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RANGELAND CARBON MARKETS

A PRIMER ON THE HISTORY, FUNCTION AND PROCESSES OF CARBON MARKETS RELEVANT TO TEXAS RANGELANDS

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LIST OF ACRONYMS

ACR American Carbon Registry
AFOLU Agriculture, Forestry, and other Land Use
ALM Agricultural Land Management

BAU Business as Usual
BEF Biodiversity & Ecosystem Futures

CAR Climate Action Reserve
CARB California Air Resources Board
CCB Climate, Community, & Biodiversity Standards
CCBA Climate, Community, and Biodiversity Alliance
CCX Chicago Climate Exchange
CDM Clean Development Mechanism
CER Certified Emissions Reduction
CFC Certified Forestry Credits
CH4 Methane
CME Chicago Mercantile Exchange
CO2 Carbon Dioxide
CO2e Carbon Dioxide equivalent
CORSIA Carbon Offsetting and Reduction Scheme for International Aviation
CRT Climate Reserve Tonnes

ERPA Emission Reduction Purchase Agreement
ERTs Emission Reduction Tons
ERT Environmental Resources Trust
ESMC Ecosystem Services Market Consortium
ETS Emissions Trading Scheme
EU ETS European Union Emissions Trading Scheme

GHG Greenhouse Gas
GM General Motors

ICAO International Civil Aviation Organization
ICAP International Carbon Action Partnership
IHS Information Handling Services

MEA Millennium Ecosystem services Assessment
Mt Megatonne
mt Metric tonne

N-GEO Nature-Based Global Emissions Offset
NGO Non-Governmental Organization
NK-CAP Noel Kempff Mercado Climate Action Project
NPP Net primary productivity
NRTs Nori Carbon Removal Tonnes

OPR Offset Project Registry

PES Payment for Ecosystem Services
PVC Plan Vivo Certificates

REDD+ Reduce emissions from deforestation and forest degradation
RGGI Regional Greenhouse Gas Initiative

SDGs Sustainable Development Goals
SEC Securities and Exchange Commission
SOC Soil Organic Carbon
SOM Soil Organic Matter

TAMU NRI Texas A&M Natural Resources Institute
TNC The Nature Conservancy
TSVCM Taskforce on Scaling the Voluntary Market

UNFCCC United Nations Framework Convention on Climate Change
UNFCCC **COP** UNFCCC Conference of Parties

VCM Voluntary Carbon Market
VCS Verified Carbon Standard
VCU Verified Carbon Unit
VERs Verified Emission Reductions
VVB Validation/Verification bodies

WCI Western Climate Initiative
WWF World Wildlife Fund

REPORT KEY

Beginning of new sub section within a chapter

End of chapter

Denotes part of the carbon offset process

FOREWARD

The purpose of this report is to provide an overview of carbon markets for natural resources professionals, landowners, agricultural producers, and others involved in making land management decisions by providing information on the background, history, processes and function of carbon markets. The authors of this report are primarily Texas natural resources management and conservation professionals. In recent years, we find ourselves asked by landowners, public land management agency representatives, local communities, and private corporate entities about carbon markets, how they function, what the implications for rangelands are, how to understand current controversies around the carbon offsets and whether they should become carbon market participants. Our hope in writing this report was to provide some of the background information needed to navigate this complex topic.

In the report we focus on those carbon markets that are most applicable to rangeland systems in Texas in an attempt to offer clarity for current voluntary carbon market system organization and processes. Given our focus and area of expertise and the complex and ever-shifting carbon market landscape, it is possible that there are nuances of policy and interpretation that are not completely covered, so we encourage readers to utilize some of the resources we cite for additional information. Furthermore, while we describe the voluntary carbon market process and function, we did not delve far into the current issues or controversies around these markets. Nothing stated in this document should be taken as an endorsement of any group, market system, or approach. Since almost all entities operating in these markets are private for-profit entities, it is not possible to discuss carbon markets without listing for-profit examples. Organizations mentioned or used as examples in this report were selected because we believed they were representative of the marketplace and important to market functioning, or because of familiarity and/or previous involvement from one or more of the authors. In this report, we do not make any claim as to their relative quality nor do we endorse any particular market approach.

There is no single strategy or market scheme that has emerged to dominate the offset credit market and no criteria or framework by which these markets are evaluated. Given the variety of approaches and groups involved in this space, landowners and land managers should carefully consider the potential obligations and requirements of these projects, as well as current controversy around carbon markets before entering into credit development contracts. There continue to be significant areas of debate as to whether the voluntary carbon market system can achieve its intended or stated benefits for climate mitigation.

The recent surge in demand and purchase of carbon offset credits has correlated with an increase in independent review and scrutiny of the carbon offset markets within the professional scientific and policy communities, as well as the public at large. There has been a steady increase in peer-reviewed studies, reports and news articles featuring examples of market flaws, including individual projects which have made inflated claims, had unreliable estimation methods, that failed for various reasons, or in some cases featured potentially fraudulent activities. Add to this that the utility of offsets for climate action is also being questioned, including when it is appropriate to use offsets, and whether the current use of offsets are actually harming efforts for climate action by allowing for inflated sustainability claims (i.e., greenwashing) that disincentivizes more meaningful action. This report does not closely examine these or other similar important concerns and neither do we closely review efforts from market participants to address them, not because they are unimportant, but because our goal was to gain a basic understanding of how carbon markets are organized and how they function.

In closing, the extent to which voluntary carbon markets can or do address these concerns will likely determine whether demand for carbon credits continues and what these markets' role within future national and global climate action will be. Either way, these markets are affecting changes on Texas lands and so land management and conservation professionals need to gain more understanding of these systems. Better informed professionals will also better prepare us for other nascent ecosystem service markets for water, biodiversity, or other services. We would like to encourage more attention and evaluation of these programs, and it is our hope that this report will help to foster a knowledgeable set of natural resources professionals and decision makers to continue that vital conversation within Texas and the country at large.

— FORREST COBB

1.0 INTRODUCTION

1.1 Ecosystem services markets

Ecosystems are dynamic and complex systems comprised of biotic components including plants, animals and microorganisms which interact with, transform, and depend upon abiotic components such as local climate or geology to sustain a functioning system. Ecosystem services are the benefits people obtain from these ecosystems and are generally described as falling into four categories:

- **Provisioning services** are directly received benefits such as food, water, timber, or fiber.
- **Regulating services** are those that moderate natural phenomena and include climate regulation, flood control, or water quality protection.
- **Cultural services** provide recreational or aesthetic benefits.
- **Supporting services** are those that support or facilitate many of the other service benefits. For example, soil formation, photosynthesis, and nutrient recycling (MEA 2005).

In the last decade, there has been an increasing number of Payment for Ecosystem Services (PES) schemes which have been developed to allow governmental, Non-Governmental Organizations (NGOs), and private organizations to pay for these public goods (i.e., ecosystem services, Kinzig et al. 2011). These market-like mechanisms are an approach to environmental management which use cash or other forms of payments to conserve and enhance these ecosystem service benefits by compensating landowners for their stewardship and management practices (Milder et al. 2010, Kinzig et al. 2011).

There are current PES schemes which have created markets for water quality and quantity, endangered species habitat, wetland mitigation, and climate change mitigation. The largest collection of PES markets, and the focus of this report, is for regulatory ecosystem services related to climate change; specifically, the removal of atmospheric carbon dioxide through natural carbon sequestration (i.e., carbon markets) and the reduction of carbon emissions from land use conversion or land management practices. While these carbon markets all differ in their application, most attempt to incentivize the landowner or land manager to enhance or conserve the ecosystem services provided by their lands.

This has generated enormous interest from landowners who are looking to capitalize on this demand. However, the design and application of these markets varies widely, and adoption of these market strategies will depend on many factors including continued demand, confidence in market benefits, market function, and the ability or desire of landowners to meet the legal requirements and management expectations within these markets.

Separate from the private market-based systems, federal agencies are increasingly being asked to consider ecosystem services in their programs, projects, and land-use planning.

On August 18th, 2022, the Office of Science and Technology Policy, Office of Management and Budget, and Department of Commerce jointly released a national strategy to develop a US system of natural capital accounting (Rahman et al. 2022). This system will estimate the contribution of ecosystem services to US economic activity in order to help direct future federal decision-making. In November 2022, the Council of Environmental Quality released "Opportunities to Accelerate Nature-Based Solutions," a guide to incorporating land use, conservation, and stewardship practices as a part of climate mitigation and other federal priority action areas. It seems likely that public agencies, especially those which regulate natural resource management, will continue to increase their use of ecosystem services concepts for decision-making in the future.

While we don't examine other systems or methods for financing the enhancement of ecosystem services in this report, it is important to note that carbon offset markets are just one financing/incentive approach in a larger global effort to utilize natural systems in climate action. This report provides a broad overview of the ecological processes which supply those climate change mitigation benefits (i.e., carbon sequestration and storage), a history of carbon markets and systems, current design and demand for carbon credits, example markets which operate or can operate in rangelands, how they function, and an overview of the requirements to generate credits under some of the major voluntary carbon markets.

2.0 SOIL CARBON DYNAMICS

2.1 The soil carbon cycle

In carbon markets, the largest carbon pool tracked within grasslands and shrubland systems is the carbon in soils. Soil carbon sequestration is the process by which carbon dioxide (CO_2) is captured, converted, assimilated, and stored in organic or inorganic forms. Soil carbon sequestration is generally presented as a rate, since it represents the amount of carbon that has been incorporated over time, generally as carbon mass per year. Carbon storage refers to the total carbon stocks, the amount of carbon already present in the soil and plant biomass. Soil carbon sequestration is driven primarily by organic carbon inputs from plant species, but local fauna, soil microbial and invertebrate communities, as well as chemical reactions between soil minerals and the atmosphere are also sources of soil carbon.

Carbon dioxide is a normal, if small (approximately 0.04%) component of the earth's atmosphere (Buis 2022). Human-driven emissions have increased CO_2 levels in the atmosphere by as much as 45% since the Industrial Age, primarily from the burning of fossil fuels (Buis 2022). Fossil fuels are ancient plant and animal hydrocarbons that form under immense pressure and temperatures underground. When fossil fuels are burned, those complex hydrocarbon molecules release energy and CO_2.

Plants convert CO_2 in the atmosphere into complex carbon molecules (e.g., glucose) through photosynthesis to be used as energy or to create plant tissues. A living plant's mass is made up mostly of water, but most of the dry mass of a plant is carbon sourced from atmospheric CO_2 and plants make up about 80% of total global biomass (Bar-On et al. 2018). When describing plant biomass in an ecosystem we will often refer to aboveground biomass (primarily plant mass in shoots, leaves, trunk, etc.) and belowground biomass (the mass of soil biota, plant roots, rhizomes, tubers, etc.; Figure 1).

Carbon enters the soil directly from root material, plant litter, and other natural depositions. Plant organic matter can also enter indirectly through animal consumption as manure, as well as through the decay and decomposition of deceased animals. These plant and animal residues, along with the living plant roots, soil fauna, and the microbial community make up soil organic matter (SOM) and soil organic residue.

Soil organic carbon (SOC) makes up around 58% of the total SOM, with oxygen and hydrogen mostly constituting the rest of SOM (Heaton et al. 2016). SOM is all the organic compounds present in the soil including plant litter, soil organisms including microorganisms, microbial products, and all other organic matter (Foth 1991). Soil organic carbon is the mass of carbon present within SOM. The decomposition of SOM results in many different carbon pools and also provides plants with important nutrients such as nitrogen, phosphorus, potassium, sulfur, and other micronutrients.

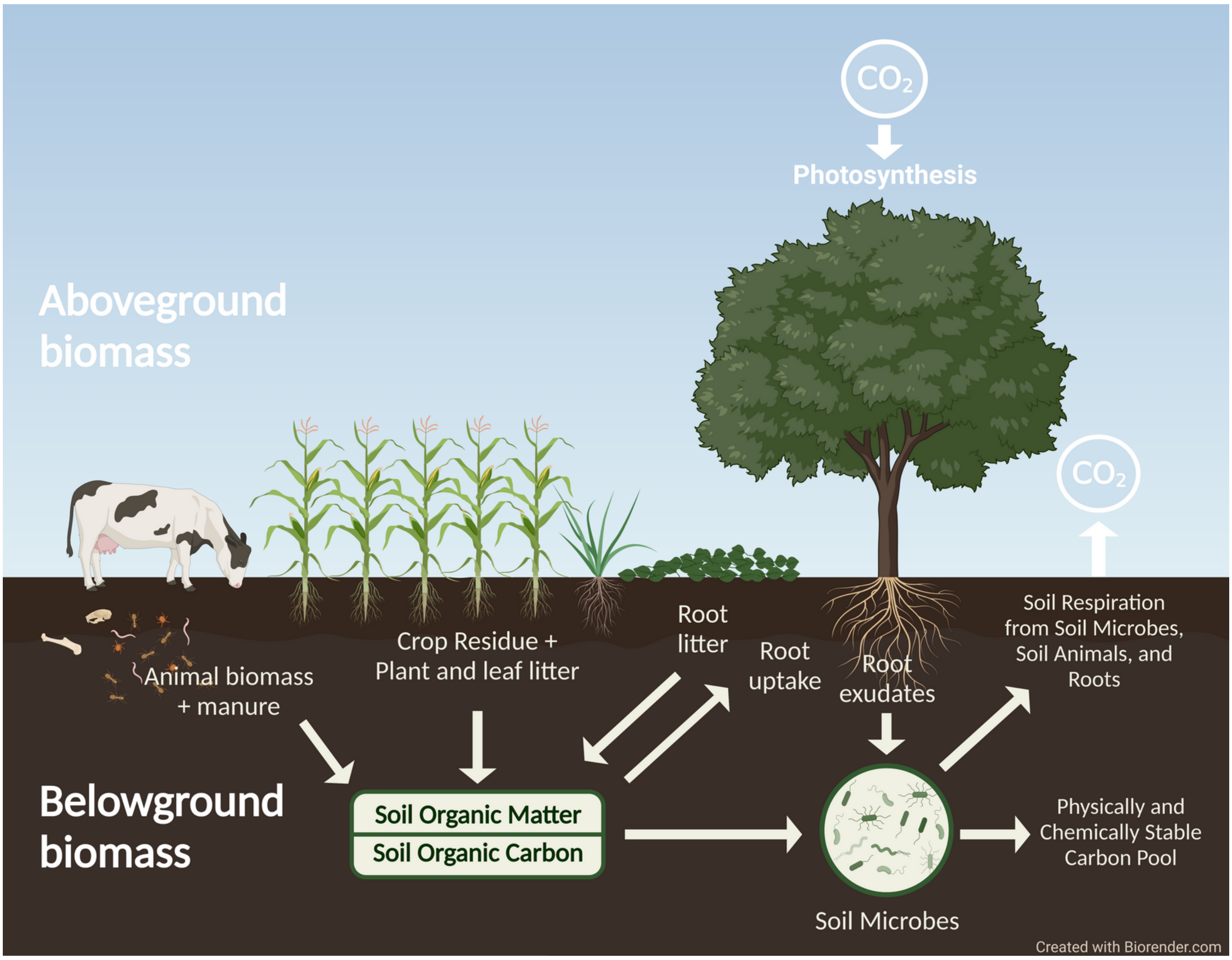

Figure 1. Soil carbon cycle with carbon inputs and outputs and the decomposition of organic matter to create stable carbon.

Decomposition of SOM occurs in various stages; thus, SOC can be present in various forms that differ in their relative stability or resistance to decomposition.

Some CO_2 is also emitted from soils, from plant roots, soil fauna and soil microbial respiration. Soils will generally sequester more carbon than emitted but changes in land use, land management, climate, or other factors can affect carbon inputs and can create a deficit and SOC reductions over time. Conversely land-use changes can encourage more carbon inputs and facilitate gain through additional sequestration of carbon in soils over time. Plant production and decomposition are major determinants that affect carbon fluxes in soil. Plant-derived compounds can persist in the soil for many years and can represent 25-50% of SOC even after 50 years with no new plant inputs (Barré et al. 2018). Soil organic carbon generally decreases with soil depth since the upper layers of soil contain the bulk of living roots and root litter (Sokol et al. 2019).

The type of ecosystem and its dominant species can determine the type, distribution, and number of organic residues that are available to become SOM.

Ecosystems like grasslands, shrublands, and forests harbor significant differences in SOC amounts and distributions throughout the soil (Figure 2, Jackson et al. 1996, Chen et al. 2018). While many SOC studies have been limited to the upper soil layers in the 0-30 cm range, root zones in certain ecosystems can extend down much farther, as much as 1 or 2 m in some soils, leading to substantial SOC at lower depths (Jackson et al. 1996).

Plant species composition can also affect SOC. For example, C4 grasses can contribute to higher rates of soil carbon sequestration than C3 grasses because they have more above and below-ground biomass, slower decomposition rates, and higher nitrogen-use efficiency (Yang et al. 2019). Vegetation types also have different responses to disturbances or management actions, such as grazing or prescribed burning, which can positively or negatively affect carbon inputs (Abdalla et al. 2018, Hou et al. 2021). In general, vegetation community diversity and richness have been shown to have a positive relationship with soil carbon (Anacker et al. 2021). Management strategies, such as afforestation or reforestation, can also increase carbon sequestration through higher inputs of surface litter and roots as well as the formation of stable macroaggregates (Liao et al. 2006).

Aside from plant organic matter inputs, many factors can affect soil carbon sequestration, soil carbon distribution, and carbon storage. For example, soil texture can impact the ability of a soil to incorporate and retain organic carbon. Even in an area with similar plant communities and productivity, soil texture can influence the amount and retention of SOM in a soil. Finer clay particles have a higher surface area and ability to bind more carbon compounds than coarser sand particles (Figure 3). Soil particles in the clay and silt fraction can chemically stabilize carbon compounds by binding to them, which can be a major form of carbon storage in some soils, while silt and clay will also protect SOM by the occlusion of organic matter in stabilized soil aggregates (Hassink 1997, Six et al. 2002). Therefore, soils with higher amounts of clay usually store more SOC (Hassink 1997, Six et al. 2002). Because of the stabilizing capacity of clay, coarser sandy or loamy soils are more susceptible to land degradation and the subsequent decomposition of SOM than clay soils and are more dependent on constant carbon inputs (Dlamini et al. 2016). All these dynamics have implications for the storage capacity of organic carbon in certain soils. Many other soil characteristics can influence the amount of SOM and rate of sequestration, but texture is an example of a broad characteristic that can influence sequestration even within a property or properties that have similar management and plant productivity.

Above and Belowground Carbon Storage by Ecosystem

Tonnes of Carbon per hectare

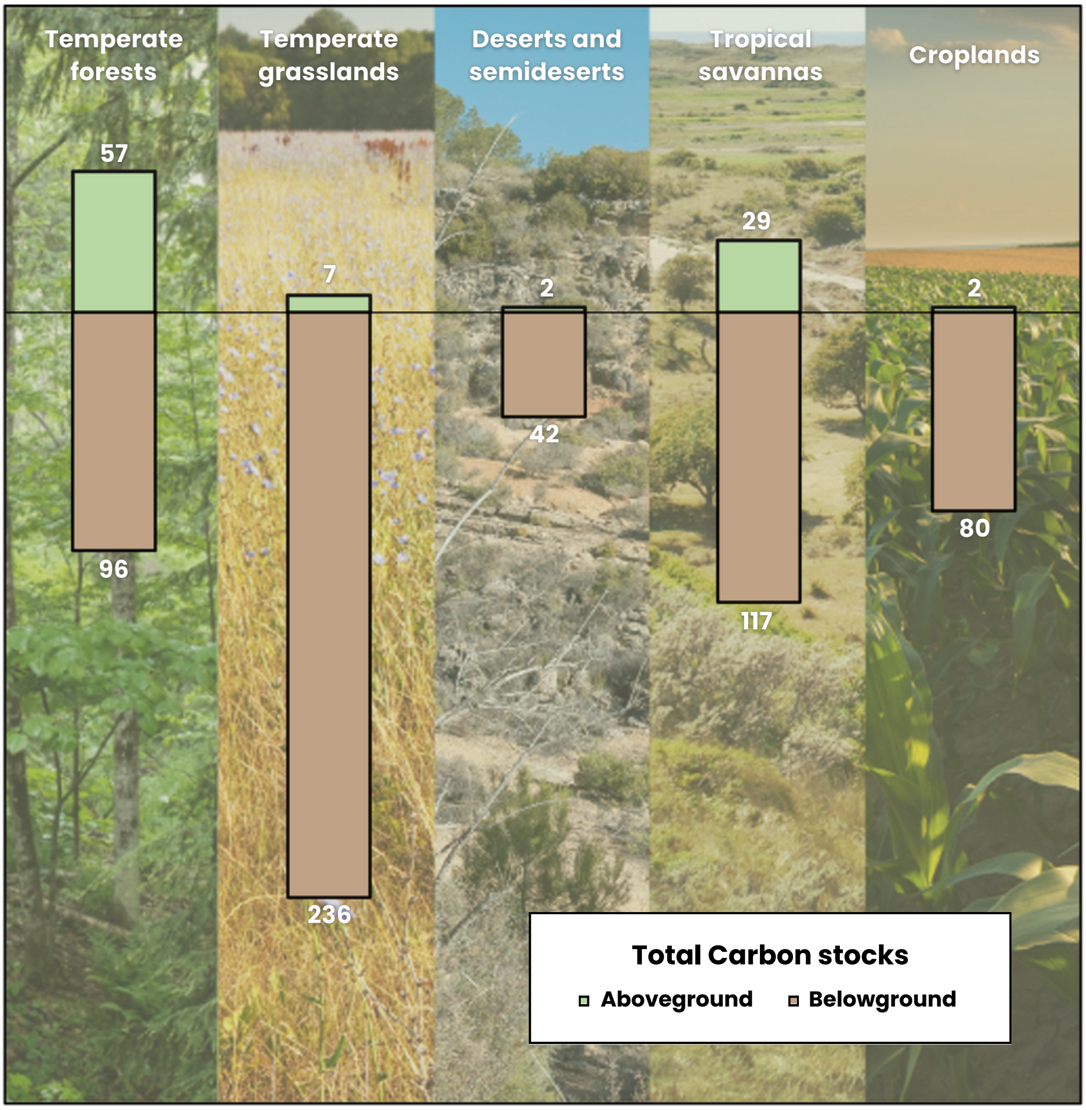

Figure 2. Mean aboveground and belowground organic carbon stocks in ecosystems across the globe. Data provided from IPCC 2000.

Outside of soil characteristics, precipitation has a major influence on soil carbon sequestration. Precipitation drives plant growth which increases carbon inputs. More precipitation also means more microbial activity and faster rates of decomposition, converting organic residues into SOM (Chen et al. 2016). Microbes contribute to the organic carbon inputs into soil and can account for around 50% of the SOC in agroecosystems (Angst et al. 2021).

Conversely precipitation can also cause carbon loss through leaching, especially under extreme precipitation events. Increased precipitation can also increase microbial respiration which is one of the primary drivers responsible for soil carbon loss (Figure 1, Liu et al. 2018).

Soil organic carbon tends to be lower in areas with higher temperatures. Higher temperatures can result in more plant growth (a.k.a. an increase in plant net primary productivity [NPP]) which adds more inputs to SOC.

However, soil microbial and invertebrate respiration will also increase, resulting in greater CO_2 emissions which can make soils a net carbon emitter (Figure 1, Kirschbaum 1995).

Many of the factors that affect soil carbon such as climate and chemical/ physical condition of soils, are out of our control. However, certain types of land management practices can influence carbon sequestration by changing carbon inputs, microbial activity, or by mitigating carbon loss. In cropping systems, there are several management activities that can be used to increase soil carbon sequestration and retention. Converting from a conventional tillage system to a no-till or reduced tillage system can help reduce soil compaction, erosion, and disturbance of aggregates (Wuaden et al. 2020). Leaving crop residues on fields instead of removing them can create higher carbon inputs into the soil (Bolinder et al. 2020).

Similarly, changing or expanding crop rotations and introducing cover crops to provide an additional source of crop residues and carbon inputs can enhance SOC (Huang et al. 2020, McClelland et al. 2021).

Grazing management can also be modified to affect soil carbon. Practices such as optimizing stocking rate, implementing rotational grazing, or improving forage production can increase carbon inputs and decrease loss of soil carbon (Derner et al. 2006, Abdalla et al. 2018). Overgrazing can decrease carbon inputs by decreasing aboveground biomass and shortening root elongation (Schuster 1964). However, an appropriate grazing intensity can increase soil carbon sequestration by promoting greater turnover of plant material and by adding manure. Rotational grazing for example can promote healthy vegetative cover and improve forage productivity (Abdalla et al. 2018).

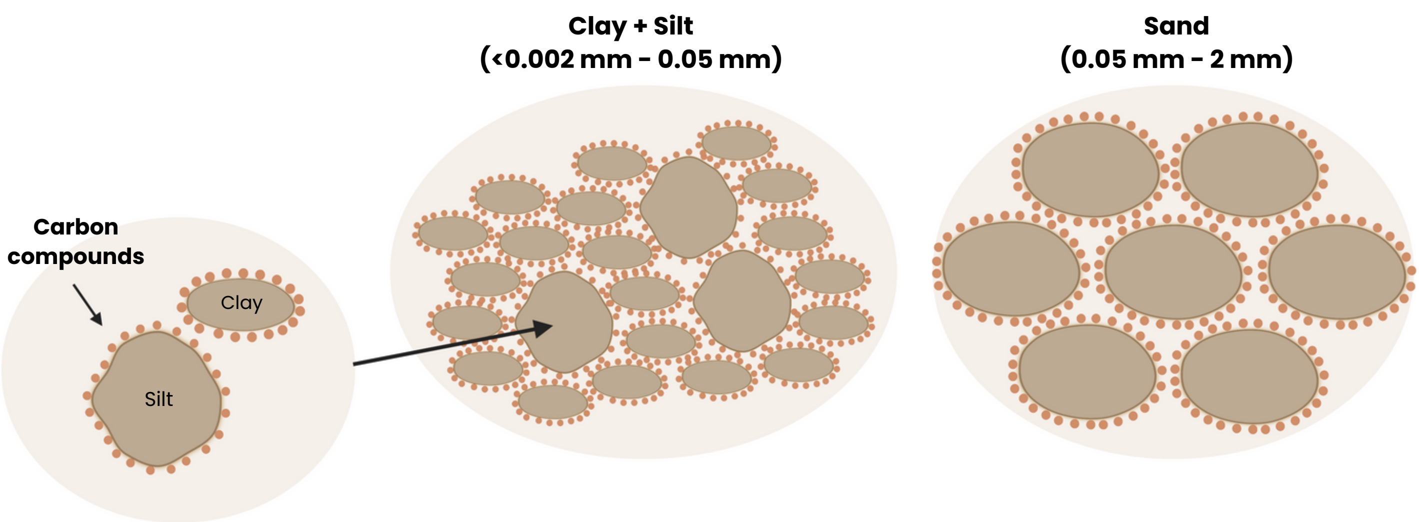

Figure 3. Diagram of carbon compounds binding to the surface area of the clay + silt fraction of soil and the sand fraction of soil illustrating that more carbon binding sites are available in a clay and silt soil than in a sandy soil.

