FIELD GUIDE TO *climate-smart* AGRICULTURE

A GUIDE FOR FARMERS & RANCHERS

Sponsored by UC AGRICULTURE AND NATURAL RESOURCES *and* CALIFORNIA CATTLE COUNCIL

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Acknowledgments

Financial support by the California Cattle Council, which made this publication possible, is gratefully acknowledged. The authors also appreciate the layout and editing assistance provided by Laura Hobbs of Laura Hobbs Design.

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Section 1.

Introduction

Chapter Overview

CHAPTER 1.

About the Field Guide

Livestock ranchers and dairy farmers play an important role in our climate change solutions. Through improved grazing management, food production, and carbon sequestration, their management of private and public lands benefits us all. Ranchers and farmers implement climate-smart agriculture practices that increase stored carbon, enhance water efficiency, and reduce greenhouse gas (GHG) emissions and ensure resilience to climate change now and in the future.

This guidebook highlights climate-smart agriculture practices, providing key messages focusing on their impact. Using the guidebook and spreadsheet, ranchers and farmers can document their management and climate-smart practice impacts, which enhance carbon storage and reduce GHG emissions. Impact categories include cost and carbon benefit. When available, costs were determined using NRCS Benefit-Cost Worksheets to provide consistent data across practices[1]. When not available, the authors used implementation cost data and their expertise to assign cost categories. Carbon benefit can be either carbon sequestration or emission avoidance, depending on practice.

1 nrcs.usda.gov/resources/guides-and-instructions/conservation-practice-benefit-cost-templates

CHAPTER 2.

Common Benefits

Air quality

A measure of solid particle and chemical pollutants in the air. Good air quality is indicated through low concentrations of pollutants.

Fire resilience

The reduction in vulnerability of a landscape to extreme wildfire.

Pathogen reduction

The reduction of the concentration of pathogens that may disrupt the soil microbiota or impact animal health.

Soil health

The continued ability of the soil to function and sustain plants and a living ecosystem. Healthy soil improves water retention, improves nutrient cycling, and provides physical support for plants.

Water quality

The suitability of the water for a particular use based on different characteristics. Good water quality in relation to agriculture means water which supports plant and production animal health while also benefiting or protecting ground and surface water biological systems.

Wildlife habitat

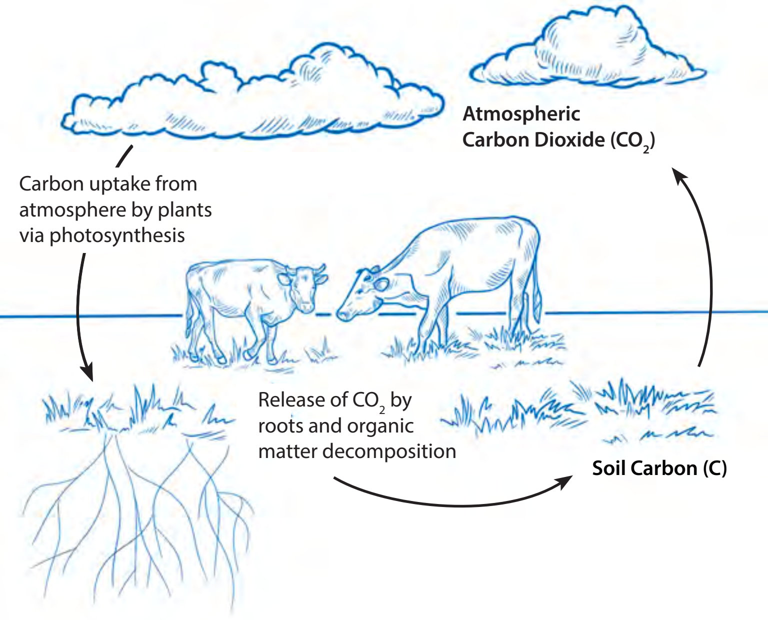
The value of habitats for important species.

CHAPTER 3.

