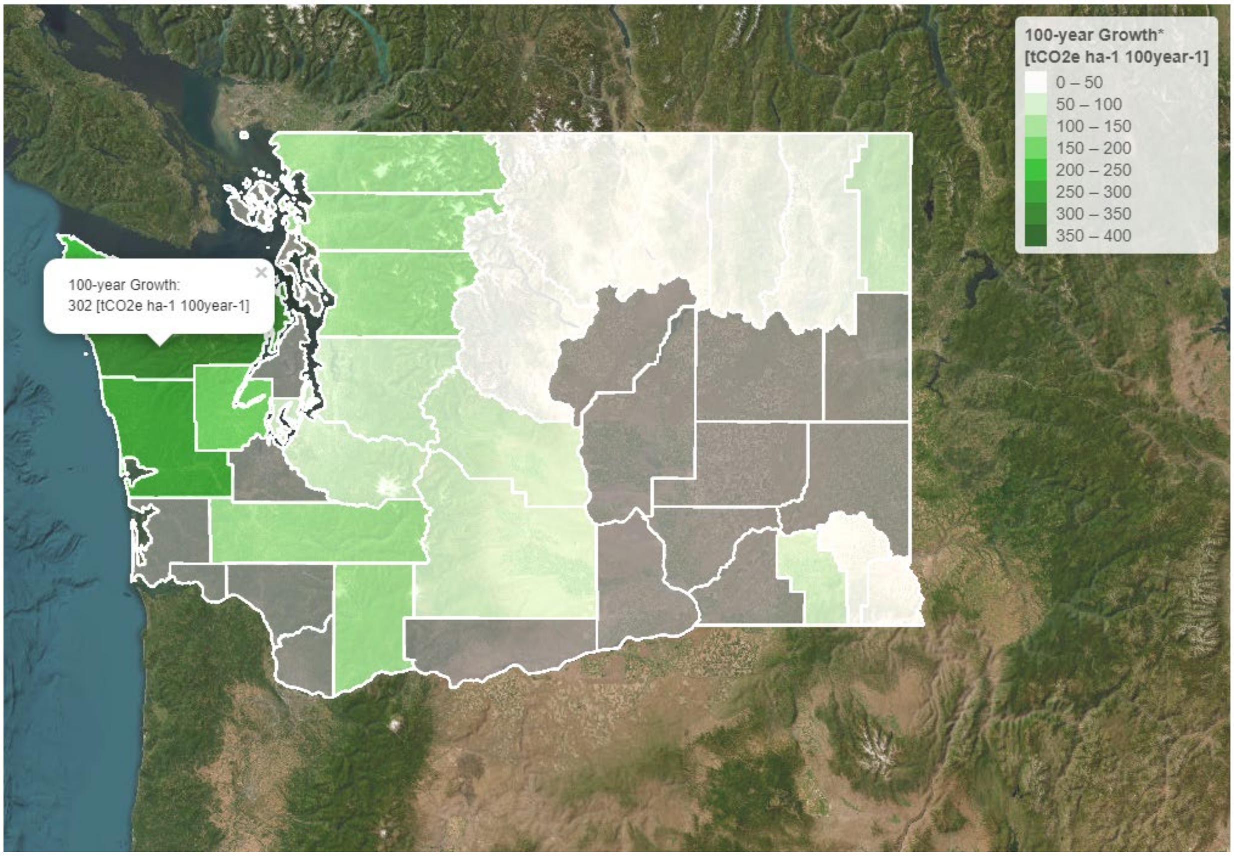


Figure E2: Forest carbon capacity for United States Forest Service lands, which is estimated based on 100-year stand growth at plots within each county and ownership type. The above was taken from the CarboSink interface. Counties without data are colored grey.

A user may also view the spatial spread of forest inventory plots that were involved in the FVS modeling this analysis for each ownership type. By clicking on a point in CarboSink, one can see the 100-year growth curve attributed to that plot.

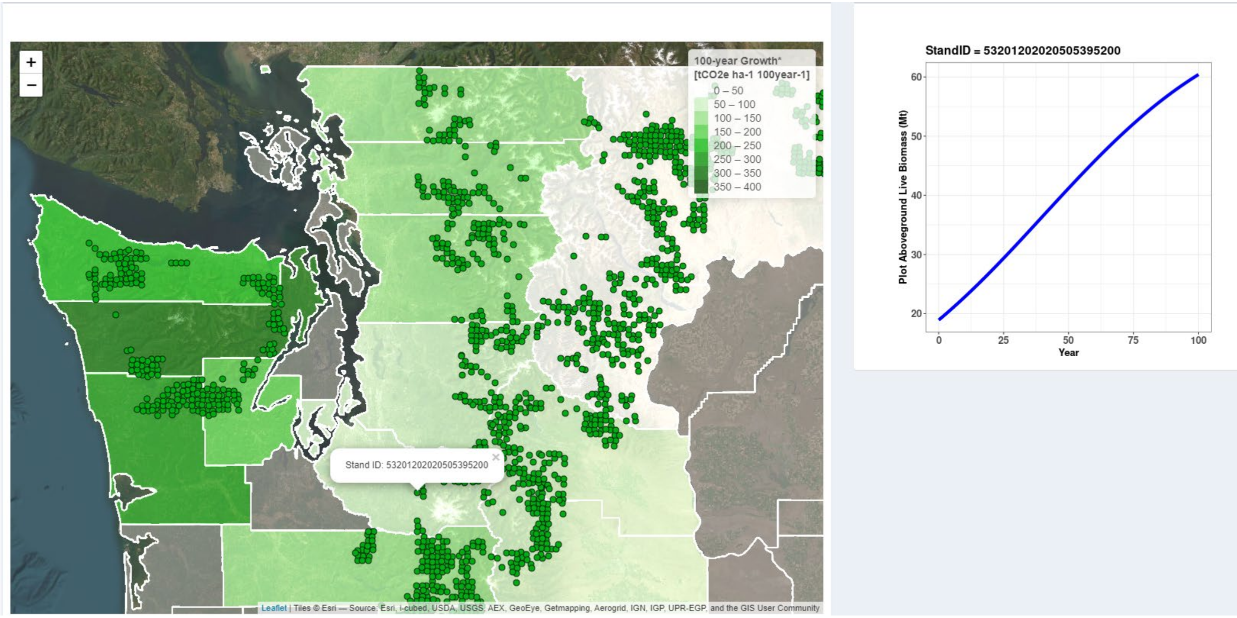


Figure E3: Zoomed in forest carbon capacity map for USFS lands. Points indicate inventory plots that were used in FVS modeling that are located in USFS lands. A 100-year growth graph indicating Aboveground Live Biomass (Mt) is shown on the right, which was the result of FVS modeling at a selected point.

Overall, we now show the maximum modeled t CO_2e 100 years into the future (e.g. 'forest carbon capacity') in CarboSink. Forest capacity was averaged across all inventory plots for each county and ownership type, since this gives a depiction of how much forest carbon will be stored across the state based on current species composition, FVS model growth mechanics, and site index. Harvesting and associated improved forestry management will occur throughout the state and this analysis is not meant to precisely represent the difference between baseline and project scenarios for IFM projects but rather the maximum estimated carbon forest sink capacity.

Appendix F: Protocols Reviewed During Phase I

Forestry

- CARB – ARR - US Forest Projects, June 25 2015
- CARB – IFM - US Forest Projects, June 25 2015
- CARB - Urban Forest Projects, October 20 2011
- CAR – US Forest Protocol version 5.1
- CAR - Urban Forest Management Protocol version 1.1
- CAR - Urban Tree Planting Protocol version 2.0
- CAR - Climate Forward, Reforestation Forecast Methodology version 1.1
- ACR - Methodology for Afforestation and Reforestation of Degraded Lands version 1.2
- ACR - Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands version 2.0
- VCS - VM0003 Methodology for Improved Forest Management through Extension of Rotation Age version 1.2
- VCS – VM0004 Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests version 1.0
- VCS – VM0005 Methodology for Conversion of Low-productive Forest to High-productive Forest version 1.2
- VCS – VM0009 Methodology for Avoided Ecosystem Conversion version 3.0
- VCS – VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest version 1.3
- VCS – VM0011 Methodology for Calculating GHG Benefits from Preventing Planned Degradation version 1.0
- VCS - VM0012 Improved Forest Management in Temperate and Boreal Forests version 1.2
- VCS – VM0015 Methodology for Avoided Unplanned Deforestation version 1.1
- VCS – VM0029 Methodology for Avoided Forest Degradation through Fire Management version 1.0
- VCS - VM0035 Methodology for Improved Forest Management through Reduced Impact Logging version 1.0
- City Forest Credits – Tree Preservation Protocol – 40 years version 12.4
- City Forest Credits – Tree Preservation Protocol – 100 years version 12.1
- City Forest Credits - City Forest Credits Afforestation Protocol – 26 years version 11.0

Agriculture

- CAR - Soil Enrichment Protocol version 2.1
- VCS - VM0017 Adoption of Sustainable Agricultural Land Management version 1.0
- VCS - VM0021 Soil Carbon Quantification Methodology version 1.0
- VCS - VM0042 Methodology for Improved Agricultural Land Management version 1.0

Grasslands

- CAR - Grassland Protocol version 2.1
- ACR - Avoided Conversion of Grasslands and Shrublands to Crop Production version 1.0
- ACR - Compost Additions to Grazed Grasslands version 1.0
- VCS - VM0026 Methodology for Sustainable Grassland Management version 1.1
- VCS - VM0032 Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing version 1.0

Blue Carbon

- VCS - VM0024 Methodology for Coastal Wetland Creation version 1.0
- VCS - VM0033 Methodology for Tidal Wetland and Seagrass Restoration version 2.0

Teal Carbon

- VCS - VM0036 Methodology for Rewetting Drained Temperate Peatlands version 1.0

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Phase I Report for RFQQ 2217 AQP

Prepared for
State of Washington Department of Ecology

Report Title
CO_2 Removal Project Standards Analysis

Date
30 June 2022

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Executive Summary

In accordance with Washington State Department of Ecology's mission to protect, preserve, and enhance the environment for current and future generations, SCS was tasked by the Department with developing and applying standards to map, categorize, and catalog the appropriateness, readiness, and robustness of terrestrial and aquatic carbon dioxide sinks in Washington for potential use as carbon offset projects in regulatory and voluntary markets.

During Phase I, SCS created CarboSink, an interactive data repository of spatial information to analyze and better understand the five carbon dioxide sinks in the State of Washington: forest, teal (freshwater ecosystems), blue (marine and coastal), rangeland (shrubland and grassland), and agriculture (pastures and cropland). A multitude of spatial data is available and numerous maps have been created. It was preliminarily determined that forest carbon contains the highest capacity on the basis of removal potential and scalability, especially in the northwest areas of the state. Soil carbon was not identified as a standalone carbon dioxide sink but is a carbon pool that can be included in all of the terrestrial and aquatic carbon dioxide sinks in the state. Additional data analysis can and will be completed in Phase 2 of this project.

SCS also undertook a review and analysis of the existing carbon offset standards in the voluntary and compliance carbon markets which would be applicable to the carbon dioxide sinks within the State of Washington. An analysis of existing protocols was also undertaken to assess feasibility (technical, cultural, and administrative). At this time, the majority of the adoption of these standards is in the forest carbon dioxide sink yet standards exist for the other carbon dioxide sinks. During Phase 2, SCS will explore the additional efforts which may lead to greater adoption of the standards in agriculture, urban forests, grasslands, and the blue carbon and teal carbon dioxide sinks. CarboSink will be further developed into an interactive electronic dashboard. Above all, both phases will contribute to the facilitation of carbon dioxide removal projects in the State of Washington while adopting, modifying, and revising protocols to ensure conformance with the state's climate laws, rules, markets, and goals.

Table of Contents

1 Introduction

1.1 About SCS Global Services

SCS Global Services (SCS) is a global leader in third-party certification, auditing, testing services, and standards. Established as an independent third-party certification firm in 1984, our goal is to recognize the highest levels of performance in environmental protection and social responsibility in the private and public sectors, and to stimulate continuous improvement in sustainable development. In 2012, Scientific Certification Systems, Inc. began doing business as SCS Global Services, communicating its global position with offices and representatives in over 20 countries.