Since rangelands encompass a wide variety of ecotypes which are grazed by domestic livestock or wild animals and include grasslands, shrublands and woodland, management approaches to increase carbon sequestration can vary. Implementing adaptive livestock management, preserving existing rangelands, restoring degraded rangelands or converting croplands to perennial grasslands by eliminating tillage, reducing soil erosion, and increasing surface litter and root biomass are all ways to protect or enhance SOC and phytomass (Gebhart et al. 1994, Sanderson et al. 2020). While there is an impressive body of research on the soil carbon implications of land management in the US, additional research is still needed to determine soil carbon implications of different management strategies especially grazing management in rangeland systems.

2.2 Soil organic carbon in Texas

Texas is a large state with a large diversity of ecosystems, soils, and land uses. Since rainfall, ecological communities, pH, historical land use, and soil properties affect SOC, it varies considerably across the state. To illustrate the regional and geographic variation of soil carbon storage see Figure 4 which provides a rough estimate of current soil carbon stocks across Texas in g C/m^2 in the first 12 inches (30 cm) of soil.

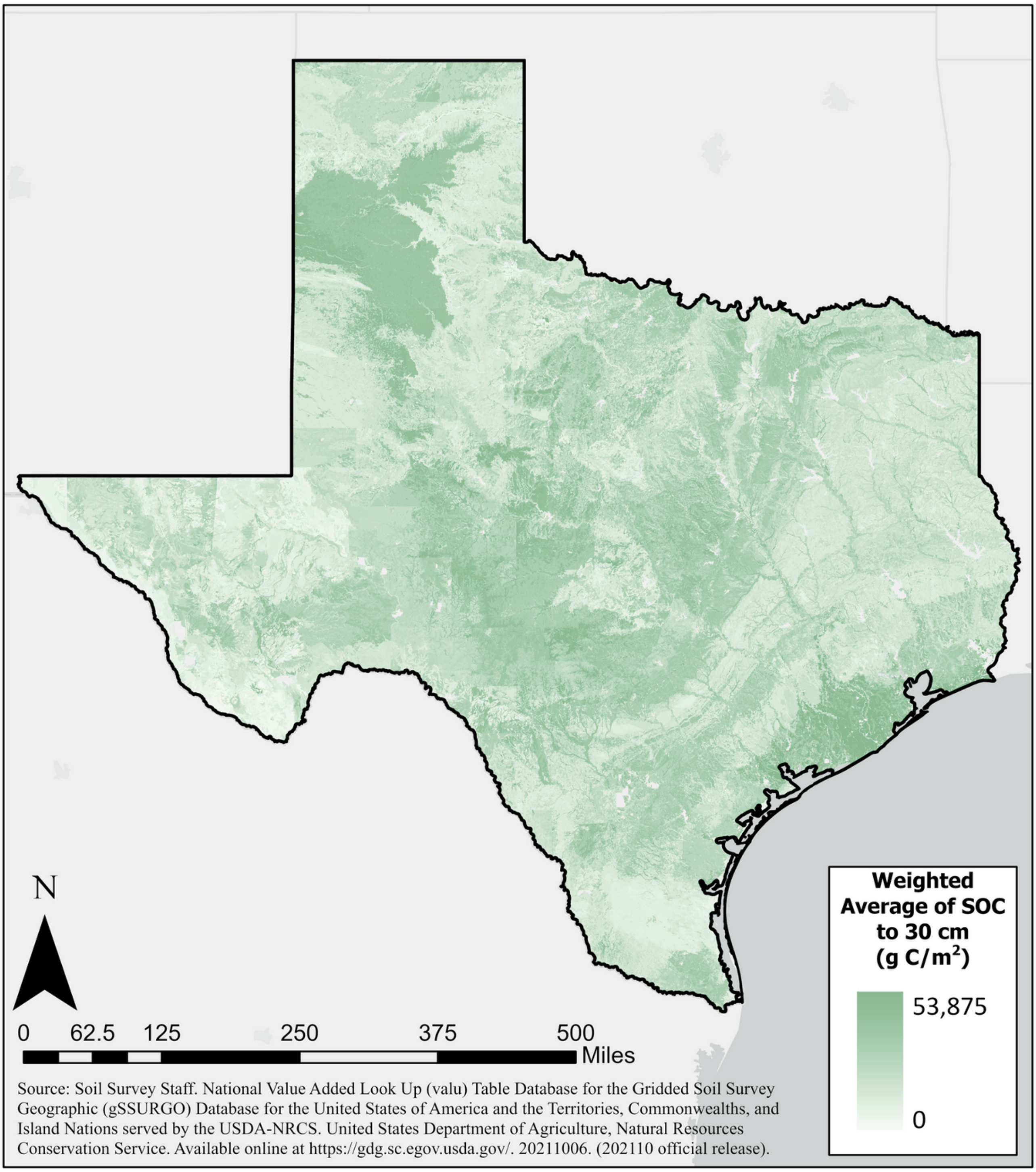

Figure 4. Soil organic carbon (g C/m^2) in Texas to a depth of 30 cm. Data sourced from gSSURGO database (USDA-NRCS 2021).

3.0 BRIEF HISTORY OF CARBON CREDITS

3.1 Emergence of int'l carbon markets

In 1988, the Maltese government initiated an international negotiating committee by submitting a resolution to the UN General Assembly requesting countries convene to discuss global climate change (UN GA 1998). Meetings began in 1990 with a goal of producing a document by the 1992 United Nations Conference on Environment and Development. Countries completed their work by the summer of 1992 and began the process of ratifying the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty that pledged member states to reduce greenhouse gases to 1990 levels. This document further pledged to continue to meet to discuss solutions to global warming. Five years later, the Kyoto Protocol emerged, an international treaty under which countries agreed to reduce emissions.

The Kyoto Protocol elaborated three Kyoto mechanisms to lower the cost associated with reducing carbon. One of those mechanisms, the Clean Development Mechanism (CDM), by virtue of its prompt start, became the first carbon crediting scheme in history (UNFCCC 1998). The CDM allowed countries to implement emissions reduction and carbon sequestration projects in developing countries to help reach their emissions targets. During CDM negotiations, forest management was debated but not included due to methodological difficulties in establishing the amount of carbon removed attributable to a project (Plantinga and Richards 2008).

As of March 2016, version 1.0 of the Standard: Applicability of Sectoral Scopes came into effect which outlines methodologies under the 15 sectoral scopes of the Kyoto Protocol (UNFCCC 2016). Scope 14 outlines methodologies for afforestation and reforestation, while scope 15 outlines methodologies for agriculture. Project proponents register activities that earn certified emissions reduction (CER) credits. These credits can be bought or banked to be used in a complex carbon accounting system to determine countries compliance with the Kyoto Protocol in the first five-year commitment period from 2008 - 2012.

Intense negotiations about the amount of carbon sequestration allowed under the CDM during the second mandatory commitment period contributed to the failure to create a second commitment period in November 2000. This coincided with the election of President George W. Bush who withdrew the United States from any further negotiations. However, negotiations at the yearly UNFCCC regarding measures to take after the end of the second commitment period (i.e., 2020) of the Kyoto Protocol eventually led to the 2015 Paris Agreement. The Paris Agreement, a legally binding, international treaty, was negotiated by 196 parties at the 2015 UNFCCC near Paris, France. The treaty set long-term goals to keep change in mean global temperatures well below 2°C preferably below 1.5°C, reduce emission levels 50% by 2030, and achieve net-zero emissions by the mid-21st century (UNFCCC 2015).

Unlike the Kyoto Protocol, the Paris Agreement requires countries to regularly submit updates on current emission levels and to develop plans to reduce emissions (UNFCCC 2015). Under Article 6 of the Agreement, a framework was developed for global carbon markets and international trading of emissions reductions to achieve lower global emission targets. The United States joined the Paris Agreement in 2015 under the Obama Administration, briefly withdrew from the treaty in 2020 during the Trump Administration, and then rejoined in 2021 under the Biden Administration (Bodansky 2021).

While no further legally binding commitment period has been successfully negotiated, proponents of climate actions within the international community have championed the need to include natural-based carbon offset projects in any future mandatory programs. The Biden Administration's 2021 National Determined Contribution (NDC), which is the US plan for meeting greenhouse gas (GHG) reduction targets under the Paris Agreement in 2015, acknowledges the role of natural carbon sequestration and storage to meet climate goals through reforestation, forest management, and application of agricultural best management practices. The NDC however, does not include a numerical target for the contribution of these natural climate solutions (United States 2021). The UNFCCC Council of Parties (COP) annual meetings are where new agreements under the UNFCCC are discussed and negotiated. At COP meetings, agreements were made that allow carbon credits generated under the CDM to be sold between companies in different countries. This allows for development of carbon credits that can be transferred internationally and used in other countries to meet NDCs under the Paris Agreement. Future guidance on international trading of credits will likely be expanded under Article 6 of the Paris Agreement at future COP meetings and may have implications for voluntary carbon market systems. Outside of internationally binding commitments, US voluntary carbon markets have developed as public and private sector net-zero emissions commitments have increased.

3.2 Carbon markets in the U.S.

Within the US, mandatory cap-and-trade programs, as well as voluntary carbon markets, have developed to reduce and compensate for state-wide and private company GHG emissions (Figure 5). Mandatory carbon programs include California's Cap-and-Trade Program (Cushing et al. 2016), Massachusetts Limits on Emissions from Electricity Generators [International Carbon Action Partnership (ICAP) 2021], the Regional Greenhouse Gas Initiative (RGGI, Murray and Maniloff 2015), and the Western Climate Initiative (WCI, Section 4.2, Cullenward et al. 2019).

California's Cap-and-Trade Program, the largest mandatory program in the US was launched in 2013 after California's 2006 Global Warming Solutions Act called for a sharp reduction of GHG emissions within the state (Cushing et al. 2016). The program includes nature and non-nature-based offset approaches with goals to reduce GHG emissions to 1990 levels by 2020, 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050 (ICAP 2021). The state aims to be carbon neutral by 2045 (ICAP 2021).

Voluntary carbon markets began to increase rapidly after 2005 with demand for methods to minimize CO_2 emissions outside of countries within the Kyoto Protocol and as demand for carbon offset programs within developed countries increased (Broekhoff et al. 2019). The world's first private/independent voluntary carbon credit registry, the American Carbon Registry (ACR), was launched in 1996 by the Environmental Resources Trust (ERT, ACR 2022). Carbon registries (also sometimes termed standards), approve protocols for offset credit generation and track credit ownership to provide transparency for offsets and the projects from which they were generated (Section 5.6, Broekhoff et al. 2019). Other successful international and domestic voluntary carbon offset programs have since been developed including the Verified Carbon Standard which was launched in 2007 and which is currently the largest voluntary carbon credit registry by volume of transacted carbon credits, discussed further in Section 5.6 (Ecosystem Marketplace 2022).

While some programs have grown over the years, there have been failed attempts to establish carbon crediting schemes and markets as well. For example, and most notoriously, the Chicago Climate Exchange (CCX). The CCX was launched in 2003, and was a voluntary, legally binding cap-and-trade program with both nature and non-nature-based projects containing more than 400 members such as DuPont, Ford, and Motorola (Tianbao 2013). CCX activities took place in all 50 states within the US, 8 Canadian provinces, and 16 countries with about 700 million metric tonnes (mt) of CO_2 credits (Tianbao 2013). Following the program's second commitment period, the CCX closed in 2010 after a significant decrease in the price of carbon credits (Sabbaghi and Sabbaghi 2017). The reasons for the closure of CCX have been intensely debated. The lack of legislation to establish a mandatory carbon market in the US left large investors disinterested in continuing to fund a voluntary cap-and-trade program. Additionally, while the CCX had been initially celebrated by climate activists, the market become flooded with credits generated from offset projects resulting in oversupply, causing prices to plummet (Sabbaghi and Sabbaghi 2017). Given plummeting prices, combined with concerns about the quality of credits being generated, the consumer community began to question the legitimacy of the program and thus to rapidly lose confidence.

The collapse of CCX irreparably damaged trust in voluntary carbon markets among many key stakeholders including landowners, agricultural producers and other key land managers who were heavily engaged by the CCX program. Many of these stakeholders, as well as potential purchasers of credits remain distrustful of voluntary carbon markets given this past experience. The CCX's failure highlights the uncertainty and potential volatility within voluntary carbon markets and emphasizes that efforts from carbon offset market participants to support confidence in the validity of the credits are vital if they want stable functioning markets to continue.

3.3 Greenhouse gas inventories

With some exceptions, large private, state, and federal entities within the US are required by the Environmental Protection Agency (EPA) to report GHG emissions. The accounting of all GHG emissions from an entity is its GHG inventory. Most GHG inventories are generated using the GHG protocol developed by the World Resources Institute, which is the standard international guidance used worldwide (Ecosystem Market Consortium [ESMC] 2021). Entities inventory their GHG emissions in three categories called "scopes" as follows:

- **Scope 1** is all GHG emissions that come directly from owned or controlled operations. Examples include company vehicles, equipment, or owned facilities.
- **Scope 2** is emissions from power generation. Emissions from power generation are indirect since power is usually purchased from a public utility.
- **Scope 3** is indirect emissions from a private entity's upstream supply chain (or value chain) as well as from downstream uses of its products. For a bakery, for example, all emissions associated with the production, milling, and transport of wheat would be part of their value chain scope 3 emissions inventory.

Corporate entities often employ different strategies for reducing emissions based on scope. For example, a switch to a renewable energy utility or purchase of renewable energy credits could be used to reduce scope 2 emissions. To reduce scope 1 emissions, a diesel vehicle fleet could be replaced by an electric vehicle fleet or the number of employee airline flights in a given year could be reduced. For any emissions a corporate entity does not directly eliminate or reduce, offset credit purchases are being utilized to achieve "net" emissions reductions. Offset credits represent a unit of avoided emissions, or of atmospheric carbon sequestered, that is then claimed (retired) by the purchaser and the credit amount subtracted from GHG emission inventories. For Scope 3 emissions, reductions can also be achieved by compensation using offset credit purchases or increasingly through a process called insetting (See Section 4.5). Carbon insetting is a growing practice which is driving the creation of many new offset programs and projects and varies considerably in approach since it is done entirely within a company's own value-chain.

HISTORY OF CARBON MARKETS

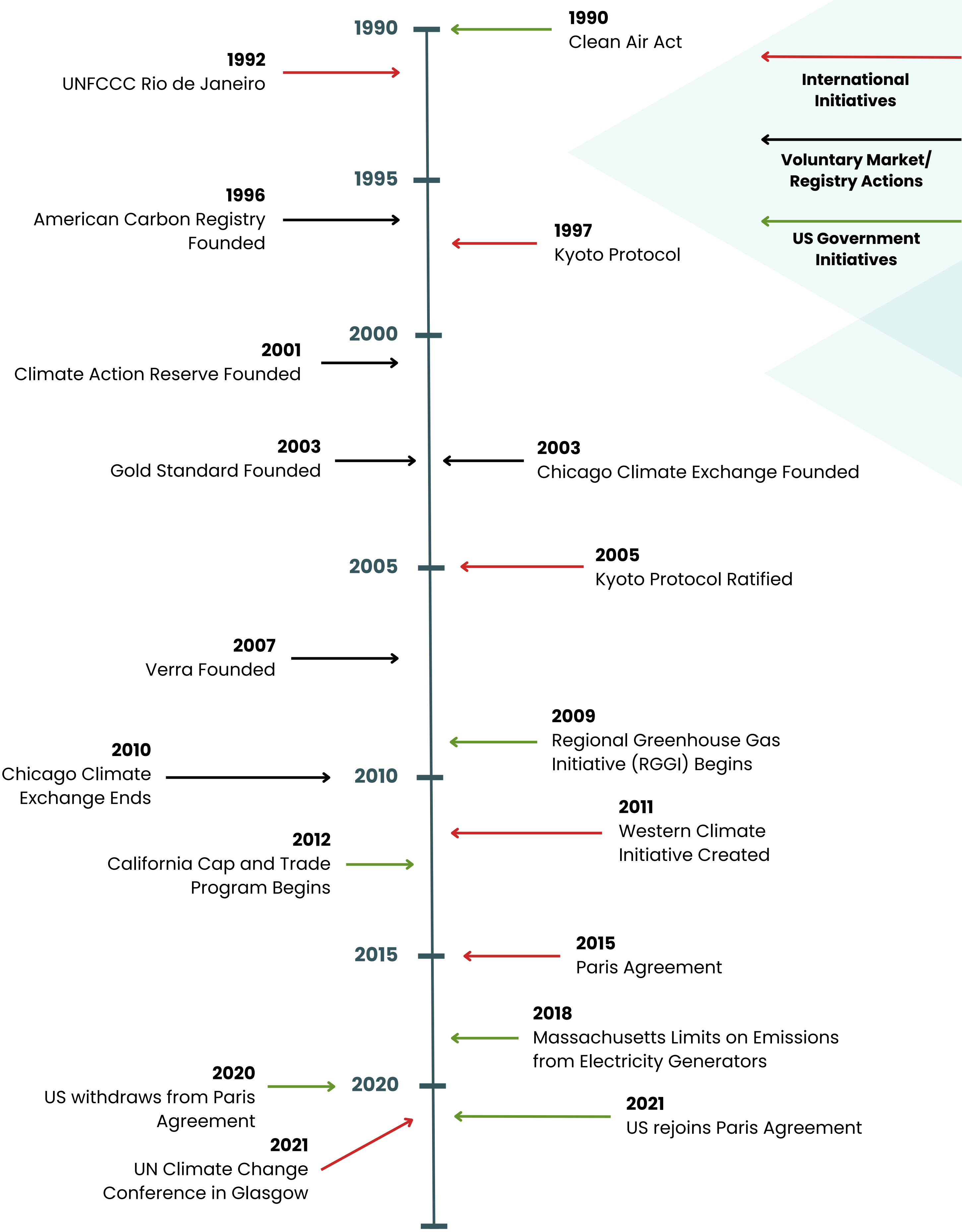

Figure 5. Timeline and history of carbon markets from 1990 to 2021.

4.0 CARBON CREDITS

4.1 Carbon offset credits

Since this report focuses on voluntary carbon offset markets we will use the terms carbon credit, verified emissions reductions, carbon offset, and carbon offset credit somewhat interchangeably. However, carbon credits can also be tied to compliance driven markets or cap-and-trade programs. Within those programs, a carbon credit can represent the right to emit a unit of carbon (also termed an allowance). A company that does not emit all its allowable carbon can sell that right (carbon credit) to another entity.

A carbon offset credit, on the other hand, is a fungible commodity that represents a unit of atmospheric GHG removed (sequestered) or GHG emissions avoided, typically 1 tonne carbon dioxide equivalent (CO_2e). In voluntary markets, projects are funded to reduce atmospheric CO_2 through removals and avoided emissions and those reductions are quantified, purchased, and eventually claimed to compensate (e.g., offset) for the purchasers' own GHG emissions (Section 5.0). Most major voluntary market groups have proprietary terms for their verified offsets (Section 5.6, Table 1) but for simplicity we will refer to all of them as credits.

There is no single standard or method by which companies utilize carbon offset credits. Many entities have emerged to try and provide guidance including the Science Based Targets Initiative (SBTi) which is a partnership that includes the World Wildlife Fund and United Nations Global Compact Initiative. SBTi is a non-profit that assists private companies in creating GHG reduction plans designed to meet international targets for limiting global warming to 1.5°C. While SBTi is not utilized universally, at the end of 2021, 2,253 companies across 70 countries and representing more than a third of global market capitalization had emissions reductions targets approved through the system (SBTi 2021). In their general guidance they recommend using "high-quality" carbon offset credits to assist in transitioning to a state of net-zero emissions and then to help eliminate residual emissions once net-zero is achieved. They do not recommend utilizing carbon offset credits in lieu of direct emission reductions and furthermore suggest limited dependence (5 - 10%) on carbon removal offsets long-term (SBTi 2021, 2022).

While most programs similar to SBTi, recommend using "high-quality" credits, there is also no one standard or criteria for judging the quality of an offset credit. In the Oxford Principles for Net Zero Aligned Carbon Offsetting, Allen et al. (2020) defines a high-quality credit as one which includes rigorous accounting, requires additionality, ensures longevity of carbon storage, and accounts for reversals along with other quality control criteria (discussed further in Section 5.5). We will use the above general definition when discussing a "high-quality" credit but that should not be taken as an endorsement of the credits or the quality of the projects that generate them. There have been attempts to evaluate how well credits fulfill or meet criteria of a "high-quality" credit. One example is the Carbon Plan initiative, a non-profit that has begun to rank the quality of various credits based on the rigor of calculations, durability of carbon benefits, safeguards and additionality requirements. In their ranking system (1-5) they found very few credits which ranked above a 2 in their quality assessment rating (Zelikova et al. 2021).

4.2 Voluntary versus compliance markets

Carbon markets are comprised of both voluntary programs which trade offset credits in the private sector, and compliance programs which are driven by national or sub-national government laws, regulations, and programs. Demand for carbon offsets within voluntary markets comes primarily from corporations, individuals, and/or private institutions, while credit demand within the compliance market is created by a regulatory mandate (Broekhoff et al. 2019).

A compliance market is regulated by national, regional, or international laws, and mandates the regulation of emissions to comply with GHG emission reduction requirements (Lovell 2010). While compliance markets have not been established within Texas, regional cap-and-trade emission trading schemes have been developed within the United States (Section 3.2, ICAP 2021).

The broadest carbon pricing system within the United States is California's Cap-and-Trade Program which was implemented by the California Air Resources Board (i.e., CARB, Cullenward et al. 2019). The program began operation in 2012 and is expected to reach 200.5 Megatonnes CO_2e ($MtCO_2e$) cap by 2030 (ICAP 2021).

Voluntary markets have proliferated within the last 20 years to meet the emerging demand for offsets (Broekhoff et al. 2021). The voluntary market began to grow after 2005 as the CDM became more established and allowed companies and/or individuals to purchase carbon offsets on a voluntary basis (Broekhoff et al. 2021). Voluntary offset credits fill a different role and function than compliance cap-and-trade allowance or offset credits and so cannot be used interchangeably. Since most offset credits are purchased and used voluntarily, they tend to be cheaper than credits in a compliance market, which are scarce relative to demand by design (Broekhoff et al. 2021). The voluntary market includes a wide range of programs, for profit and non-profit entities, standards, and protocols but is dominated by four standards/registries: Verra, American Carbon Registry, Gold Standard, and Climate Action Reserve discussed further in Section 5.2 and 5.6.

4.3 Demand for carbon offsets

Interest in carbon offsets has surged and is being driven in the US primarily by corporate net-zero emissions targets. Companies that had not already begun setting goals for reducing GHG emissions from their operations and products are facing increasing pressure from customers, investors, governments, and the public to reduce their impact on climate change. The US Securities and Exchange Commission (SEC) recently proposed new requirements in March 2022 that would significantly expand mandated climate-related disclosures from public companies (SEC 2022). Climate change-related lawsuits filed by individuals and NGOs have more than doubled since 2015 and are being joined by lawsuits filed by cities and states across the US against large corporate entities, especially the fossil fuel industry (Gil 2022, Kaminski 2022). Investing groups and asset managers are also beginning to demand increased climate commitments from companies. For example, the signatories to the Net Zero Asset Managers Initiative, which represent 292 asset managers with approximately 68 trillion USD in assets, have committed to adjusting their investment strategies to support limiting warming to 1.5 °C including seeking out companies with net-zero commitments (The Net Zero Asset Managers Initiative 2022).

In reaction to this and other pressures, an increasing number of companies have declared net-zero commitments, including 21% of the world's largest companies as of 2021 (Black et. al 2021). Net-zero commitments are typically publicly announced, non-binding goals to prevent any net increase in GHG emissions from operations as inventoried in scope 1, 2, and 3 emissions (Section 3.3, Shetty 2021). Most net-zero announcements will also set a target year for achieving those reductions anywhere from 2025 to 2050. The strategies for achieving these net-zero commitments vary but generally involve a combination of direct emissions reductions, insetting (Section 4.5), and offsetting strategies. Many corporate net-zero plans have leaned heavily on offset credit purchases.

For example, in January 2021, General Motors (GM) announced plans to achieve carbon neutrality by 2040 by ramping up electrical vehicle motor production, switching to renewable energy providers, and through the purchase of carbon offsets that include nature-based projects (General Motors 2021). Jeff Bezos announced in 2019 that Amazon would reach net-zero in 2040 by switching to 100% renewable energy and by investing $100 million in nature-based carbon offset projects (Thorbecke 2019). Even organizations like the Boston Red Sox have declared carbon neutral goals with Fenway Park announcing in March 2022 that they will be financing the purchase of carbon offsets (Moroney 2022).

These net-zero goals often assume, or are dependent on, financing nature-based carbon offset projects. Microsoft has declared a net-zero emissions goal for 2030 but has further committed to removal of all carbon emissions from the lifetime of the company by 2050 through direct emissions reductions, insetting, and from purchase of offset credits, labeled in Figure 6 as carbon removal (Smith 2020).

Global carbon pricing revenue in 2021 was around $84 billion, and for the first time the voluntary carbon offset market value exceeded $1 billion (The World Bank 2022). Carbon credit markets grew by 48% in 2021, with the total number of credits issued since 2007 equaling 4.7 billion tCO_2e (The World Bank 2022).

4.4 Nature-based carbon offsets

Like many companies, most offset purchases made by Microsoft in FY21 were from nature-based projects which are those that seek to remove CO_2 from the atmosphere by conserving, restoring, or better managing ecosystems and agricultural lands. Offset projects funded by Microsoft for FY21 included forestry improvement, cropland management, and holistic cattle grazing with contracted durability ranging from 13 years to 100 years (Microsoft 2021).

Within voluntary markets, nature-based offsets are those that typically involve agriculture, forestry, and land use projects often abbreviated as AFOLU. Nature-based carbon credits were the largest portion of the voluntary carbon market by volume in 2021 (Ecosystem Marketplace 2022).