Carbon Sequestration vs. Carbon Avoidance

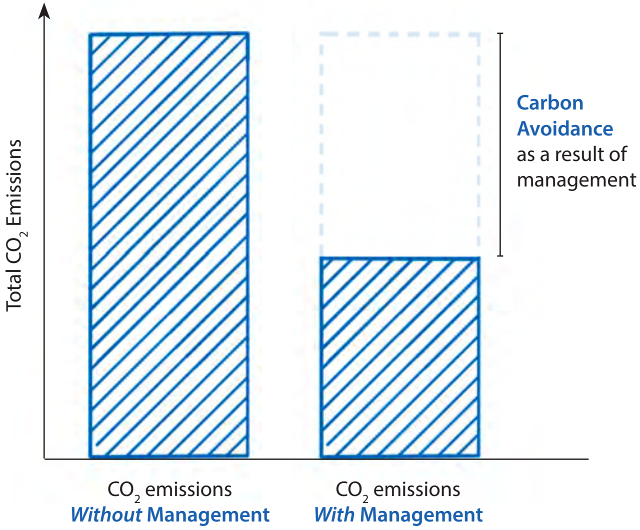
Carbon Sequestration

Carbon sequestration describes the process of capturing and storing atmospheric carbon primarily in soils, woody materials, vegetation, and aquatic environments. Carbon is sequestered through photosynthesis by plants and stored in the plant material or transferred into the soil.



Carbon Avoidance

Carbon avoidance describes the prevention of carbon being released into the atmosphere, reducing emissions at the source. This includes practices which reduce carbon intensive fuel use, mitigate fire risk, reduce anaerobic digestion processes, and others.



CHAPTER 4.

NRCS Practices

The United States Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) programs are available to ranchers and farmers to implement management practices on working lands to enhance climate benefits and protect natural resources.

This guidebook organizes climate smart practices within four categories: grazing land, manure management, woody establishment, and enteric methane. Ranchers and farmers can use this guidebook to document their climate smart practices and provide talking points on their benefits to all users.

Practices in this Guide:

CHAPTER 5.

What is climate-smart agriculture?

Climate-smart agriculture brings an integrated approach to managing landscapes in an effort to adapt livestock and crop agricultural practices to the impacts of climate change and, when possible, counteract it by reducing GHG emissions from agriculture or sequestering already present emissions.

Talking Points

When speaking on climate-smart agriculture practices, focus on three key messages:

- How climate-smart agriculture contributes to your goals;
- Climate-smart agriculture increases productivity and incomes, enhances resilience of livelihoods and ecosystems, and reduces GHG emissions from the atmosphere;
- Address how the agricultural sectors work towards becoming more climate-smart every day.

Each practice includes a bulleted list of benefits from implementation to share with audiences. For more information on how to effectively communicate to the public about climate-smart agricultural practices, contact your local University of California Cooperative Extension (UCCE) farm advisor.

Section 2.

Climate and Agriculture

Section Overview

CHAPTER 1.

Climate Change Overview

Climate Change describes a long-term change in **weather** patterns, such as temperature and rainfall, in a region's **climate**. Models predict changes in climate, using collected data such as global land and sea temperature rise, sea level change, and frequency and severity of extreme weather events.

Weather refers to the short-term state of atmospheric conditions locally.

Climate refers to the long-term (typically 30 years or more) regional or global weather patterns.

CHAPTER 2.

Definition of GHGs

Greenhouse Gas (GHG) Emissions are gasses that trap heat in the atmosphere. The primary greenhouse gasses associated with agriculture include carbon dioxide, methane, and nitrous oxide. The impact of each gas on climate change depends on the concentration, how long the gas stays in the atmosphere, and the global warming potential.

Global Warming Potential (GWP) allows comparisons across GHG to determine climate impact. Specifically, GWP is the measure of how much energy the emissions of 1 ton of a gas will absorb over a given time period, relative to the emissions of 1 ton of carbon dioxide. The larger the GWP, the more the GHG warms the Earth compared to carbon dioxide.

Carbon Dioxide (CO_2) is the primary GHG in the atmosphere, accounting for about 80% of emissions. Combustion of fossil fuels (coal, natural gas, and oil) for transportation and energy is the greatest source of CO_2 emissions. Agricultural land (cropland, pastures, rangeland, forests) acts as a net sink for CO_2 by removing it through photosynthesis.
GWP = 1