SCS' Greenhouse Gas (GHG) Verification Program has been verifying carbon offsets since 2008 and to date has verified over 296 million tonnes of CO2e, providing GHG verification services to a wide array of industries including manufacturing, transportation, municipalities, and non-profit organizations. The GHG Verification Program draws upon SCS's established expertise to serve the global carbon market.

1.2 Objectives

The main objective of this effort includes the following: to develop and apply appropriate carbon protocols to map, categorize, and catalog the suitability, readiness, and robustness of terrestrial and aquatic carbon dioxide sinks in Washington for potential use as carbon offset projects in regulatory and voluntary carbon markets. This report may be used to assess conformity of existing, new, and modified carbon offset protocols or methodologies with Washington's climate laws, rules, markets, and goals for carbon dioxide removal projects. Although carbon dioxide sinks were the primary focus of this investigation, nitrogen and methane sinks were also considered and therefore, sinks will be referred to more broadly as carbon dioxide sinks throughout this report.

Phase 1 of the project includes four tasks. Three broad tasks drove the project's investigation and informed Task 4, this report:

- Task 1: Identify the location of various carbon dioxide sinks across Washington and estimate capacity of each
- Task 2: Develop categorization standards that represent the suitability of the available data for use with existing and developing carbon offset protocols to facilitate the development of carbon removal projects
- Task 3: Apply a cross-walk between the categorization standards developed in Task 2 with the database developed in Task 1 to summarize the how existing carbon dioxide sinks in Washington could serve (in whole or in part) within the framework of a carbon removal project under the protocol regime identified by the standards developed in Task 2.

The refinement of the analytical system in Phase 2 will include: consideration of out-of-jurisdiction protocols (Task 5) and developing protocols (Task 6), implementation of a sensitivity analysis of existing protocols (Task 7), a reassessment of Task 3 (Task 8), mapping new standards to carbon dioxide sinks (Task 9), and a final report (Task 10). Protocol and methodology will be used interchangeably for the purposes of this report.

2 Task 1 Assessment Process

SCS developed the CarboSink data repository for location identification and capacity estimation for various carbon dioxide sinks across Washington. The first stage of this project required the organization of a data repository, or centralized storage location, of spatial datasets relevant to identifying and quantifying carbon dioxide sink locations and capacities, respectively. Spatial datasets must be processed so that a collection of disparate data share the same projection system, spatial extent, and are otherwise formatted and ready for calculations and other analytical operations. Following the repository creation, SCS defined carbon dioxide sinks according to information from carbon dioxide protocols and mapped these out with available data. A data-driven approach that featured a mix of process modeling (e.g., in the case of forest growth), simple statistics, and 'mapping numbers' according to spatial datasets enabled estimations of carbon dioxide sinks at the county and ownership levels. As with any data-driven approach, the main constraint is the availability of accessible on-the-ground measurements to serve the basis for any 'number mapping'.

2.1 Carbosink Data Repository Development

The following flowchart summarizes the general approach taken to establish a robust data repository that serves the basis for Task 1 and downstream tasks:

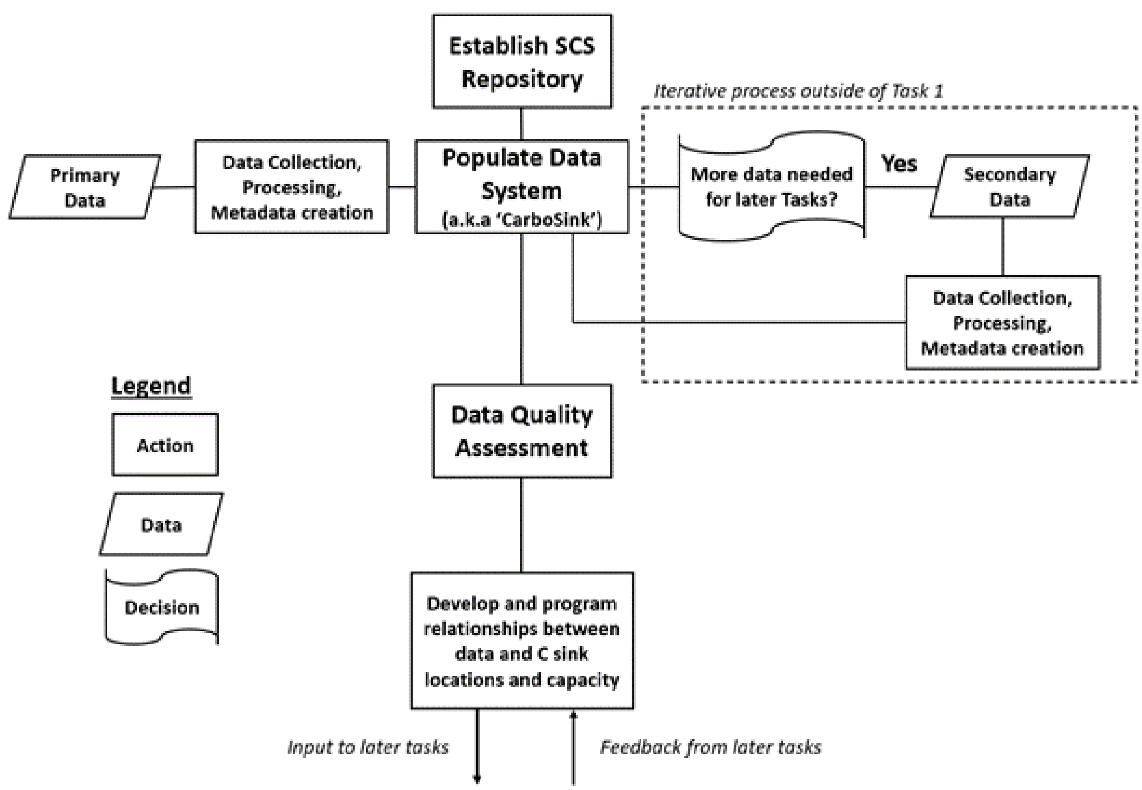

Figure 1: Flowchart representing the CarboSink data repository development process

Data gathering, processing, and integration is an iterative process. Some sinks have substantially more data available for quantifying sink capacity and location, such as forests.

SCS pulled data from the following sources (These particular sources informed the overall analysis, but this is a non-exhaustive list.):

- Smithsonian Environmental Research Center's (SERC) Coastal Carbon Atlas (includes data from Blue Carbon working group)[1]: datasets for identifying aquatic carbon sinks.
- Washington forest carbon inventory via the Forest Inventory and Analysis program[2]: datasets for identifying terrestrial carbon sinks.
- United States Dept. Agriculture (USDA) Soil Survey Geographic database (SSURGO)[3]: soil variables that can identify wetlands and potential carbon storage capacity of soils in general[4].
- United States Geological Survey (USGS) National Land Coverage Datasets (NLCD) 2001-2019[5]: latest in a series of 30 m resolution land coverage datasets that can be used to delineate land use classes, including wetlands and cropland. The NLCD dataset stretches over 2001 to 2019 at 5-year intervals, which enables analyses surrounding the relationship of carbon storage and fluxes with land use change across the state of Washington.
- National Wetland Inventory[6]: spatial dataset delineating different wetland types across the entire state of Washington developed by the U.S. Fish and Wildlife Service. This inventory is accepted as a reliable data source for identifying the spatial extent and types of wetlands for blue and teal carbon protocols.
- Washington State Department of Natural Resources (DNR) Kelp forest inventory[7]: kelp forests are an important carbon sink to consider within the domain of blue carbon. Identifying the location of these sinks is possible with this DNR dataset.
- U.S. Forest Service ownership[8]: delineates ownership of forested areas according to various government entities across the state.
- Tribal lands ownership[9]: delineates areas owned by tribal entities across the state.
- Geospatial Multi-Agency Coordination Group Wildfire extent from 2001-2019[10]: delineates areas impacted by wildfires from 2001-2019.
- Wildland Fire Perimeters to Date Wildfire extent from 2020-2021[11]: delineates areas impacted by wildfires from 2001-2019.
- Department of Ecology salmon migration potential[12]: delineates stream channels with attributes associated with erosion and water quality parameters.
- Washington Department of Natural Resources forestry data request[13]: RS-FRIS plot data, planned and completed and the silviculture and harvest, including tree measurements, plot locations, associated metadata, and forest management activity GIS layer.

[1] https://www.pnwbluecarbon.org/clients
[2] https://www.fs.usda.gov/pnw/page/pnw-fia-inventory-data
[3] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627
[4] https://scholarsphere.psu.edu/resources/ea4b6c45-9eba-4b89-aba6-ff7246880fb1
[5] https://www.mrlc.gov/data/nlcd-2019-land-cover-conus
[6] https://www.fws.gov/wetlands/data/state-downloads.html
[7] https://wadnr.maps.arcgis.com/apps/MapSeries/index.html?appid=6b32b37740a443cb8e8848a8614879a2
[8] https://data.fs.usda.gov/geodata/edw/datasets.php
[9] https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/Data
[10] https://data-nifc.opendata.arcgis.com/datasets/nifc::historic-perimeters-2019/about

[11] https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-2022-wildland-fire-perimeters-to-date/about
[12] https://ecology.wa.gov/Research-Data/Data-resources/Geographic-Information-Systems-GIS/Data#c
[13] Request delivered over email to Doug Baldwin (Request ID 6324; delivered 6/14/2022

SCS processed and integrated the above sources into the data repository 'CarboSink', which currently exists on SCS' servers. This data enables the identification of carbon dioxide sink locations and initial quantification of carbon dioxide sink capacity and forest sink sequestration rates across the state.

2.2 Identification of Sink Locations

Two variables represent the broadest spatial scale of carbon dioxide sink attribution across Washington state that is relevant for analyzing suitability of carbon projects: county boundaries and ownership class. This is appropriate given the spatial distribution of forest inventory plots across the state and the need to efficiently summarize carbon dioxide sink characteristics state-wide.

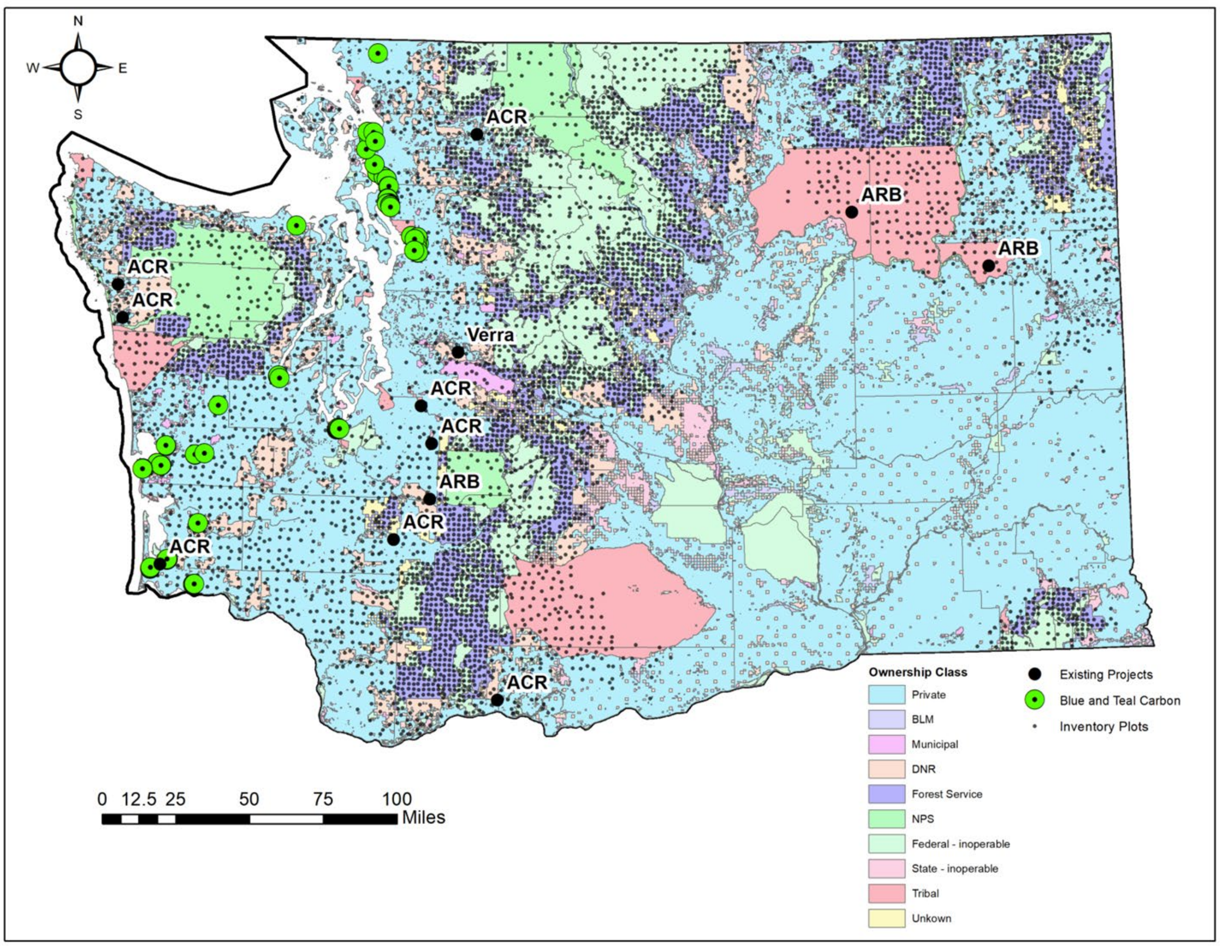

Figure 2: Union of ownership layers and counties with existing carbon projects overlaid (indicated as black points, labeled according to associated registry). Some projects occur at multiple locations, so the points indicate an instance of a project, rather than unique, individual projects (there are 12 points

belonging to 9 unique projects). Small grey points indicate forest inventory plots used for growth modeling, and green points indicate locations where sediment carbon was sampled to quantify blue and teal carbon stocks.