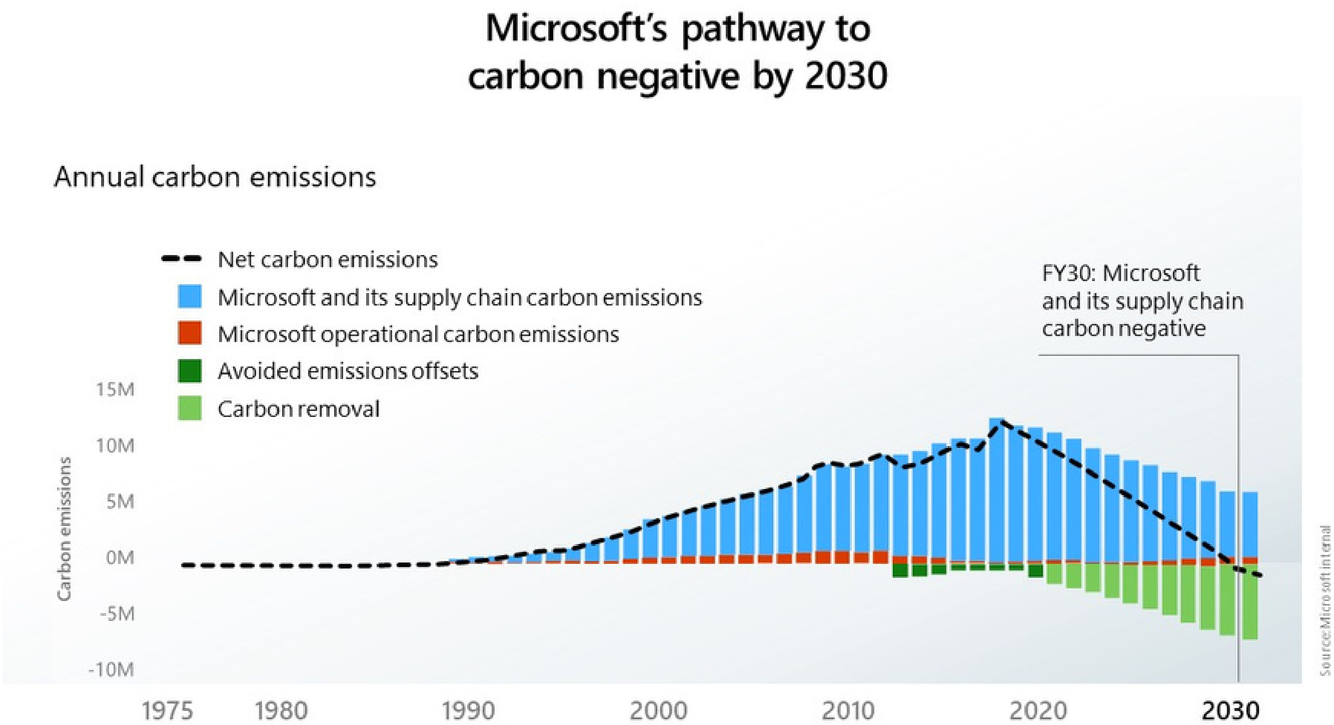

Figure 6. Microsoft emissions reduction plan for achieving negative emissions by 2030, reproduced here from Smith 2020.

These types of projects aim to protect, transform, and restore ecosystems to protect stored carbon or sequester additional carbon from the atmosphere. Examples of nature-based offset projects include grassland management, sustainable forest management, and avoided conversion of undeveloped lands. While these nature-based projects often represent a substantial portion of projects within voluntary markets, many offset projects are not nature-based. Industrial carbon capture and storage (CCS) projects, sequester carbon through industrial processes such as CO_2-driven enhanced oil and gas recovery or by CO_2 injection into deep saline formations. Other examples of non-nature-based offset projects include avoided emissions from switches to renewable energy sources or from changes in transportation options (e.g., replacing vehicle fleets with electric vehicles).

Companies, stakeholders, governments, and NGOs have worked on the scalability of AFOLU projects as well standardizing methods for implementing them (Taskforce on Scaling the Voluntary Market [TSVCM] 2021). This process is difficult as it requires peer review from experts in various disciplines (e.g., forestry, rural development, agriculture, economics, and local stakeholders). In addition, measuring carbon storage and sequestration within natural systems is challenging and can lead to over or under-estimations and/or leakage (Section 6.3, Section 6.6, Badgley et al. 2021).

Standardized frameworks, nature-based protocols, and technology to generate and quantify sequestration have been developed by various entities to attempt to mitigate the various risks associated with these projects and have resulted in many different approaches and protocols for measuring nature-based offsets (TSVCM 2021).

Projects in forestry and land management have dominated AFOLU projects by volume of credits issued (227 Megatonnes [Mt] CO_2e in 2021), as compared with agricultural projects (1 MtCO_2e in 2021, Figure 7). There has however been increased interest in developing grassland/rangeland projects given that grasslands contain potentially more resilient carbon stocks than forests which are susceptible to loss of carbon from drought and wildfires (Dass et al. 2018). Grasslands also make up a sizable portion of land coverage in the Western US and generally have more adaptable management options for sequestering carbon alongside current human use in comparison to forests (Dass et al. 2018). There are still relatively few carbon credits being issued from projects conducted in Texas versus other states (Figure 9). However, given the surge in demand for these projects in 2021, carbon offset projects may increase and have the potential to impact land use practices. Applied research and pilot programs are urgently needed to ensure that these projects function as intended and to seek opportunities for generating additional co-benefits during project implementation that will serve to protect and restore grassland ecosystems.

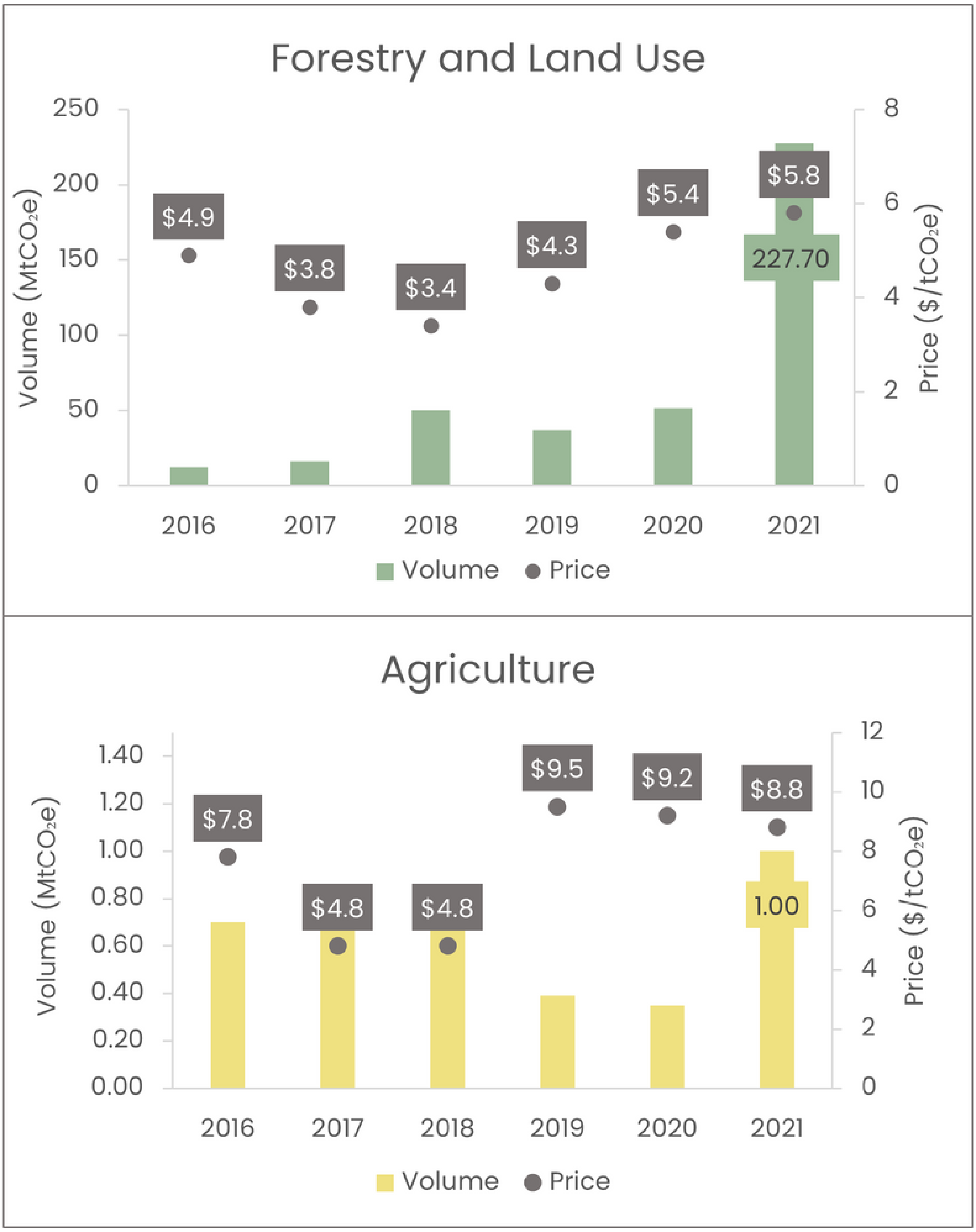

Figure 7. Global voluntary carbon market transaction volumes in $MtCO_2e$ and prices per ton CO_2e from 2016 - 2021 by project category: a) Forestry and Land Use, and b) Agriculture. Adapted from data on the EM Data Intelligence & Analytics Dashboard (https://data.ecosystemmarketplace.com) and from Forest Trends' Ecosystem Marketplace 2022.

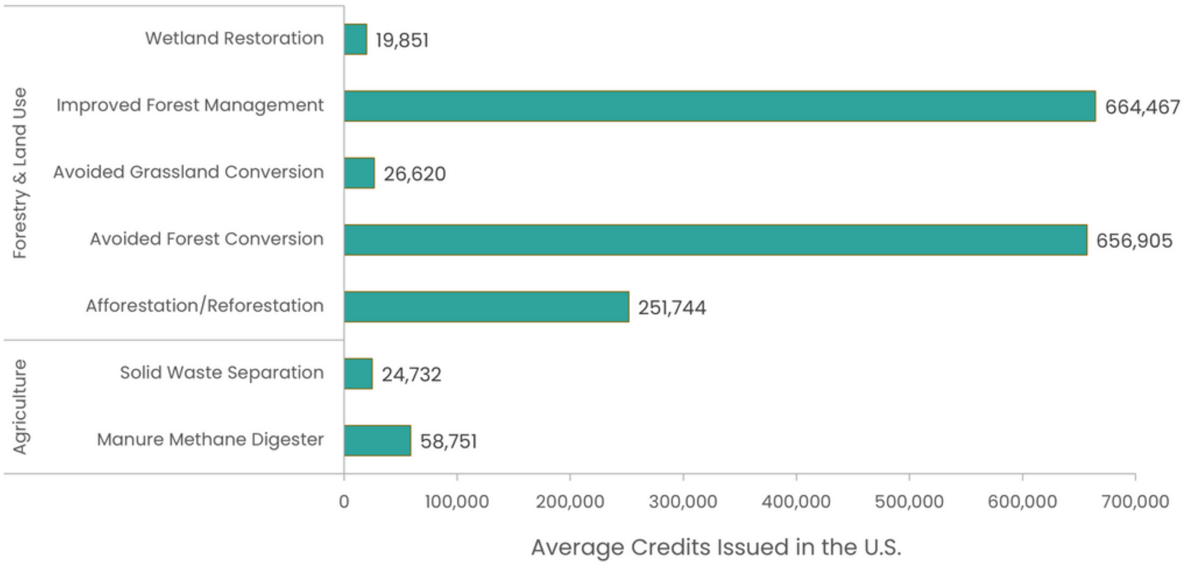

Figure 8. Average number of credits issued per project for the 7 nature-based project types in the US from four major project registries from 2002 to 2021 (CAR, ACR, VCS, and GOLD). Data sourced from Berkeley's Voluntary Registry Offsets Database (So et al. 2022).

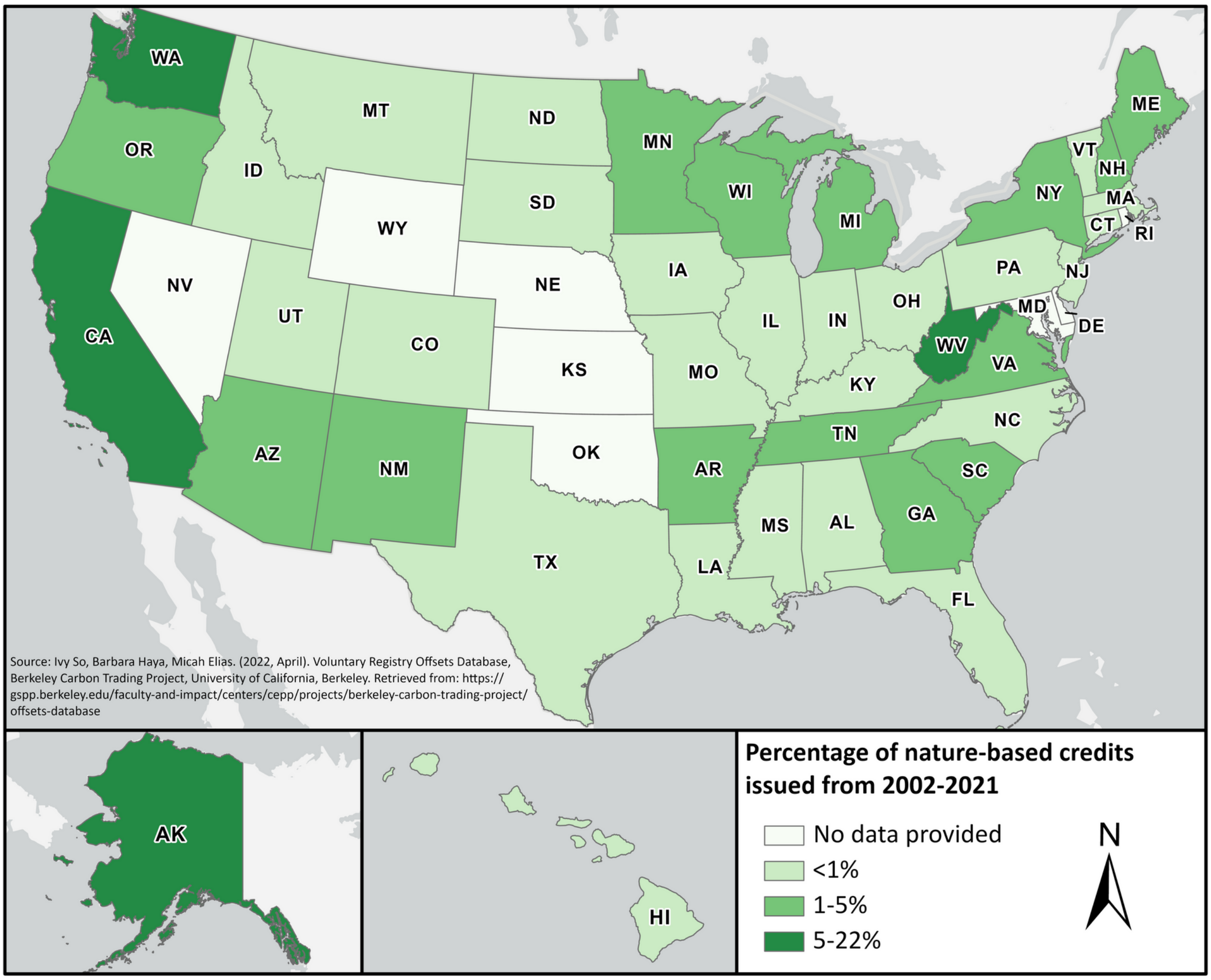

Figure 9. Number of nature-based credits issued from four major project registries (CAR, ACR, VCS, and GOLD). Data is limited to projects that are only in one state. Data sourced from Berkeley's Voluntary Registry Offsets Database (So et al. 2022).

4.5 Insetting

Insetting is the process by which an organization (primarily private companies) invest in emissions reductions and carbon sequestration (carbon removal) within their own value chain. Insetting is used to reduce or compensate for scope 3 emissions and is increasingly utilized since the reductions and removals are more direct and can generate additional economic co-benefits within a company's value-chain. Some inset projects can involve the generation of an externally verified credit or can be conducted entirely within an organization or company and result in an internal emission reduction or carbon removal claim (Section 5.3.1, 5.4.1). For example, a company could fund agricultural producers within their own value chain to adopt cover cropping or sustainable grazing and so make an emissions reduction claim based on their own assessment, without using an outside organization's certified or verified protocols (Section 5.5). Independently certified and verified credit systems are still sometimes utilized in insetting even though the credits are not sold. There is still incentive for some companies to invest in additional verification within insetting since it can provide a more robust system for GHG accounting.

Estimating scope 3 GHG emissions is challenging, which makes proper accounting of removals within a value-chain all the more difficult. There also can be less incentive for methodological rigor, since actions are internal to a company and not a tradable commodity. Requirements such as additionality, leakage, sampling methodology, and permanence, discussed more in Section 5.0 and 6.0, are central to most carbon offset credit markets but may or may not be included within an insetting process. Companies are utilizing a variety of different approaches in addressing scope 3 emissions offsetting or insetting (Figure 10).

The rise of carbon insetting has created a demand for independent verification protocols and project developers which will verify, track, and quantify carbon sequestration but which may have fewer requirements than found in a "high-quality" emission offset (Section 5.2). Since insetting is a relatively new phenomenon, there are fewer standards in place, although emerging strategies do often mimic those of the more established voluntary offset markets. This document focuses primarily on "high-quality" emission offset credits, but many of these methods are utilized to varying degrees within insetting strategies as well.

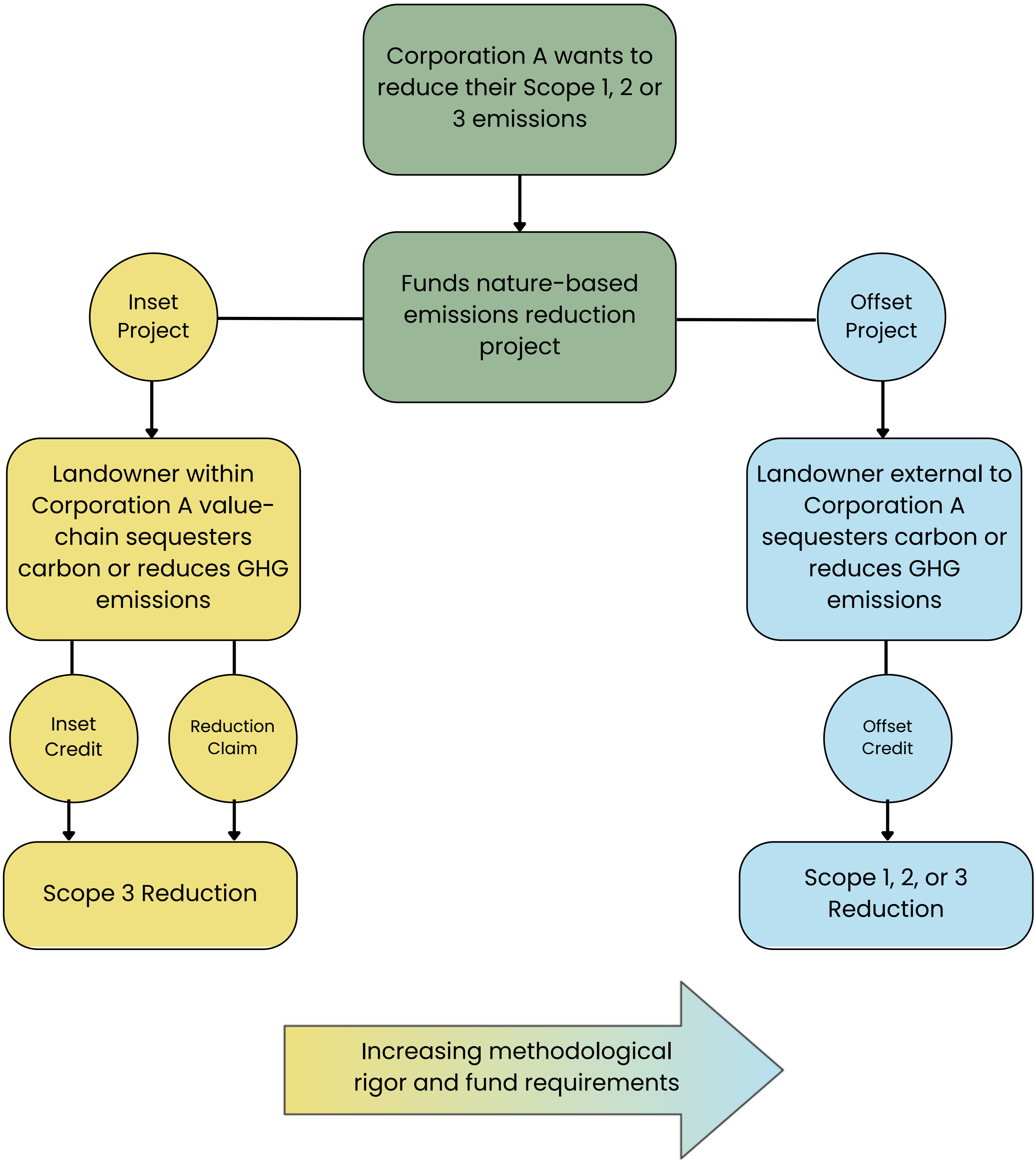

Figure 10. Overview of the inset and offset project utility, function, and relative level of effort.

5.0 THE NATURE-BASED CARBON OFFSET PROCESS

5.1 Introduction

Nature-based offset projects reduce atmospheric carbon by funding changes in agriculture, forestry, or land use that result in avoided carbon emissions, an additional amount of carbon sequestration, or more carbon storage protection than would have occurred without project funding. As introduced in Sections 2.1 and 4.4, carbon sequestration in AFOLU projects is primarily due to photosynthesis, which converts CO_2 into organic carbon. In grasslands, soil carbon is often the primary carbon pool, which is tracked or monitored to determine total carbon removal; however, sometimes above and belowground plant biomass is also considered.

The amount of net atmospheric carbon removed is then quantified, credited, purchased, and the offset credit claimed by a purchaser to reduce their own emissions inventory (Figure 11).

To meet demand, numerous carbon markets have emerged to supply nature-based offset credits. These markets are a dynamic and ever-evolving set of voluntary programs. While they often share some commonalities, most markets differ in application and approach. In their review of US voluntary carbon credit markets, Plastina (2022) characterized carbon credit markets as “an unarticulated patch of co-existing programs with different rules,

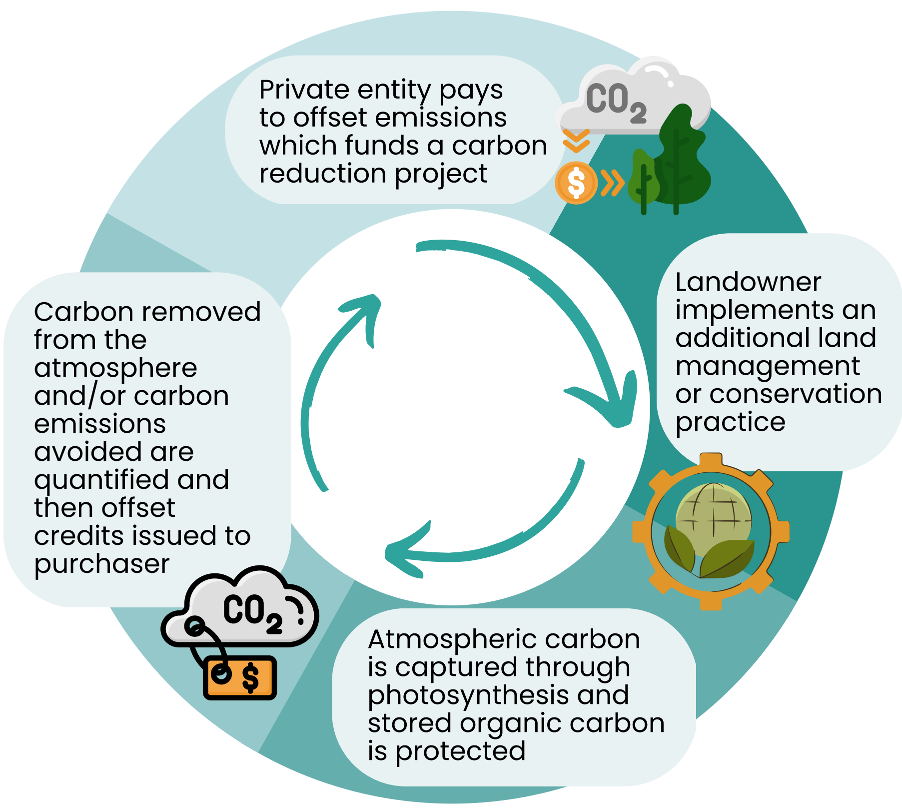

Figure 11. Broad overview of the nature-based voluntary carbon credit approach to offsetting emissions.

incentives, and penalties, rather than a cohesive and transparent market." Given the amorphous and fragmented nature of the markets, the challenge in summarizing and presenting the crediting process here is that most markets operate slightly differently with different definitions, protocols, standards, and structures. However, we have attempted to provide an overview of the carbon offset process to assist in understanding market functioning and implications for land use.

5.2 Offset credit process

While the following is not a comprehensive overview of the nature-based offset credit process, it should give the reader an informed overview of the major roles, elements, and types of organizations typically involved in generating offset credits.

The process shown in Figure 12 is most appropriate for producing a "high-quality" offset credit (Section 4.1), most often used to compensate for scope 1 emissions. As discussed in Section 4.1 and Section 5.9, a "high-quality" offset credit is loosely described as those that have been implemented according to recognized standards and meet additionality, permanence, and independent third-party verification requirements (Section 5.9, Plastina 2022). However, depending on the purchaser or protocol, similar processes can be and are used for scope 3 offsets or as part of an insetting process.

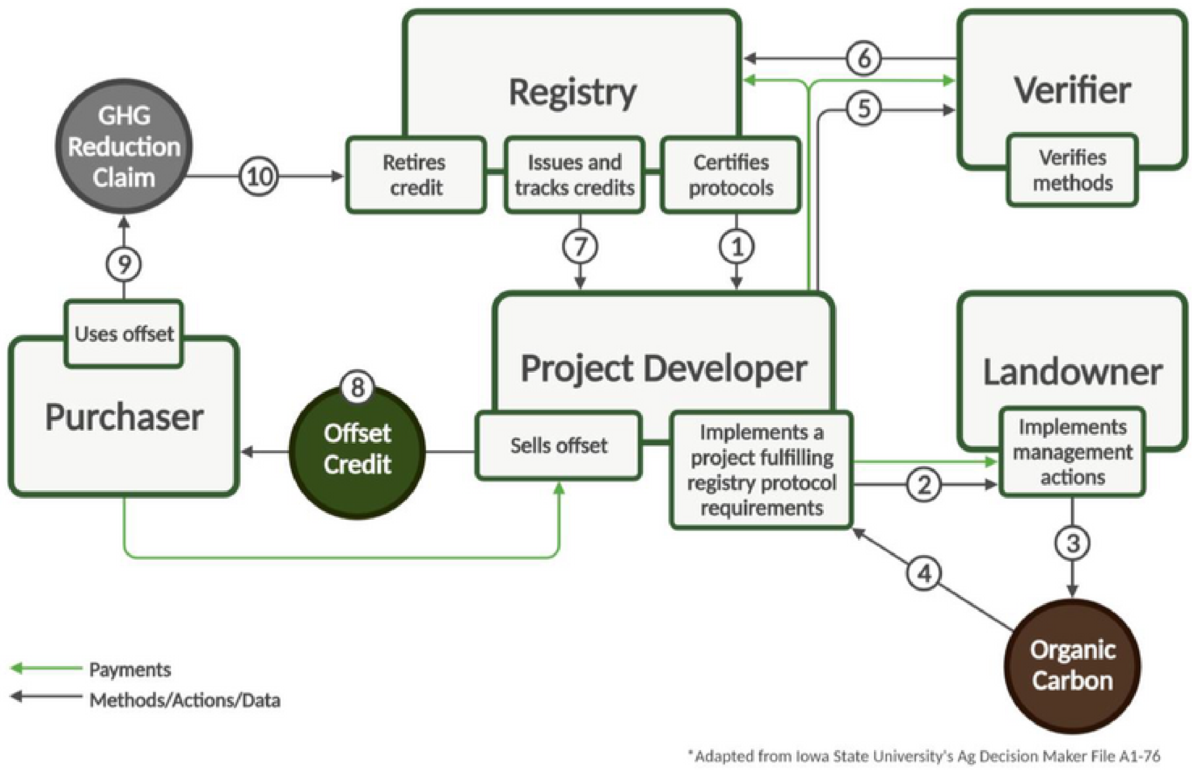

Figure 12. Overview of the traditional voluntary carbon offset credit generation process. Adapted from Plastina 2022.