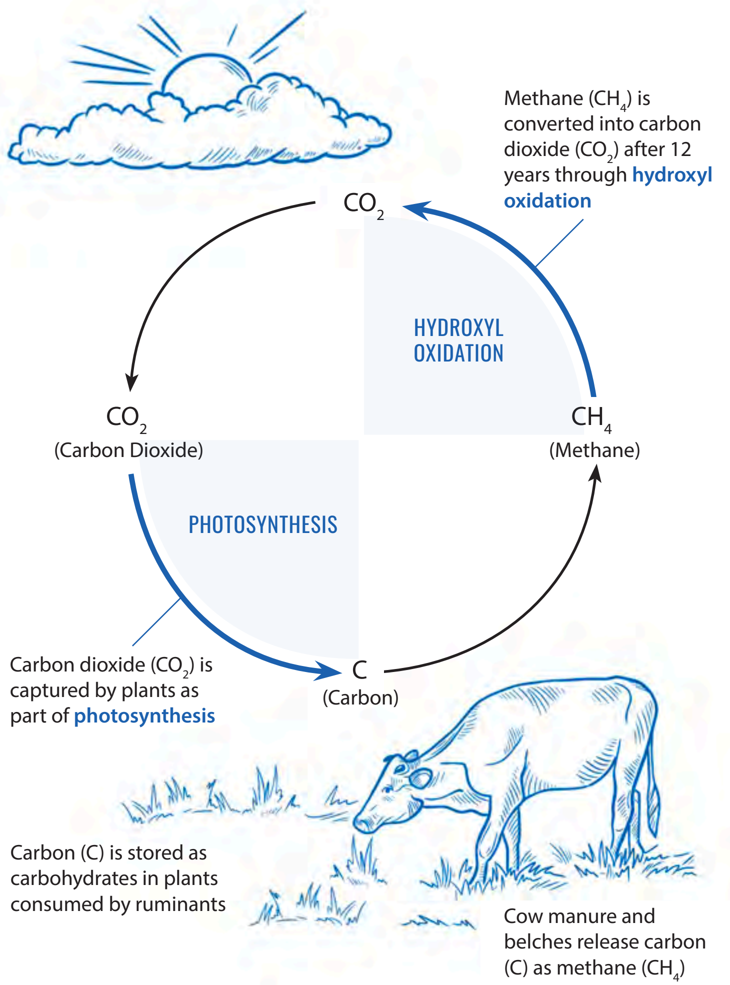
Methane (CH_4) accounts for around 10% of the GHG emissions. Methane is produced within the rumen of ruminant livestock (cattle, sheep, goats), through anaerobic digestion, among other sources.
GWP = 25

Nitrous Oxide (N_2O) accounts for around 6% of GHG emissions. The majority of human-caused N_2O emissions can be traced back to the use of fertilizers in agriculture.
GWP = 265

Fluorinated Gases, a man-made product, are emitted through manufacturing and industrial processes. There are four main categories: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF3). These gases account for 3% of US gas emissions but trap much more heat.
GWP = 1,000 to 10,000+

Gas	Global Warming Potential (GWP)
CO_2	1
CH_4	25
N_20	265
Fluorinated Gases	1K-10K+

The Biogenic Carbon Cycle



CHAPTER 3.

The Biogenic Carbon Cycle

The biogenic carbon cycle centers around **carbon sequestration** through plants. **Ruminant animals** exhale methane, which is converted into CO_2. Plants remove CO_2 from the atmosphere and deposit that carbon into plant leaves, roots, and stems while oxygen is released back into the atmosphere, a process known as photosynthesis. Ruminant animals graze the plants, allowing for greater plant production and sequestration, and the cycle continues.

Carbon sequestration is the process of capturing, securing, and storing carbon dioxide from the atmosphere.

Ruminant animals are hoofed mammals with a four-chambered stomach, allowing them to digest fibrous plant material through microbial fermentation, using the fermented by-products for energy. Ruminant livestock include cattle, sheep, and goats.

CHAPTER 4.

Climate Impacts on Animal Agriculture

Agriculture relies heavily on natural resources and weather. Volatility in the amount of rainfall or shifts in temperature have the ability to take a toll on agricultural viability. Climate change impacts animal agriculture in three main ways:

Animal Health: Severe weather, particularly extreme temperatures, causes increased stress on production animals, impacting overall health (increased health cost) and reducing performance (reduced meat and milk production).

Land Productivity: Climate change directly affects yields of pasture and rangeland available for grazing and harvested feed crops. These changes may require more irrigation, reduce the grazing season, or flood crops. Extreme weather may also lead to wildfire, risking life and agricultural commodities.

Soil and Water: Extreme weather, especially heavy rains, lead to increased erosion and nutrient depletion of soil. Eroded soils may runoff to surface waters and increase sedimentation and nutrient loading, harming water quality.

