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CARBON FARMING TOOLKIT

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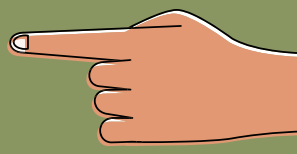
Core Concepts

The Problem at Hand

This year, the Intergovernmental Panel on Climate Change issued its most significant warning yet: that the actions of humans have undoubtedly warmed the atmosphere, ocean and land.



Humans both directly cause greenhouse gas emissions that contribute to the warming of the planet, and practice agricultural methods that cause soil erosion and damage soil health. Not only are humans depleting the natural resources that we depend on, we also have a waste problem that is increasing exponentially: vast amounts of food and organic materials are sent to landfills each year, which significantly contributes to the greenhouse gas emissions that cause the warming of our planet.

Call to Action

While reducing emissions is necessary to slow the greenhouse effect, we must also explore and adopt strategies to sequester carbon.

The Strategy: CARBON FARMING

It focuses on moving carbon content from the atmosphere into the soil through a variety of methods, including the application of compost to soil. Eco-Cycle's Community Carbon Farming Project encourages community members to practice carbon farming in their own backyards and observe the impacts, empowering them to be part of the solution.

Core Concepts

Benefits of Carbon Farming

A brief overview

Sequesters carbon

- Carbon pulled down from the atmosphere and stored in soil, increasing soil health

Builds healthy soils

- More nutrient dense soils
- Greener, faster growing lawns and plants
- Increased beneficial soil microbial activity
- Higher crop yields with less need for agricultural inputs

Improves ecosystem health

- Increased water holding capacity of soil
- Reduced erosion potential

Reduces waste

- By promoting circular economies, i.e. treating waste as a resource

Provides a communal purpose

- Participants play an active role in contributing to a climate solution

Core Concepts

Sectors of a Community

Communities have many components; important sectors include: individuals, organizations, local governments, businesses, and educational centers. Each of these sectors of a community can play an important role in the expansion of community carbon farming.

Individuals	When individuals make the connection between their own backyards and carbon sequestration, they are equipped to adopt carbon farming as a practice and share it with others.
Education	Schools connect students, families, education professionals, and city/state-level policy. Schools have great potential to extend the concept and practice of carbon farming to multiple sectors of communities.
Entrepreneurs	Entrepreneurs have the capability to connect people and resources, which makes them a unique asset to expand and promote carbon farming as a means to combat climate change.
Municipal	Municipalities, as well as community groups, have the ability to provide supportive policy, resources, funding, and networks for growing carbon farming initiatives within the greater community.

Introduction

Eco-Cycle

Founded in 1976, Eco-Cycle is committed to cultivating a zero-waste, circular economy. Originally focused solely on recycling, the compost department is a newer initiative within Eco-Cycle's organization that holds a lot of potential for creativity and flexibility in project implementation.

Dan Matsch, former farmer and current Director of Eco-Cycle's Compost Department, initiated the Community Carbon Farming Campaign to recognize the need for both emissions reduction and carbon sequestration at a local level.[1] Dan believes that community science can contribute to knowledge and data collection while reclaiming soil carbon in our own backyards.

Methodology and Intent

This toolkit showcases current carbon farming practices and gives recommendations to those looking to engage in community carbon sequestration. Surveys were conducted with key actors in the field to better understand carbon farming in each of these segments of society. Survey questions ranged from intentions and goals of carbon farming projects to technical requirements for operating compost facilities.

The toolkit identifies gaps in current projects and gives advice for future implementation. Findings from this journalistic endeavor are outlined in the following sections.

How to Use This Toolkit

This toolkit was developed by the University of Colorado Masters of the Environment Eco-Cycle Capstone team. The team has partnered with Eco-Cycle of Boulder to provide guidance for those looking to become more engaged with carbon farming.

Each section of the toolkit will address a different segment of society, which we have divided into four categories:

1. Individual participants with access to yards
2. Educational centers and programs
3. Small business owners and entrepreneurs within the compost industry
4. Municipalities and advocacy groups centered on local government

This toolkit contains tailored recommendations for each of the targeted audiences to implement community-wide carbon farming practices.

The creation of a larger carbon farming network requires input and support from all levels of the community to be successful. There is promise and potential in soil carbon farming, giving communities the opportunity to be proactive about climate action and waste reduction in their own backyards.