While this process does not have a single starting point, we will start with protocol development under a registry:

1. A registry reviews and certifies protocols that can be used to generate credits (Section 5.6). These protocols outline land management activities, permanence, additionality, monitoring, and other requirements that must be met before the registry will issue credits (See Section 6.0). These protocols are available for anyone to use to develop a nature-based offset project if they can meet the requirements.

2. A project developer is anyone or any organization that develops and implements projects using an approved protocol (See Section 5.7). Often the project developer is a separate entity, but registries and landowners can also act as a project developer. In this example (Figure 12), a project developer implements a registry protocol by entering a contract with, and paying a landowner to, implement certain actions on their land. The project developer will ensure that all protocol requirements are met including the monitoring and net carbon sequestration quantification methods. These responsibilities can also sometimes be shared between the project developer and the landowner.

3. The landowner typically enters a contract with the project developer in which they agree to implement all actions and requirements to meet protocol conditions. Under most protocols these management actions must be additional or new practices (See Section 6.2). Example actions include changing grazing patterns, restoring degraded lands, or switching to no-till agriculture. Landowners must often abide by many other requirements as well (Section 6.0). For example, the protocol might have a permanency requirement that mandates the project area sign a conservation easement or agree to remain under prescribed management for 20 years or more.

4. Once actions have been implemented and all requirements are met, the project developer takes the information and data from the project and uses the protocol to estimate the amount of net carbon sequestered in the relevant carbon pools (above or belowground biomass, soil organic carbon, etc.). Most protocols will also consider any emissions incurred during the project in their net emissions calculations as well as the amount of emissions avoided. The estimated net carbon sequestered, along with all other project information and data are then sent to a third-party verifier.

5. The third-party verifier receives and reviews the project and decides whether it has met protocol requirements and that all information is correct (Section 6.7). This may include site visits during implementation or other similar verification actions.

6. If the amount of net carbon sequestered or emissions avoided is verified, then the third-party verifier sends the information to the registry to issue credits.

7. The registry receives the verified information from the third-party verifier. The registry will then issue credits to the project developer. Each credit is a unique serial number that represents a unit of atmospheric carbon equivalents reduced (generally 1 tonne CO_2e). The owner of the serial number (the project developer) is recorded in the registry database (Section 5.6).

8. The project developer can then sell the credits to a purchaser. The purchaser can be the end-user who will claim the offset, or it can be brokers and aggregators who will further bundle offsets for later sale. Due to the long timelines required for these projects, sometimes projects are financed and purchased through an emission reduction purchase agreement (ERPA) which allows investors to pre-pay for offsets from project developers and landowners (Section 5.10). It should be noted that project developers can also function as brokers or aggregators and sometimes the three terms are used interchangeably.

9. Once the credit is purchased by the end-user it can then be used to claim a GHG emission reduction and subtract the company's GHG inventory by the offset amount (1 tonne CO_2e).

10. The process of claiming the credit benefit is called "retiring" since the registry will retire the unique serial number of each credit after it is used. Retiring the unique serial number is intended to ensure no double-counting of carbon sequestered (Section 5.6).

In the voluntary offset model, payments flow from the purchaser to the project developer. The project developer then pays all the associated organizations involved in the process including the landowner, the third-party verifier, and the registry. The timing of payments depends on the individual contracts and business model of the project developer. Payments may be made in advance, or only at the time of sale of the credits. While payments may be made in advance, it is worth noting payments may be retracted/reversed if stored carbon is rereleased (i.e., reversal, Section 6.6). Penalties for reversals vary from forfeiting credits to being required to refund payments in full. To mitigate this risk, many protocols will require a reserve of non-tradeable carbon credits (i.e., buffer pool) that are generated under the protocol to be set aside in the case of unforeseen losses in soil carbon stocks (e.g., leakage, Section 6.6). Payment models often differ however, in some, the landowner may be required to shoulder the monitoring and verification costs for example.

5.3 Example processes under the major registries

In this section, three examples of carbon markets are given, all three of which utilize protocols from at least one of the four largest US voluntary carbon registries (Section 5.6).

5.3.1 ESMC

The Ecosystem Services Market Consortium (ESMC) began building its carbon program in 2017 (Figure 13, ESMC 2022). ESMC is a non-profit and currently utilizes one registry, Gold Standard. ESMC operates as and works with project developers, develops protocols for review and certification by Gold Standard, provides landowner assistance, and conducts research.

ESMC has several protocols under review by Gold Standard for scope 3 credits. ESMC works with only one verifier, SustainCert, who provides third-party verification and shares the data with Gold Standard before credits are issued. ESMC utilizes ERPAs in the funding of carbon projects for buyers directly and through various brokerage organizations.

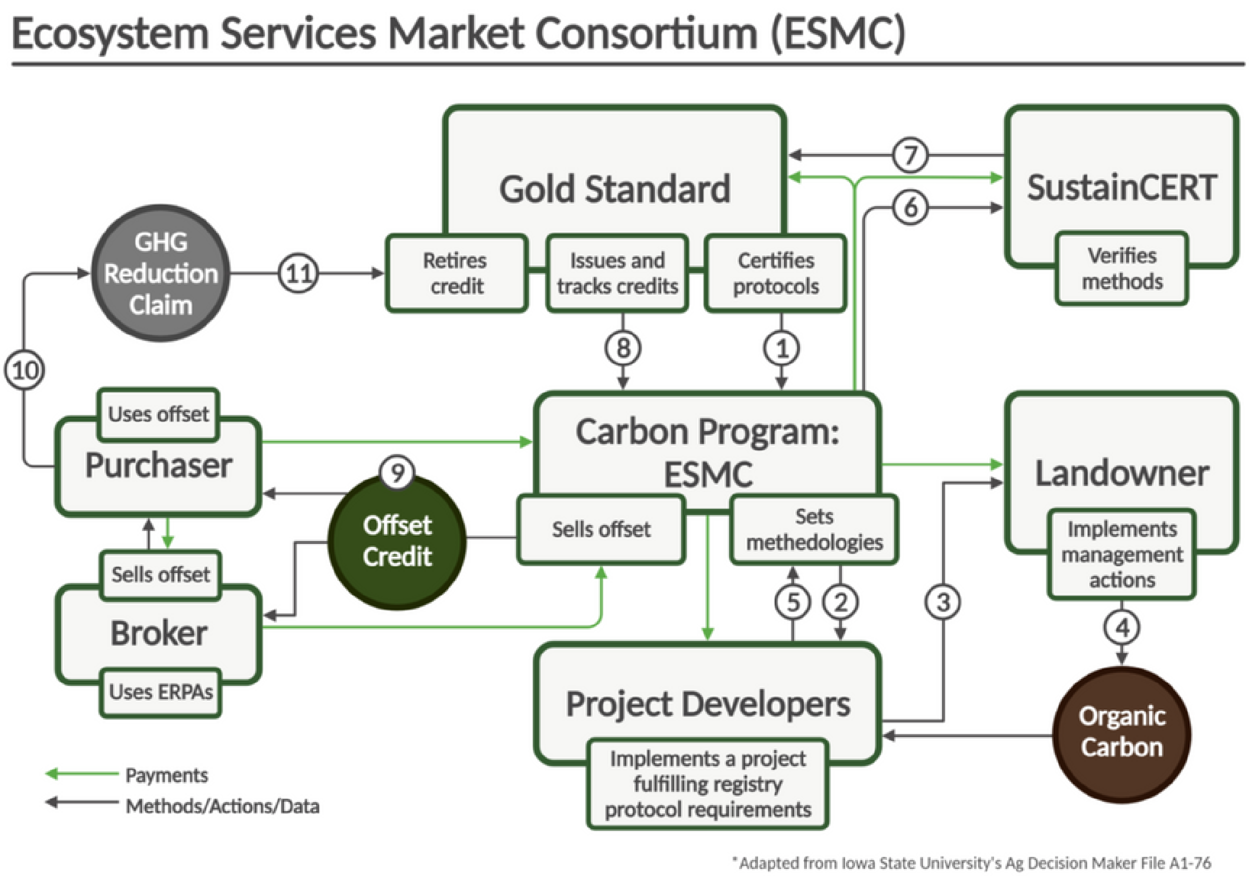

Figure 13. Overview of the Ecosystem Services Market Consortium offset/inset credit generation process. Adapted from Plastina 2022.

5.3.2 Carbon by Indigo

Indigo Carbon was developed by Indigo Ag and launched in 2019 (Figure 14, Indigo 2022). Indigo Carbon uses two registries (Verra and CAR) to certify protocols and retire, issue, and track credits. Indigo Carbon only uses one protocol from each registry to conduct offset projects, the Soil Enrichment Protocol developed by CAR and the Methodology for Improved Agricultural Land Management which was coauthored by Indigo. Indigo acts as project developer and works directly with farmers and partner organizations (e.g., Corteva) to implement projects (Indigo 2022). Indigo Carbon has also acquired Soil Metrics, a soil science company to conduct its measurement, reporting, and verification. Finally, similar to ESMC, Indigo Carbon works with one verifier, Aster Global Environmental Solutions. Once verified, Verra or CAR will issue credits to Indigo. Indigo claims that at least 75% of the profits from the offset credit sale are then directly paid to the farmer (Indigo 2022).

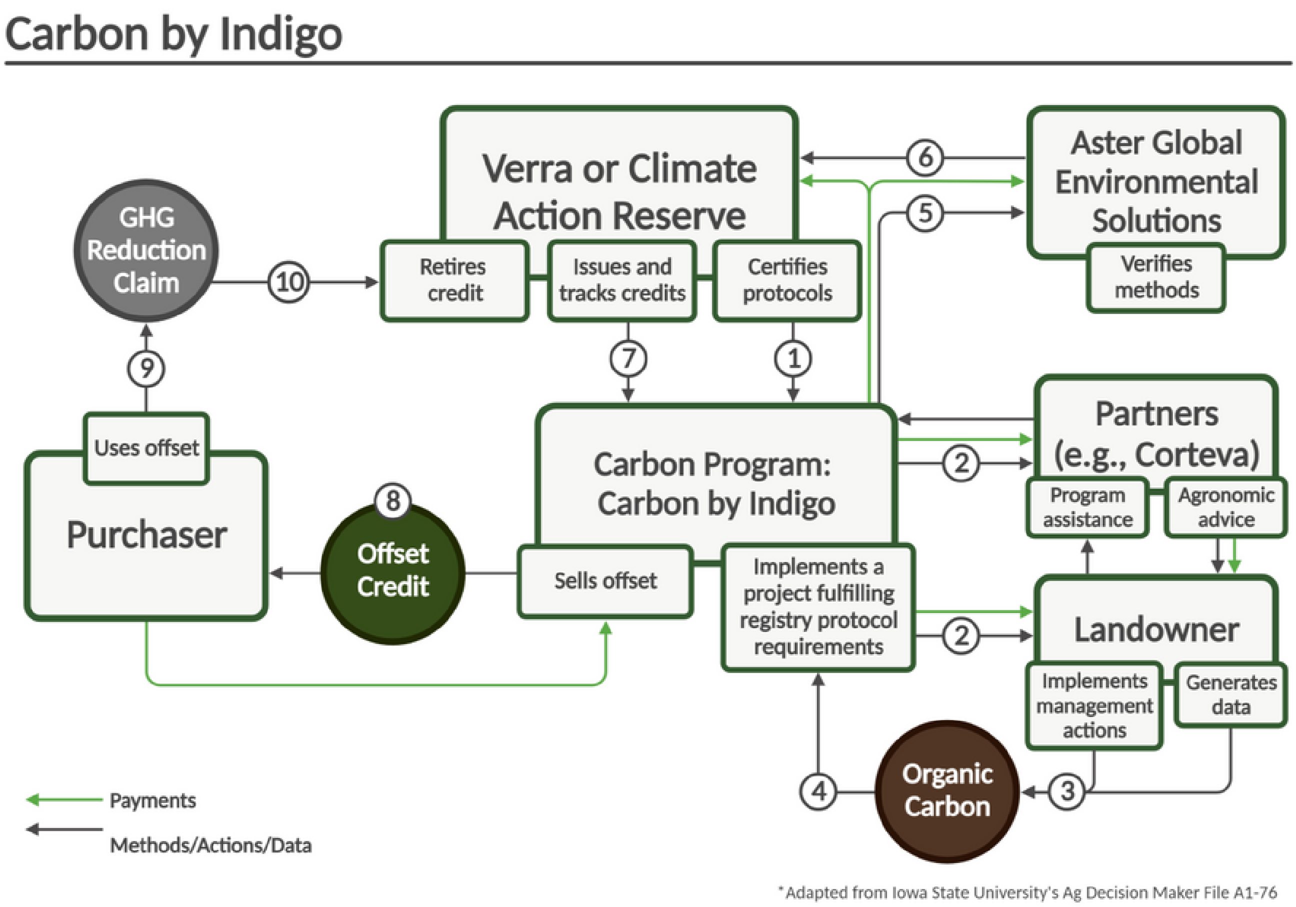

Figure 14. Overview of the Indigo Carbon offset credit generation process. Adapted from Plastina 2022.

5.3.3 Bayer Carbon

The Bayer Carbon Program, released by Bayer in 2021, offers farmers incentives for implementing carbon-smart farming practices (Figure 17, Bayer Carbon 2022). Currently, Bayer Carbon works primarily with Gold Standard to certify protocols and retire, issue, and track credits. Bayer Carbon acts as the sole project developer in their program and pays landowners to implement agricultural practices for a per-acre payment basis.

Project data is shared with Bayer Carbon through the company's Climate Fieldview platform (Plastina 2022). Bayer Carbon then utilizes multiple verifiers to meet third-party review requirements. Finally, once verified, data is given to the registry and the registry issues the credits to Bayer Carbon. Bayer Carbon then sells to a broker or to an end-user.

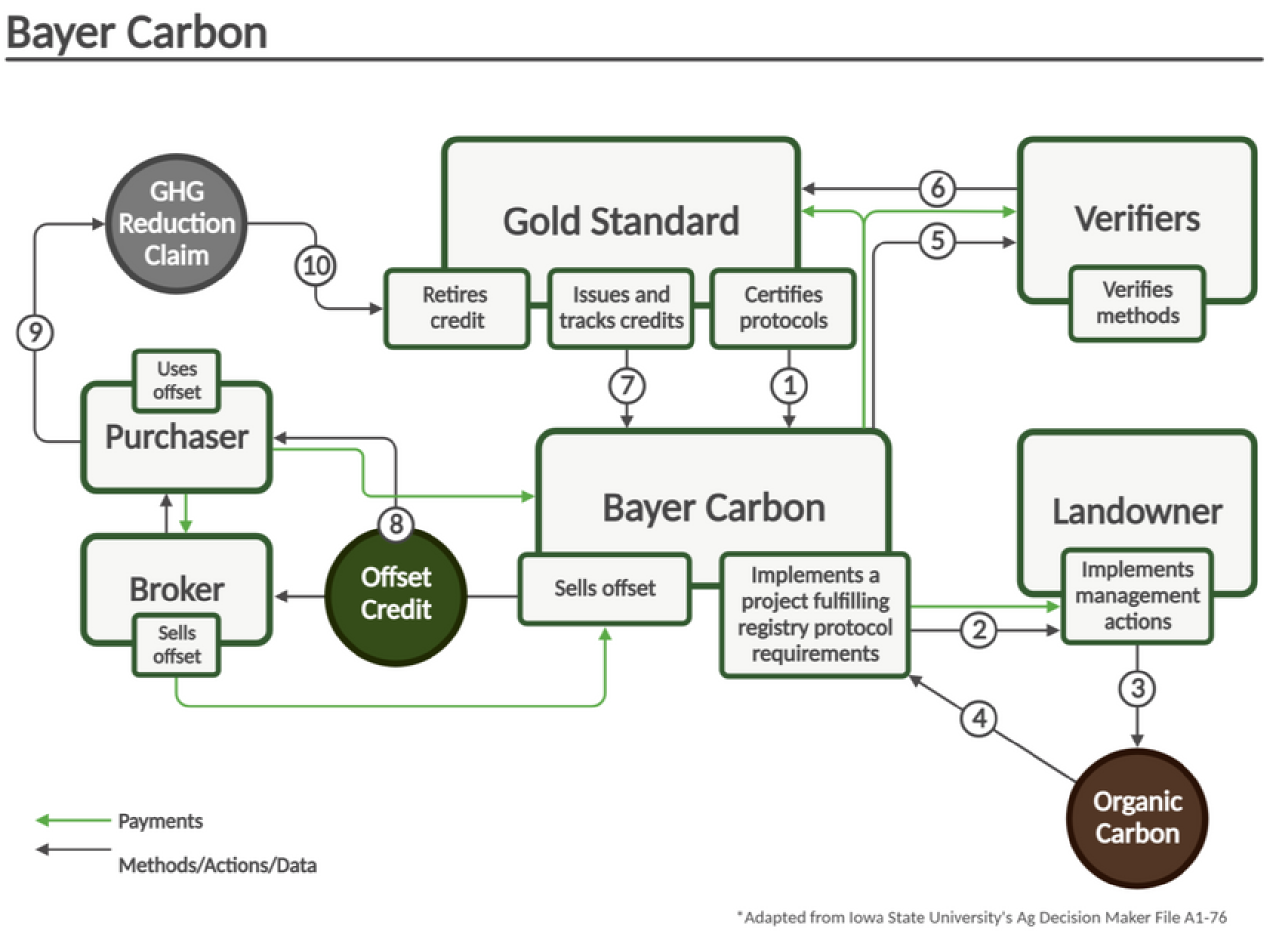

Figure 15. Overview of the Bayer Carbon offset credit generation process. Adapted from Plastina 2022.

5.4 Example processes outside of the major registries

There are many carbon offset programs that operate outside of the major US registries/standards (Section 5.6). The two selected here operate in Texas and have a similar structure and organization. Both organizations cite issues or impracticality of major registry protocols as the reason for their creation and as the argument for their approach.

5.4.1 BCarbon

The BCarbon standard was created by the Baker Institute Soil Carbon Working group at Rice University (Figure 16, BCarbon 2022). BCarbon is its own standard and creates protocols with the stated goal of making the process more accessible to working lands (BCarbon 2022). One primary and important deviation from most international standards is that BCarbon has redefined additionality and permanence, discussed further in Section 6.2 and listed in Appendix II (BCarbon 2022). As of July 2022, there were two project developers which utilized the BCarbon Standard protocols, Grassroots Carbon and Future Foods. Grassroots Carbon also utilized protocols under the Verra standard and through the Verra Registry system.

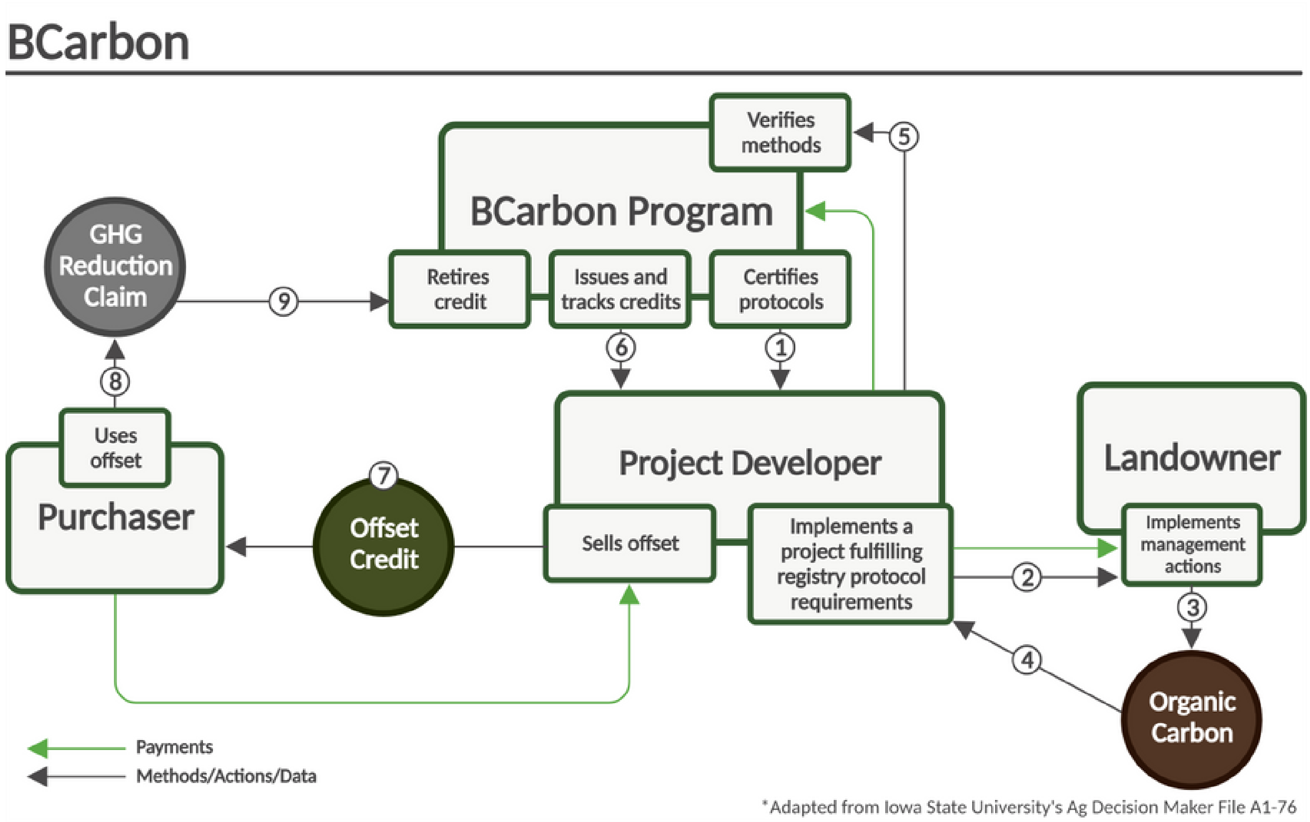

Figure 16. Overview of the BCarbon credit generation process.

5.4.2 City Forest Credits

The City Forest Credits (CFC) registry was founded in 2015 and has created protocols for carbon offset projects from urban tree planting or forest preservation projects (Figure 17, CFC 2022). Their stated goal in developing a new standard was to create protocols which would work well in urban forestry programs where other registry protocols were considered impractical (CFC 2022). In 2007 Austin, Texas mayor Steve Adler pledged that the City of Austin would be carbon neutral by 2040 (City of Austin 2022). As part of their climate mitigation strategy, the Austin Watershed Protection Department and Parks and Recreation Department piloted a program to purchase carbon offsets from tree planting projects conducted within Travis County (Tree Folks 2022). TreeFolks, a Texas-based non-profit that conducts tree planting and reforestation projects has utilized the CFC registry protocols to generate carbon credits from that reforestation program. The City of Austin has committed to purchasing all carbon offset credits generated from this project and as of year 1 of the project has purchased 871 out of a total 8709 estimated project credits (CFC 2022).

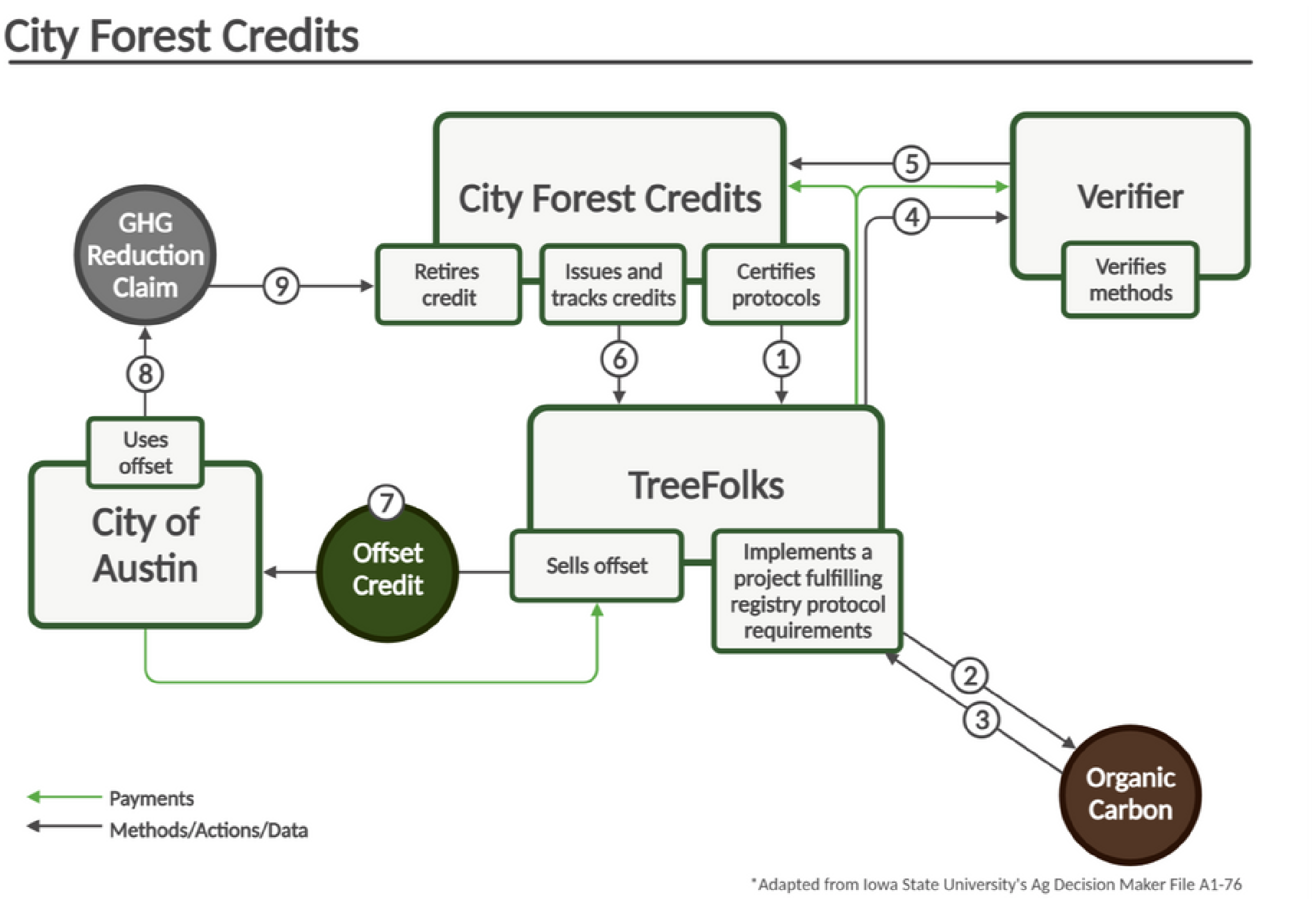

Figure 17. Overview of the City Forest Credits offset credit generation process.