Section 3.

Climate-Smart Ag Practices

Section Overview

CLIMATE-SMART PRACTICES

Range and Pasture Lands

CHAPTER 1.

Range & Pasture Lands Overview

Rangelands are non-arable land that is not suitable for growing crops, but may be suitable to produce forage for livestock and wildlife grazing. **Pastures** are lands that have been agronomically improved for the production of forage plants for livestock.

Climate-smart practices provide a multitude of environmental benefits on range and pasture lands. By implementing these practices, producers play a critical role in both mitigating and adapting to climate change. Ecosystem services (the benefits provided by the natural environment to humans) include:

- Provisioning – food and habitat
- Regulating – carbon sequestration
- Cultural – recreation
- Supporting – nutrients & water cycle

Key Climate-Smart Strategies for Range & Pasture Management

Matching livestock grazing production needs with changing rangeland and pasture resources can enhance the resilience of livestock systems to climate change. Optimal grazing leads to improved grassland productivity and delivers adaptation and mitigation benefits. Key climate-smart strategies for rangeland management include:

- Prescribed Grazing Management *(p. 33)*
- Range Planting *(p. 35)*
- Brush Management *(p. 37)*
- Mechanical Treatment *(p. 39)*
- Compost Application *(p. 41)*
- Prescribed Burning *(p.43)*

Prescribed Grazing

Prescribed Grazing

Environmental Benefits

Vegetation management with grazing and/or browsing animals to achieve specific ecological, economic, and management objectives. Benefits include more desired plant species composition, improved water quality and/or quantity, improved riparian and/or watershed function, maintenance and/or enhancement of wildlife habitat, reduced soil erosion, improved soil health, and management of fine fuel loads.

Talking Points:

- Improved grazing can lead to increased production of forage for grazing animals
- Prescriptive grazing management allows plants to recover from grazing, enhancing the rooting depth of plant to increase carbon storage
- A grazing system that allows for rest can lead to enhanced biodiversity
- Managed grazing can result in healthier grazing animals, both domestic and wildlife

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Range Planting

Range Planting

Environmental Benefits

The seeding and establishment of non woody and woody plant species for the improvement of vegetation composition and productivity of the plant community to meet management goals. Range planting is designed to improve forages and cover for livestock and wildlife. Benefits include a reduction of erosion, improved water quality and storage, and a more stabilized carbon balance and sequestration.

Talking Points

- Seeding perennial species can improve forage quantity and quality for livestock
- Improved forage can increase rooting depth and structure, which can increase carbon sequestration
- Improved forage production assist in competing with invasive or undesired species

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Brush Management

Brush Management

Environmental Benefits

The management or removal of woody plants including those that are invasive and toxic. Brush management is designed to achieve the desired plant community based on species composition, structure, density, and canopy cover or height. Benefits include a more desired plant community, restored vegetative cover to protect soils, controlled erosion, reduced sediment, improved hydrology, enhanced fish and wildlife habitat, and reduced invasive plant species.

Talking Points

- Increased the health of plant communities
- Breaks up the vertical fuel continuity, which can reduce wildfire severity
- Allows other species to intersperse in the cleared areas
- Creates a more diverse plant community, increasing desired species for livestock and wildlife
- A more diverse plant community can increase water capture and infiltration

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

Grazing Land Mechanical Treatment

Grazing Land Mechanical Treatment

Environmental Benefits

Grazing land mechanical treatment involves treating or modifying soil and plant conditions using mechanical tools to meet the desired purpose. The benefits include reduction of compacted soil layers, improved soil permeability, reduced water runoff and increased infiltration. Mechanical treatments can break up root-bound conditions and thatch to increase plant vigor and renovate and stimulate the plant community for greater productivity and yield.

Talking Points

- Reduced compaction by breaking up soil layer
- Improved soil permeability, thus increasing water infiltration and capture
- Increased permeability and less compacted soil, results in more perennial species
- Increased perennial species can sequester more soil carbon

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

Compost Application

Compost Application

Environmental Benefits

The application of carbon-based amendments derived from plant materials or animal byproducts. Compost application increases soil biological activity and diversity to enhance root health and promote resistance to pathogens. Compost can improve soil organic matter, sequester carbon, enhance soil carbon stocks, improve soil aggregate stability, and improve habitat for soil organisms.