Background Information

Anthropogenic Greenhouse Gas Emissions

Climate change is the most important global challenge of this century. The Intergovernmental Panel on Climate Change (IPCC) 2021 report states "it is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred."[2] This warming is a direct result of a steady accumulation of greenhouse gas (GHG) emissions in the Earth's atmosphere. Many scientists agree that at this point in time, it is not enough to just reduce emissions, but humans must also find ways to sequester carbon from the atmosphere to keep global warming temperatures under a 1.5 C increase.

Industrial Agriculture and the Erosion of Soils

To meet the rising demand of food within a growing population, the agricultural industry underwent a transformation during the post World War II era often referred to as "the agricultural industrial revolution." Food systems in industrial nations began shifting from small agriculture farms to large scale monoculture practices, with heavy input use from fertilizers, chemicals, and farm machinery. This increased output of food production had dramatic implications on soil health, water pollution, and soil carbon content. Most agricultural soil today has lost over half of its organic carbon content since pre-industrial times.[3] Carbon in soil is what provides a healthy structure to soil ecosystems and provides nutritional value to the foods we eat. Over a generation of extractive farming and nonregenerative land management practices have caused a depletion of soil carbon content and global death of working lands.[4]

Organic Waste Problem

Since the dawn of civilization, humans have had a waste problem. In the United States alone, more than 60 million tons of food is wasted each year.[5] Organic materials such as food scraps and yard trimmings produce methane and significantly contribute to GHG emissions when anaerobically decomposed in a landfill.[6] Community members, business owners, and policymakers have the opportunity to create partnerships and manage their waste in a more circular and less extractive manner.

Carbon Farming's Role

Carbon farming is not a silver bullet solution to these issues, but can be an integral part of the greater effort to build a better future. It will take a range of actions, from consumption reduction to increased efficiencies to compostable packaging, to solve the wicked problems we face. Carbon farming is one of many practices to address the intersecting problems of climate change, soil erosion, and organic waste.

Four main approaches to community carbon farming: [7]

Reduction in tillage intensity	Intensification of crop systems	Adoption of yield-promoting amendments	Establishment of perennial vegetation
Tillage is the mechanical agitation of topsoil by farmers for planting, harvesting, or weed suppression purposes	Utilizing crops with longer growing seasons such as natural grasses, perennials, and cover crops allow for greater amounts of carbon to be stored underground	Both commercial, mineral fertilizers and organic amendments such as livestock manure or compost are known to increase yield	Climate and soil conditions influence the rates at which carbon will accumulate on revegetated land
Tillage promotes carbon loss by leaving soils more prone to erosion and less capable of water retention	This allows for increased carbon sequestration through photosynthesis but also may provide benefits of keeping soil cool by shade and suppressing carbon decomposition rates	When used in conjunction with better crop varieties, more efficient pest control, improved water management and more efficient fertilizers, higher yields will translate to higher soil carbon content	Arid climates where natural growth is less productive will generally sequester less carbon than regions with a more humid climate and naturally active cropland

Application of Compost

In both the literature and stakeholder interviews, the adoption of yield-promoting amendments, such as the application of compost, have been found to be the most effective of the aforementioned carbon sequestration techniques.[8] This finding has helped guide recommendations in the following toolkit, as much of the soil amendments for carbon farming mentioned are centered around application of compost.

However, because of the diversity of land conditions and climate, a best practice in one region might not have the same results in another with differing conditions. Community participation in citizen science carbon farming projects will help to identify the benefits of each practice in a localized context.

INDIVIDUALS

Be a Backyard Carbon Farmer!

This section of the carbon farming toolkit is for individuals who would like to contribute to a local climate solution: backyard carbon farming.

"If we are to be successful in the fight against climate change, we must go beyond reducing emissions to actively removing carbon from the atmosphere."[9] Carbon farming is a hands-on way for community members to fight climate change in their own backyard. The practice of backyard carbon farming is simple: apply compost to your lawn. It's that easy. However, carbon farming in its simplicity is a powerful act.

"Everywhere we see dirt – from our gardens to our parks to our highway medians – is an opportunity to build healthier soil and fight climate change."

- Eco-Cycle

Why Should You Be A Backyard Carbon Farmer?

It's easy! And it benefits the environment and the participants themselves.

01 Get involved in a tangible climate solution right in your own backyard.

02 Learn about your own yard as an ecosystem, and how you can manage your ecosystem in a way that sequesters carbon, saves water, and becomes more resilient to our changing climate.