2.3 Forest Growth Modeling and Quantifying Sequestration Characteristics

SCS conducted an extensive modeling effort of 6,032 inventory plots across Washington. An automated approach at running the Forest Vegetation Simulator (FVS: https://www.fs.fed.us/fvs/) forest growth and yield model enabled SCS to project physical tree characteristics (e.g., diameter at breast height, tree height) 100 years into the future using forest measurements collected at each plot as the initial conditions. The plots cover a wide range of counties and ownership classes across the state (Figure 2), however some county-ownership polygons contained only 'null' plots (plots on a regular grid that were not measured) or had too few points to get a reliable mean estimate of forest growth parameters (nominal cut-off is < 5 viable plots). County-ownership polygons with <5 non-null points were dropped from the analysis altogether. Site index, where available, was used to limit growth, and the keyword 'no triple' was used for all modeling.

The California Air Resources Board (ARB; https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols/us-forest-projects/2015) aboveground tree volume and biomass approach produced biomass estimates for each modeled tree at each time-step. The ARB approach is specifically designed for species and areas across Washington for carbon projects (see link above), making this an ideal method for estimating biomass. These tree estimates were then aggregated to the plot level, yielding biomass projections (metric ton per acre) for 6,032 locations across the state 100 years into the future.

We fit a Boltzmann-style sigmoidal curve to projections at all available plots as a means to consistently quantify growth rates and maximum capacity (e.g., where the s-curve 'levels' off) uniformly. SCS conservatively assigned maximum capacity as the highest projection if the s-curve's 'leveling off point' (upper functional limit) is higher than the highest FVS projection. The sigmoid is formalized by the following:

$$\text{AGB} = \frac{A1 - A2}{\left(1 + \exp\left(\frac{Year - x0}{dx}\right)\right)} + A2, \qquad (1)$$

where A1 is the minimum biomass on the curve, A2 is 'maximum capacity', 'Year' is model year (ranges from 0 or 'present' to 100), x0 is the model year where the inflection of the curve occurs, dx is related to the steepness of the s-curve at its inflection, and AGB is aboveground tree biomass (Mt/acre). The 'L-BFGS-B' optimization algorithm (Byrd et al, 1995) minimizes the sum of square errors during the fitting process to provide the best-fitting parameter estimates. To directly quantify the curve's slope at the inflection, which is an approximation of the 'average' growth rate over the curve itself, we take the first derivative of the curve:

$$\text{Change} = \frac{A2 - A1}{4 \cdot dx}, \quad (2)$$

where ‘Change’ is the slope of the curve at the inflection. The location of the inflection point itself over the modeling period (x0) could be negative if the plot has already ‘passed’ the inflection by the start of the modeling period, which indicates a plot with a distribution of larger trees that has a slower growth rate relative to a more sparsely populated plot with smaller trees. The x0 could also be greater than 100, which indicates a relatively young or sparsely populated plot with near-exponential growth. There were at least two plots with very high, outlier change values, which were caused by abrupt shifts in biomass projections, and these were removed from further analysis.

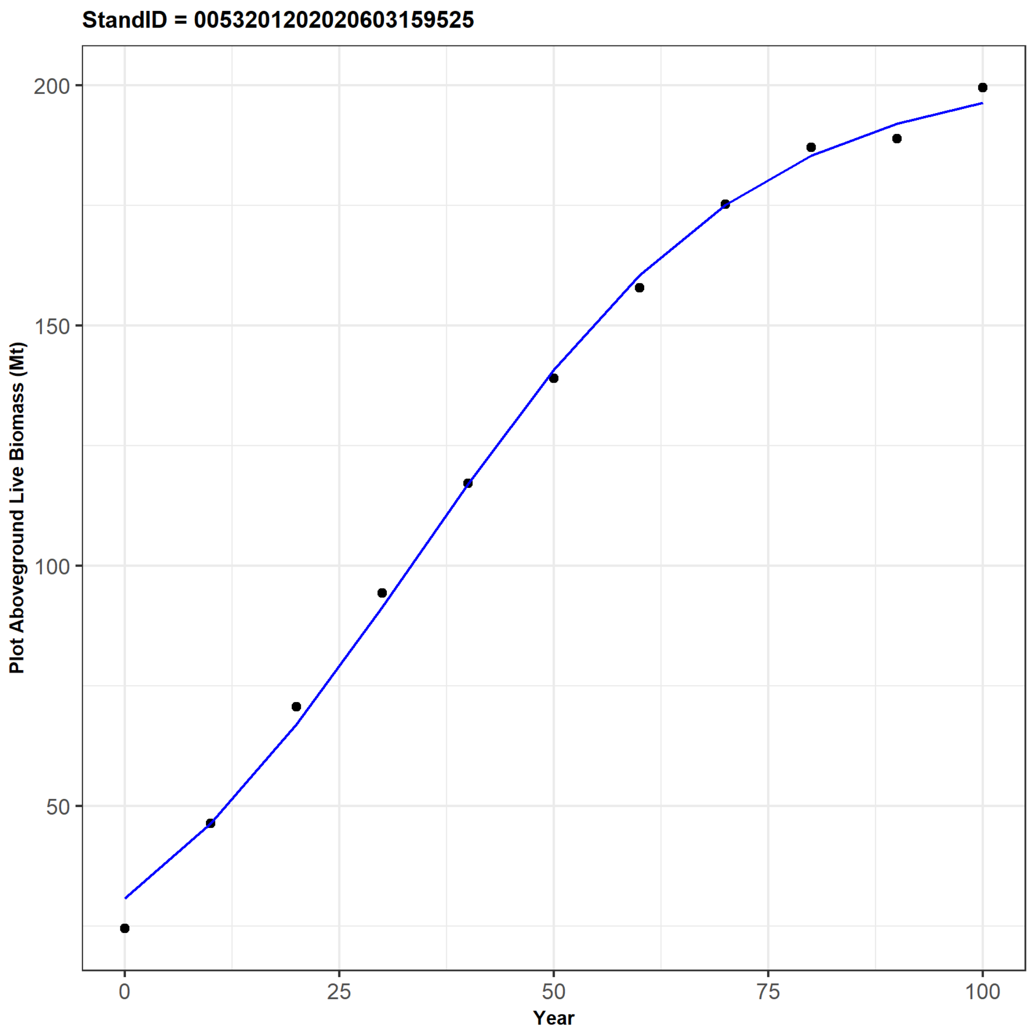

Figure 3: Example of plot-level biomass projection and corresponding s-curve fit to the data using the steps described above. The year of inflection for this curve (x0) is year 34, the rate of change at inflection is 2.58 metric tons of biomass per year, and since this curve will eventually level off at a biomass greater than the maximum FVS projection (after year 100), this plot’s ‘maximum capacity’ is the highest black point at 199.5 Mt/acre.

The Change and Capacity (estimated 'maximum capacity') parameters were summarized for each county-ownership polygon. The difference between the Capacity of each plot (converted from biomass to metric tons of CO2 equivalents by multiplying biomass Capacity by 0.5*3.664) and the associated ARB common practice assessment area metric was calculated to relate the plot's maximum capacity to area forestry common practice statistics. Negative values (Capacity < Common Practice) indicate a plot will likely not sequester enough CO2 to be viable for forestry-related carbon projects. The difference between Capacity and Common Practice tCO2e was averaged for each county-ownership polygon.

2.4 Soil Carbon Capacity Across Different Sinks

The gridded SSURGO data product (100 m resolution) provides bulk density (units: g cm-3) and fraction of soil organic carbon (units: g/g) for consistent depths (0, 5, 15, 30..., 100cm) across the United States. SCS conservatively ignored the relatively low bulk density 0 cm layer and calculated total carbon storage for the 5, 15, and 30 cm layers. Total storage is calculated with:

$$SOCS = BD*SOC*Thickness, \quad (3)$$

where BD is bulk density (g/cm3), SOC is fraction of soil organic matter content (dimensionless), Thickness is the thickness of the layer applied in the calculation (cm), and SOCS is soil organic carbon storage (g/cm2). The result was converted to metric tons C per hectare, given the relatively common convention of how soil organic carbon storage is reported.

The NLCD spatial dataset provided enough information to define the spatial location of terrestrial carbon dioxide sinks across Washington (shrubland, grassland, agriculture, and forest). The SOCS grid was masked according to each sink and then summarized for each county across Washington. Given the large spatial extent of Washington, this process was computationally intensive, but it provided relatively precise estimates of carbon across the state consistently using the same soils data source.

2.5 Blue And Teal Carbon Identification and Capacity

The SERC sediment carbon core data, NLCD wetland grids (emergent and woody wetland designations), and national wetland inventory (estuarine and freshwater designations) all provided enough location to parse the SERC point data into teal and blue carbon groupings. Blue carbon is partially defined as estuarine woody and emergent wetlands, while teal carbon is defined as freshwater woody and emergent wetlands. Although some working definitions focus the teal carbon domain on freshwater ecosystems in close proximity to the coast, SCS expanded the domain to freshwater ecosystems across the state, acknowledging a high degree of uncertainty in doing so.

The sediment organic carbon storage (SOCS: same acronym as soil organic carbon storage) was calculated in the same manner as soil organic carbon storage with equation 3 for individual layers in the SERC dataset, then summed for each core. The SOCS blue and teal carbon estimates at the core-level were then summarized for each of their associated blue and teal carbon group.

Kelp forests are another crucial component of the blue carbon domain, and these were mapped using data from the WA Dept of Natural Resources kelp forest layer.

Finally, SCS assigned averages of the two different wetland components of teal and blue carbon based upon the summarization of SERC data for these grouping to a grid of woody and emergent blue and teal carbon cells. The extrapolation of SOCS values from points collected close to the coastline to grid cells across the state is highly uncertain, but we conducted this exercise with the understanding that 'inland' teal carbon measurements represent a large data gap. In the same manner as soil SOCS, grid cells within each county polygon were summarized to the county-level (Appendix C).

2.6 Carbosink Dashboard Interface Development

An interactive, digital interface is underdevelopment, which will enable users to query the CarboSink repository and produce data tables such as those listed in Appendices A-B. A GIS interface component will also enable spatial data exploration from spatial datasets within CarboSink. Furthermore, a user may analyze the suitability of different carbon projects in a particular area with this tool, assuming there is enough underlying data to facilitate this analysis (Tasks 2-3).