Talking Points

- Increased soil organic matter
- Increased carbon sequestration

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Prescribed Burning

Prescribed Burning

Environmental Benefits

A planned fire application to a predetermined area. The benefits include management of undesirable vegetation, improved plant community structure and composition, improved distribution of grazing and browsing animals to improve forage-animal balance, improved and maintained habitat for soil organisms, enhanced soil health, and improved pest, pathogen, and disease management. Reduction of vegetation can aid in reduced wildfire hazards from biomass accumulation.

Talking Points

- Reduction of fire severity
- Improved structure composition of plant communities
- Improved forage for grazers & wildlife
- Reduction of invasive species

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

CLIMATE-SMART PRACTICES

Manure Management

CHAPTER 2.

Manure Management Overview

When managed in a pond, manure digests anaerobically producing GHGs, particularly methane. Climate-smart agriculture practices remove a portion of manure solids from the manure pond, or prevent them from entering, reducing the amount of **anaerobic digestion** that occurs. With less feedstock (i.e. manure, organic matter) for **methanogens** to digest, less methane is produced. The removed manure solids may be composted to produce a soil amendment for improved carbon sequestration in the field.

Anaerobic digestion - is the process where organic matter is broken down in the absence of oxygen, producing biogas such as methane and CO_2

Aerobic digestion - is the process where organic matter is broken down in the presence of oxygen, producing CO_2 as a by-product

Methanogens - are methane forming microorganisms which live in anaerobic conditions and oxygen inhibits their growth and reproduction

Key Climate-Smart Strategies for Manure Management

Climate-smart manure management for livestock and dairy includes both mitigation and adaptation strategies. When it comes to mitigation, producers should consider impacts on other potential greenhouse gas emissions (such as nitrous oxide) or sinks (such as carbon sequestration). In general, liquid manure management systems lead to anaerobic conditions and increased methane production, and switching to practices that manage manure in drier, aerobic conditions reduces methane emissions. Energy-saving practices have also been demonstrated to be effective in reducing the dependence of intensive systems on fossil fuels.

Climate-smart strategies for manure management include:

- Prescribed Grazing Management *(p. 33)*
- Range Planting *(p. 35)*
- Brush Management *(p. 37)*
- Mechanical Treatment *(p. 39)*
- Compost Application *(p. 41)*
- Prescribed Burning *(p.43)*

Anaerobic Digester

Anaerobic Digester

Environmental Benefits

A sealed system operating without oxygen that allows anaerobic bacteria to breakdown organic matter (manure) and produce biogas (methane and carbon dioxide). Biogas can be converted into alternative energy, such as electricity or fuel, while the digestate (the material remaining after anaerobic digestion) can be applied to fields as fertilizer. Benefits of digester installation include odor management, energy production from biogas conversion, and capture of methane.

Talking Points

- Digesters capture potent GHGs and restrict their release into the atmosphere
- Captured gases can be converted into green energy sources, such as fuel and electricity

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

Compost Bedded Pack Barn

Compost Bedded Pack Barn

Environmental Benefits

A barn containing an open lying surface where manure and urine are mixed into a bedding twice daily using a rototiller or field cultivator, oxygenating the material and providing an aerobic environment. Tilling the surface also incorporates the manure piles into the bed, ensuring a clean, dry surface for the udder. The compost bedded pack holds approximately $^{2}/_{3}$ of the manure, reducing the volume of manure entering the anaerobic pond.

Talking Points

- The open area of the pack allows for storage of approximately $^{2}/_{3}$ of manure, reducing the volume entering an anaerobic environment
- Twice daily stirring maintains an aerobic composting environment within the top layers of the pack
- Stirring the pack incorporates manure and urine into the pack and drys the surface, offering a dry surface for cows to lie

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

Manure Composting

Manure Composting

Environmental Benefits

An area to facilitate aerobic decomposition of manure, other organic material (bedding, removed vegetation, feed waste), or both, into a final product sufficiently stable for storage, on-farm use (bedding), and application to land as a soil amendment. Common methods include windrow, in-vessel, or aerated static pile composting. Each method must heat to 131 °F for the entire composting length (3 or 15 days, depending on method) to kill pathogens and weed seeds.