5.5 Standards and protocols

Within voluntary and compliance markets, standards provide guidance and a consistent approach to quantifying, monitoring, and reporting carbon removal and emission reductions (Broekhoff et al. 2019). Specifically, a carbon standard sets rules, requirements, and protocols for projects and programs and specify how offset credits can be generated, certified, and issued (Streck et al. 2021). Typically, standards are developed by international NGOs or governments that have the capacity to provide quality control and are intended to safeguard the quality of verified credits within the voluntary carbon market (Streck et al. 2021). In order for projects to generate verified and certified carbon reductions under a standard, they must comply with the standards' requirements. Organizations like Gold Standard, create these requirements and then act as or manage registries to track the generation, transfer, and transaction of offset credits (Streck et al. 2021). These organizations develop or approve protocols (sometimes also referred to as methodologies) for nature-based and non-nature-based projects that fulfill or meet these standards to produce "high-quality" credits (Section 4.1; Broekhoff et al. 2019). Project protocols outline the agreements, and specific procedures project developers and landowners must commit to when conducting their carbon credit development project. Protocols provide the criteria and guidance on eligibility, activities, additionality, monitoring technique, permanence requirements, crediting periods, reversal and leakage contingencies, and verification process (Section 6.0, Broekhoff et al. 2019).

Project developers and landowners must follow the protocols approved by a registry under its relevant standard (Broekhoff et al. 2019). First, protocols will outline eligibility, for example the eligible lands by region, land use type, applicable cropping, or ecosystem type (e.g., grassland, forest), and what management activities are allowable (Broekhoff et al. 2019).

Most standards require that the activities implemented by the landowner under the project be "additional." Although there are many ways that additionality is defined, most definitions are that the practice was adopted directly because of project financing (not some other cause), are not already legally required or funded, and are not a common practice already applied in the region. This underlies the basic premise of most credit offset payment models, the assertion that funding projects has led to an increase in carbon removal or avoided emissions beyond pre-existing baseline values. Additionality standards and the definition of additionality differ broadly within voluntary markets and the effectiveness of the additionality standards and tests are a constant source of controversy and research. There are however some emerging alternative approaches, BCarbon, for example, does not require that practices employed be additional but will issue credits based on any carbon sequestered between project sampling periods (Appendix II). Techniques for monitoring carbon stocks (field sampling or modeling methodologies) and the frequency of that monitoring are usually also outlined but can also vary considerably (Grimault et al. 2018).

A protocol provides all guidance and requirements for developing a nature-based emissions reduction and carbon removal project that will meet the standards of the registries. Protocols usually describe for example, the criteria for determining what constitutes an additional practice versus business as usual (Gold Standard 2020). Some protocols will even outline a specific percentage that carbon stocks must increase from the baseline value during the project period (Verra 2022a).

Most protocols within the major registries require that projects ensure carbon will remain sequestered for a set period of time. This is addressed in the protocol crediting period (i.e., what time period CO_2e reductions are eligible for credit issuance) and permanence requirements (i.e., how long carbon must remain sequestered/stored; Michaelowa et al. 2019). A reversal occurs when carbon is re-released into the atmosphere (Broekhoff et al. 2019). For example, in 2021, wildfires in California and Oregon eliminated tree biomass that was part of multiple verified carbon offset projects (Choi-Schagrin 2021). Protocols will outline the methods for identifying risk of reversals and how the risks can be mitigated.

Many protocols will require a reserve of non-tradeable carbon credits (i.e., Buffer pool) to be set aside in the case of unforseen losses in soil carbon stocks (e.g., reversal, Climate Action Reserve 2010).

In the case of the 2021 wildfires, the buffer pool was likely insufficient to cover the reversals. Under some protocols there can be penalties for unaccounted reversals varying from forfeiting credits to refunding payments in full (Climate Action Reserve 2010). When discussing reversals, protocols will also address leakage. Leakage occurs when carbon emissions are shifted or increased due to activity shifts (e.g., livestock displacement, reduction in crop yield, Fowlie and Reguant 2021). For example, if a carbon offset credit project required a reduction of livestock stocking rate on a property, but the stocking rate of the adjacent property were increased as a result, that would be considered leakage. Leakage provisions are meant to reduce the risk that a project merely shifts carbon emissions versus reducing them.

For additional details on protocols and review of 15 protocols relevant to rangelands see Section 6.0 and Appendices I - VI. Protocols reviewed in this report (Appendix I – VII) were developed under many different standards including the Verified Carbon Standard, Climate Action Reserve, Gold Standard, American Carbon Standard. These four standards/registries issue the majority of voluntary credits in the world and generally follow or consider international guidance from the IPCC, contained within UNFCCC CDM guidance, or other internationally recognized sources.

Protocols under three additional standards, Nori, Regen Network, and BCarbon were also reviewed and summarized. These three standards are relatively new and do not always follow guidelines like the four major standards/registries.

5.6 Registries

Carbon registries approve protocols that meet their standards for offset credit generation, and track credit ownership to provide transparency for offsets and the projects from which they were generated (Broekhoff et al. 2019). Organizations that maintain registries usually also create and manage standards and so we use the term somewhat interchangeably for some of these organizations like Verra or the Climate Action Reserve. Registries are responsible for issuing and validating/certifying credits for each unit of avoided emissions or carbon removed (Bernstein et al. 2010). Before a registry issues credits, they will have a verification process to determine that the project has met the registry standard usually through a third-party verifier (Section 6.7, Broekhoff et al. 2019). Registries track the number of credits generated from each project, the sale of credits, and retirement of credits (Bernstein et al. 2010). To track credits and reduce the risk of double counting, registries assign each verified credit a serial number (Descheneau 2012, Broekhoff et al. 2019). When the credit is sold, the registry will record transfer of ownership from the seller to the buyer. Once the final purchaser claims the credit (i.e., subtracts the credit amount from their emission inventory), the registry will retire the serial number so the credit cannot be resold (Broekhoff et al. 2019). Most registries and carbon programs issue their own branded or labeled offset credits which, although they are generally equal to 1 tonne CO_2e, are generated using different protocols and methods and so are not directly transferable or equivalent (Table 1). While there are many programs and registries in voluntary markets, four registries issue the majority of carbon offset credits globally: Verra, Gold Standard, the American Carbon Registry, and the Climate Action Reserve (Figure 18).

Registry	Branded Credit Issued
American Carbon Registry	Emission Reduction Tons (ERT)
Climate Action Reserve	Climate Reserve Tonnes (CRT)
Gold Standard	Verified Emissions Reductions (VER)
Verra	Verified Carbon Units (VCU)
SocialCarbon Standard	Verified Carbon Units (VCU)
Plan Vivo Registry	Plan Vivo Certificates (PVC)

Table 1. Branded offset credits for six voluntary carbon registries in the US.

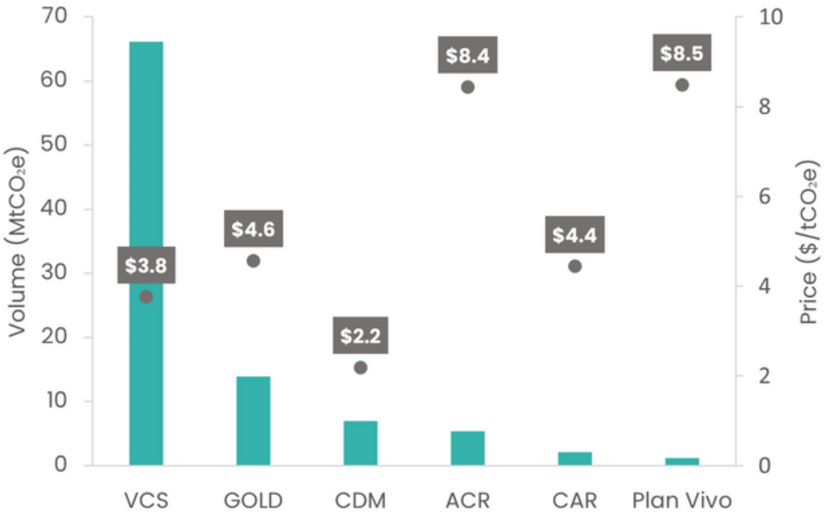

Figure 18. Globally transacted voluntary carbon credit volume and average price by standard/ registry in 2020. Adapted from the EM Data Intelligence & Analytics Dashboard on Ecosystem Marketplace, A Forest Trends Initiative (https://data.ecosystemmarketplace.com).

The American Carbon Registry, the first private voluntary offset program in the world, was founded in 1996 and operates in both the global voluntary and compliance markets (ACR 2022). ACR oversees the registration and verification of carbon offset projects following its approved carbon accounting protocols. Within compliance markets, ACR was approved in 2012 as an Offset Project Registry (OPR) for the California Cap-and-Trade program and in March of 2020 by the Council of the International Civil Aviation Organization (ICAO) to supply emission reduction units for compliance under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA, ACR 2022). Many registries, including ACR, report emission reductions or removal as CO_2e. CO_2e is calculated to determine the amount of metric tonnes of net GHG emissions that have the same global warming potential as one metric tonne of CO_2. ACR's electronic registry system supports a wide range of nature and non-nature-based protocols including the Avoided Conversion of Grasslands and Shrublands to Crop Production protocols.

The Climate Action Reserve registry was founded in 2001 as the California Climate Action Registry (CAR 2022). CAR operates within the North American voluntary and compliance carbon markets. Similar to the ACR, CAR serves as an approved OPR for California's Cap-and-Trade program registry (CARB 2022). CAR supports both nature and non-nature-based carbon offset projects (e.g., CAR U.S. Livestock Protocol).

The Gold Standard was founded in 2003 by the World Wildlife Fund (WWF) and other NGOs to help achieve the United Nations Sustainable Development Goals (SDGs, Gold Standard 2022). The Gold Standard was created with a self-stated intention to serve as a benchmark for carbon markets and set international standards for carbon offset credits within the worldwide carbon market. As of 2022, the Gold Standard had over 1,900 projects in over 90 countries (Gold Standard 2022).

Most registries track credits via environmental market depository software provided by separate providers. The ACR, CAR, and Gold Standard registries all utilize APX Inc. as their primary service provider (Broekhoff et al. 2019). APX Inc. was founded in 1996 and is a registry software provider for environmental markets in GHGs around the world (APX 2022). APX works with ACR, CAR, and Gold Standard to track and enable trading of emissions credits.

Verra develops/manages two standards and programs (Verified Carbon Standard [VCS] and Climate, Community, & Biodiversity Standards [CCB], Broekhoff et al. 2019). Verra was founded in 2007 by environmental and business leaders and serves as an approved OPR for California's Cap-and-Trade Program (Verra 2022a).

As of 2022, Verra had issued 881 million verified carbon credit units and has 1,786 projects in more than 80 countries (Verra 2022a). VCS is by far the world's largest voluntary GHG program, representing 62% of all CO_2e credit issuances by volume in 2021 (World Bank 2022). VCS was launched in 2006 and tracks all its carbon credits (Verra 2022a). The VCS program was one of the first global standards to make requirements for developing credits from AFOLU projects (e.g., forest and wetland conversion and restoration, agricultural land management, VCS 2016). Verra also manages the CCB Standard (Broekhoff et al. 2019). The CCB Standard developed by the Climate, Community, and Biodiversity Alliance (CCBA) in 2005 acts as a project design standard and does not verify carbon offset credits or provide a registry (Broekhoff et al. 2019).

The CCB Standard is intended to be applied early to any land management projects (e.g., forest conservation and restoration, agroforestry, sustainable agriculture) including those within the VCS program to certify climate, community, and biodiversity benefits (Verra 2022a) and to ensure local community and biodiversity benefits (Broekhoff et al. 2019). To earn CCB Standards approval, projects must meet 17 required criteria (e.g., Net Positive Climate Impacts) outlined under the Standard. Projects can also earn Gold Level Status by meeting three additional optional criteria (e.g., Climate Change Adaptation Benefits). As of 2022, 37 CCB projects have been validated and 79 CCB projects have been verified in over 60 countries with about 70 million tonnes of CO_2e annual emissions reductions (Verra 2022a).

The SocialCarbon Standard is managed by Biodiversity & Ecosystem Futures (BEF) but was developed by the Ecologica Institute in 1998 with the first project validated in 2008 (Broekhoff et al. 2019, SocialCarbon Standard 2022). Similar to CCB Standards, the SocialCarbon Standard is typically used in conjunction with another program (e.g., VCS) and does not quantify or verify carbon offset credits. In 2022, SocialCarbon became a full standard for Nature-Based Solutions. Biodiversity & Ecosystem Futures, an environmental registry service, manages the projects as well as issues, tracks, transfers ownership, and retires social carbon credits. As of 2022, 63 projects have been developed across 5 countries under the SocialCarbon Standard (SocialCarbon Standard 2022).

Plan Vivo Registry is also administered by IHS (Information Handling Services) Markit (Broekhoff et al. 2019, IHS Markit 2022). The first Plan Vivo Standard was created in 2001/2002 and all offset credits are issued, transacted, and retired on the IHS Markit Registry. As of April 2021, there were 27 projects registered and over 5 million tonnes of CO_2 were estimated to be removed from the atmosphere (Bohannon 2021, Plan Vivo 2022).

Similar to APX Inc., IHS Markit manages global carbon credits within its financial market-based registry for both the Social Carbon Registry and Plan Vivo Registry (Broekhoff et al. 2019). IHS Markit's environmental registry provider sector was founded in 2009 and tracks all projects and issues, transfers, and retires credits. All credits are searchable and viewable by registered buyers to ensure continued participation, investment, and efficiency within the carbon market. As of June 2022, IHS Markit supported 126 countries and has tracked 6,197 projects (IHS Markit 2022).

5.7 Project developers

Project developers (sometimes termed project proponents) play a central role in nature-based carbon offset projects by working with registries/standards, verification bodies, and landowners to develop projects all around the world (Hamrick and Gallant 2018). Typically, a project developer is an independent entity; however, a landowner, company, carbon program, or registry can also act as a project developer. Specifically, to develop carbon credits, project developers initiate projects that implement a protocol certified by a registry/standard, collaborate with partners, develop contracts with landowners, and bear the financial responsibility of project implementation (Kolmuss et al. 2008). Project developers work internationally, nationally, and regionally to identify and develop carbon offset opportunities (Kolmuss et al. 2008). However, most project developers (97%) will initiate projects in only one country, and only a few operate globally (Filmanovic 2021). The project developer market is predominately located in India, United States, China, and Turkey with the top 20 developers accounting for over a third (39%) of all carbon offset projects (Filmanovic 2021). The top 5 developers account for 19% of all issuances globally (Filmanovic 2021). To further internalize and accelerate the crediting process, large developers have begun forming partnerships with intermediaries and capital providers, as well as forming carbon programs with additional capacity within the carbon market space (Filmanovic 2021).

To implement a carbon credit project, project developers enter into a contract with a landowner to sequester carbon and generate credits according to a standard protocol (Bayon et al. 2006, Broekhoff et al. 2019). For example, Grassroots Carbon may initiate or manage projects with landowners that follow BCarbon or Verra protocols, depending on which program fits the project requirements or landowner needs (Mooiweer 2022). Similarly, Anew Climate, the largest project developer in North America, develops projects following protocols released by multiple registries (Bluesource 2022). Project development includes implementing activities according to registry protocols (e.g., preventing grassland conversion or development), ensuring monitoring of carbon stocks follow the protocol methodologies, and ensuring all other land use, third-party verification, leakage, permanence, or reversal agreements are followed and implemented (Broekhoff et al. 2019). For example, once a project is ready for external review, Anew Climate will conduct an on-site visit with a third-party verifier to assess that project activities are being implemented and to verify results of monitoring data. If verified, the registry will then issue credits to Anew Climate which can then be sold (Kollmuss et al. 2008). Project developers will then use funds from the sale of generated carbon credits to pay the verifier, registry, and landowner with the distribution of payments varying with project developer.

5.8 Carbon programs

Carbon programs can range from international or government regulatory bodies, to NGO and private organizations. Sometimes the major registries are also described as carbon programs. Focusing on private carbon program organizations, such as Indigo Carbon, the primary difference from a project developer is that they usually fill more roles in protocol development, credit generation, landowner assistance, basic and applied research, credit purchase, or the credit sale process. Many of these same carbon programs may also function as aggregators, bundling offset projects or issued credits, discussed further in Section 5.10. A carbon program is more broadly engaged in the carbon offsetting and insetting process than a project developer and will often employ project developers as part of its overall program.

5.9 Third-party verifiers

Third-party verification is a requirement of the loosely defined "high-quality" offset credit. To provide this, third-party verification auditors known as validation/verification bodies (VVB) conduct third-party assessments of projects to confirm all project data and methods (Brammer and Bennett 2022). Typically, registries will have a list of approved auditors that project developers may use to verify their carbon credits. For example, Verra currently has more than 20 VVBs across five continents that are approved under the VCS program to validate projects (Verra 2022a). To become an approved VVB within the the program, the third-party verifier is required to sign an agreement with Verra and must be accredited by a VCS-recognized accreditation body (Verra 2022a). Gold Standard also provides a list of accredited VVBs and auditors within each organization for project developers to choose from for their current project (Gold Standard 2022).

Before net carbon sequestered or emissions avoided can be certified, they must first be reviewed to assess whether they meet the registry standard requirements (Brammer and Bennett 2022). Credit quality criteria requirements are outlined within the approved standards and protocols and are followed by third-party verifiers when verifying credits generated within a project (Brammer and Bennett 2022). For example, ACR requires all third-party verifiers follow the ACR Validation and Verification Standard when reviewing projects.

Verification of activities differs between each project and protocol; however, typically, methods require ongoing monitoring and reporting of activities and of carbon sequestration or emissions reductions (Brammer and Bennett 2022). For example, NativeEnergy, a project developer, verifies a project's performance after the first year in partnership with their VVB, Aster Global. A final verification round is conducted again several years later as a final confirmation (NativeEnergy 2022). ACR and Verra have a stated requirement that projects undergo a site visit verification at intervals no longer than five years (ACR 2022, Verra 2022b).

5.10 Brokers and aggregators

Often the cost and time associated with registering, monitoring, verifying, and selling credits can hinder project development (Brammer and Bennett 2022). Aggregators and brokers operate in the carbon market by aiding in selling, as well as generating an abundant supply of credits while minimizing project costs (Garnache and Merel 2012). Typically, aggregation can be undertaken by individuals and/or organizations to reduce transaction and business costs as well as in managing performance risk (Brammer and Bennett 2022). Overall, there are two types of aggregation: project and contract aggregation (Emissions Reduction Fund 2017). Project aggregation occurs when multiple projects using the same carbon protocol are grouped into a single registered project. The second, contract aggregation, occurs when multiple projects, sometimes using different methods (i.e. under different protocols and registries), are grouped into a single credit purchase bid (Emissions Reduction Fund 2017).

Often aggregators hold responsibility for delivery and underperformance under the carbon abatement contracts (Emissions Reduction Fund 2017). An aggregator may enter a carbon abatement contract with multiple project developers or may undertake all aspects of a project and aggregate multiple projects across various sites into one project (Brammer and Bennett 2022). The aggregator also may register each project separately with the intention of bundling projects into a single contract later (Diamant 2011).

Brokers act as middleman for the transaction of carbon credits after they have been issued in exchange for a commission (Capoor and Ambrosi 2007). Brokers, unlike project developers, do not take any responsibility or ownership of a project (Broekhoff et al. 2019). While brokers mainly operate within the compliance carbon market, there has been a recent increase of brokers within the voluntary carbon market as well (Walters and Martin 2012). Brokers tend to be more involved in the compliance market due to the higher volumes and higher price transactions as compared to the voluntary market. Brokers, like all other entities involved in carbon credit development are paid from the proceeds of credit sales. Therefore, broker involvement can necessitate higher sale prices to cover their additional costs or can potentially reduce the amount of funds available from other entities after sale. Some of the largest US brokers include Anew Climate and CME Group.

Anew Climate which formed after a merger with Blue Carbon and Elemental Markets, acts as both a project developer and a broker and represents both buyers and sellers within environmental and energy commodity markets.

CME Group aids in the buying and selling of offset credits and funding other emission reduction and carbon removal projects (CME Group 2022, Evolution Market 2022). Some project developers use Emission Reduction Purchase Agreements (ERPAs) to buy and sell carbon credits. An ERPA is a legally binding agreement between a buyer and seller that identifies responsibilities, rights, and obligations to manage project risks (Peskett 2010). Generally, an ERPA outlines quantity and price as well as the delivery and payment schedule of offsets (e.g., consequences of non-delivery, general obligations of the seller and buyer, project risks, Peskett 2010). Both of these groups act as intermediaries within the carbon markets.

6.0 REVIEW OF RANGELAND CARBON CREDIT PROTOCOLS

6.1 Introduction

Protocols are often detailed, dense, and have nuances of application which require some degree of familiarity. Familiarity with these protocols is the hallmark and specialty of project developers and carbon programs in facilitating and coordinating the generation of carbon offset credits. This report does not attempt an in-depth evaluation of all rangeland protocols, however, the following section provides some key sections to review in determining ineligible or impractical protocols for specific working lands. Protocol requirements have been summarized here in 6 broad categories for 15 protocols we have reviewed and consider applicable for rangelands and grasslands (Section 6.2 - 6.7, Appendices I – VI). We also briefly describe some general legal implications a landowner might encounter with any nature-based projects with or without an intermediary project developer (Section 6.8).

6.2 Eligibility in land use and practice

Protocols outline project requirements (e.g., land use, practice, and permanence) landowners and project developers must use to determine if the proposed site is eligible. Specifically, protocols will outline land use eligibility such as: (1) geographic scope (e.g., International, United States); (2) applicable land types (e.g., rangeland or forest land); and (3) minimum enrollment size (i.e., acreage needed to support project).

In addition to land type or general land use requirements, all potential project sites must meet land practice or activity requirements as well and be able to pass an additionality test (in most cases) intended to ensure more carbon is sequestered or emissions avoided than Business As Usual (BAU) scenarios. Protocols will outline: (1) specific eligible management activities (e.g., reduced fertilizer application); (2) ineligible or prohibited practices (e.g., draining wetlands); (3) whether additional or new activities are required (most require additionality); and (4) additionality criteria (how to determine whether a practice is considered additional). Finally, protocols will outline permanence requirements that a project site must meet. These requirements outline the obligations under the protocol intended to address risk of short term reversals. For example, a protocol may require the project site enter into a conservation easement, or that project site management or condition should remain unchanged for 25 years after project implementation. A broad summary of some of these requirements for 15 protocols can be found in Appendix II Eligibility in Land Use, Practice, and Management.

6.3 Sampling and modeling

To encourage consistency in measurement and estimation of biomass, activity, and soil carbon between registered projects under the same protocol, many protocols outline specific monitoring methodologies.

Most protocols will also outline baseline data requirements and will state if baseline data will be collected one time (static) or if prior years of historic data are needed to calculate baseline levels (dynamic). This baseline is meant to provide an estimate of the GHG emissions or amount of carbon removal that would have occurred independent of project financing.

Protocols will state whether field sampling is required, how frequent sampling events must occur, the methodologies landowners or project developers must follow, and if/which models should be used when calculating emissions or carbon sequestration. Some protocols are very prescriptive while some have loose guidance or leave monitoring methods up to the discretion of the project developer. The Verra Methodology for Improved Agricultural Land Management (VM0021) protocol for example has three different measurement scenarios which can be utilized. After each monitoring period, many protocols will have reporting requirements in order to confirm all data is tracked and reductions remain on target. A broad summary of some of these requirements for 15 voluntary carbon protocols can be found in Appendix III Sampling, Monitoring, and Reporting.

6.4 Sequestration and emissions reduction quantification

Protocols outline how to quantify net emissions reductions including carbon sequestered from each project, emissions avoided, and/or emissions incurred. A protocol will identify the carbon pools that will be considered or excluded in calculating carbon removal. Within rangeland systems, soil organic carbon is often the only or primary carbon pool monitored for carbon sequestration and storage, but some will also consider changes in live or dead plant biomass (above and/or below-ground). Inorganic carbon may also be monitored under some protocols, for example, in Verra's Soil Carbon Quantification Methodology (VM0021) protocol.

Additionally, many protocols will only issue offset credits based on net carbon reductions which will include all carbon sequestered and all GHG emissions from operations in the project area. If project emissions are considered, a protocol will discuss how each emission type [e.g., methane (CH_4) from cattle or nitrous oxide (N_2O) from fertilizer use] must be quantified. Finally, all emission reduction and carbon removal data are usually standardized and reported as CO_2e to make different GHGs comparable within the same project boundary. This includes leakage considerations for any emissions that are shifted outside of the project boundary discussed more in Section 6.6. Therefore, protocols often provide guidance on accounting methods for emission sources and conversion to CO_2e. A broad summary of some of these requirements for 15 voluntary carbon protocols can be found in Appendix IV Emissions Reduction Quantification.

6.5 Payment strategy

When developing project protocols, some registries will outline the financial and data retention requirements landowners and/or project developers must follow. For example, project protocols may detail how long (i.e., crediting period) and at what intervals the registry will verify total reductions (e.g., 10 years, renewable up to 30 years). Protocols will also detail whether project aggregation is allowed. Through aggregation of projects, landowners may be able to minimize costs by partnering with other landowners and/or project developers to produce more offset credits. Protocols will also often state if the stacking of payments and incentives is permitted within the project area. For example, whether a carbon offset project can be implemented on a project site which also receives funding for activities under the USDA-NRCS Conservation Stewardship Program.

Finally, protocols outline data archiving requirements (e.g., landowners must keep data for 10 years after information is generated or 7 years after it is verified) and data sharing requirements (e.g., does the landowner retain data or is data owned by the developer or registry). A broad summary of some of these requirements for 15 voluntary carbon protocols can be found in Appendix V Payment Strategies.