03 Act as a citizen scientist by contributing data to a larger network in order to advance the collective understanding of soil carbon sequestration rates.

04 Easy and quick set-up with very low maintenance.

05 Carbon farmers notice greener, healthier, faster-growing lawns, as well as faster growing plants.

06 Participants notice they save water.

WHAT IS COMPOST?

Compost is the nutrient-rich material that results from the controlled decomposition of organic matter.[10] Organic matter most commonly includes food scraps and yard trimmings.

What are the benefits of compost and carbon farming?

REDUCES WASTE

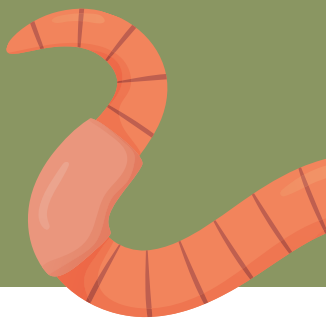
BUILDS HEALTHY SOIL

SAVES WATER

PREVENTS EROSION

SEQUESTERS CARBON!

Benefits of Carbon Farming

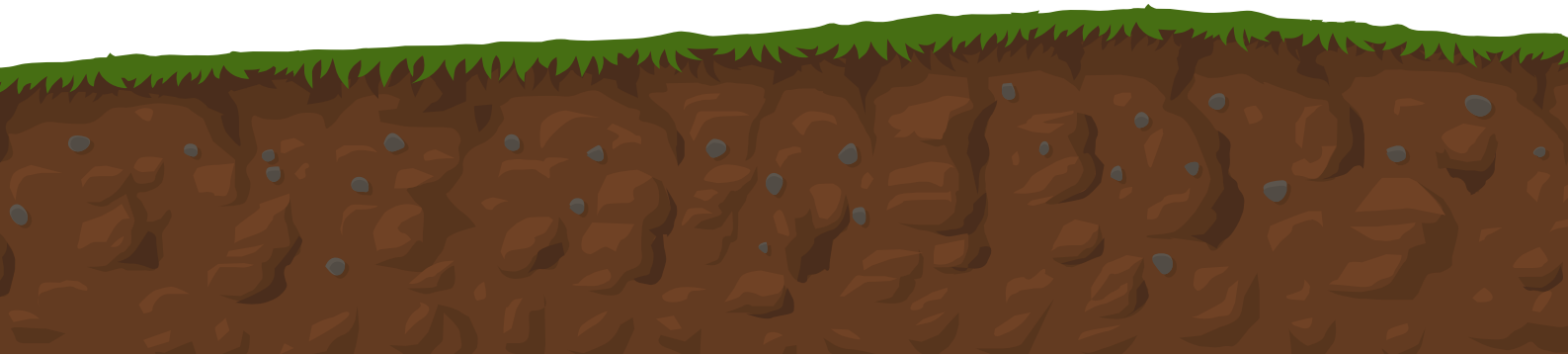


REDUCES WASTE

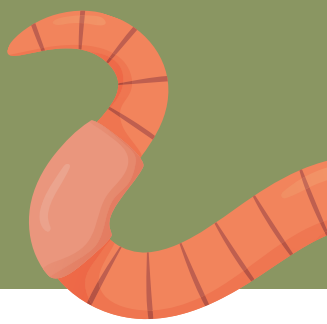
Carbon farming contributes to a more localized, circular economy by reducing organic waste and subsequent emissions. According to the EPA, nearly half of the trash in the United States is biodegradable material that could be composted.[11] Carbon farming reduces this waste and thus reduces human-caused methane emissions due to food and yard waste decomposing in landfills.

The EPA states, "municipal solid waste landfills are the third-largest source of human-related methane emissions in the United States."[12] This is especially significant because methane is an extremely potent greenhouse gas -- more than 25 times as powerful as carbon dioxide at warming the global atmosphere.[13] What is the source of the landfills' methane emissions? Decomposing organic matter, *such as food waste and yard scraps*. However, this very organic matter contributing to global warming could *instead* be diverted from landfills and composted -- at which point it could be utilized to sequester carbon dioxide from the atmosphere and contribute to cooling the planet and reversing climate change, as opposed to the opposite. According to the EPA, "because methane is both a powerful greenhouse gas and short-lived compared to carbon dioxide, achieving significant reductions would have a rapid and significant effect on atmospheric warming potential." The US is is the fourth largest emitter of methane in the world, as a result, we have a large potential to reverse global emissions.[14]

The act of turning organic materials into compost ensures they are not wasted or emitting greenhouse gasses after all, rather that compost can now be utilized as a source of nutrients for soil building. This is how we cultivate a circular economy.