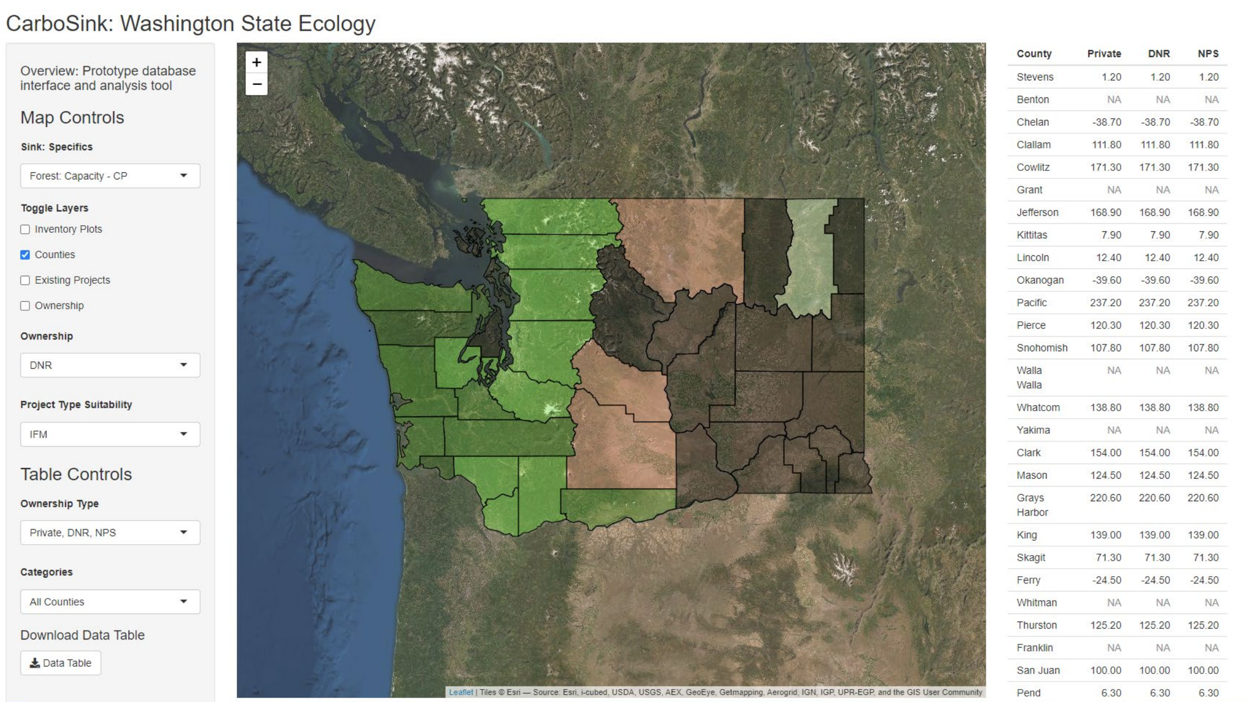

Figure 4: Preliminary interface for the interactive dashboard linking to CarboSink data repository

2.7 Task 1 Findings

SCS identified five carbon dioxide sinks in Washington including: forest, teal (freshwater ecosystems), blue (marine and coastal), shrubland, grassland, and agriculture (pastures and cropland). These have been mapped and are shown in Figure 5. Forest carbon dioxide sinks dominate Washington in the western and northeastern parts of the state, with agriculture dominating the southeastern region.

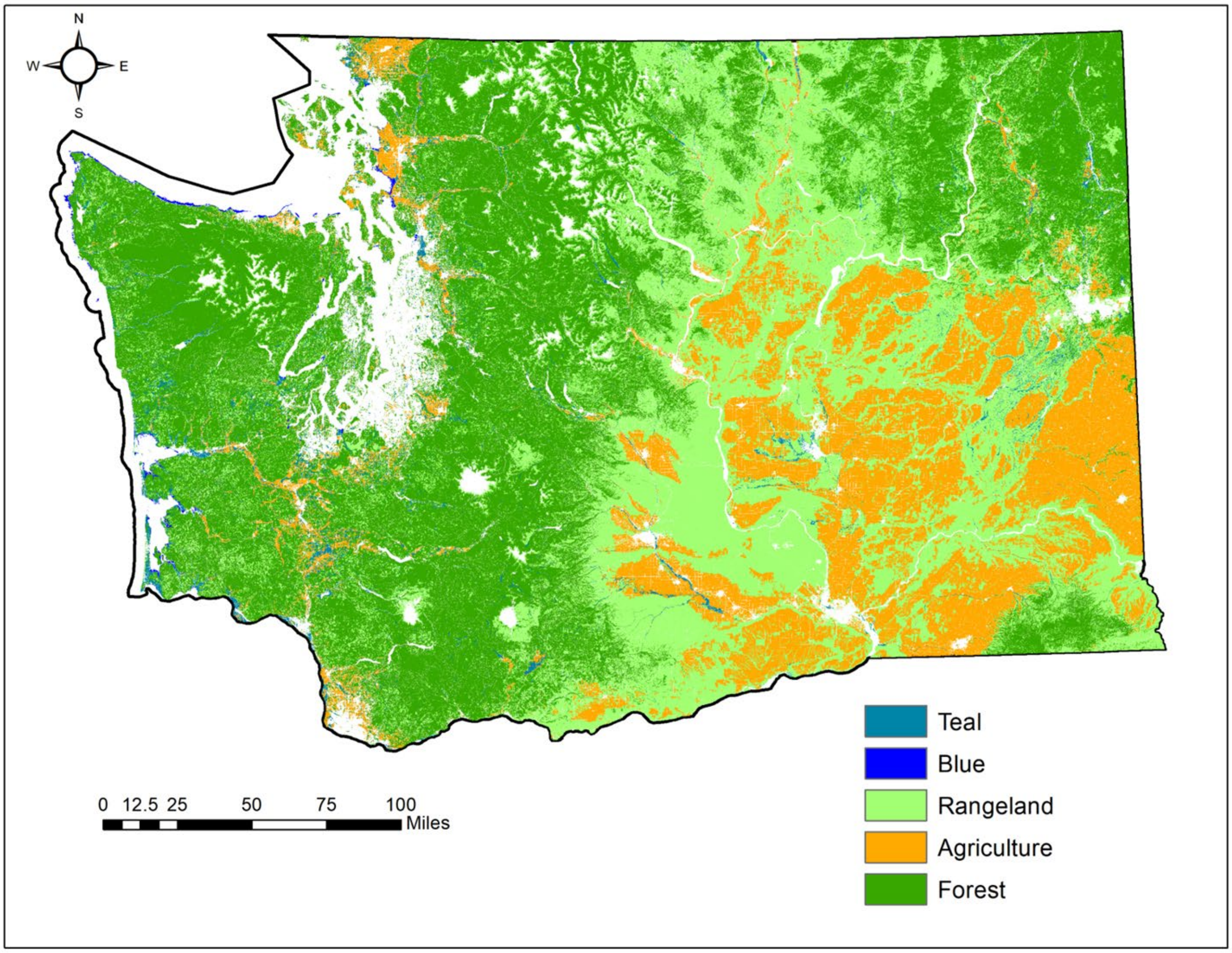

Figure 5: Map of Carbon Dioxide Sinks for the State of Washington

Table 1 contains the area encompassed by each of the five carbon dioxide sinks. The forest sink is the largest with almost 18 million acres. This carbon dioxide sink includes lands that are in natural forest, urban forest or have the potential to be forested. Rangeland, which is comprised of the grassland and shrubland ecosystems has 13.4 million acres. Rangeland is followed by agriculture which is comprised of cropland and pasture. The aquatic carbon dioxide sinks, teal and blue, cover the smallest areas. Teal carbon dioxide sink area approaches 900,000 acres based on this analysis, which includes inland freshwater ecosystems. Blue carbon, the marine and coastal sink, covers the smallest area with approximately 42,000 acres (not including the extent of kelp forests). Though not a separate carbon dioxide sink, the soil carbon pool is extremely important because it underlies all the terrestrial and aquatic carbon dioxide sinks. The extent of 'viable' soil data (i.e., area with 100m resolution gridded soil data) is 42,376,264 acres, while an estimate of Washington's total area is 45,632,000 acres. About 7.1% of the area in Washington is developed urban space, open water, exposed bedrock, and other surfaces not conducive to soil mapping.

Carbon Dioxide Sinks	Acreage
Forest	17,709,779
Rangeland	3,422,200
Agriculture	7,163,786
Teal Carbon	897,829
Blue Carbon	42,136

Table 1: Acreage of the Five Carbon dioxide sinks in Washington State

There are multiple methods to represent the condition of the carbon dioxide sinks; we have limited our analysis to two ways. The first describes the amount of carbon stored in the sinks throughout the State of Washington when common practices are applied to the sinks (Figure 6). The highest capacities are demonstrated in the national park areas in northwest Washington due to the predominately old-growth forests that are regulatorily protected from harvests. The species composition of these old-growth forests is a major driver in the high capacity, mechanistically speaking. The lowest capacities are in the central portion of the state which is associated with sites that have received repeated large-scale fires that have not been fully reforested.

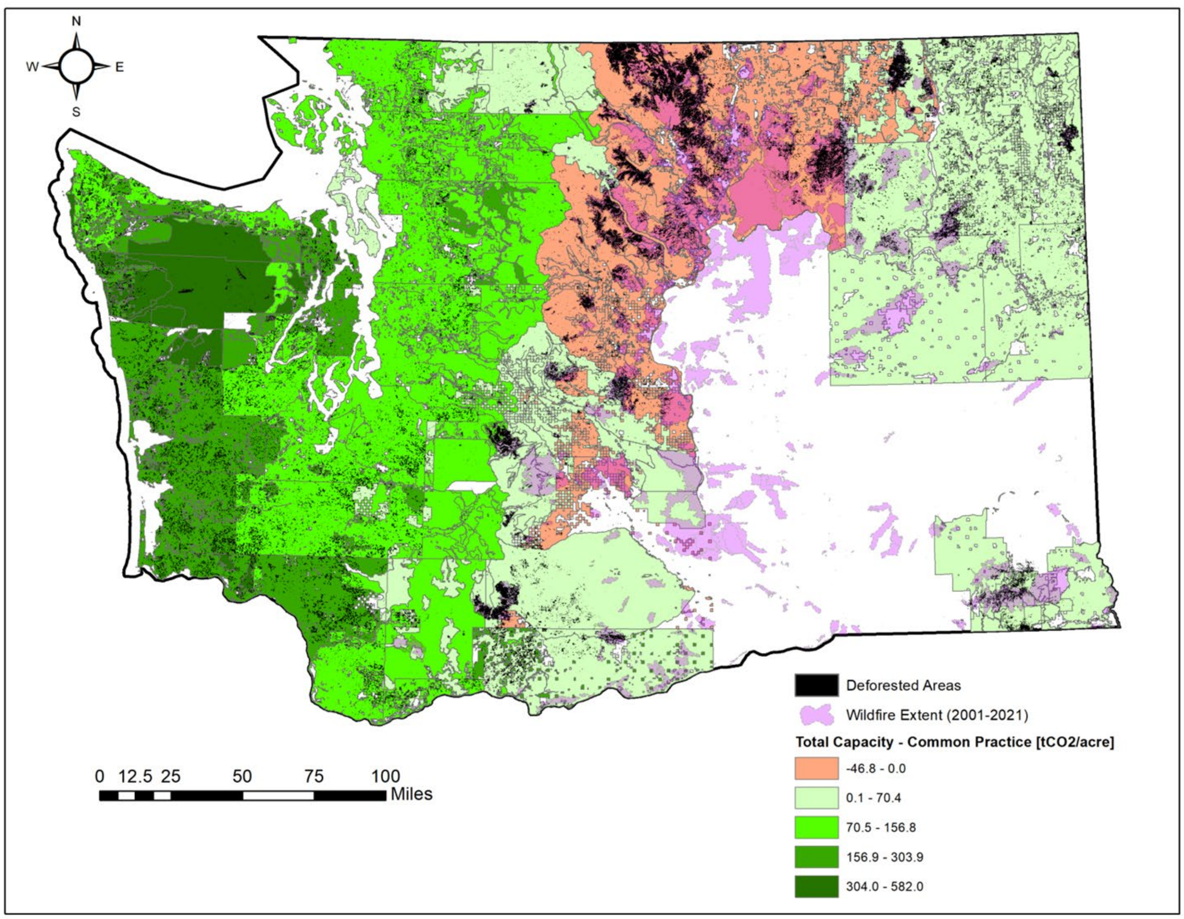

Figure 6: Estimates of Capacity (estimated during FVS modeling) minus Common Practice at the ownership-county level (see Figure 2). Black shading indicates areas that were forested prior to 2019 are no longer forested. Purple shading indicates estimated wildfire extents from events occurring 2001-2021.