6.6 Reversals and leakage

Most protocols have requirements intended to ensure that carbon will remain sequestered for a set amount of time. Protocols will outline how to monitor and mitigate reversals and leakage including when landowners/ project developers must contact the registry informing them of a reversal, methods for identifying risk of reversals, and how to mitigate the chance of a reversal (e.g., buffer pools). Reversal occurs when sequestered carbon is re-released into the atmosphere or post-intervention emissions are higher than baseline.

Leakage occurs when reduction of GHG emissions within a project directly or indirectly causes an increase in GHG emissions elsewhere. Protocols also often outline how to define and track leakage including what activities must be accounted for as leakage during the project (e.g., manure application), and how unintended increases in emissions due to activity shifts (e.g., livestock displacement) must be calculated. A broad summary of some of these requirements for 15 voluntary carbon protocols can be found in Appendix VI Reversals and Leakage.

6.7 Verification method

To generate a verified offset credit from a project, protocols will set monitoring, reporting, and verification processes. These requirements may include how often an offset credit must be verified, methods for verifying a credit, and/or who may verify, sometimes even specifying a specific third-party verifier. A broad summary of some of these requirements for 15 voluntary carbon protocols can be found in Appendix VII Verification Methods.

6.8 Legal implications

While protocols outline the practices required to meet the registry standards, the agreements and contracts put in place between parties to meet those protocol requirements may impose some legal requirements that cannot be fully captured here since they will apply on a project-by-project basis. In her review of contracts associated with these sorts of projects, Lashmet (2022) outlined some key concerns that landowners should be aware of before entering into a contract for a project. While by no means comprehensive, some selected examples from Lashmet's work are given below to illustrate these concerns:

- **Control of land** – given the permanence and activity requirements under some protocols (Appendix II) some leased lands may be precluded from entering into a project agreement. This is especially true if the lease is shorter than the protocol permanence requirement or crediting periods (Appendix II and V). In either case the leaseholder and lessee would both be required to adhere to all protocol requirements.
- **Implications for energy development** – to be eligible for a project under certain protocols, a landowner may need to exclude parts of a property from any future energy development. If a surface owner cannot or will not ensure that energy development is excluded from the project area in the future, they may not meet the permanence and activity requirements of many protocols (Appendix II). This would be relevant for oil and gas as well as renewable energy development in some cases.
- **Activity implications** – since net emissions are quantified under some protocols, contracts may include provisions against introducing new emission sources within project boundaries, such as new vehicles, to ensure that net emission reduction targets are met.
- **Land title implication** – the landowner may be asked to enter into a restrictive covenant, lien, or conservation easement to meet certain protocol permanence and activity requirements.
- **Penalties** – since there are numerous activities, accounting, and land use requirements under the various protocols, contracts may contain penalties and termination clauses if these conditions are not met.

These examples illustrate that a carbon offset project agreement will usually create additional requirements that can alter landowner operations beyond the specific project boundaries and for many years.

7.0 GLOSSARY OF TERMS

Additionality: There are different tests and standards used to judge additionality. However, in carbon offset projects, additionality refers to the requirement that the financial incentive from the carbon offset project be deemed the primary cause of the intervention that led to increased carbon removal or voided emissions. For example, if the actions undertaken in a carbon offset project are required for ANY other legal reason, then most guidelines would indicate additionality could not be claimed.

Aggregation: Refers to the grouping or bundling of projects and/or offset credits. To minimize the cost of project development, multiple projects using the same protocol can be grouped into a single registered project. Alternatively, to meet demand, multiple offset credits, sometimes generated using different protocols, can be bundled into a single bid.

Allocation: Refers to permitted emissions under an emissions trading scheme. Each permit sets the allowable emissions for the permit holder and thus their "allocation" of emissions which can be used or traded and sold.

Avoided Emissions: In this report, avoided emissions refer to estimates of emissions that would have occurred in the absence of intervention. Some protocols such as the avoided land-use protocols will generate offsets based on the amount of emissions avoided from preventing land use conversion. Used interchangeably in some cases with emissions reductions.

Baseline: Refers to the measurement of any current pre-intervention values or to any quantified estimates of future values under a baseline scenario. For example, baseline soil organic carbon values pre-project implementation or projected soil organic carbon in 10 years under a business-as-usual scenario, see below.

Baseline Scenario: A baseline scenario is the assumed conditions under which a baseline estimate can be made. A baseline scenario, sometimes used interchangeably with "business as usual," assumes that past management and development trends will continue in the absence of intervention. These set of conditions will determine the variables used in estimating baseline values.

Business as Usual (BAU): Used interchangeably or in tandem with baseline scenario, see above.

Cap-and-Trade: A system designed by a governmental institution or authority to limit emissions by setting a cap on the total amount GHG that can be emitted within an area or sector while also creating and allowing a market for those limited number of allowable emissions. Permits, also known as allowances, are given to companies which can be traded if the full allowance is not utilized. The intention is to create a market incentive for emitters to reduce emissions while also slowly lowering the total allowable emissions over time.

Carbon Credit: A carbon credit is a fungible commodity that represents a unit of atmospheric GHG reduction typically of 1 tonne CO_2e. Carbon offset credits represent a GHG reduction through avoided emissions, or carbon removal (sequestration) which can be traded and used as an emission reduction claim against the purchasers' own GHG emissions. A carbon credit representing allowable emissions is found in cap-and-trade systems and allows the owner/purchaser to emit the credit amount as part of their operations. In this report we use carbon credit synonymously with carbon offsets or other types of verified emissions reduction assets.

7.0 GLOSSARY OF TERMS CONTINUED

Carbon Market: Both voluntary or compliance markets function to allow entities to buy, sell, and trade credits to regulate GHG emissions or to offset their own emissions.

CO_2 equivalent (CO_2e): A way of standardizing the reporting of all GHG emissions (e.g. CO_2, CH_4, etc...). All GHGs are converted to a unit of CO_2e representing the global warming potential of one metric tonne of CO_2. For example, 1 tonne of CH4 would be converted to approximately 25 tonnes CO_2e since methane has 25 times the global warming potential of carbon dioxide.

Carbon offset: Carbon offsets, which are sometimes used interchangeably with carbon credits, specifically refer to a unit of atmospheric carbon removed or emissions avoided which can be purchased and sold in voluntary compliance markets. Carbon offsets typically represent 1 tonne of CO_2e and can be utilized to compensate for the purchasers GHG emissions.

Carbon offsetting: Carbon offsetting is the process by which companies fund avoided emissions and carbon removal projects which occur external to their organization, and utilized those reductions and removals to compensate for their own GHG emissions (i.e. subtract offset amount from emissions inventory).

Carbon pool: Sometimes used interchangeably with carbon sink, it represents a reservoir in an ecosystem which has the capacity to take, store, and release carbon. In grassland ecosystems the primary carbon pools, are in order of relative mass; soils, belowground plant biomass, and aboveground plant biomass.

Carbon reduction: In the context of the nature-based carbon offset markets, carbon reduction refers to the net reduction of CO_2 from the atmosphere through photosynthesis driven removal, from avoided emissions (protecting stored carbon from release), or reduction of direct emissions sources (reduction of fertilizer use for example).

Carbon removal: In the context of nature-based carbon markets, it refers to removing carbon dioxide from the atmosphere through photosynthesis.

Carbon sequestration: Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide, used interchangeably with removal in some instances.

Carbon stock: Can also be used interchangeably with carbon storage, represents the amount of carbon currently within a carbon pool or within multiple carbon pools in an area.

Compliance Market: Compliance markets sell credits which are tied to a regulatory program created by national, regional, and/or international programs. Compliance markets in cap-and-trade systems for example, facilitate the sale of a carbon credits which represents the right to emit GHGs, usually equivalent 1 tonne CO_2e.

Crediting Period: The crediting period usually starts when project activities begin or when GHG emissions reductions or removals are achieved. The crediting period is the length of the project lifetime when quantified emissions reductions and removals will generate offset credits. Protocols may specify a minimum, maximum, a range, or specific number of years.

7.0 GLOSSARY OF TERMS CONTINUED

Credit Stacking: This can refer to receiving payments for different ecosystem service benefits from the same project (i.e. carbon credits and water credits), or it can refer to generating carbon offset credits from multiple protocols/registries within the same project. Credit stacking is not allowable under some protocols.

Credit Quality Criteria Initiative: Developed by the Environmental Defense Fund, World Wildlife Fund, and Oeko-Institut, the Carbon Credit Quality Initiative was made to guide buyers on carbon credits in a growing market. It uses seven criteria to score and evaluate programs.

Emissions Cap: A limit on the amount of GHG emissions that can be emitted by an entity or within a political boundary (i.e. state). These are typically found in regulatory cap-and-trade programs.

Emissions Reductions: Refers to a reduction in the amount of GHG released into the atmosphere. Within nature-based carbon markets, avoided land-use conversion could be considered an emission reduction, since land-use conversion often results in the release of organic carbon into the atmosphere. As a second example, reducing use of nitrogen fertilizer could be an emission reduction since overuse of fertilizer can lead to release of GHGs. This is sometimes used interchangeably in this report with avoided emissions.

Emissions Trading: The trading of emissions allowances within a compliance market.

Insetting: The process by which companies invest in GHG emissions reductions or carbon removal within their own value chain in order to compensate for or reduce their GHG emission inventory. For companies which have land or other natural assets in their value-chain, nature-based reduction projects can be funded within their value chain and used to reduce scope 3 emissions. Inset credits are not traded or sold to other organizations but are generated and utilized internally to reduce emission inventories. Inset credits can be generated using a process similar to the offset credit market.

Leakage: Leakage occurs when reduction of GHG emissions within a project directly or indirectly causes an increase in GHG emissions elsewhere. Leakage can be separated into activity leakage and market leakage. Protocols will usually take leakage into account when estimating emissions. When leakage occurs, there is a decrease in net GHG reductions since emissions are merely displaced, not sequestered.

Metric Tonne of CO_2: A metric tonne of carbon dioxide, which is equal to 2,204.62 lbs. This is different from a U.S. ton, which is equal to 2,000 lbs.

Mitigation: In the context of climate change prevention, any efforts to reduce or prevent GHG emissions, or to remove CO_2 from the atmosphere in order to avoid future impacts from climate change.

Payment stacking: Projects that are funded both through offset purchases while also utilizing other payments for example, from the USDA Farm Bill programs. This would be receiving two or more payments for the same conservation action. Some protocols may prohibit or limit this practice if it is considered to have negated the additionality standard.

7.0 GLOSSARY OF TERMS CONTINUED

Permanence: The timeline requirements for sequestered carbon or management intended to ensure meaningful climate change mitigation. Permanence requirements are intended to ensure sequestered carbon remains stored long-term or mitigate risk of short-term reversals. Most protocols will outline a timeframe when carbon stocks must be protected against reversals which are referred to as permanence. Penalties are usually outlined if permanence requirements are not met.

Project developer: Project developers can be a single person, team, or organization that initiates, bears the financial burden of, and who is legally responsible for running an offset project. This includes identifying and working with landowners, implementing a protocol certified by a registry, collaborating with partners, etc.

Project proponent: Sometimes used interchangeably with project developer, see above.

Protocol: Protocols outline land management activities, reporting, permanence, additionality, monitoring, and other requirements that must be met to generate credits. The term methodology is sometimes used interchangeably or used to refer to specifically to methodologies contained within a protocol, depending on the registry.

Registry: A registry reviews and certifies protocols that can be used to generate offset credits and are responsible for issuing, certifying, tracking ownership, sale, and retirement of offset credits.

Retire: A registry will retire the serial number assigned to each offset credit once it is used to claim a GHG emission reduction by the purchaser. This is intended to mitigate risk of double counting.

Reversals: Reversals occur when sequestered carbon is re-released into the atmosphere or post-intervention emissions are higher than baseline. A buffer pool of credits is usually set aside as a reserve of non-tradeable carbon credits that will be used to compensate for reversals. In cases of reversals that are larger than the buffer pool, penalties can include forfeited credits or requirement to refund payments in full.

Scope 1 emissions: GHG emissions that come directly from owned or controlled corporate operations. Examples include from company vehicles, equipment, or from owned facilities.

Scope 2 emissions: Emissions from power generation used by an operation. Emissions from power generation are usually indirect since power is typically purchased from a public utility.

Scope 3 emissions: All indirect emissions not included in Scope 2, caused indirectly by a corporation through its upstream supply chain and downstream emissions. For example, for a bakery, all emissions associated with the production, milling, and transport of wheat would be part of their scope 3 emissions inventory.

Soil carbon sequestration: Soil carbon sequestration is the rate at which CO_2 is captured, assimilated, and stored in the soil in organic or inorganic forms.

Soil organic carbon: Soil organic carbon refers only to the carbon component of organic compounds in the soil.

7.0 GLOSSARY OF TERMS CONTINUED

Soil organic matter: Soil organic matter is the organic component of the soil and consists of both living and dead organic components. Sources of soil organic matter include plants and animals. It is composed of many elements; mainly carbon, hydrogen, oxygen.

Validation: After a project design document is created, an entity or individual, usually an approved third-party validation and verification body, will review that a project design meets the requirements set by the standard.

Verification: To verify a carbon credit, an entity or individual, usually an approved third-party validation and verification body, monitor project data and verify that carbon sequestered, avoided emissions, or emissions reductions were generated and estimated according to all project protocols, and ensures the appropriate number of credits will be issued by project.

Voluntary Carbon Market: A market that enables collective voluntary transactions of carbon credits. Voluntary carbon markets have no centralized marketplace and is highly fragmented, composed of many different entities and discrete programs.

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APPENDIX I. GENERAL PROTOCOL DESCRIPTIONS

Protocol	Major US Standard/ Registry	General Description	Key Protocol Information (See page numbers)
Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	Yes	A protocol for projects that enhance soil carbon sequestration or reduce emissions on agricultural lands through adoption of agricultural land management activities.	**Additionality** - Appendix II pg. 67; **Permanence** - Appendix II pg. 67; **Leakage** - Appendix VI pg. 101; **Reversals** - Appendix VI pg. 101; **Land Use Eligibility** - Appendix II pg. 67; **Practice Eligibility** - Appendix II pg. 67; **Monitoring** - Appendix III pg. 82; **Credit Quantification** - Appendix IV pg. 90; **Payment Strategy** - Appendix V pg. 95; **Verification** - Appendix VII pg. 106
Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)	Yes	A protocol for projects that enhance soil carbon sequestration or reduce emissions on agricultural lands through adoption of agricultural land management activities especially regenerative agriculture.	**Additionality** - Appendix II pg. 68; **Permanence** - Appendix II pg. 68; **Leakage** - Appendix VI pg. 101; **Reversals** - Appendix VI pg. 101; **Land Use Eligibility** - Appendix II pg. 68; **Practice Eligibility** - Appendix II pg. 68; **Monitoring** - Appendix III pg. 82; **Credit Quantification** - Appendix IV pg. 90; **Payment Strategy** - Appendix V pg. 95; **Verification** - Appendix VII pg. 106
Adoption of Sustainable Land Management, v 1.0 VERRA (2011)	Yes	A protocol for projects that reduce emissions on agricultural lands through adoption of agricultural land management activities including but not limited to manure management, use of cover crops, compositing crop residuals, and introduction of trees onto the landscape.	**Additionality** - Appendix II pg. 69; **Permanence** - Appendix II pg. 69; **Leakage** - Appendix VI pg. 101; **Reversals** - Appendix VI pg. 101; **Land Use Eligibility** - Appendix II pg. 69; **Practice Eligibility** - Appendix II pg. 69; **Monitoring** - Appendix III pg. 83; **Credit Quantification** - Appendix IV pg. 90; **Payment Strategy** - Appendix V pg. 95; **Verification** - Appendix VII pg. 106
Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)	Yes	A protocol designed to quantity changes in carbon accrual from conservation, ecosystem restoration, agricultural projects, as well as other projects where management directly or indirectly affects changes in soil carbon.	**Additionality** - Appendix II pg. 70; **Permanence** - Appendix II pg. 70; **Leakage** - Appendix VI pg. 101; **Reversals** - Appendix VI pg. 101; **Land Use Eligibility** - Appendix II pg. 70; **Practice Eligibility** - Appendix II pg. 70; **Monitoring** - Appendix III pg. 83; **Credit Quantification** - Appendix IV pg. 91; **Payment Strategy** - Appendix V pg. 96; **Verification** - Appendix VII pg. 106

APPENDIX I. GENERAL PROTOCOL DESCRIPTIONS CONTINUED

Protocol	Major US Standard/ Registry	General Description	Key Protocol Information (See page numbers)
Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	Yes	A protocol designed to quantity changes in GHG emissions and soil organic carbon stocks through the adoption of improved agricultural practices to achieve avoidance of emissions as well as increases in soil carbon stock.	**Additionality** - Appendix II pg. 71; **Permanence** - Appendix II pg. 71; **Leakage** - Appendix VI pg. 102; **Reversals** - Appendix VI pg. 102; **Land Use Eligibility** - Appendix II pg. 71; **Practice Eligibility** - Appendix II pg. 71; **Monitoring** - Appendix III pg. 84; **Credit Quantification** - Appendix IV pg. 91; **Payment Strategy** - Appendix V pg. 96; **Verification** - Appendix VII pg. 106
Nori Croplands Methodology, v 1.3 NORI (2021)	No	A protocol designed to quantity increases in soil organic carbon stocks resulting from the adoption of improved regenerative soil treatment and cropping practices.	**Additionality** - Appendix II pg. 72; **Permanence** - Appendix II pg. 72; **Leakage** - Appendix VI pg. 102; **Reversals** - Appendix VI pg. 102; **Land Use Eligibility** - Appendix II pg. 72; **Practice Eligibility** - Appendix II pg. 72; **Monitoring** - Appendix III pg. 84; **Credit Quantification** - Appendix IV pg. 91; **Payment Strategy** - Appendix V pg. 96; **Verification** - Appendix VII pg. 106
Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	No	A protocol intended to provide a holistic assessment of multiple ecological state indicators for grasslands prescribed grazing regimes including climate mitigation through increases in soil organic carbon stocks as well as co-benefits including soil health, animal welfare and ecosystem health.	**Additionality** - Appendix II pg. 73; **Permanence** - Appendix II pg. 73; **Leakage** - Appendix VI pg. 102; **Reversals** - Appendix VI pg. 102; **Land Use Eligibility** - Appendix II pg. 73; **Practice Eligibility** - Appendix II pg. 73; **Monitoring** - Appendix III pg. 85; **Credit Quantification** - Appendix IV pg. 92; **Payment Strategy** - Appendix V pg. 97; **Verification** - Appendix VII pg. 106
BCarbon Soil Carbon Credit Systems BCARBON (2021)	No	A protocol designed to measure and quantify changes in below-ground stored carbon over time on working lands properties.	**Additionality** - Appendix II pg. 74; **Permanence** - Appendix II pg. 74; **Leakage** - Appendix VI pg. 103; **Reversals** - Appendix VI pg. 103; **Land Use Eligibility** - Appendix II pg. 74; **Practice Eligibility** - Appendix II pg. 74; **Monitoring** - Appendix III pg. 85; **Credit Quantification** - Appendix IV pg. 92; **Payment Strategy** - Appendix V pg. 97; **Verification** - Appendix VII pg. 107

APPENDIX I. GENERAL PROTOCOL DESCRIPTIONS CONTINUED

Protocol	Major US Standard/ Registry	General Description	Key Protocol Information (See page numbers)
Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)	Yes	A protocol is designed to measure and quantify emissions reductions and removals from restoration of degraded lands and afforestation projects.	**Additionality** - Appendix II pg. 75; **Permanence** - Appendix II pg. 75; **Leakage** - Appendix VI pg. 103; **Reversals** - Appendix VI pg. 103; **Land Use Eligibility** - Appendix II pg. 75; **Practice Eligibility** - Appendix II pg. 75; **Monitoring** - Appendix III pg. 86; **Credit Quantification** - Appendix IV pg. 92; **Payment Strategy** - Appendix V pg. 97; **Verification** - Appendix VII pg. 107
Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)	Yes	A protocol to estimate the amount of emissions avoided by preventing the conversion of grasslands and shrublands to annual crop production.	**Additionality** - Appendix II pg. 76; **Permanence** - Appendix II pg. 76; **Leakage** - Appendix VI pg. 103; **Reversals** - Appendix VI pg. 103; **Land Use Eligibility** - Appendix II pg. 76; **Practice Eligibility** - Appendix II pg. 76; **Monitoring** - Appendix III pg. 86; **Credit Quantification** - Appendix IV pg. 93; **Payment Strategy** - Appendix V pg. 98; **Verification** - Appendix VII pg. 107
Methodology for sustainable grassland management, v 1.1 VERRA (2021)	Yes	A protocol to estimate emissions reductions and removals from adopting sustainable grassland management practices such as rotational grazing or restoration of severely degraded land.	**Additionality** - Appendix II pg. 77; **Permanence** - Appendix II pg. 77; **Leakage** - Appendix VI pg. 103; **Reversals** - Appendix VI pg. 103; **Land Use Eligibility** - Appendix II pg. 77; **Practice Eligibility** - Appendix II pg. 77; **Monitoring** - Appendix III pg. 87; **Credit Quantification** - Appendix IV pg. 93; **Payment Strategy** - Appendix V pg. 98; **Verification** - Appendix VII pg. 107
Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)	Yes	A protocol to quantify emissions reductions and changes in soil carbon stock from adoption of grassland management techniques such as manipulating stocking rates, rotational grazing or altering fire regimes including fire frequency, intensity, or timing.	**Additionality** - Appendix II pg. 78; **Permanence** - Appendix II pg. 78; **Leakage** - Appendix VI pg. 104; **Reversals** - Appendix VI pg. 104; **Land Use Eligibility** - Appendix II pg. 78; **Practice Eligibility** - Appendix II pg. 78; **Monitoring** - Appendix III pg. 87; **Credit Quantification** - Appendix IV pg. 93; **Payment Strategy** - Appendix V pg. 99; **Verification** - Appendix VII pg. 108

APPENDIX I. GENERAL PROTOCOL DESCRIPTIONS CONTINUED

Protocol	Major US Standard/ Registry	General Description	Key Protocol Information (See page numbers)
Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)	Yes	A protocol to estimate and quantify emissions reductions and removals from activities that prevent the conversion of forest to non-forest and of native grassland and shrubland to a non-native state.	**Additionality** - Appendix II pg. 79; **Permanence** - Appendix II pg. 79; **Leakage** - Appendix VI pg. 104; **Reversals** - Appendix VI pg. 104; **Land Use Eligibility** - Appendix II pg. 79; **Practice Eligibility** - Appendix II pg. 79; **Monitoring** - Appendix III pg. 88; **Credit Quantification** - Appendix IV pg. 94; **Payment Strategy** - Appendix V pg. 99; **Verification** - Appendix VII pg. 108
Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)	Yes	A protocol to quantify and estimate emissions reductions associated with projects that prevent loss of soil carbon due to conversion of grassland to cropland as well as other associated GHG emissions.	**Additionality** - Appendix II pg. 80; **Permanence** - Appendix II pg. 80; **Leakage** - Appendix VI pg. 104; **Reversals** - Appendix VI pg. 104; **Land Use Eligibility** - Appendix II pg. 80; **Practice Eligibility** - Appendix II pg. 80; **Monitoring** - Appendix III pg. 88; **Credit Quantification** - Appendix IV pg. 94; **Payment Strategy** - Appendix V pg. 100; **Verification** - Appendix VII pg. 108
Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)	Yes	A protocol to quantify reductions in GHG emissions and removals from carbon sequestration by changing soil tillage practices.	**Additionality** - Appendix II pg. 81; **Permanence** - Appendix II pg. 81; **Leakage** - Appendix VI pg. 105; **Reversals** - Appendix VI pg. 105; **Land Use Eligibility** - Appendix II pg. 81; **Practice Eligibility** - Appendix II pg. 81; **Monitoring** - Appendix III pg. 89; **Credit Quantification** - Appendix IV pg. 94; **Payment Strategy** - Appendix V pg. 100; **Verification** - Appendix VII pg. 108