Talking Points

- Composting of manure solids or slurry reduces the anaerobic digestion processes to reduce GHG emissions
- Composted manure can act as an on-farm bedding source for freestall beds, reducing off-farm inputs
- The composting process kills pathogens which might disrupt the soil microbiota when applied to range or pasture land
- Composting kills weed seeds, reducing the risk of weed establishment in range and pasture land

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

Manure Separation

Manure Separation

Environmental Benefits

Equipment (mechanical separation) or a settling basin used to separate a portion of solids from liquid manure. Separation allows for more strategic nutrient management and improved fertigation of effluent (liquid waste).

Talking Points

- Separation can remove 15 to 60% volatile solids (organic matter converted to methane during anaerobic digestion) from entering an anaerobic manure pond, depending on the system
- Separated manure allows for easier composting
- When separated, liquid fertigation can occur more easily without clogging

Impact Summary:

Emissions Avoidance
Impact Type

Impact Measurement

Implementation Cost

CLIMATE-SMART PRACTICES

Woody Establishment

CHAPTER 3.

Woody Establishment Overview

During the past century, many rangelands have been affected by the spread of woody plants. Drivers include the lack of overall management, changes in climate, atmospheric CO_2, herbivory, and fire regime. Relative importance of different factors vary among regions. Strategic selection and planting should be based upon the landowner's goals, habitat, and the potential to achieve climate goals.

Key Climate-Smart Strategies for Woody Establishment

Livestock and dairy producers who establish woody species can generate carbon sequestration in perennial biomass and soils while delivering the co-benefits of providing wildlife or pollinator habitats. The establishment of trees or shrubs can also reduce erosion, improve water quality and quantity, improve ambient air quality and strengthening plant health by reducing plant damage by wind. Woody establishment can also provide forage, shade and/or shelter for livestock.

Climate-smart strategies for woody establishment include:

- Hedgerow Planting *(p. 61)*
- Tree/Shrub Establishment *(p. 63)*
- Windbreak/Shelter Belt Establishment *(p. 65)*
- Riparian Forest Buffer *(p. 67)*
- Silvopasure *(p. 69)*

Hedgerow Planting

Hedgerow Planting

Environmental Benefits

The establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose the benefits habitat, including food, cover, and corridors for terrestrial wildlife, enhances pollen, nectar, and nesting habitat for pollinators, and provides food, cover, and shade for aquatic organisms that live in adjacent streams or watercourses.

Talking Points

- Increased habitat and biodiversity
- Increased pollinators
- Increased carbon sequestration

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Tree/Shrub Establishment

Tree/Shrub Establishment

Environmental Benefits

The appropriate establishment of woody plants by planting seedlings or cuttings, by direct seeding, and/or through natural regeneration to enhance desirable plant diversity, productivity, and health. It can create habitat for desired wildlife species that are compatible with ecological characteristics of the site, and increase carbon sequestration and storage.

Talking Points

- Increase carbon sequestration
- Increased shade
- Increased habitat and biodiversity

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Windbreak/Shelter Belt Establishment

Windbreak/ Shelterbelt Establishment

Environmental Benefits

The establishment, enhancement and/or renovation of windbreaks, also known as shelterbelts, which are single or multiple rows of trees and/or shrubs in linear or curvilinear configurations. They can reduce soil erosion from wind, enhance plant health and productivity by protecting plants from wind-related damage, and increase carbon storage in biomass and soils.

Talking points:

- Greater plant diversity increases habitat for a multitude of species
- More carbon will be sequestered in the soil
- Plant health and productivity will increase, wind erosion will be reduced
- Increased plant vigor

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Riparian Forest Buffer

Riparian Forest Buffer

Environmental Benefits

Areas predominantly covered by trees and/or shrubs that are located adjacent to and up-gradient from a watercourse or water body. Buffers can reduce the transport of sediment to surface water, and reduce transport of pathogens, chemicals, pesticides, and nutrients to surface and groundwater. Buffers can maintain or increase total carbon stored in soils and/or perennial biomass to reduce atmospheric concentrations of greenhouse gasses.

Talking points:

- Buffers can maintain soil, reducing soil erosion
- Buffers provide a vegetation strip to capture pathogens, chemical and pesticides, reducing impacts to surface and groundwater

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

Silvopasture

Silvopasture

Environmental Benefits

Pastures that are managed, either by planting or selective removal of appropriate trees and forages to provide forage, shade, and/or shelter for livestock, enhance wildlife habitat, Improve biological diversity, and increase carbon sequestration and storage.