From Figure 6 we see that the northeast and southeast contain areas with low positive Capacity after accounting for Common Practice that are currently deforested. These areas could potentially feature in reforestation projects assuming wildfire risk is reasonably mitigated. Permanence must be feasibly demonstrated to a validation/verification body (VVB) for a reforestation project to pass validation.

The following map (Figure 7) describes the growth rates using the appropriate variant of Forest Vegetation Simulator (FVS) and Forest Inventory and Analysis (FIA) inventory plots to determine the growth rates of the trees on the plot. 'Growth rate class' is derived from the year of the inflection point modeled in each plot's growth curve: 'Slowing' indicates the inflection point has already passed before year 0 of the FVS simulation, 'Medium' indicates the inflection is sometime within 100 years from year 0, and 'High' indicates the inflection will not be reached until after 100 years into the future.

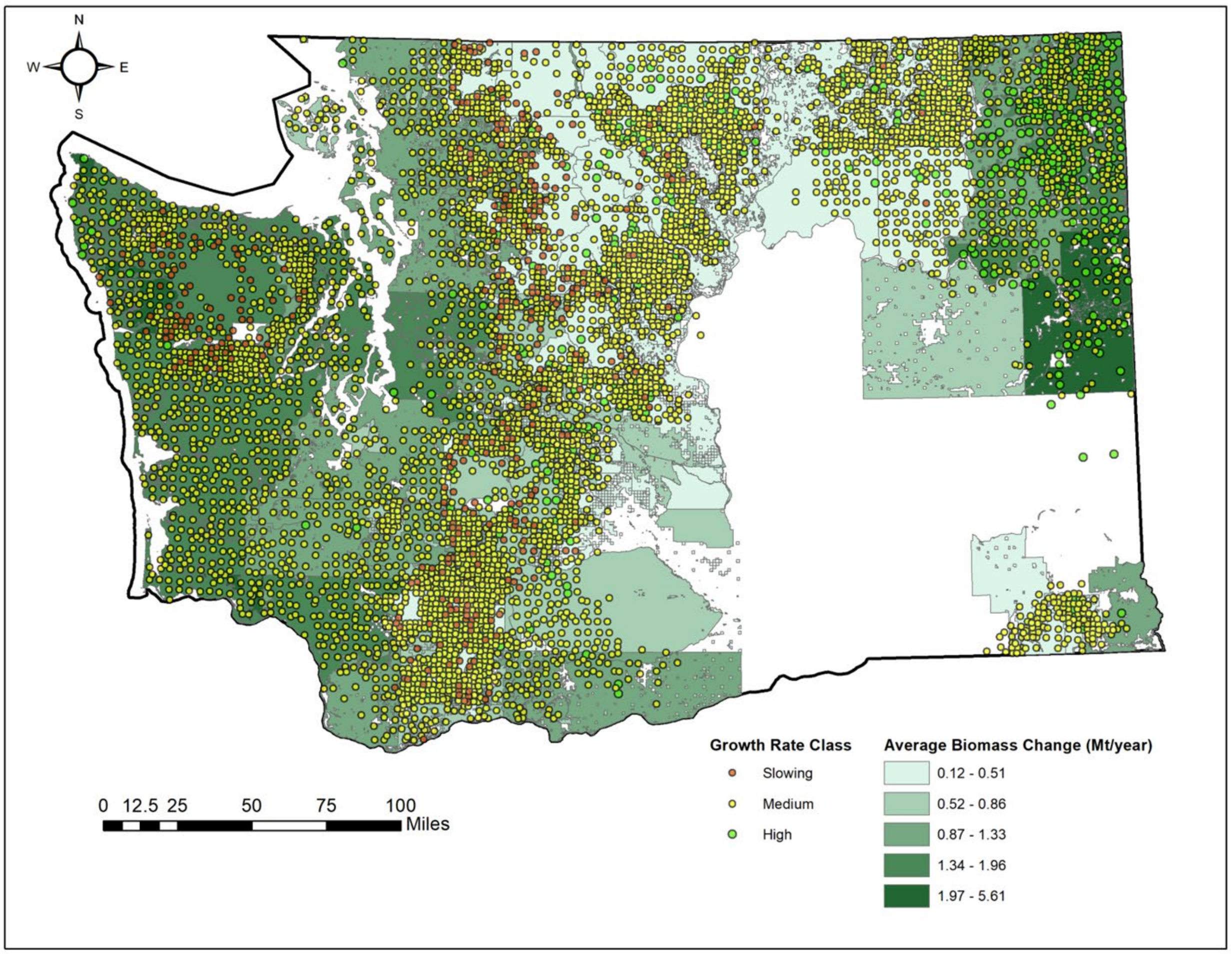

Figure 7: Estimation of growth rates at the ownership-county level (see Figure 2) based upon FVS modeling at forest inventory plots across the state. 'Growth rate class' is derived from the year where an inflection occurs in a plot's growth curve (see text above for further details).

The summation of the growth shows the potential for sequestrating carbon in the western forests receiving the most rainfall, followed by the northeastern portion of the state that is out of the rain-shadow effect from the Cascade Range. When combining the maps in Figures 6 and 7, one can locate regions within Washington with the largest potential for new forest sequestration projects that can capture the maximum amount of carbon for storage in forests.

Larger reservations, such as those of the Confederated Tribes and Bands of the Yakama Nation and the Confederated Tribes of the Colville Reservation were determined to have a lower or negative capacity compared to common practice and may be able to sequester more carbon with a management system that emphasizes carbon sequestration. Wildfire may be a factor to consider since there was likely an unintentional reversal in this compliance carbon project due to the Summit Trail Fire which burned many tens of thousands of acres.

Similarly, forests on the eastern slope of the Cascades have a lower feasibility for Improved Forest Management (IFM) carbon scenarios due to the higher risk of wildfire. A closer look at just Washington Department of Natural Resources (DNR) lands shows a moderate to high capacity for IFM projects.

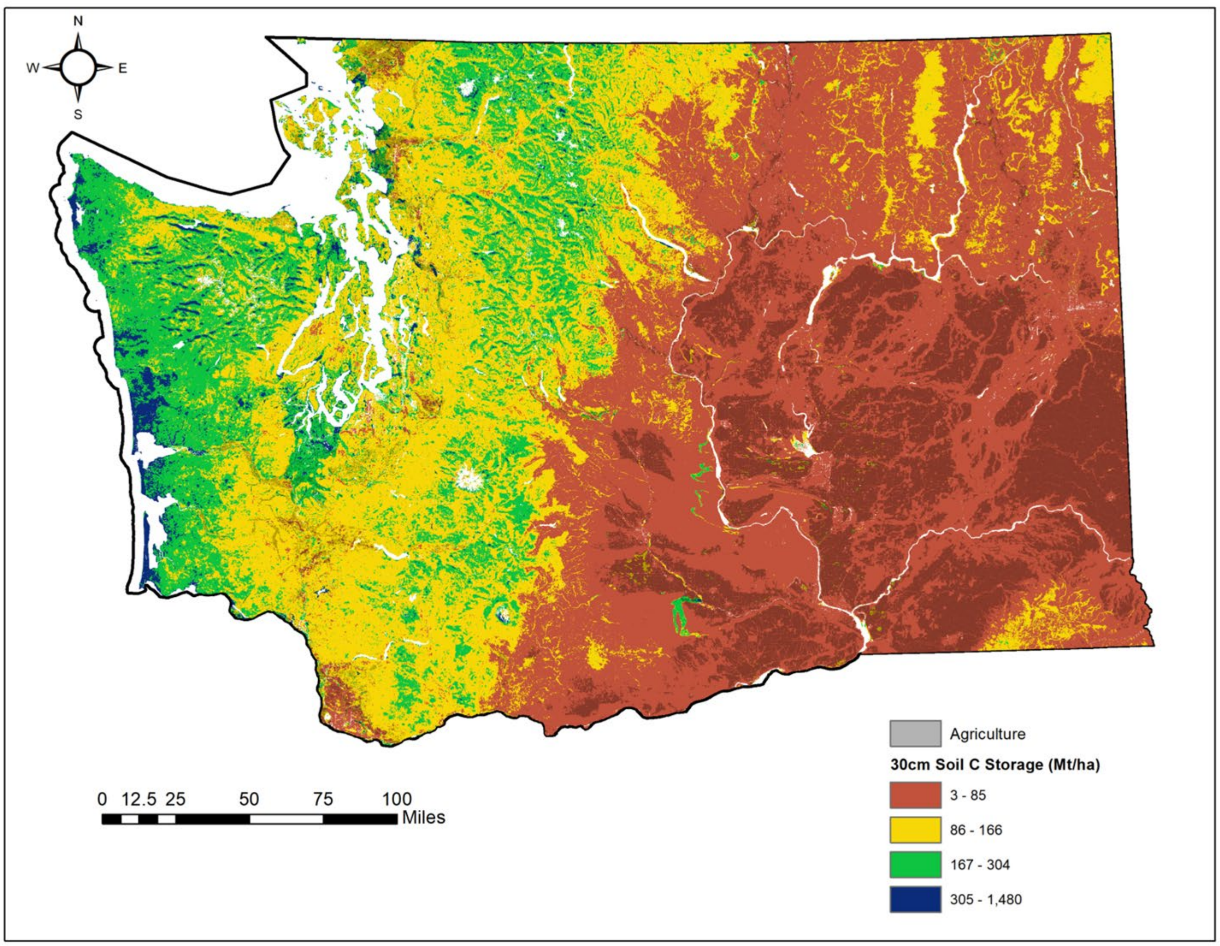

Figure 8: Soil carbon storage in the top 0-30 cm estimated from gridded soil variables bulk density and fraction of soil organic carbon. The grid is 100 m resolution across viable areas of Washington. Grey shading indicates areas of pasture and cropland sinks.

Soils are the largest carbon pool by area, but it is difficult to analyze as they must rely on intensive sampling and analysis schemes. However, the state-wide distribution of the soil variables bulk density and fraction of soil organic carbon enables the mapping of potential soil carbon storage (Figure 8).

The United Nations Food and Agriculture Organization (FAO) launched an effort to estimate the soil carbon sequestration potential for agricultural soils based upon environmental conditions and agricultural management practices. The FAO has made a suite of open-source tools available to conduct RothC soil organic carbon modeling that can be driven by local datasets (https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/global-soil-organic-carbon-sequestration-potential-map-gsocseq/en/). SCS has identified this as a potentially beneficial next step in our analysis to quantify soil organic carbon capacity in agricultural areas across Washington with respect to different management practices in a highly localized manner. Clay content is an important driver in soil sequestration modeling, where higher clay content generally indicates greater potential for soil organic carbon sequestration. Figure 9 shows an estimate of average clay content in the first 0-30 cm of the soil profile across Washington.