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE

Protocol		Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)
Land Use Eligibility	**Geographic Scope**	Non-federal lands in the US including territories, and tribal lands.
	Applicable Cropping Systems and Land Use	Must be grassland or cropland. Projects must remain in agricultural production throughout the crediting period.
	Minimum Enrollment SIze?	Not stated.
Practice Eligibility	**Additionality criteria**	Determined by a performance additionality standard test criteria including adopting or stopping practices that impact SOC storage where that practice is not already performed on > 50% of cropland/pasture area within the County, and where the practice is not already required by law.
	Ineligible or Prohibited Practices	Some practices may not be eligible if it is shown that they are already a common practice in the area (see additionality criteria). Areas which have been cleared of native ecosystems or other restored or protected areas may not be eligible. Project activities which decrease carbon stocks in woody perennials or which introduce broadscale organic amendments may not be eligible due to the potential to shift systems toward lower grassland biodiversity.
	Eligible Management Activities	Project activities can include one or more changes to: fertilizer application, soil amendments, water management, tillage/residue mgmt., crop planting, fossil fuel usage, and grazing practices.
	New Activities Required	Yes. Soil enrichment protocol requires a project activity to be implemented that enhances soil carbon sequestration on agricultural lands through the adoption of sustainable agricultural land management activities.
Permanence Eligibility	**Landowner Permanence Commitment**	Credits are issued as a proportion of a 100-year permanence period. The full amount would be paid with 100 year permeance.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)
Land Use Eligibility	Geographic Scope	International.
	Applicable Cropping Systems and Land Use	Project activities must be implemented on land that is, and remains, either cropland or grassland throughout the project crediting period.
	Minimum Enrollment SIze?	Sample unit (i.e., field).
Practice Eligibility	Additionality criteria	(1) Establish that the change in practice would NOT have occurred because of cultural/social barrier without the project and (2) demonstrate that the proposed project activities are not already a common practice (< 20% local adoption).
	Ineligible or Prohibited Practices	The project area must not have been cleared of native ecosystems within the 10-year period prior to the project start date. Restrictions exist if project activity involves the application of biochar. If biochar is used, it must be produced using feedstock that would otherwise have been left to decay in aerobic or anaerobic conditions or been burned in an uncontrolled manner. Additionally, the project activity cannot occur on a wetland.
	Eligible Management Activities	Project activities include: reduced fertilizer application, improved water management, reduced tillage and improved residue management, improved crop planting and harvesting, and improved grazing practices. Other regenerative ag practices can be included where GHG benefits can be reliably demonstrated.
	New Activities Required	Yes. A change constitutes adoption of a new practice, cessation of a pre-existing practice, or adjustment to a pre-existing practice that is expected to reduce GHG emissions and/or increase GHG removals. Any adjustment must exceed 5% of the pre-existing value.
Permanence Eligibility	Landowner Permanence Commitment	30 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Adoption of Sustainable Land Management, v 1.0 VERRA (2011)
Land Use Eligibility	Geographic Scope	International. Methodology based on the project, "Western Kenya Smallholder Agriculture Carbon Finance Project".
	Applicable Cropping Systems and Land Use	Applicable to projects that introduce sustainable agriculture land management practices (SALM) in croplands or grasslands. Applicable to areas where the soil organic carbon would remain constant or decrease in the absence of the project.
	Minimum Enrollment SIze?	Not stated.
Practice Eligibility	Additionality criteria	The project must use the most recent version of the CDM combined tool to identify the baseline scenario and demonstrate additionality.
	Ineligible or Prohibited Practices	The project may not occur on wetlands.
	Eligible Management Activities	SALM project activities may include, but are not limited to manure management, use of cover crops, returning composted crop residuals to the field, and the introduction of tress into the landscape.
	New Activities Required	Yes. New project activities require the introduction of sustainable agriculture land management practices.
Permanence Eligibility	Landowner Permanence Commitment	30 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)
Land Use Eligibility	Geographic Scope	International.
	Applicable Cropping Systems and Land Use	Projects must be cropland or grassland. Applicable to conservation, ecosystem restoration and agricultural projects, as well as other projects where the management of soils directly, or management of hydrology, fertility and vegetation systems, can affect changes in soils and soil carbon.
	Minimum Enrollment SIze?	Not stated.
Practice Eligibility	Additionality criteria	Project proponent must demonstrate that the proposed project activity is additional using the latest version of the CDM Combined tool.
	Ineligible or Prohibited Practices	Project activities must not include changes in surface and shallow (<1m) soil water regimes through flood irrigation, drainage, or other significant anthropogenic changes in the ground water table. Additionally, the project activity must not cause a significant change in termite populations, as compared with the baseline scenario.
	Eligible Management Activities	Available to a range of project activities designed to improve soils including: changes to agricultural practices, grassland and rangeland restoration, reductions in erosion, grassland protection projects, treatments designed to improve diversity and productivity of grassland and savanna plant communities.
	New Activities Required	Yes. Projects must implement new activities focused on improving cropland management, grassland management, or for cropland and grassland land-use conversions.
Permanence Eligibility	Landowner Permanence Commitment	30 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)
Land Use Eligibility	**Geographic Scope**	International.
	Applicable Cropping Systems and Land Use	Land with a cropping system that has been in place for at least 5 years prior to project implementation.
	Minimum Enrollment SIze?	Variable. See approved protocols.
Practice Eligibility	**Additionality criteria**	All projects must demonstrate they would not have been implemented without the benefits of carbon certification using CDM Additionality Tool, or showing local adoption rate of <5% in the area; and the using the Gold Standard activities list.
	Ineligible or Prohibited Practices	Wetlands or forests ineligible. Biomass burning for site preparation is ineligible. Project activities shall not include changes in surface and shallow soil water regimes. The project activity must not lead to land use conversion. Activities which cause reduction in crop yield are ineligible.
	Eligible Management Activities	Encompasses a range of activities/scales that may be more specifically related to management practices depending on SOC Activity Modules which are developed on an ongoing basis.
	New Activities Required	Yes. Improved agricultural practices must be adopted as part of project activities.
Permanence Eligibility	**Landowner Permanence Commitment**	Permanence required within crediting period. Percentage of credits go to a buffer to mitigate against losses.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Nori Croplands Methodology, v 1.3 NORI (2021)
Land Use Eligibility	Geographic Scope	Continental United States.
	Applicable Cropping Systems and Land Use	US croplands including those producing a wide variety of annual veg, grain, fruit, and perennial orchards.
	Minimum Enrollment SIze?	N/A
Practice Eligibility	Additionality criteria	Nori will only issue credits representing incremental CO_2 drawdown and retention arising from an activity or practice change that is reasonably expected to result in a net new CO_2 removal and CO_2 retention.
	Ineligible or Prohibited Practices	Because the conversion of forests or grasslands to cropland results in significant net CO_2 releases to the atmosphere, croplands that were converted from forests or grasslands after December 31, 1999 are not eligible.
	Eligible Management Activities	Eligible project activities include: changing/expanding crop rotations and crop intensity, introducing cover crops and/or shifting from annual to perennials, reducing tillage intensity and/or adopting new residue mgmt. techniques, new irrigation techniques, substituting synthetic fertilizers with OM additions.
	New Activities Required	Yes. Nori requires new practices to be adopted in croplands or substituting perennial grasses or woody biomass in wetlands, riparian or buffer zones that were previously cropped.
Permanence Eligibility	Landowner Permanence Commitment	10 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)
Land Use Eligibility	Geographic Scope	International.
	Applicable Cropping Systems and Land Use	Grasslands, shrublands and pastures only.
	Minimum Enrollment SIze?	None stated as long as a minimum number of samples taken per 1000 hectares.
Practice Eligibility	Additionality criteria	Criteria not stated within the protocol. However, Regen Network Registry states a practice must be additional and adopted from a pre-approved list of regenerative grazing best management practices.
	Ineligible or Prohibited Practices	When examining the correlation between percent SOC and remote sensing data, simple regression models can only be fit to satellite imagery, ancillary data or derived indices may not be used. Any practices which do not meet animal welfare standards mentioned in the protocol would also be prohibited.
	Eligible Management Activities	Activities must be additional and a new practice can be adopted from a pre-approved list outlining regenerative grazing best management practices.
	New Activities Required	Yes. A project must be implemented that will aid in minimizing the release of carbon by altering prescribed grazing methods.
Permanence Eligibility	Landowner Permanence Commitment	25 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		BCarbon Soil Carbon Credit Systems BCARBON (2021)
Land Use Eligibility	Geographic Scope	United States private and tribal lands as well as internationally.
	Applicable Cropping Systems and Land Use	Standard applies to cropland or grazing land that is proven by testing to sequester carbon and remains in production for ten years after each credit award year, with a "true-up" after five years.
	Minimum Enrollment SIze?	There is no minimum or maximum acreage specified.
Practice Eligibility	Additionality criteria	BCarbon redefines additionality as a property rights concept. If a landowner can prove that they are adding atmospheric carbon to the soil or as tree biomass, they have a right to sell that stored carbon. On the other side, emitters own the carbon dioxide they release and have the right to pay landowners to remove and store their carbon dioxide emissions in the soil. BCarbon defines additionality as any carbon storage that is ensured through the sale of credits.
	Ineligible or Prohibited Practices	This protocol is directed to below-ground carbon measurements only and so does not encompass the evaluation of above-ground carbon accrual associated with the land management practices. Measurement of soil carbon based on Loss of Ignition (LOI) methods is not accepted under this protocol.
	Eligible Management Activities	Protocol may be applied to any land management practice that enhances and maintains below-ground carbon in a way that preserves or improves soil health.
	New Activities Required	No. If a landowner can prove that they are adding atmospheric carbon to the soil or trees, they have a right to sell that stored carbon. BCarbon projects are additional because storage would not be ensured without the sale of credits.
Permanence Eligibility	Landowner Permanence Commitment	The initial permanence commitment required by BCarbon is ten years, which is renewable each subsequent year when new credits are issued.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)
Land Use Eligibility	Geographic Scope	International. However, if the Forest Vegetation Simulator is used, projects must be located in the United States.
	Applicable Cropping Systems and Land Use	Applicable to afforestation and reforestation project activities that are implemented on degraded lands that are expected to remain degraded or continue to degrade in the absence of the project.
	Minimum Enrollment SIze?	Not stated; however, a regeneration monitoring area must be at least 1/4 hectare in size be similar to the project area, and be established outside of the project area.
Practice Eligibility	Additionality criteria	Project proponents shall demonstrate additionality through the ACR three-prong test.
	Ineligible or Prohibited Practices	If at least a part of the project activity is implemented on organic souls or wetlands, intentional manipulation of the water table is not allowed. No more than 10% of the area may be disturbed as a result of soil preparation for planting. Species planted are restricted to historic native species in the project area. Litter should remain on site and may not be removed in the project activity. Ploughing/ripping/scarification must be limited to the first five years and not repeated within a period of 20 years.
	Eligible Management Activities	Independent evaluation of a proposed afforestation or reforestation project activity by a designated operational entity against the requirements of the Clean Development Mechanism (CDM) needed.
	New Activities Required	Yes. A new afforestation/reforestation project activity must be implemented on degraded lands.
Permanence Eligibility	Landowner Permanence Commitment	A permanence period is not stated; however, to ensure permanence of a project, ACR requires projects with a risk of reversal to assess and mitigate risk.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)
Land Use Eligibility	**Geographic Scope**	United States.
	Applicable Cropping Systems and Land Use	Grassland or shrubland only; Must be qualified as shrubland or grassland for ten years prior to start date.
	Minimum Enrollment Size?	Not stated.
Practice Eligibility	**Additionality criteria**	Required to demonstrate that the project activity is surplus to regulations and reduces emissions below "business as usual" for rates of conversion of grassland to cropland in the US, based on practice test and performance standards.
	Ineligible or Prohibited Practices	No more than 25% of the land can be Land Capability Class VII and VIII. Grassland or shrubland on organic soils or peatlands, or wetland acres within grassland/shrubland tracts are ineligible. Where livestock are present, manure is not managed, stored, or dispersed in liquid form. Additionally, livestock must not be managed in a confined area (i.e., feedlot).
	Eligible Management Activities	Avoid conversion of grassland and shrubland to cropland.
	New Activities Required	Yes, a new project activity must be implemented to prevent the conversion of grasslands and shrublands to annual crop production.
Permanence Eligibility	**Landowner Permanence Commitment**	Projects must commit to maintain, monitor, and verify project activity for a minimum project term of 40 years. However, the minimum project term is not equated with the assurance of permanence.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Methodology for sustainable grassland management, v 1.1 VERRA (2021)
Land Use Eligibility	Geographic Scope	International. Located in a region where precipitation is less than evapotranspiration for most of the year and leaching is unlikely to occur.
	Applicable Cropping Systems and Land Use	Grassland at start of project that is degraded and baseline scenario that shows the land will continue to be degraded.
	Minimum Enrollment SIze?	There is no minimum or maximum acreage specified.
Practice Eligibility	Additionality criteria	Must demonstrate the additionality of the project using the most recent version of the VCS Tool for demonstration of additionality. The most plausible baseline scenario must be assessed together with the project scenario.
	Ineligible or Prohibited Practices	Project area must not have been cleared of native ecosystems within 10-years prior. Project activities must not include land use change. Project activities must not lead to an increase in the use of fossil fuels and fuel wood from non-renewable sources for cooking and heating. Wetlands or peatlands are ineligible.
	Eligible Management Activities	Activities that introduce sustainable grassland management practices such as: rotation of grazing animals between grassland areas, limiting the number of grazing animals on degraded grassland, restoring severely degraded grasslands by replanting with grasses and ensuring appropriate management.
	New Activities Required	Yes. new sustainable grassland management practices must be adopted.
Permanence Eligibility	Landowner Permanence Commitment	20 years.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)
Land Use Eligibility	Geographic Scope	International.
	Applicable Cropping Systems and Land Use	Must be grassland in the baseline and project scenarios. Expected to be on grasslands that historically have experienced SOC loss.
	Minimum Enrollment SIze?	For projects that propose to modify grazing, the maximum individual project size is 3 million ha or 5% of a country's land area currently or potentially used to graze livestock.
Practice Eligibility	Additionality criteria	Must use the latest version of the VCS tool for demonstration of additionality.
	Ineligible or Prohibited Practices	Project must result in no net increase in the density of or time spent by animals in confined corrals that would cause dung to pile up and cover more than 50% of the ground. Methods cannot be used with project activities that involve mechanical vegetation removal or soil tillage. Methods can also not be used in a project area that receives a net import of inorganic or organically-derived fertilizer.
	Eligible Management Activities	The project activities eligible to apply this methodology include manipulation of number and type of domestic livestock grazing animals and/or grouping, timing and season of grazing in ways that sequester soil carbon and/or reduce methane emissions. Altering fire frequency and/or intensity, in ways that increase carbon inputs to soil, is also an included activity.
	New Activities Required	Yes. New project activities focused on the adjustment of fire practices and grazing to produce a sustainable grassland.
Permanence Eligibility	Landowner Permanence Commitment	Not stated.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)
Land Use Eligibility	Geographic Scope	International. Under certain conditions, projects must be located in a tropical ecosystem.
	Applicable Cropping Systems and Land Use	Forests and grasslands.
	Minimum Enrollment SIze?	It is recommended plots be at least one hectare.
Practice Eligibility	Additionality criteria	Must use the latest version of the VCS tool for demonstration of additionality.
	Ineligible or Prohibited Practices	Project accounting areas must not contain peat soil. If livestock is being grazed within the project area in the project scenario, there must be no manure management taking place. Project activities must not result in significant GHG emissions.
	Eligible Management Activities	Project activities must apply to accounting for avoided emissions from planned deforestation and degradation, unplanned deforestation and degradation, planned conversion, and unplanned conversion.
	New Activities Required	Yes. A project activity must be implemented that prevents the conversion of forest to non-forest and of native grassland and shrubland to a non-native state.
Permanence Eligibility	Landowner Permanence Commitment	No period stated; however, a pooled buffer account that holds non-tradeable buffer credits will be used to cover the non-permanence risk.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)
Land Use Eligibility	Geographic Scope	Conterminous US and tribal areas.
	Applicable Cropping Systems and Land Use	Grasslands.
	Minimum Enrollment SIze?	Not stated.
Practice Eligibility	Additionality criteria	Projects must satisfy the following criteria to be considered additional: the performance standard test, the legal requirement test; and limits on payment and credit stacking. Projects must demonstrate surplus GHG reductions additional to what would have occurred in the absence of an offset carbon market.
	Ineligible or Prohibited Practices	Projects may not employ synthetic fertilizer additions. Livestock manure must not be managed in liquid form. Additionally, other recreational or economic activities may occur within the project area; however, the activity cannot threaten the integrity of the soil carbon stocks. Tree canopy may not exceed 10% of the land area on a per-acre basis.
	Eligible Management Activities	Prevention of emissions of GHGs to the atmosphere through conserving grassland belowground carbon stocks and avoiding crop cultivation activities on an eligible project area.
	New Activities Required	Yes. Project activity must be implemented to prevent GHG emissions through conserving grassland belowground carbon stocks and avoiding crop cultivation activities.
Permanence Eligibility	Landowner Permanence Commitment	Maintain stored carbon for at least 100 years following the issuance of CRTs. Employ a qualified conservation easement and project implementation agreement.

APPENDIX II. ELIGIBILITY IN LAND USE, PRACTICE AND MANAGEMENT PERMANENCE CONTINUED

Protocol		Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)
Land Use Eligibility	**Geographic Scope**	International.
	Applicable Cropping Systems and Land Use	Managed cropping systems (e.g., single crop or crop rotation) have been in place for at least five years prior to project implementation. Only mineral soil types are eligible.
	Minimum Enrollment SIze?	Not stated.
Practice Eligibility	**Additionality criteria**	All Gold Standard projects are required to demonstrate that they would not have been implemented without the benefits of carbon certification.
	Ineligible or Prohibited Practices	The project area shall not be on wetlands. Proposed projects on sites with organic soils are ineligible. No biomass burning for site preparation is allowed in the project scenario. Project activities shall not include changes in surface and shallow (<1m) soil water regimes, or other significant anthropogenic changes in the ground water table. No reduction in crop yield can be attributed to the project activity. This methodology is not applicable to no tillage techniques including strip tillage and direct drill practices.
	Eligible Management Activities	Conservation tillage methods are applied including reduced tillage where residue, is left to protect soil. At least 30 percent of the soil surface must remain covered by residue to reduce soil erosion by water. Activities in the project area must result in sequestration of carbon in soil, which result in an increased soil organic carbon content.
	New Activities Required	Yes. Conservation tillage practices must be implemented to avoid soil and moisture loss in turn reducing CO_2 emissions.
Permanence Eligibility	**Landowner Permanence Commitment**	No specific time stated. Under permanence protocol states "project participants shall demonstrate other motivations to participate in the project than generating CO_2-certificates."

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS

Protocol		Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)
On-site Sampling	Baseline (dynamic/ static)	Dynamic. The baseline is based on 3 - 5 years of historic BAU management. Baseline emissions will be remodeled each year using climate and SOC data from the project cultivation cycle.	Dynamic. The baseline is a minimum of 3 years and covering at least one full crop rotation. Baselines are required to be reassessed every 10 years.
	Field sampling required?	Yes.	Yes, SOC and bulk density must be measured.
	Frequency of Sampling	Soil sampling must occur at project initiation and every 5 years.	Measurements must occur every 5 years or less.
	Required Sampling Protocol?	Yes. Sampling details provided in SEP protocol.	No. The protocol states soil sampling should follow established best practices.
	Are models involved?	Yes. No specific model required, 5-year measurements are used to validate and adjust modeled estimates.	Yes, no specific model required, but must be publicly available, shown to be successful under peer review, able to support repetition, and validated per datasets and procedures detailed in VMD0053. The same model and parameter sets must be used in both the baseline data and project scenarios.
Project Reporting	Monitoring/ Reporting?	Monitoring is ongoing with results reported annually. Reporting periods are individual cultivation cycles (may be greater or less than a calendar year), and a verification may include as many as 5 reporting periods.	Every five years or prior to each verification event if less than 5 years

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Adoption of Sustainable Land Management, v 1.0 VERRA (2011)	Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)
On-site Sampling	Baseline (dynamic/ static)	Static. It is assumed that the baseline removals due to changes in SOC are zero.	Static. It is assumed that the current carbon content of the soils will stay the same throughout the project crediting period under the baseline scenario.
	Field sampling required?	Yes.	Yes.
	Frequency of Sampling	N/A	Once every five years.
	Required Sampling Protocol?	Yes. The project proponent shall use the CDM EB approved General Guidelines for Sampling and Surveys for Small-Scale CDM Project activities.	Yes, VMD0021 Estimation of Stocks in the Soil Carbon Pool, v1.0 for soil sampling.
	Are models involved?	Yes, the Roth-C model. If other models are used, revisions are required. Additionally, there must be studies that demonstrate that the use of the Roth-C model is appropriate for the IPCC climactic regions of 2006 IPCC AFOLU Guidelines or the agroecological zone in which the project is situated.	Yes, the DNDC model is required. Requires soil sampling coupled with modeled estimates for N_2O and CH_4.
Project Reporting	Monitoring/Reporting?	An Activity Baseline and Monitoring Survey (ABMS) is conducted annually; SOC modeling undertaken every 5 years.	At least once every five years.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	Nori Croplands Methodology, v 1.3 NORI (2021)
On-site Sampling	Baseline (dynamic/ static)	Static. Baseline is scenario that represents the continuation of historical land management practices that are being followed at least 5 years before project start date.	Dynamic. GGIT provides 10-year projections of SOC stock for both historic baseline and adoption scenarios for each enrolled field.
	Field sampling required?	Depends. No, unless the landowner chooses to follow Approach 1 (requires on-site measurements document baseline and project SOC stocks).	No, relies on Greenhouse Gas Inventory Tool (GGIT).
	Frequency of Sampling	At least once every five years.	N/A
	Required Sampling Protocol?	Yes, approved Methodologies include VCS VMD0021 and the ICRAF protocol.	N/A
	Are models involved?	Under Approach 2, no specific model is required. If using Approach 2, model/calculations must be supported by local/regional validation data. Validation of model via direct measurement is required.	Relies on GGIT platform. Data for model is required every year but needs to be verified by a third-party every 3 years.
Project Reporting	Monitoring/ Reporting?	Outlined within each Soil Carbon Activity Module.	Must update data annually in Nori app. but projects need verification at least every 3 years, with a final project audit after the 10 years.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	BCarbon Soil Carbon Credit Systems BCARBON (2021)
On-site Sampling	Baseline (dynamic/ static)	Static. Baseline calculated as the total SOC stocks from the initial monitoring date.	Static. Baseline soil carbon measurements taken at beginning of project.
	Field sampling required?	Yes. Field sampling required.	Yes. Belowground carbon and soil bulk density must be measured.
	Frequency of Sampling	The minimum number of soil sampling rounds for a 10-year crediting period is 5 and must be conducted on the first and last years of the project. 2 soil sample rounds should occur consecutively during the first and last 2 years.	Soil samples at initiation of project and every 5 years.
	Required Sampling Protocol?	Yes, on-site sampling is used to calibrate the remote sensing approach.	Sampling details provided in BCarbon's Protocol for Measurement, Monitoring, And Quantification of The Accrual of Below-Ground Carbon Over Time
	Are models involved?	No. Simple regressors or machine learning models are utilized to model SOC stocks from remote sensing.	Yes, no specific model required. Each model used will be reviewed and evaluated by the project team.
Project Reporting	Monitoring/ Reporting?	After each monitoring round, a report with soil sampling results must be submitted to the registry.	The protocol provides for yearly reporting and interim credit issuance based on literature or modeling studies. True ups are required at least every five years based on field verification.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)	Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)
On-site Sampling	Baseline (dynamic/ static)	Static. Changes in carbon stock of above-ground and below-ground biomass of non-tree vegetation may be conservatively assumed to be zero for all strata in the baseline scenario.	Static. The Baseline determination requires a demonstration of the land-use scenario of cropland in the absence of the project activity and a description of the avoided cropland management practices. The baseline management scenario must be updated every 5 years.
	Field sampling required?	Yes. Project proponents are required to take several field measurements in the planned project area.	Yes. If direct measurements approach is taken, then field sampling is required.
	Frequency of Sampling	Monitoring must occur every five years since the year of the initial verification. Each regeneration monitoring area must be reassessed at intervals not to exceed 10 years.	Minimum every 5 years.
	Required Sampling Protocol?	Yes. Each parameter monitored has a specific procedure listed to follow.	Yes. Direct measurement of SOC must be taken according to requirements in ISO 10381-2:2003 Soil Quality sampling - Part 2: Guidance on sampling techniques.
	Are models involved?	Yes, a tree growth model must be used. The U.S. Forest Service's national forest growth model (Forest Vegetation Simulator [FVS]) can be used as a tool to estimate carbon stock changes.	If modeling approach is taken, yes. The DAYCENT or other models may be used. Otherwise, direct measurements are taken.
Project Reporting	Monitoring/ Reporting?	Parameters are monitored every 5 years and the regeneration monitoring area must be examined close to the project start date to determine baseline values and re-assessed at intervals not to exceed 10 years.. Project monitoring report should be completed for each reporting period.	Reevaluation of soil carbon and subsequent updates must occur at minimum once every five years. Projects must submit a GHG monitoring report for each reporting period.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Methodology for sustainable grassland management, v 1.1 VERRA (2021)	Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)
On-site Sampling	Baseline (dynamic/ static)	Static. The most plausible baseline scenario is calculated for 5 consecutive years before project start date. Option 1: Baseline is computed maximum carbon stocks that occurred within the previous 10 years. Option 2: Procedures outlined in the protocol are used to determine the value of baseline less than 2 years prior to the project start time.	Static. Project proponent shall demonstrate baseline conditions for the 10 years prior to the project date. Baseline can be determined from analysis of past satellite images. The project proponent must gather documentation of historic management plans and baseline vegetation for baseline.
	Field sampling required?	Depends. Yes, if Option 2 is chosen. Direct measurements of SOC can be taken (Option 2) or a modeling approach (Option 1) may be used.	Yes. Both modeled and measured approaches require sampling of soils and measurement of bulk density and SOC.
	Frequency of Sampling	If SOC is measured, monitoring must occur every 5 years, while if SOC is modeled it must be modeled every year.	If modeling, re-calibration needs to occur every 5-10 years. If measuring, measurements must occur every 1 to 2 years.
	Required Sampling Protocol?	No, but soil sampling must follow a scientifically established method or nationally approved standard.	Yes, data parameters have a protocol cited for how to sample each parameter.
	Are models involved?	Yes, if Option 1 is chosen. A biogeochemical model that has been accepted in peer review and validated for the project region (e.g., CENTURY soil organic matter model) can estimate the annual change in SOC stocks.	Yes, if using a modeled approach, a peer-reviewed model for soil carbon dynamics must be used.
Project Reporting	Monitoring/ Reporting?	If option 2 is selected, parameters must be monitored every 5 years. If Option 1 is selected annual changes in SOC stocks must be estimated each year of the project under each of the identified management practices of stratums. A validation report and monitoring report are required for verification.	If the measured approach is taken, emissions are measured every 1-2 years. If the modeled approach is taken, emissions are estimated at regular intervals after the initial estimation (i.e., every 5-10 years depending on the productivity of the site). A validation report and monitoring report are required for verification.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)	Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)
On-site Sampling	Baseline (dynamic/ static)	Dynamic. Land is forest, grassland, and shrubland types for 10 years minimum prior to the project start date. The baseline scenario for projects is conversion to agriculture or anthropogenic use.	Dynamic. The baseline emission equations rely on emission factors that model the emissions of a full year, in ten-year groups. So, baseline emission factors need to be reassessed every ten years.
	Field sampling required?	Yes. Sample plots are used to estimate carbon stocks in selected pools at a particular point in time.	No. A composite modeling approach is used.
	Frequency of Sampling	Monitoring must occur minimum every five years.	A reporting period may not exceed 12 months in length, except for the initial reporting period, which may cover up to 24 months. Reporting periods must be contiguous; there must be no gaps in reporting during the crediting period of a project once the first reporting period has commenced.
	Required Sampling Protocol?	Yes. The data parameters to be measured have a measurement method cited for each parameter as well as how often each parameter must be measured.	Yes, there is a required modeling approach to estimate emissions. The model is performed using the same build of the DAYCENT model that is used for the estimation of the inventory of U.S. Greenhouse Gas Emissions and Sinks.
	Are models involved?	Yes. changes in measured carbon stocks are used with the cumulative emissions model to quantify net GHG emissions or removals.	Yes, emission factors are developed with the composite modeling approach. This approach greatly simplifies the quantification and monitoring of grassland projects, as compared to an approach based on site-specific sampling and modeling.
Project Reporting	Monitoring/ Reporting?	The length of each monitoring period must be less than or equal to five years. A validation report and monitoring report are required for verification.	A reporting period may not exceed 12 months in length, except for the initial reporting period. To meet the verification deadline, the project owner must have the required verification documentation submitted within 12 months of the end of the verification period. No more than six reporting periods (max 72 months) can be verified at once during the projects crediting period.