Talking points:

- Increased carbon sequestration and storage with larger tree mass
- Increased shade and shelter for livestock and wildlife
- Increased biological diversity and enhanced habitat for wildlife
- Increased forage production for livestock, better managed grazing lands

Impact Summary:

Carbon Sequestration
Impact Type

Impact Measurement

Implementation Cost

CLIMATE-SMART PRACTICES

Enteric Methane

CHAPTER 4.

Enteric Methane Overview

Enteric methane is produced by rumen microbes in the digestive tract of ruminant animals, which decompose and ferment feed and produce methane as one of many by-products. Enteric methane production is directly related to the level of intake, the type and quality of feed, the amount of energy consumed, animal size, growth rate, and a number of other factors. Increasing the efficiency and productivity of ruminant animals decreases the amount of emissions per unit of product and increases profit.

Key Climate-Smart Strategies for Enteric Methane

Implementing climate smart practices could curtail up to 70% of ruminant methane emissions, depending on the method or nature of the nutritional intervention. Dietary manipulation by changing the feed composition is one of the most direct and inexpensive approach to lessen enteric methane levels. Feed manipulation remains the most cost-effective approach, attaining a substantial 60% reduction in methane just by meticulously selecting the type or quality of forage and optimizing the concentrate to forage ratio in feed. Many organic and inorganic feed additives have the potential to decrease CH4 production by directly or indirectly transforming the rumen microbial community.

Climate-smart strategies for woody establishment include:

- Methane Inhibitors *(p. 75)*
- Feed Efficiency *(p. 77)*

Methane Inhibitors

Methane Inhibitors

Methane inhibitors block the formation of methane by altering the methanogenesis pathway (conversion of H_2 and CO_2 to CH_4), reducing the amount of methane produced by microbes in the rumen. Red seaweed, a future organic option, has the potential to reduce enteric methane emissions by up to 55% in dairy cattle and 90% in beef cattle.A synthetic option, 3-nitrooxypropanol (3-NOP), has the potential to decrease enteric methane yield by up to 30% in dairy cattle and 45% in beef cattle. Tannins and essential oils, fermentation modifiers (provides additional benefits outside of just methane inhibition), reduce protein breakdown in the rumen, allowing protein to be utilized by the animal instead of the rumen microbiota. Tannins may reduce enteric methane by 13-16% in dairy cattle.

Talking Points

- Red seaweed and 3-NOP work by altering the methanogenesis pathway
- Additions of methane inhibitors to the diet show no impact on meat and milk production, quality, or safety in current research
- Fermentation modifiers, such as tannins and essential oils, provide additional benefits to animal performance
- No current organic options approved for carbon credits

Feed Efficiency

Feed Efficiency

Feed efficiency is a measurement of the relative ability of animals to turn feed nutrients into animal products (meat, milk, fiber, etc.). Increasing feed efficiency helps lower costs by decreasing the amount of feed needed, as well as decreasing the land needed to grow feed for cattle. Feed efficiency in livestock has steadily increased over time as new technologies and breeding practices have been introduced. Ionophores increase propionate production (a volatile fatty acid used as an energy source in ruminates) increasing milk production in dairy cattle. Branched-chain volatile fatty acids supplemented in diets increase nutrient digestibility in the rumen, improving performance in ruminants. Other factors may reduce feed efficiency. Stressors (heat stress, exercise, disease, etc.) shift nutrients from production to bodily maintenance. Fiber and forage quality also impact feeding efficiency.

Talking Points:

- Increasing feeding efficiency increases the production of meat and milk per amount of feed consumed, reducing emissions and cost of production
- Selective breeding, such as cattle with heritability traits in feed efficiency, will improve this trait in offspring
- Ensuring external stressors are minimal maintains feed efficiency
- Formulating precise diets helps maintain feed efficiency

Section 4.

Conclusion

Chapter Overview

Interested in your farm or ranch's impact?

UCCE developed a Climate Smart Agriculture Worksheet that will allow livestock and dairy producers to document conservation practices and assess the climate mitigation results.*

For the online tool, visit:

For a physical sheet, contact UCCE Sonoma at 707-565-2621.

My Impact:

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**Values extrapolated using resources from the California Air Resources Board and California Department of Food and Agriculture Alternative Manure Management Program Calculator and Healthy Soils Program COMET-Planner Tool*