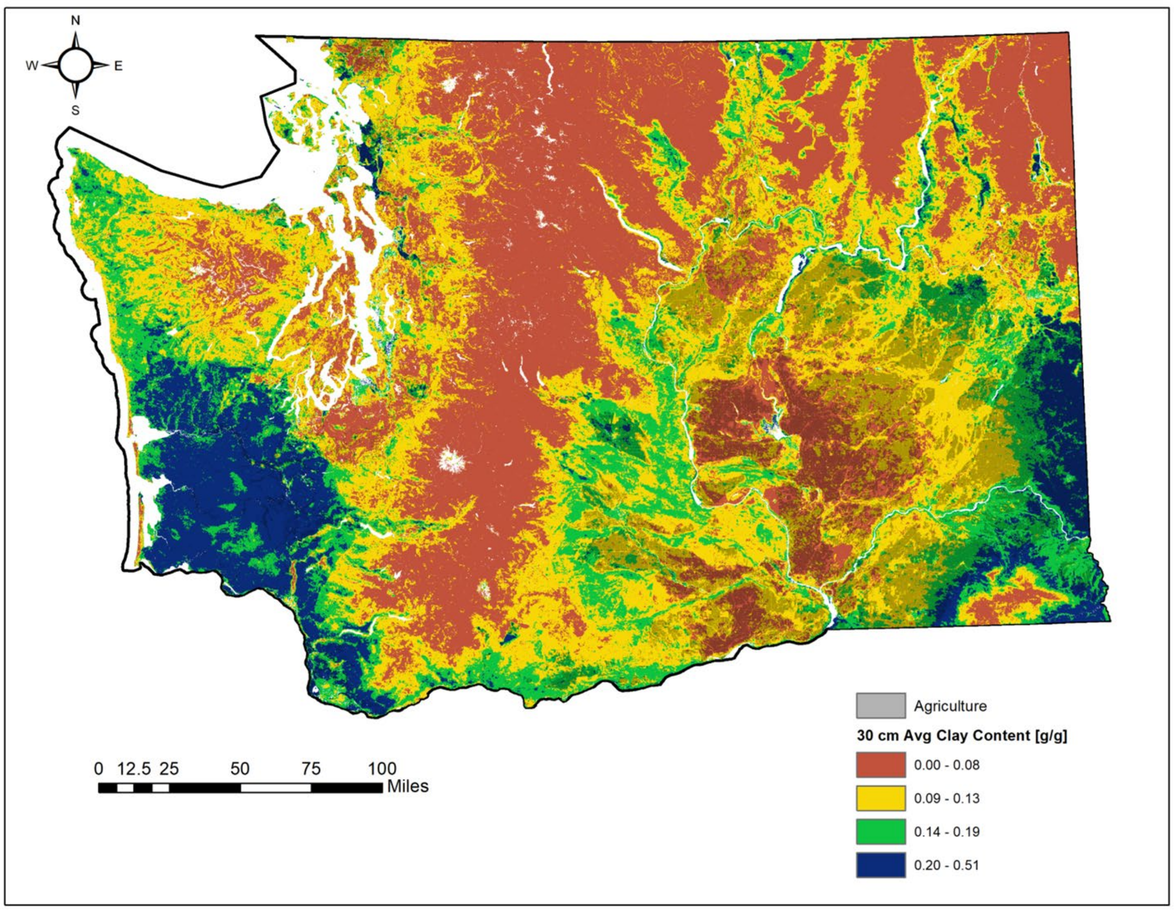

Figure 9: Average soil clay content in the top 0-30 cm estimated from gridded soil datasets. The grid is 100 m resolution across viable areas of Washington. Grey shading indicates areas of pasture and cropland sinks.

Degraded grasslands and pasturelands may also present opportunities for afforestation projects, where grasslands and pasturelands with higher clay content would generally provide a higher carbon capacity verses areas with lower clay content. As with the reforestation commentary, any afforestation projects would need to mitigate wildfire risk to be viable in the southeast and northeast.

The most significant potential source for additional sequestration of carbon is in the southeastern part of the state with medium clay contents, as this area has a low concentration of soil carbon but the presence of clay facilitates higher soil sequestration rates. This low soil carbon concentration could indicate that many of these soils were formed following recent volcanic activities or allowed land activities that depleted soil carbon. Additional information from soil sampling at a local level and process modeling is needed to determine the full potential of soils and carbon management (Figures 8 and 9).

The final sink is related to marine and wetland areas, including freshwater systems (teal carbon) and saltwater systems (blue carbon). The teal carbon dioxide sink occurs throughout the state (Figure 5), and the blue carbon dioxide sink is only along the coast in isolated groups.

Woody and emergent freshwater wetland systems are similar in measured carbon storage (Figure 10), both of which are higher than the blue carbon emergent estuarine wetlands class. The woody estuarine wetlands generally have higher storage than the other blue and the teal classes, however only 3 measurements were available to formulate the distribution shown in Figure 10 for this class. In general, more core measurements are necessary for the 'blue' estuarine and marine ecosystems to get a reliable carbon storage estimator for components of blue carbon. Core measurements coupled with kelp forest vegetation samples would also greatly aid the understanding of blue carbon storage. Likewise, measurements from inland freshwater wetlands would significantly improve the understanding of teal carbon storage.

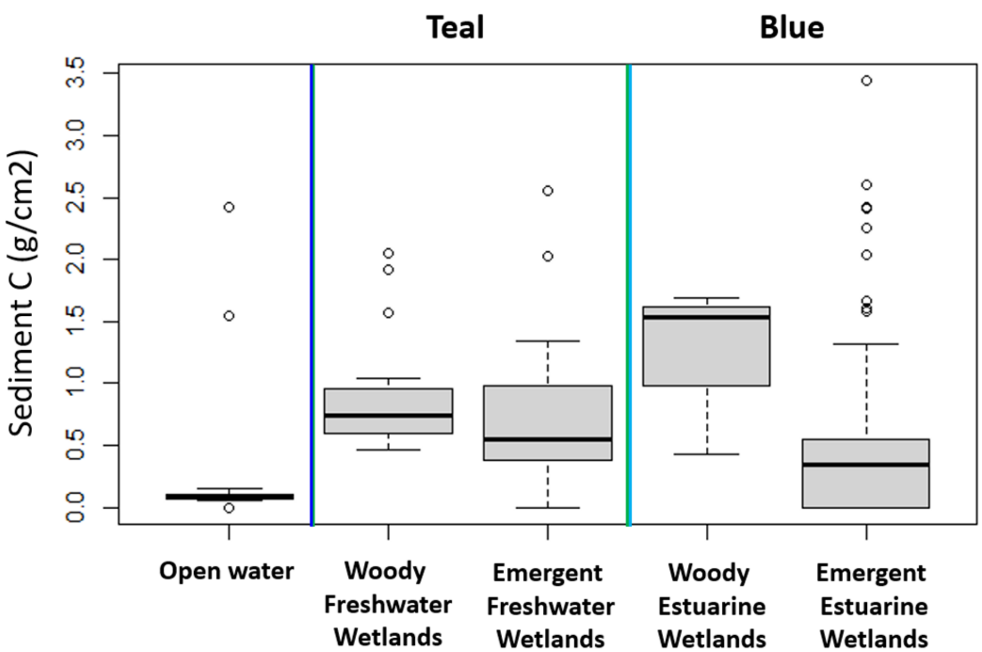

Figure 10: Boxplots showing the distributions of different components of teal and blue carbon dioxide sinks based upon SERC sediment core data. The 'open water' indicates where cores were collected in marine areas not associated with wetlands.

Sediment cores that were placed in open water areas consistently show very little carbon storage, indicating that teal and blue carbon ecosystems do enhance carbon storage when compared with carbon stored in open marine systems (Figure 10).

Ownership

The ownership map for Washington is described in Figure 2 above. Private ownership dominates the state, but there are numerous areas of public ownership including several large national parks as well various extents of tribal lands.

3 Task 2: Categorization Standards

3.1 Method and Criteria

The objective of Task 2 is to develop categorization standards to apply to the inventory of carbon dioxide sinks in Washington developed in Task 1 to assess the suitability, readiness, and robustness of the available data for use with existing carbon offset protocols to facilitate the development of carbon dioxide removal projects.

The SCS team has utilized its extensive knowledge of the methodologies and standards across the array of GHG schemes to determine the suitability of each carbon dioxide sink in the State of Washington by way of the following steps:

1. Develop a Hierarchy of Suitability for each CO2 sink
2. Determine Criteria for Technical Suitability for each CO2 sink
3. Determine Criteria for Administrative Suitability for each CO2 sink
4. Determine Criteria for Financial Suitability for each CO2 sink

SCS reviewed each protocol for key factors which could either support or preclude the applicability of the standard to the carbon dioxide sinks of the State of Washington. SCS identified requirements which have the highest likelihood of being a barrier to project development.

Examples of suitability criteria considered include:

- Data availability (i.e., for baseline and project calculations)
- GHG removal potential
- Cultural or stakeholder concerns and considerations (e.g., common practices and associated risks, representatives of disadvantaged or tribal communities)
- Land ownership (e.g., conservation easements and protected areas, legal and/or policy requirements)
- Existing and developing projects for the CO2 sink
- Buffer pool contributions and associated risks such as wildfire.

3.2 Standards and Methodology Review

The SCS team thoroughly reviewed approximately 30 existing robust protocols and methodologies relevant to the identified carbons sinks from the voluntary and compliance carbon markets such as the California Air Resource Board (CARB), the Climate Action Reserve (CAR), the American Carbon Registry (ACR), and Verra's Verified Carbon Standard (VCS) (Appendix D). Reviewed methodologies and protocols were limited to those beneath these registries and schemes due to their reputable standards. Methodologies and protocols will be used interchangeably for purposes of this report.

The information gathered from the existing standards informed the technical, cultural, and administrative feasibility conclusions for each carbon dioxide sink. This analysis is aggregated and summarized in the following tables. The technical feasibility analysis for each carbon dioxide sink included the examination of available data for determining project specifics such as baseline, additionality, and project scenario, and the financial burden of gathering such data (Table 2). The GHG removal potential of predominant greenhouse gases (carbon dioxide, nitrogen, and methane) was also evaluated and categorized as either none, low, medium, or high. The cultural feasibility entailed potential stakeholder considerations and land ownership factors (Table 3). The applicability of reviewed methodologies and protocols within the State of Washington was also considered, specifically in the context of projects registered or developing in the state (Table 4).

3.3 Task 2 Findings

The results of this analysis demonstrate that there are a variety of potentially applicable existing methodologies and protocols for each carbon dioxide sink. The majority of the existing methodologies, which currently function beneath the framework of ACR, ARB, CAR, and VCS, can be applied to all landowner classes, including federal, state, tribal, and private lands. California Air Resources Board is an exception as projects on federally managed lands are not accepted. No agency policies that restrict the adoption of a standard were identified.

The forest carbon, blue carbon, and teal carbon dioxide sinks have well-understood protocols that have a greater potential for easy implementation in the State of Washington. However, the agriculture, shrubland, and grassland data collection methods and existing data are still in the early days of development in comparison which may make them more challenging to execute immediately. It may be beneficial to work closely with the entities who that created the particular methodology or protocol to acquire the knowledge to correctly implement and/or refine them.

Regarding removal potentials, each sink is categorized relative to each other with respect to per unit area removals (e.g., tonnes per acre) in effort to standardize for the differences in the total land area of each sink. The four project types within the forest carbon dioxide sink (e.g. improved forest management (IFM), afforestation/reforestation/revegetation (ARR), avoided conversion (AC), and urban forestry (UF) are the only sinks to provide 'high' potential carbon dioxide removals.

Carbon Sink	Technical Feasibility			
	Data Availability	GHG Removal Potential (Low, Medium, High)		
	Unknowable, Developing, or Well Understood	CO2	N2	Methane
Forest	Well understood	Removal: High Reduction: High Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: None Emissions: Low
Agriculture	Developing	Removal: Low Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Low	Removal: None Reduction: Low Emissions: Medium
Rangeland	Well understood	Removal: None Reduction: Low Emissions: Low	Removal: Low Reduction: Low Emissions: Medium	Removal: None Reduction: Low Emissions: Medium
Blue Carbon	Well understood	Removal: Low Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: Low	Removal: None Reduction: None Emissions: Low
Teal Carbon	Well understood	Removal: Low Reduction: Low Emissions: Low	Removal: None Reduction: None Emissions: None	Removal: None Reduction: None Emissions: Medium

Table 2: Summary of the technical feasibility of existing standards and methodologies applied to the carbon dioxide sinks across the State of Washington.

Carbon Sink	Cultural Feasibility	
	Cultural, Stakeholder Concerns	Land Ownership
	(Requirements Included in Methodology/Protocol?)	(Requirements Included in Methodology/Protocol?)
Forest	Included: Stakeholder consideration is included in ARB, ACR, VCS, and other registries reviewed.	No exclusions per ACR and VCS. Federal land restrictions per ARB.
Agriculture	Included: Local Stakeholder Consultation + Public Comment Period per VCS Standard.	No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Rangeland	Included: Local Stakeholder Consultation + Public Comment Period per VCS Standard.	No exclusions** specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Blue Carbon	Included: Local Stakeholder Consultation + Public Comment Period per VCS Standard	No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.
Teal Carbon	Included: Local Stakeholder Consultation + Public Comment Period per VCS Standard	No exclusions specified per VCS Standard: Project and jurisdictional proponents shall demonstrate that they have the legal right to control and operate project or program activities.