Benefits of Carbon Farming



BUILDS HEALTHY SOILS

The act of applying compost to a lawn directly contributes to the health of the soil by enriching it with nutrients and soil biota, balancing its pH, and contributing to the diversity of the soil microbiome. As a result, healthier soils contribute to healthier plant growth and the suppression of weeds and plant diseases, which then results in healthier, more nutrient-rich foods--without the use of fertilizers or pesticides.

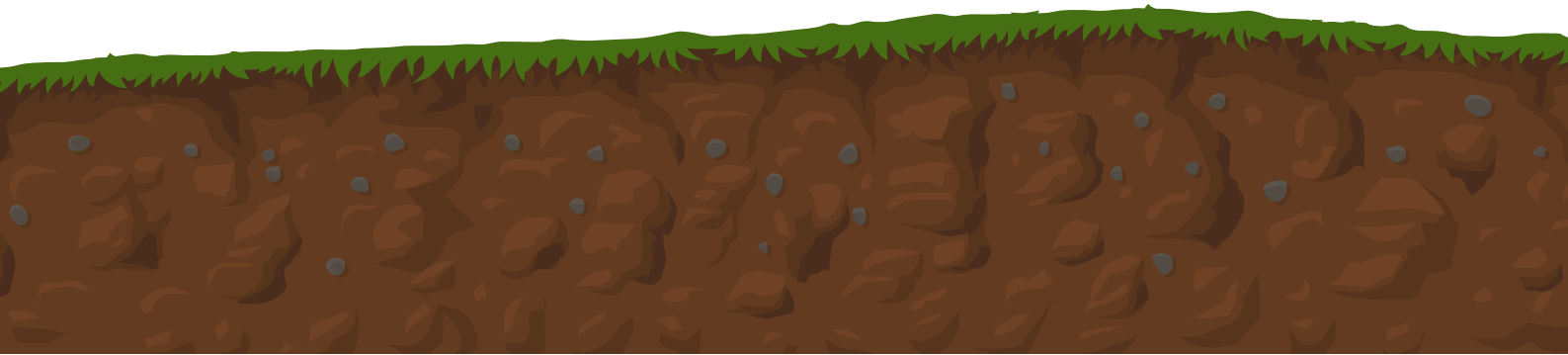
For more information on the importance of soil review the Food and Agriculture Organization of the United Nations' Soils Portal or their report on the Status of the World's Soil Resources.

PREVENTS SOIL EROSION

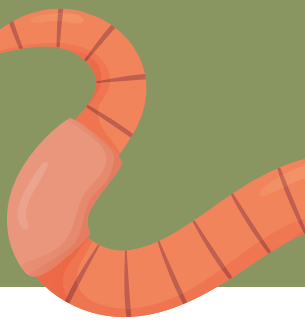
As compost better equips soil to absorb and transfer water, it also allows the soil to bind together more and create a less favorable environment for erosion to take place. This is incredibly important as soil is a finite resource--meaning its loss is not recoverable during a human lifespan.[15]

Key figures on soil erosion according to the Food and Agriculture Organization of the United Nations[16]:

- It can take up to 1,000 years to produce just 2-3 cm of soil.
- 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050.
- Soil erosion can lead up to a 50% loss in crop yields.



Benefits of Carbon Farming



SEQUESTERS CARBON!

When compost is applied to soils it promotes the uptake of carbon dioxide by plants and converts it into vegetation--in other words, it sequesters carbon from the atmosphere and thereby reduces greenhouse gas emissions that contribute to climate change. Soil's ability to store carbon is three times more than that of plants or our atmosphere.[17]

The carbon sequestration potential of soils increases over time, thus acting as an ongoing, continuous benefit that multiplies over the years.

SAVES WATER

Compost has the ability to more efficiently absorb water and simultaneously prevent run-off and flooding. This process also contributes to increased stormwater management.