APPENDIX III. SAMPLING, MONITORING, AND REPORTING REQUIREMENTS CONTINUED

Protocol		Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)
On-site Sampling	Baseline (dynamic/ static)	Static. Baseline SOC stocks are calculated as the sum of stocks in each stratum area. Baseline SOC shall be quantified using 1 of 3 approaches. Approach 1: SOC is measured in a number of soil profiles within each stratum. Approach 2: SOC is quantified from data in peer-reviewed literature. Approach 3 quantifies SOC using modeling.
	Field sampling required?	Yes. If Approach 2 is used, measurement of soil carbon is required.
	Frequency of Sampling	The project owner is required to submit a monitoring report annually. Additionally, at least every five years, the project owner shall undergo a performance review according to the Gold Standard Agriculture Requirements'.
	Required Sampling Protocol?	Yes. If approach 2 is used accepted protocols are the ICRAF protocol and the VCS SOC Module.
	Are models involved?	Yes, if approach 3 is used. If approach 3 is used, SOC is modeled using the approach documented in IPCC 2006.
Project Reporting	Monitoring/ Reporting?	The project owner is required to submit a monitoring report annually containing at least the information listed in the Gold Standard 'Agriculture Requirements' as well as parameters listed as annual recording. Every five years, the project owner shall undergo a performance review. according to the Gold Standard 'Agriculture Requirements'.

APPENDIX IV. CARBON REMOVAL AND EMISSIONS REDUCTION QUANTIFICATION

Protocol		Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)	Adoption of Sustainable Land Management, v 1.0 VERRA (2011)
Reduction Quantification	What carbon pools are included to calculate carbon removal	Soil organic carbon only.	Soil organic carbon, tree biomass, and shrub biomass.	Soil organic carbon and woody perennial biomass.
	Does protocol include GHG emissions in net reductions	Yes. CO_2, N_2O, and CH_4 are considered.	Yes. CO_2, N_2O, and CH4 are considered. However, if approach 2 (measure and remeasure) is used, only CO_2 is quantified.	Yes. CO_2, CH_4, and N_2O are considered.
	Quantification of net GHG emissions	CO_2, N_2O and CH_4 are accounted for via modeling or emission factors.	CO_2 is measured via soil organic carbon. CH_4 is measured via soil methanogenesis. N_2O is measured via use of nitrogen fertilizers, and use of nitrogen fixing species. Only CO_2 is measured via soil organic carbon. Approach 3: CO_2 is measured via fossil fuels. CH_4 is measured via enteric fermentation, manure deposition, and biomass burning. N_2O is measured via use of nitrogen fertilizers, use of nitrogen fixing species, manure deposition, and biomass burning.	CO_2 is measured via burning of fossil fuels. CH_4 is measured via burning of biomass and burning of fossil fuels. N_2O is measured via use of fertilizers, use of N-fixing species, burning of biomass, and burning of fossil fuels.
	Conversion to CO_2e?	Emissions measured in tCO_2e.	Baseline and project emissions are defined in terms of flux of CH_4, N_2O, and CO_2 in tCO_2e.	Emissions measured in tCO_2e.

APPENDIX IV. CARBON REMOVAL AND EMISSIONS REDUCTION QUANTIFICATION CONTINUED

Protocol		Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)	Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	Nori Croplands Methodology, v 1.3 NORI (2021)
Reduction Quantification	What carbon pools are included to calculate carbon removal	Primarily soil organic carbon. However, when significant change is expected, the aboveground and belowground biomass of grass and woody species are also used to quantify carbon reductions.	Soil organic carbon only.	Soil organic carbon only.
	Does protocol include GHG emissions in net reductions	Yes. CO_2, N_2O, and CH_4 are considered.	Yes. N_2O and CH_4 are considered. However, more than 50% of project emission reductions should come from SOC sequestration.	No.
	Quantification of net GHG emissions	Both current emissions of N_2O and CH_4 are estimated within the project area following VMD0019 Emissions of Non-CO_2 GHGs from soils protocol. Future emissions are projected as well using VMD0019 Methods.	Accounted for by tracking increased nitrogen fertilizer input, increased combustion of fossil fuels and electricity use, and other agrochemical emissions (increased use of agrochemicals, especially pesticides or non-N fertilizers).	N/A
	Conversion to CO_2e?	Not stated.	Emissions measured in tCO_2e.	The NRT is denominated in CO_2e. One tonne of incremental SOC stock gain is multiplied by 44/12 (gCO_2/gC) to reflect the amount in CO_2e. that is deemed to be removed from the atmosphere when 1 tonne of SOC stock gain is detected.

APPENDIX IV. CARBON REMOVAL AND EMISSIONS REDUCTION QUANTIFICATION CONTINUED

Protocol		Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	BCarbon Soil Carbon Credit Systems BCARBON (2021)	Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)
Reduction Quantification	**What carbon pools are included to calculate carbon removal**	Soil organic carbon only.	Soil organic carbon only.	Live aboveground and belowground biomass of tree species, dead wood, wood products, and litter carbon pools.
	Does protocol include GHG emissions in net reductions	Yes, GHGs from livestock and fertilizer are considered.	No.	Yes. CH_4 is considered.
	Quantification of net GHG emissions	GHG emissions from livestock and fertilizer inputs must be recorded each year to calculate creditable carbon change (according to IPCC guidelines).	N/A	CH_4 is included in accounting from burning of woody biomass.
	Conversion to CO_2e?	Converting soil organic carbon stocks to CO_2e stocks can be done by multiplying the SOC stocks (in metric tonnes) by a conversion factor of 3.67.	Not stated.	Not stated.

APPENDIX IV. CARBON REMOVAL AND EMISSIONS REDUCTION QUANTIFICATION CONTINUED

Protocol		Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)	Methodology for sustainable grassland management, v 1.1 VERRA (2021)	Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)
Reduction Quantification	**What carbon pools are included to calculate carbon removal**	Soil organic carbon. Above and below ground woody and non-woody species biomass, excluding tree biomass is optional to include.	Soil organic carbon and above and below ground woody biomass.	Soil organic carbon and woody aboveground biomass.
	Does protocol include GHG emissions in net reductions	Yes, N_2O and CO_2 are considered. CH_4 is optional to include.	Yes. N_2O, CH_4, and CO_2 are considered.	Yes. CH_4 is considered.
	Quantification of net GHG emissions	N_2O and CO_2 from soil management are included, while CO_2 from fossil fuel combustion and CH_4 from livestock emissions is optional.	N_2O is accounted for via the use of fertilizers, burning of biomass, manure deposition on grassland and use of N-fixing species. CH_4 is accounted for via the burning of biomass, manure deposition on grassland, and animal respiration/ enteric fermentation. CO_2 is accounted for via farming machinery.	CH_4 is quantified via livestock grazing animal censuses, and CO_2e emissions from biomass burning included.
	Conversion to CO_2e?	Emissions measured in tCO_2e.	Emissions expressed in CO_2e.	Emissions measured in tCO_2e.

APPENDIX IV. CARBON REMOVAL AND EMISSIONS REDUCTION QUANTIFICATION CONTINUED

Protocol		Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)	Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)	Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)
Reduction Quantification	What carbon pools are included to calculate carbon removal	Above and below-ground tree and non-tree biomass, dead wood, soil organic carbon, long-lived wood products are all carbon pools that can be used to calculate reductions.	Above and belowground biomass and soil organic carbon.	Soil organic carbon only.
	Does protocol include GHG emissions in net reductions	Yes, CO_2, CH_4, and N_2O are considered.	Yes. N_2O and CH_4 are considered.	Yes. Emissions from increased fertilizer input and fuel combustion are considered.
	Quantification of net GHG emissions	CO_2 is accounted for via flux in carbon pools. CH_4 is accounted for via livestock (a required source when emissions from grazing are not de minimis). N_2O is accounted for via synthetic fertilizer.	N_2O is accounted for via soil nitrogen dynamics and fertilization, burning, grazing, and irrigation. CH_4 is accounted for via burning and grazing.	Emissions from increased N fertilizer, either synthetic or organic, is calculated. Emissions from increased combustion of fossil fuels and electricity use is calculated.
	Conversion to CO_2e?	Emissions measured in tCO_2e.	Emissions measured in tCO_2e.	Emissions measured in tCO_2e.

APPENDIX V. PAYMENT STRATEGIES

Protocol		Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)	Adoption of Sustainable Agricultural Land Management, v 1.0 VERRA (2011)
Payment Strategy	**Crediting Period**	10 years, renewable 2 times up to 30 years. A project could continue indefinitely, provided new fields were added over time.	For agriculture land management projects, crediting period is 7 years, twice renewable for a total of 21 years.	For agriculture land management projects, crediting period is 7 years, twice renewable for a total of 21 years.
	Payment Stacking Allowed?	Yes. Stacking offsets with other payments (such as NRCS payments) may be permissible in some circumstances.	Depends. If biochar is used, there may not be any other carbon incentive awarded for the production of biochar applied on the project area.	Not stated.
	Data retention/ sharing?	Project developers must keep required records for 10 years after info is generated or 7 years after it is verified); Data will not be publicly available.	All data collected as a part of monitoring process, including QA/QC data, must be archived electronically, and be kept at least two years after the end of the last project crediting period.	Project proponent shall ensure that all documents and records are kept for at least two years after the end of the project crediting period
	Aggregation Methods (Is aggregation of projects into larger units allowed?	Yes.	Yes.	Yes, projects may contain more than one discrete area of land.

APPENDIX V. PAYMENT STRATEGIES CONTINUED

Protocol		Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)	Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	Nori Croplands Methodology, v 1.3 NORI (2021)
Payment Strategy	**Crediting Period**	Minimum of 20 years, renewed at most 4 times with a total project crediting period not to exceed 100 years.	Depending on SOC Activity Module, 5-20 years.	Project registration term is a minimum of ten years and can be renewed. Each time NRTs are issued after verification, credit term is extended (generating a rolling 10-year crediting period).
	Payment Stacking Allowed?	Not stated.	Not stated.	No. Agreement says they cannot register any carbon removal claims on the Nori marketplace that are also listed for sale in another market.
	Data retention/ sharing?	Project proponent shall ensure that all documents and records are kept for at least two years after the end of the project crediting period.	Electronic archive of all monitoring data collected in last crediting period of up to 2 years.	Project owner must retain records for 10 years.
	Aggregation Methods (Is aggregation of projects into larger units allowed?	Yes, projects may contain more than one discrete area of land.	Yes.	Yes, projects may encompass fields or the whole farm and multiple fields and farms can aggregate into a larger project.

APPENDIX V. PAYMENT STRATEGIES CONTINUED

Protocol		Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	BCarbon Soil Carbon Credit Systems BCARBON (2021)	Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)
Payment Strategy	**Crediting Period**	10 years with an option to renew; each renewal period is 10 years and there is no limit on renewals.	Annual crediting period with renewal of 10-year land use restriction.	Not stated directly in the protocol; however, ACR standard states crediting period for projects is 10 years unless otherwise stated in the approved methodology.
	Payment Stacking Allowed?	Not stated.	Not stated.	Depends. ACR allows for offset project registration simultaneously on ACR and other voluntary or compliance GHG programs or registries only in cases where the simultaneous registration is disclosed and approved by both programs/registries and offsets issued for the same unique emissions reductions do not reside concurrently on more than one registry.
	Data retention/ sharing?	Raw data will be kept for the project permanence period plus 5 years.	All data collected will be available in some form or another (to be determined) to the public.	All data collected as part of monitoring must be archived electronically and be kept at least two years after the end of the project crediting period.
	Aggregation Methods (Is aggregation of projects into larger units allowed?	Yes, sites must have similar soil types and be located within the same pre-defined geographic region following USGS national land cover database classifications.	Yes, but only if tracts are similar and testing is accomplished in a manner that is representative of all tracts.	Yes. A project proponent proposing an aggregate shall submit a GHG project plan encompassing all project sites, fields, parcels, or facilities with a single project start date and crediting period.

APPENDIX V. PAYMENT STRATEGIES CONTINUED

Protocol		Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)	Methodology for sustainable grassland management, v 1.1 VERRA (2021)
Payment Strategy	Crediting Period	Crediting Period must be at least 5 years but no more than 40 years and cannot be renewed.	Minimum of 20 years, renewable at most 4 times with a total project crediting period not to exceed 100 years.
	Payment Stacking Allowed?	Yes. Payment programs administered by government entities (e.g., Conservation Reserve Program) are not considered legal barriers to participation in a carbon offset program. Enhancement programs administered by government entities (e.g., Environmental Quality Incentives Program or Conservation Stewardship Program) do not purport to pay for the preservation of grasslands, and are considered compliant with this methodology's requirements.	Not stated.
	Data retention/ sharing?	The VVB shall retain reports, measurements and other project related documents. Where soil samples are collected, these shall be maintained by the project developer until at least the next scheduled verification event (i.e., 5 years).	All data collected as part of monitoring must be archived electronically and be kept at least two years after the end of the project crediting period.
	Aggregation Methods (Is aggregation of projects into larger units allowed?	The project area includes either one contiguous parcel, or multiple parcels of land. In the case of aggregated projects, fields must have qualified as grassland/shrubland for at least 10 years prior to the date of enrollment into the aggregate.	Yes, aggregation of grassland parcels with multiple landowners is permitted, with aggregated areas treated as a single project area.

APPENDIX V. PAYMENT STRATEGIES CONTINUED

Protocol		Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)	Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)
Payment Strategy	**Crediting Period**	Minimum of 20 years, renewable at most 4 times with a total project crediting period not to exceed 100 years.	Minimum of 20 years, renewable at most 4 times with a total project crediting period not to exceed 100 years.
	Payment Stacking Allowed?	Not stated.	Not stated.
	Data retention/ sharing?	Project proponent shall ensure that all documents and records are kept for at least two years after the end of the project crediting period.	Project proponent shall ensure that all documents and records are kept for at least two years after the end of the project crediting period.
	Aggregation Methods (Is aggregation of projects into larger units allowed?	Not stated.	Yes. Each project activity instance is treated as a project accounting area in a single project area. All project activities that are grouped must be in the same region and must each meet all the requirements of this method.

APPENDIX V. PAYMENT STRATEGIES CONTINUED

Protocol		Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)	Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)
Payment Strategy	**Crediting Period**	Emissions reductions may only be reported during the crediting period, up to a maximum of 50 years. Project lifetime for an AGC project is up to 150 years.	The project crediting period shall be fixed to 10 years and cannot be renewed.
	Payment Stacking Allowed?	Yes. The opportunity for credit and payment stacking may be available for specific credits that can demonstrate additionality or government programs that do not have overlapping purposes. However, the rules of most government funded programs will likely limit these opportunities.	Not stated.
	Data retention/ sharing?	Project owners are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. The information is not publicly available but can be requested by the verifier or reserve.	Not stated.
	Aggregation Methods (Is aggregation of projects into larger units allowed?	Multiple projects may be managed together as a project cooperative.	Not stated.

APPENDIX VI. REVERSALS AND LEAKAGE

Protocol	Carbon Offset Risks	
	Reversals	**Leakage**
Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	A percentage of credits go to buffer pools to mitigate risks of unavoidable reversals (e.g. drought, fire, flood).	Accounts for leakage related to displacement of livestock outside the project area and sustained decline in yields for crops grow in the project area.
Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)	A number of buffer credits are applied via the VCS AFOLU Non Permanence Risk Tool; When stocks show losses, "procedures in the most current version of the VCS Registration and Issuance Process for loss or reversal events are followed."	Accounts for leakage of manure application from outside the project area, productivity declines and displacement of livestock outside the project boundary (# of livestock in project scenario must not be lower than number of livestock in historic period).
Adoption of Sustainable Land Management, v 1.0 VERRA (2011)	A number of buffer credits are applied via the VCS AFOLU Non Permanence Risk Tool; When stocks show losses, "procedures in the most current version of the VCS Registration and Issuance Process for loss or reversal events are followed."	Leakage: use of fuel wood/fossil fuels from non-renewable sources due to decrease in use of manure and/or residuals. Leakage is determined through the ABMS undertaken annually during the project period. If ABMS survey data shows that >10% of project households use non-renewable biomass from outside the project, then leakage is considered significant and shall be calculated.
Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)	A number of buffer credits are applied via the VCS AFOLU Non Permanence Risk Tool; When stocks show losses, "procedures in the most current version of the VCS Registration and Issuance Process for loss or reversal events are followed."	Projection of leakage due to displacement of grazing, fodder and agricultural production. If livestock grazing decreases under a project, project proponents must estimate emissions from displaced livestock. Market leakage is also accounted for if production declines and leads to outside demand elsewhere.

APPENDIX VI. REVERSALS AND LEAKAGE CONTINUED

Protocol	Carbon Offset Risks	
	Reversals	**Leakage**
Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	A fixed percentage of validated and verified credits must be transferred to Gold Standard Compliance Buffer if SOC activity results in sequestration (as opposed to emission reduction).	Specific Activity Modules will address leakage but generally relate to: shifting crop production to other lands to compensate for yield reductions, emissions from increased C runoff.
Nori Croplands Methodology, v 1.3 NORI (2021)	Model inputs to GGIT include climate data and so dynamic baseline and project projections can account for any "bad" years. In the current pilot stage, Nori is paying farmers with cash up front and an equivalent amount of restricted tokens (a cryptocurrency that is restricted for 10 years). If a supplier intentionally releases carbon or makes a fraudulent carbon claim, Nori quantifies this value into NRTs and recover the equivalent value of the NRT from the restricted NORI tokens.	If/when the project is defined as a subset of the entire farm operation, the NRT claim verification process will establish whether or not the incremental SOC stock gains realized within the project boundaries directly result in SOC stock losses outside the boundaries elsewhere on the farm(s) for which the selected fields are a subset. Protocols states, "Research and experience to date suggest that when we account for all sources of on-farm GHGs, it is most unlikely that the adoption of the practices listed above will cause no net increase in total farm GHGs".
Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	With each issuance of credit, a default contribution of 20% to each credit issuance will go to the Buffer Pool to account for risk of reversal. This contribution can be issued back to Project Proponent at the end of the final monitoring and verification., provided carbon stock levels are above those of the previous verification round.	Each Credit Class will define appropriate procedures to address leakage; if an activity shows significant leakage over time, Regen Registry will remove those activities from approved practices.

APPENDIX VI. REVERSALS AND LEAKAGE CONTINUED

Protocol	Carbon Offset Risks	
	Reversals	Leakage
BCarbon Soil Carbon Credit Systems BCARBON (2021)	10% of credits go to the buffer pool for land conversion or subsurface soil disturbance.	Leakage is proposed to be addressed by a life cycle assessment principle that is under development, meaning that any increase in the life cycle emissions must be deducted; no deduction for existing emissions. Decreased emissions are not credited either.
Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)	To mitigate risk of reversal, project proponents contribute an adequate number of ERTs to a buffer pool to account for reversal. The buffer contribution is a percentage of the project's reported offsets. If the project proponent elects to make the buffer contribution in non-project ERTs or using an alternative risk mitigation mechanism approved by ACR, the percentage of project ERTs going to the buffer pool will be set to zero.	Under this methodology, GHG emissions due to agricultural activity displacement may occur and therefore, leakage is estimated.
Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)	Sequestration projects will be terminated if a reversal causes a project's stocks to decrease below baseline levels prior to the end of the minimum project term. To assess the risk of reversal and termination, the project proponents shall conduct a risk assessment addressing internal, external, and natural risks using the most recently approved ACR Risk Assessment Tool.	Market leakage is the primary source of potential leakage. A conservative default value of 20% market leakage may be used for avoided conversion of grasslands or shrublands to commodity crops in the United States.
Methodology for sustainable grassland management, v 1.1 VERRA (2021)	AFOLU buffer credits must be deposited into the AFOLU pooled buffer account when the project requests issuance of VCUs. Buffer credits must be deducted from total emission reductions to determine the number of emission reductions eligible to be issued as VCUs. AFOLU buffer credits that must be deposited into the AFOLU pooled buffer account must be calculated by multiplying non-permanence risk rating by the change in carbon stocks in a given monitoring period.	The only potential sources of leakage include: (1) Market leakage due to reduction in the production of livestock products within the project boundary; (2) Displacement of grazing beyond project boundary. Leakage must be quantified using VCS Module VMD0033 Estimation Emissions from Market Leakage, and VCS module VMD0040 Leakage from Displacement of Grazing Activities, respectively.

APPENDIX VI. REVERSALS AND LEAKAGE CONTINUED

Protocol	Carbon Offset Risks	
	Reversals	**Leakage**
Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)	Where a reduction in fire frequency occurs, woody plant carbon stocks will increase as a consequence and reversals of past and ongoing losses of woody plant biomass may be conservatively excluded. This means baseline emission removals from existing woody perennials would equal zero.	Leakage would primarily occur from displacement of livestock to other grazing land. If livestock move more than 2 kilometers from the project boundary it is considered leakage. Market leakage is generally minimal in ALM projects. If a reduction in livestock occurs, it must be estimated as market leakage. If leakage does occur, it must be quantified.
Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)	In the event that the quantified emissions reductions for any monitoring period are negative as a result of carbon stock losses, the project proponent must follow procedures for loss events. Differences must be addressed through the pooled buffer account.	Leakage from both activity shifting and market leakage are considered. Emissions from activity shifting leakage are calculated using the leakage emissions model and activity shifting leakage area, while market leakage is estimated using a market leakage area and default values.
Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)	The protocol distinguishes between avoidable and unavoidable reversals. For avoidable reversals, the project owner must transfer to the Reserve a quantity of CRTs from its reserve account equal to the size of the reversal. For unavoidable reversals, the Reserve shall retire a quantity of CRTs from the reserve grassland buffer pool equal to the size of the reversal in metric tonnes of CO_2.	Avoided grassland conversion projects would result in leakage if the project activities result in the conversion of other grassland outside of the project area. The reserve has taken a conservative approach and assumes a 20% leakage effect from grassland projects. Thus, leakage emissions during the reporting period are calculated by multiplying baseline emissions during the reporting period by the leakage discount factor (0.2).

APPENDIX VI. REVERSALS AND LEAKAGE CONTINUED

Protocol	Carbon Offset Risks	
	Reversals	**Leakage**
Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)	Any areas leaving the project during the project duration are conservatively considered full reversals (i.e. loss of all carbon sequestered). The project owner is responsible to maintain or compensate carbon loss to the level of CO_2-certificates already issued. Additionally, a fixed percentage of the CO_2-certificates shall be transferred in the compliance buffer.	Leakage may occur in relation to shift of crop production to other lands to compensate for yield reductions or to emissions from increased C runoff. While the project site is actively maintained for commodity production during the project-crediting period, yield-related leakage risks are relatively small. Carbon losses resulting from a reduction in crop yield and activity shift to a non-project land are calculated in a specific calculation period. To avoid undue accounting for leakage after temporary yield increases, reduction in crop yield is always calculated against the lowest yield in the project area since project start.

APPENDIX VII. VERIFICATION METHODS

Protocol	Carbon Credit Validation Verification/Certification Method
Soil Enrichment Protocol, v 1.0 CLIMATE ACTION RESERVE (2020)	ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify projects.
Methodology for Improved Agricultural Land Management v 1.0 VERRA (2020)	All validation/verification is carried out by 3rd party auditors (aka validation/verification bodies; VVBs).
Adoption of Sustainable Land Management, v 1.0 VERRA (2011)	All validation/verification is carried out by 3rd party auditors (aka validation/verification bodies; VVBs).
Soil Carbon Quantification Methodology, v 1.0 VERRA (2012)	All validation/verification is carried out by 3rd party auditors (aka validation/verification bodies; VVBs).
Soil Organic Carbon Framework Methodology, v 1.0 GOLD STANDARD (2020)	Third-party verification by approved VVB.
Nori Croplands Methodology, v 1.3 NORI (2021)	ISO accredited (e.g. approved verifiers in good standing in any of the three existing major offset credit registries operating in the United States, Climate Action Reserve, American Carbon Registry, and Verra) are automatically eligible to provide verification services to Suppliers in the Nori marketplace, upon providing proof of accreditation.
Methodology for GHG and Co-Benefits in Grazing Systems, v 0.91 REGEN NETWORK (2021)	Third-party verification accredited under ISO 14065 and/or approved by established registries (VCS, Gold Standard, CAR, CDM, Carbon Farming Initiative).

APPENDIX VII. VERIFICATION METHODS CONTINUED

Protocol	Carbon Credit Validation Verification/Certification Method
BCarbon Soil Carbon Credit Systems BCARBON (2021)	Not stated directly how the verification process works with the protocol; however, it is stated to be eligible for verification, certification, and credit issuance by BCarbon, a final project report shall be produced. Additionally, a moral metes and bounds survey by a licensed surveyor does not need to be completed, but an accurate description and accompanying map must clearly outline the project boundary with sufficient detail such that the verification and certification entity can validate the boundaries.
Afforestation and Restoration of Degraded Lands, v 1.2 AMERICAN CARBON REGISTRY (2017)	All VVBs must be accredited in sector of methodology and approved by ACR and accredited under ISO 14065 by the American National Standards Institute; or accredited by the UNFCCC as Accredited Independent Entities approved under Joint Implementation or Designated Operational Entities approved under the Clean Development Mechanism. Validation of the GHG project plan only occurs once per crediting period; however, renewal of the crediting period requires a new validation. Once every five years, proponents must submit a verification statement based on a full verification including a filed site visit, and an updated assessment of risk of reversal and updated buffer determination.
Avoided Conversion of Grasslands and Shrublands to Crop Production, v 2.0 AMERICAN CARBON REGISTRY (2019)	Each project should be verified through the end of their crediting period. The avoided conversion project type are unique such that certain validation and verification procedures are allowed that supersede the ACR Verification and Validation Standard. Site-visits are not required, however, the verifier must be able to reach a reasonable level of assurance via review of documents and supplemental material.
Methodology for sustainable grassland management, v 1.1 VERRA (2021)	The grassland management plan and record of the plan implemented during the crediting period must be available for validation and verification. VVBs approved by Verra are assigned to assess each project against the VCS program rules and requirements that must be carried out according to the methodology. VVBs chosen are verified, independent 3rd parties approved by Verra.

APPENDIX VII. VERIFICATION METHODS CONTINUED

Protocol	Carbon Credit Validation Verification/Certification Method
Methodology for the adoption of sustainable grasslands through adjustment of fire and grazing, v 1.0 VERRA (2015)	Because activities may be demonstrated annually, emission reductions may be verified annually if desired. Under the VCS program, VVBs approved by Verra are assigned to assess each project against the VCS program rules and requirements that must be carried out according to the methodology. VVBs chosen are verified, independent 3rd parties approved by Verra.
Methodology for avoided ecosystem conversion, v 3.0 VERRA (2014)	Completed, VCS-approved templates must be provided to the VVB. Validation and verification is a risk-based process and shall be carried out in conformance with ISO 14064-3:2006 and ISO 14065:2013. VVBs are expected to follow the guidance provided in the VCS Validation and Verification Manual when validating or verifying projects and conducting methodology assessments under the VCS Program.
Grassland Project Protocol, v 2.1 CLIMATE ACTION RESERVE (2020)	VVBs will review for completeness the sources, sinks, and reservoirs identified for a project, and review the appropriateness of the methodologies and management systems that the grassland project owner uses to gather data and calculate baseline and project emissions. VVBs will also investigate areas that have the greatest potential for material misstatements. Site visits during verification are strongly recommended but are not mandatory.
Agriculture Methodology for increasing soil carbon through improved tillage practices, v 0.9 GOLD STANDARD (2015)	Auditor shall assess the adequacy of the sampling and shall revisit a series of soil pits to verify the project owner's assessment.

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