Table 3: Summary of cultural feasibility of existing standards and methodologies applied to the carbon dioxide sinks across the State of Washington.

Carbon Sink	Administrative Feasibility		
	Applicability	**# Projects Registered**	**# Projects in Process**
Forest	Applicable for WA. Active under ARB, CAR, and some smaller registries such as City Forest Credits.	- *Forest:* 7 in WA ACR Winston Creek ACR Puget Sound Energy ACR Nature Conservancy WA Rainforest ARB Colville Tribe ARB Nisqually - Ashford WA ARB Spokane Tribe VCS VM0012 King County - *Urban Forest:* 1 City Forest Credits in King County, WA - *Afforestation/Reforestation:* 9, but none in WA or adjacent states.	- *Forest:* 2 in WA ACR Rainier Gateway (Pierce County, WA) ACR Columbia River (Columbia, Pacific, Klickitat, Skamania, Yakima Counties, WA) - *Urban and Afforestation/Reforestation* None in WA or adjacent states.
Agriculture	Potentially applicable for WA. Active under VCS (VM0042, VM0017, VM0022).	4, but none in WA. Other projects in adjacent states and beyond may be identified and researched.	19, but none in WA. Other projects in adjacent states and beyond may be identified and researched.
Rangeland	Potentially applicable for WA. Active under VCS (VM0032, VM0026).	3, but none in WA. Other projects in adjacent states and beyond may be identified and researched.	4, but none in WA. Other projects in adjacent states and beyond may be identified and researched.
Blue Carbon	Potentially applicable for WA. Active under VCS (VM0024, VM0033).	1, but none in WA or adjacent states.	3, but none in WA or adjacent states.
Teal Carbon	Potentially applicable for WA. Active under VCS (VM0036).	None in WA or adjacent states.	None in WA or adjacent states.

Table 4: Summary of administrative feasibility of existing standards and methodologies applied to the carbon dioxide sinks across the State of Washington.

All other sinks provide medium to low GHG removals or reductions. Agriculture and grasslands provide the most potential for nitrogen and methane reductions, often related to irrigation, grazing, and manuring practices. While teal carbon dioxide sinks account for a smaller land area than agricultural and grassland/shrubland sinks, they can potentially provide 'medium' methane reductions and have well-understood protocols which could make these sinks 'lower hanging fruit' than the agricultural and grassland/shrubland sinks. Similarly, while blue carbons sinks provide less land area and less removal potential per unit area, the well-understood protocols around blue carbon could provide greater near-term feasibility.

Currently, there is notable potential for adopting forest carbon projects within Washington. Nine forest projects, distributed across at least twelve locations, have been adopted or are in process statewide, as shown in Figure 2. These are a under a mix of registry frameworks: three ACR, three ARB, one VCS, and one under City Forest Credits (an urban forest specific registry). There are currently no afforestation/reforestation/revegetation projects registered in the State of Washington, however there are nine in California under the ARB-ARR protocol which focus on post-wildfire rehabilitation and may provide viable examples for projects in wildfire affected areas on non-federally managed land in the central and eastern portions of Washington. Additionally, many more under VCS, ACR, and Climate Action Reserve (CAR) ARR have been undertaken in the continental United States. There are currently no examples of blue, teal, agriculture, or grasslands/shrublands projects in Washington, but there are examples of each within the continental United States under VCS, CAR, and ACR.

Community and stakeholder involvement is an important consideration for successful implementation of a carbon project. Both ACR and VCS standards require local community stakeholder consideration. Two ARB projects have been adopted on tribal resources that demonstrate a pathway to involve overburdened communities in these programs so that they can receive the many benefits these programs may offer to communities.

4 Task 3: Cataloging & Mapping Standards to Carbon Dioxide Sink

4.1 Method and Criteria

The objective of Task 3 is to perform a crosswalk of results from Task 1 and Task 2:

1. Perform QA/QC of the comprehensive assessment, inventory, itemization, and summation of potential and existing carbon dioxide sinks in Washington by standard
2. Review and interpret results of CarboSink. SCS will be focused on a developing a preliminary database which clearly demonstrates each carbon dioxide sink's potential, readiness, and suitability to serving (in whole or in part) as a carbon dioxide removal project under the protocol

4.2 Task 3 Findings

In addition to the findings from Tasks 1 and 2 above, Task 3 identified data gaps which could lead to further inquiry and research during Phase 2: Analytical Refinement &Protocol Scenarios.

4.2.1 Kelp forest capacity (blue carbon dioxide sink)

SCS could supplement the extent of kelp forests based upon available data because there is uncertainty that this mapping has captured the full extent of kelp forests in coastal areas of Washington. Furthermore, data on the carbon storage capacity of kelp forests is lacking and SCS may need to conduct additional literature searches to fill in this data gap.

4.2.2 Inland freshwater carbon dioxide capacity (teal sink)

While SCS has included inland freshwater systems into the teal sink, estimators listed in Table C1 (Annex C) are based upon sediment cores taken in coastal areas. SCS may want to devote additional time to reviewing peer-reviewed literature to expand the mapping and understanding of teal carbon storage for inland freshwater wetland ecosystems.

4.2.3 Soil sequestration modeling for agricultural areas

The FAO's accessible, open-source modeling approach to projecting soil organic carbon sequestration in agricultural soils could enable SCS to develop similar estimates of maximum soil organic carbon capacity across Washington based upon different agricultural management practices. This venture would greatly enhance our understanding of soil organic carbon capacity in agricultural sinks beyond our current estimates of soil organic carbon storage based on available soil data. FAO has established an open access data repository that SCS can utilize for this type of modeling (https://github.com/FAO-GSP/GSOCseq-scripts), and it is possible to automate these soil sequestration simulations across the state for agricultural sink soils.

6.4 Uncertainty mapping

SCS did calculate error statistics for all averages and ownership-county level statistics shown in the maps throughout Section 3. Reporting the uncertainty around these numbers is important for communicating our level of confidence of our sink capacity estimates across the state. Our next large-scale spatial data processing task will be to efficiently map out uncertainty in our estimates, and we will incorporate this information in the dashboard interface.

5 Conclusions and Key Takeaways

During Phase I, SCS identified the existing data and protocols to map, categorize, and catalog the suitability, readiness, and robustness of terrestrial and aquatic carbon dioxide sinks in Washington for potential use as carbon offset projects in regulatory and voluntary carbon markets. During Phase 1, SCS developed CarboSink, an interactive data repository of spatial information and identified five carbon dioxide sinks in the State of Washington: forest, teal (freshwater ecosystems), blue (marine and coastal), rangeland (shrubland and grassland), and agriculture (pastures and cropland).

The forest carbon dioxide sink has the largest acreage as well as the highest capacity for carbon dioxide removal per acre. This potential is the greatest in the northwest areas of the state as well as in the Western Cascades. In the Eastern Cascades, there is also potential but as in many areas of the West, the risk of wildfire is a factor to be considered. Unintentional reversals from wildfires could negate carbon removals. In the southeastern portion of the state, there is a potential for agricultural projects due to the higher clay content. While soil carbon was not identified as a standalone carbon dioxide sink, it is a carbon pool that can be included in all of the terrestrial and aquatic carbon dioxide sinks in the state and should be considered when assessing carbon dioxide removal potential.

During Task 2, SCS reviewed and analyzed the existing carbon offset standards in the voluntary and compliance carbon markets. An analysis of existing protocols was also undertaken to assess feasibility (technical, cultural, and administrative). The largest adoption of the standards has been in the forest the forest carbon dioxide sink. Nine projects, in both the voluntary and compliance markets have been registered. Nonetheless, all carbon dioxide sinks have the potential for adoption. During Phase 2, SCS will explore the additional efforts which may lead to greater adoption of the standards in agriculture, rangeland, and the blue carbon and teal carbon dioxide sinks. SCS will also continue to build the CarboSink dashboard into a scalable web-based system. We will work with Washington Ecology to ensure its effective functionality and user-friendly interface. Both phases will contribute to the facilitation of carbon dioxide removal projects in the State of Washington while adopting, modifying, and revising protocols to ensure conformance with the state's climate laws, rules, markets, and goals.

Appendix A: Task 1 Forest Carbon Summary

Table A1: Average maximum capacity of aboveground tree biomass sequestration predicted by growth modeling on FIA forest inventory plots (units: metric tons of biomass per acre).

County	Forest Service	Other Federal	Private	NPS	Industrial (uncertain)	DNR	Tribal	Municipal	Other State
Asotin	38	41	44						
Chelan	48	48	19	59	43				
Clallam	223	170	114	284		190	99		
Clark			136			126			
Columbia	54	50	34						
Cowlitz		76	147			120			
Ferry	39	31	20		16		36		
Garfield	34	43							
Grays Harbor	262	342	174			207	151	229	
Island			117						
Jefferson	302	139	155	371		250			
King	95	100	134		64	111		127	
Kitsap			183						
Kittitas	68	53	50		87	27			35
Klickitat		79	47			139	44		
Lewis	123	97	124		72	157			
Lincoln			30						
Mason	158	188	135			132			
Okanogan	27	21	16			28	25		
Pacific			183			180			
Pend Oreille	56	52	37		47				
Pierce	91	131	123	108	51	97			
San Juan			123						
Skagit	115	102	90	90		122			
Skamania	105	80	96		64	109			
Snohomish	140	93	121			118			
Spokane			53						
Stevens	48	48	34		52	40	40		
Thurston			130			187			
Wahkiakum			169			265			
Whatcom	106	77	141	71		91			
Whitman			79						
Yakima	57	74				36	59		26

Table A2: Average growth rate of aboveground tree biomass at the inflection of a growth curve produced by growth modeling on FIA forest inventory plots (units: metric tons of biomass per acre).

County	Forest Service	Other Federal	Private	NPS	Industrial (uncertain)	DNR	Tribal	Municipal	Other State
Asotin	0.48	0.23	1.28						
Chelan	0.44	0.40	0.22	0.45	0.33				
Clallam	1.45	0.77	1.93	1.36		1.41	2.50		
Clark			1.12			0.96			
Columbia	0.36	0.30	0.28						
Cowlitz		0.35	1.50			1.02			
Ferry	0.45	0.41	0.40		0.12		0.47		
Garfield	0.61	0.27							
Grays Harbor	1.47	1.67	1.81			1.78	1.67	1.74	
Island			1.10						
Jefferson	1.73	0.98	1.56	1.38		2.06			
King	0.73	0.61	1.50		0.51	0.95		1.08	
Kitsap			1.53						
Kittitas	0.67	0.48	0.64		0.53	0.28			0.26
Klickitat		1.23	1.03			0.79	0.93		
Lewis	0.75	0.55	1.33		0.78	1.21			
Lincoln			0.85						
Mason	1.24	1.02	1.39			1.07			
Okanogan	0.26	0.36	0.16			0.23	0.36		
Pacific			1.83			1.79			
Pend Oreille	1.79	1.77	1.68		1.47				
Pierce	0.68	0.74	1.11	0.55	0.49	0.78			
San Juan			0.86						
Skagit	0.79	0.49	0.91	0.39		1.02			
Skamania	0.71	0.47	0.67		0.59	0.67			
Snohomish	0.97	0.47	1.11			1.10			
Spokane			2.04						
Stevens	1.65	1.96	1.14		0.68	1.45	1.42		
Thurston			1.19			1.73			
Wahkiakum			1.93			2.12			
Whatcom	0.73	0.46	1.32	0.34		0.78			
Whitman			5.61						
Yakima	0.54	0.59				0.33	0.53		0.22

Table A3: Difference between maximum capacity of aboveground tree biomass predicted by growth modeling on FIA forest inventory plots and aboveground mean common practice statistics from ARB assessment criteria (i.e., Max Growth Capacity – Common Practice; units: metric tons CO2e per acre; **Note, different units from Tables A1-2**).