As a result, the treated soil (and any grasses or other plants that grow in it) is more drought resistant and resilient to climate change.[18]

How to Start Carbon Farming

*Current backyard carbon farmers described set-up as easy, quick, and straightforward. Most participants noted that **training and set-up took no more than 3 hours from start to finish**––time that can easily be split up if needed.*

Materials Needed

- Shovel, or other tool to apply compost
- 10' x 20' piece of lawn & measuring tape
- Compost: 4 cubic feet of mature, stable compost
- Smart phone & LandPKS app

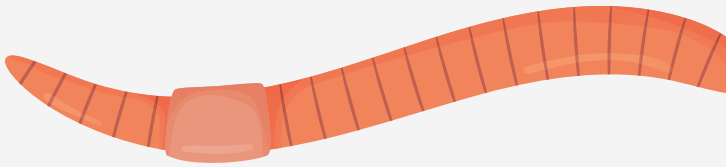
Time Commitment

- Training videos: 1 hour & 45 minutes
- Set-up & soil sampling: 1 hour or less
- Maintenance: seasonal compost applications & soil samples, no further maintenance beyond normal lawn care

Cost Expected

- Compost: $10-$35 for a 1.5 cubic foot bag of compost
- Annual lab tests (optional): $80-$140 total depending on the lab and how much detail you would like to receive

Steps to Follow



01 Sign up! Eco-Cycle will follow up with instructions via email

02 Watch the training videos (five videos totaling 1hr 45min)

03 Measure a 10' x 20' piece of lawn to conduct the carbon farming

04 Divide the piece of lawn in half so that there is a control side

05 Leave the control side as is and apply compost to the treatment side

06 Download LandPKS, a mobile app that assists in storing data about your trial plots (the Eco-Cycle training videos walk you through this)

07 Take base soil samples and send them into a lab to see the real carbon sequestration rates in your plot over time (the Eco-Cycle training videos walk you through this)

08 Recommended labs include: Our Sci through their Real Food Campaign ($20/sample with 4 samples of various depths needed each time) or through a local land grant university such as Colorado State University's soil lab ($35/sample but it includes more data)

09 Soil tests can be done as often as annually or every three years

10 Print a sign to post in your yard that you are carbon farming!

11 Join the carbon farmers Facebook group to connect with others

Advice & Tips for Success

Current carbon farmers provide insight for beginners

- Mark the location of your test plots with a landmark that is somewhat permanent (boulders, trees, stone steps, etc.).

- Although not directly necessary, some participants with hard soil found it useful to purchase a soil sampling probe for their plots, while others used tools at home such as an apple corer.

- Apply compost after you have taken your soil sample so that it does not get in the way.

- Don't smother the grass! Leave the compost on the surface of the grass and gently rake it in with a leaf raker. Try to spread it over the grass as evenly as possible. There only needs to be ½" of compost covering the whole test plot.

- Many participants chose to apply compost to their whole lawn because of how green and healthy the compost made their grass (being careful to avoid the control plot). This is a great way to increase the health of your lawn and its sequestration potential.

Soil sampling by carbon farmer Nancy Stone

How to Start Carbon Farming

Eco-Cycle Training Videos

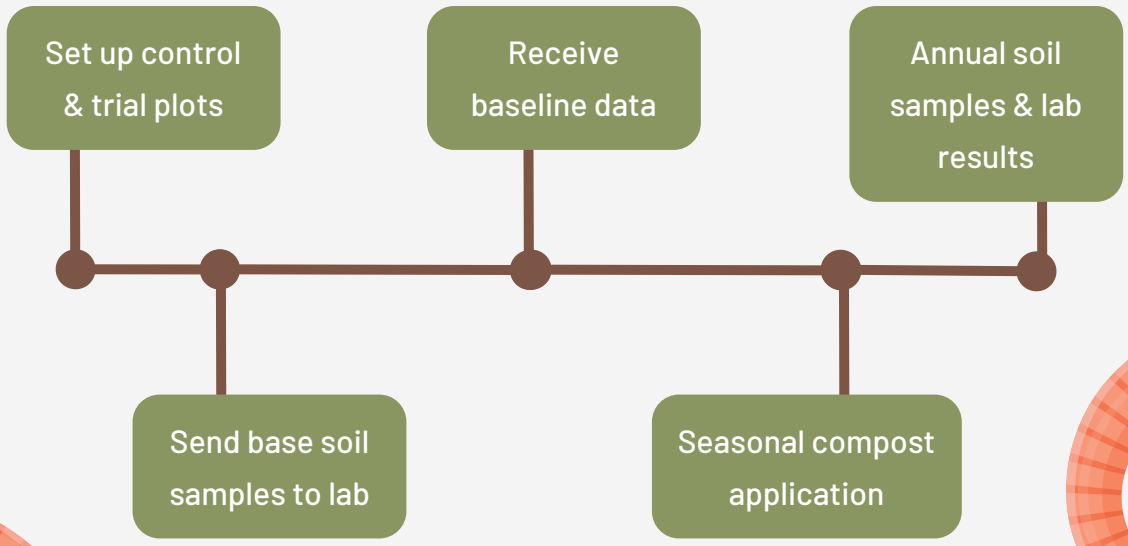
- Observational Carbon Farmer Introductory Training Webinar (50:15)
- Introduction to the Carbon Farming Project & Getting Started (9:56)
- Setting Up Your Land Plot on LandPKS (14:58)
- Soil Tests (21:19)
- Getting and Applying Compost (3:43)
- Share the Word and Stay Engaged (5:25)

Compost applied to carbon farming plot

Maintenance Required

- Apply compost seasonally
- Take lab samples annually to compare to your base samples
- Otherwise, water, mow and maintain your lawn as usual!

TIMELINE



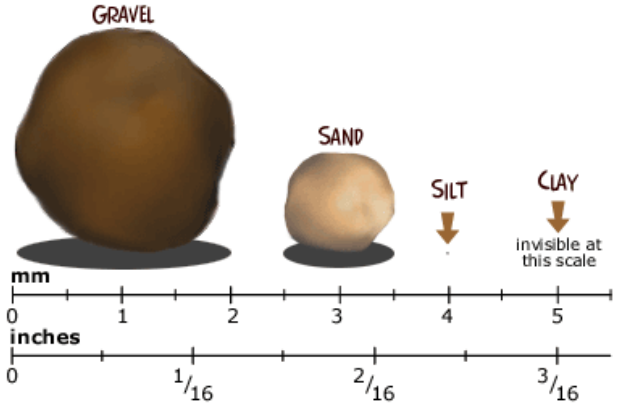
How to Understand Lab Data

There are a few key factors that are important to understand before reviewing your soil test lab results.

SOIL TYPE

In order to properly contextualize your lab results, you first need to understand what *type* of soil you have: sand, silt, or clay.

The specific type of soil you have in your yard will impact how certain factors change over time and the overall sequestration *limitations and potential* of your soil. This is because soil texture impacts the soil's ability to store nutrients, carbon, and water.



Sandy soil

- Largest particles
- Less capacity to store nutrients and water = less capacity to store organic matter and sequester carbon

Silty soil (also called loam soil)

- Medium-sized particles
- Balance nutrient- and water-holding capacity with porosity = ideal for growing plants

Clay soil

- Smallest particles
- Holds nutrients and water very effectively = highest capacity to store organic matter and sequester carbon

Note

- Soil can be any combination of the above
- Find more information here

How to Understand Lab Data

WHAT THE LAB TESTS FOR

There are three main soil components that will be tested over time in order to understand the carbon sequestration potential of the land. These components are soil respiration, soil organic matter, and the total organic carbon percentage of the soil.

Soil respiration

- Just as humans exhale carbon dioxide (CO_2), soil is composed of tiny microbes that exhale CO_2. These microbes are an essential aspect to the health of the soil. Soil respiration is a measurement of the CO_2 released from the soil in order to discern the level of microbial activity present.[19]
- For more information: USDA Natural Resources Conservation Service's Soil Respiration Soil Health Guide

Soil organic matter

- Answers the question "Am I building soil?"
- Refers to "the fraction of the soil that consists of plant or animal tissue in various stages of breakdown (decomposition)." [20]
- Contributes to soil productivity in numerous ways
- For more information: Cornell University's Soil Organic Matter Fact Sheet

Total organic carbon percentage

- Answers the question "Am I sequestering carbon"
- An increase of total organic carbon percentage over time indicates that carbon is being sequestered out of the atmosphere and stored in the soil
- For more information: European Union Science Hub's Science Update

Although soil tests should be done yearly in order to track the progress of the trial plots, it will take around 3 years to gain an accurate picture of the impact you are having on the soil. *In order to keep carbon sequestered in the soil, carbon farming must be a long-term, ongoing practice.*