County	Forest Service	Other Federal	Private	NPS	Industrial (uncertain)	DNR	Tribal	Municipal	Other State
Asotin	29	33	39						
Chelan	0	0	-39	20	-9				
Clallam	304	207	112	420		243	102		
Clark			154			140			
Columbia	57	49	20						
Cowlitz		52	171			129			
Ferry	9	-5	-25		-33		5		
Garfield	20	38							
Grays Harbor	383	530	221			282	179	323	
Island			65						
Jefferson	455	157	169	582		357			
King	85	94	139		29	109		135	
Kitsap			201						
Kittitas	42	12	8		70	-28			-5
Klickitat		73	16			182	9		
Lewis	137	89	128		43	196			
Lincoln			12						
Mason	191	248	125			121			
Okanogan	-29	-47	-40			-31	-14		
Pacific			237			232			
Pend Oreille	41	33	6		24				
Pierce	78	142	120	110	5	80			
San Juan			100						
Skagit	123	98	71	77		129			
Skamania	105	59	90		32	112			
Snohomish	168	82	108			117			
Spokane			42						
Stevens	26	26	1		33	11	13		
Thurston			125			244			
Wahkiakum			213			387			
Whatcom	106	52	139	42		79			
Whitman			102						
Yakima	31	54				-6	36		-9

Appendix B: Task 1 Soil Carbon Storage Summary Across Sinks

Table B1: Average soil carbon storage down to 30 cm depth and the acreage containing soil carbon storage data for each sink. SOCS = soil organic carbon storage (units: metric tons per hectare). "Shrub" and "Grass" are components of the Rangeland sink, and "Crop" and "Pasture" are components of the Agriculture sink. We list separately for investigative purposes.

County	Crop SOCS	Crop Acreage	Forest SOCS	Forest Acreage	Shrub SOCS	Shrub Acreage	Grass SOCS	Grass Acreage	Pasture SOCS	Pasture Acreage
Adams	34	694547	48	114	32	184466	32	288540	34	11383
Asotin	49	55492	76	68166	59	82105	55	183034	55	3213
Benton	34	419741	72	37	29	330346	31	243210	29	11848
Chelan	70	23321	125	853764	107	431314	93	373248	72	7965
Clallam	148	208	206	909044	209	67507	200	18180	163	21001
Clark	95	1608	113	161737	114	23571	114	7528	95	66536
Columbia	46	169137	85	149307	71	70213	51	134160	52	15482
Cowlitz	120	1436	123	517744	123	65535	118	33240	116	24780
Douglas	38	381588	68	11935	38	479549	40	236463	57	4962
Ferry	65	1594	78	884021	73	343268	75	149218	98	2109
Franklin	37	392538	50	141	31	190726	32	159895	37	1120
Garfield	46	156341	82	77668	66	38594	50	165262	48	3959
Grant	40	746904	79	390	35	581448	31	247650	45	0
Grays Harbor	183	2780	224	898015	230	94647	218	40831	173	28411
Island	189	1206	166	63632	176	3926	209	2300	169	19027
Jefferson	259	53	205	910189	209	2	254	1	NA	0
King	149	1505	146	854924	142	68800	138	20330	121	34579
Kitsap	234	11	126	141245	124	11816	137	5760	168	4111
Kittitas	56	9498	101	532734	105	24	102	13	NA	0
Klickitat	38	142996	78	311281	57	282009	44	381097	74	13122
Lewis	104	1832	141	1115993	128	117372	122	43790	109	105240
Lincoln	41	706635	66	35932	43	2	40	294316	46	7020
Mason	217	211	163	438402	159	58552	156	21098	182	8295
Okanogan	54	58697	91	1071065	78	1105708	73	910192	64	27466
Pacific	512	164	205	401222	204	58459	199	28197	177	8009
Pend Oreille	60	1176	81	738178	74	78844	79	32976	78	7944
Pierce	129	1722	143	607276	135	73392	150	47611	131	33033
San Juan	144	38	148	69367	154	1171	187	3624	146	15185
Skagit	173	54248	157	757852	158	72617	153	28223	127	36346
Skamania	94	1022	142	876539	135	67790	136	29151	103	3606
Snohomish	177	11762	162	906336	148	82210	146	23050	141	45184

Spokane	52	314955	64	251578	54	207688	52	159898	57	8519
Stevens	63	38321	75	1018457	69	312629	68	134932	76	15866
Thurston	207	966	149	236390	145	31769	142	14226	166	57516
Wahkiakum	192	146	174	114647	170	14986	170	6574	177	4914
Walla Walla	40	472752	79	25906	39	104664	37	162113	51	3089
Whatcom	120	40350	170	839597	175	131096	161	47731	121	70544
Whitman	48	957121	64	11389	43	85312	41	223250	46	43128
Yakima	46	372558	98	817048	63	554059	51	774245	49	17694

Table B2: Average clay content over 30 cm depth and the acreage containing clay content data for each sink. SOCS = soil organic carbon storage (units: metric tons per hectare). "Shrub" and "Grass" are components of the Rangeland sink, and "Crop" and "Pasture" are components of the Agriculture sink. We list separately for investigative purposes.

County	Crop SOCS	Crop Acreage	Forest SOCS	Forest Acreage	Shrub SOCS	Shrub Acreage	Grass SOCS	Grass Acreage	Pasture SOCS	Pasture Acreage
Adams	0.08	694547	0.10	114	0.08	184466	0.09	288540	0.08	11383
Asotin	0.19	55492	0.14	68166	0.18	82105	0.19	183034	0.20	3213
Benton	0.08	419741	0.14	37	0.10	330346	0.10	243210	0.09	11848
Chelan	0.12	23321	0.05	853764	0.07	431314	0.07	373248	0.11	7965
Clallam	0.14	208	0.11	909044	0.11	67507	0.12	18180	0.14	21001
Clark	0.24	1608	0.18	161737	0.18	23571	0.18	7528	0.21	66536
Columbia	0.15	169137	0.10	149307	0.14	70213	0.14	134160	0.18	15482
Cowlitz	0.21	1436	0.16	517744	0.16	65535	0.15	33240	0.19	24780
Douglas	0.10	381588	0.11	11935	0.09	479549	0.10	236463	0.12	4962
Ferry	0.13	1594	0.07	884021	0.09	343268	0.08	149218	0.15	2109
Franklin	0.07	392538	0.12	141	0.07	190726	0.09	159895	0.08	1120
Garfield	0.18	156341	0.10	77668	0.16	38594	0.17	165262	0.18	3959
Grant	0.08	746904	0.16	390	0.09	581448	0.10	247650	0.09	0
Grays Harbor	0.22	2780	0.19	898015	0.19	94647	0.19	40831	0.23	28411
Island	0.17	1206	0.07	63632	0.07	3926	0.09	2300	0.11	19027
Jefferson	0.11	53	0.10	910189	0.09	2	0.09	1	NA	0
King	0.11	1505	0.07	854924	0.06	68800	0.07	20330	0.12	34579
Kitsap	0.08	11	0.08	141245	0.09	11816	0.08	5760	0.08	4111
Kittitas	0.16	9498	0.06	532734	0.06	24	0.07	13	NA	0
Klickitat	0.12	142996	0.11	311281	0.11	282009	0.12	381097	0.14	13122
Lewis	0.20	1832	0.13	1115993	0.16	117372	0.17	43790	0.24	105240
Lincoln	0.12	706635	0.11	35932	0.10	2	0.11	294316	0.11	7020
Mason	0.10	211	0.13	438402	0.13	58552	0.12	21098	0.16	8295
Okanogan	0.11	58697	0.06	107106	0.08	110570	0.08	910192	0.12	27466

				5		8				
Pacific	0.14	164	0.23	401222	0.22	58459	0.22	28197	0.28	8009
Pend Oreille	0.12	1176	0.05	738178	0.06	78844	0.08	32976	0.27	7944
Pierce	0.15	1722	0.06	607276	0.07	73392	0.06	47611	0.09	33033
San Juan	0.18	38	0.11	69367	0.12	1171	0.12	3624	0.14	15185
Skagit	0.20	54248	0.07	757852	0.06	72617	0.06	28223	0.12	36346
Skamania	0.16	1022	0.08	876539	0.09	67790	0.08	29151	0.22	3606
Snohomish	0.20	11762	0.07	906336	0.06	82210	0.07	23050	0.11	45184
Spokane	0.18	314955	0.09	251578	0.11	207688	0.13	159898	0.17	8519
Stevens	0.15	38321	0.08	101845 7	0.10	312629	0.10	134932	0.16	15866
Thurston	0.11	966	0.17	236390	0.16	31769	0.15	14226	0.17	57516
Wahkiakum	0.23	146	0.23	114647	0.24	14986	0.24	6574	0.24	4914
Walla Walla	0.12	472752	0.19	25906	0.11	104664	0.12	162113	0.17	3089
Whatcom	0.10	40350	0.06	839597	0.05	131096	0.05	47731	0.10	70544
Whitman	0.17	957121	0.18	11389	0.13	85312	0.13	223250	0.14	43128
Yakima	0.10	372558	0.07	817048	0.11	554059	0.12	774245	0.12	17694

Appendix C: Task 1 Blue and Teal Carbon Storage Summary

Table C1: Average sediment organic carbon storage and the acreage of blue and teal carbon dioxide sinks. SOCS = sediment organic carbon storage (units: g/cm2).

County	Teal SOCS	Teal Acreage	Blue SOCS	Blue Acreage
Stevens	0.74	30356		0
Benton	0.74	3585		0
Chelan	0.83	15080		0
Clallam	0.83	21757	0.63	1311
Cowlitz	0.78	20447		0
Grant	0.69	29368		0
Jefferson	0.82	25130	0.54	1341
Kittitas	0.83	12311		0
Lincoln	0.69	23039		0
Okanogan	0.78	46742		0
Pacific	0.79	44323	0.52	9023
Pierce	0.82	32541	0.56	1015
Snohomish	0.79	41809	0.50	2637
Walla Walla	0.76	5186		0
Whatcom	0.77	39862	0.52	779
Yakima	0.78	45761		0
Clark	0.78	20884		0
Mason	0.82	27658	0.54	2262
Grays Harbor	0.82	76495	0.55	5129
King	0.82	29912	0.66	228
Skagit	0.78	26254	0.51	4051
Ferry	0.80	17245		0
Whitman	0.70	13939		0
Thurston	0.80	35387	0.55	993
Franklin	0.74	6427		0
San Juan	0.74	4194	0.53	1169
Pend Oreille	0.75	23063		0
Skamania	0.83	12178		0
Columbia	0.71	2715		0
Island	0.71	5257	0.51	1061
Kitsap	0.82	10809	0.56	851
Lewis	0.82	65916		0

Klickitat	0.73	12978		0
Adams	0.71	12643		0
Spokane	0.73	36345		0
Garfield	0.71	306		0
Asotin	0.72	465		0
Wahkiaku	0.73	15397	0.63	306
Douglas	0.72	3624		0

Appendix D: Existing Standards Reviewed

CARB

- US Forest Projects
- Urban Forest Projects

Climate Action Reserve

- Grassland Protocol Version
- Forest Protocol
- Urban Forest Management Protocol
- Soil Enrichment Protocol Version
- Climate Forward, Reforestation Forecast Methodology Version 1.1

American Carbon Registry

- Methodology for Afforestation and Reforestation of Degraded Lands
- Avoided Conversion of Grasslands and Shrublands to Crop Production (ACoGS)
- Compost Additions to Grazed Grasslands
- Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on Non-Federal U.S. Forestlands

Verified Carbon Standard

- VM0003 Methodology for Improved Forest Management through Extension of Rotation Age
- VM0004 Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests
- VM0005 Methodology for Conversion of Low-productive Forest to High-productive Forest
- VM0009 Methodology for Avoided Ecosystem Conversion
- VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest
- VM0011 Methodology for Calculating GHG Benefits from Preventing Planned Degradation
- VM0012 Improved Forest Management in Temperate and Boreal Forests (LtPF)
- VM0015 Methodology for Avoided Unplanned Deforestation
- VM0017 Adoption of Sustainable Agricultural Land Management
- VM0021 Soil Carbon Quantification Methodology
- VM0024 Methodology for Coastal Wetland Creation
- VM0026 Methodology for Sustainable Grassland Management (SGM)
- VM0029 Methodology for Avoided Forest Degradation through Fire Management
- VM0032 Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing
- VM0033 Methodology for Tidal Wetland and Seagrass Restoration
- VM0035 Methodology for Improved Forest Management through Reduced Impact Logging

- VM0036 Methodology for Rewetting Drained Temperate Peatlands
- VM0042 Methodology for Improved Agricultural Land Management

City Forest Credits

Tree Planting Protocol, Version 9