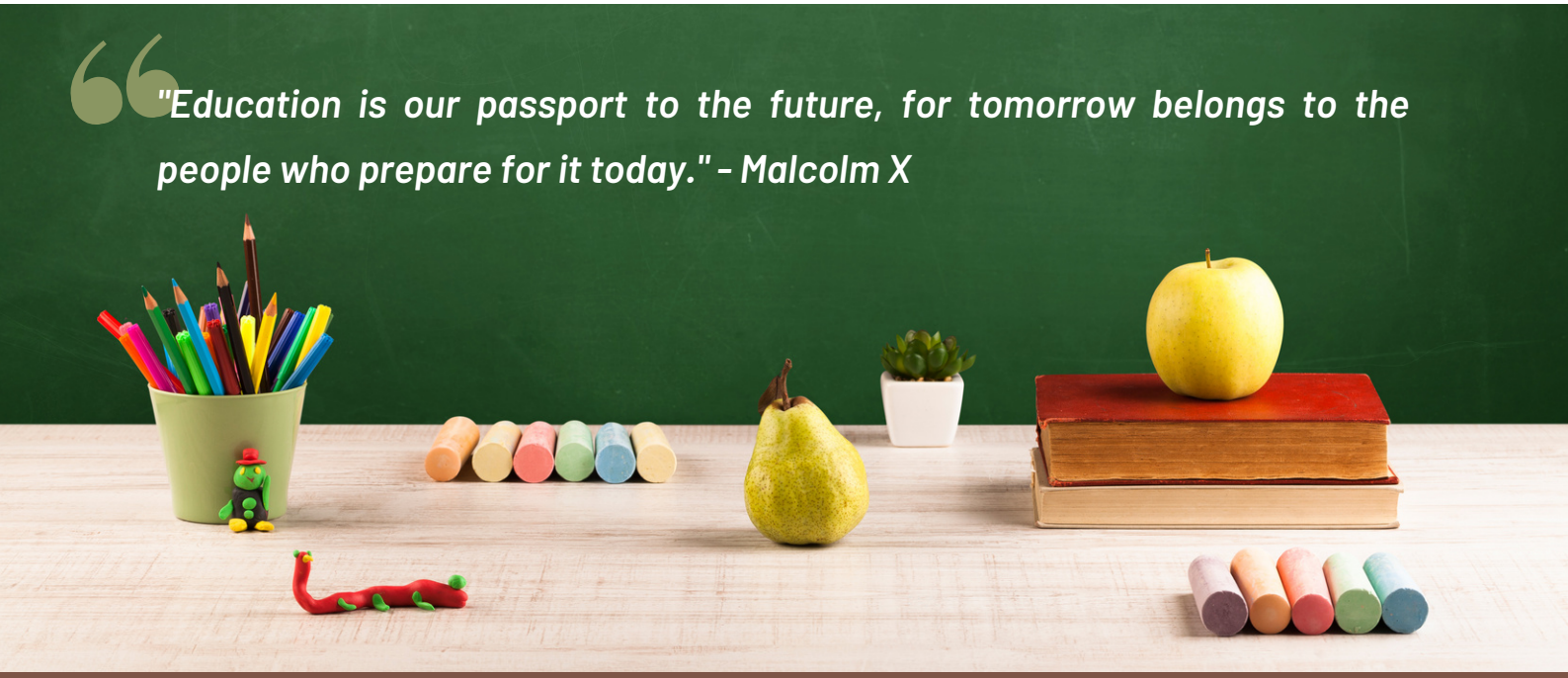
EDUCATIONAL PROGRAMMING

Introduction

This guide provides an overview of methods used to familiarize traditional K-12 students with the importance of soil health and the practice of carbon farming; however, these principles and content can also be incorporated into other educational settings, such as community gardens, extracurricular learning centers, or summer camps.

The educational sector is unique in that it is a pivotal space that serves as a transition for youth beyond their formative years into the bigger world. The educational system that a student traverses has numerous impacts on the development of their worldview, their ability to think critically and innovatively, and the way they perceive and relate to the world around them. Education spaces are specifically intended for the imparting of knowledge, making them an ideal place to be presented with a program that is intended to expand knowledge and ideas.

Carbon farming is a practice that, when incorporated into school programs, can serve as a tool for students of all ages - as well as educators and parents - to conceptualize the importance and impacts of soil health and a circular economy on their own green spaces.



What is Educational Programming?

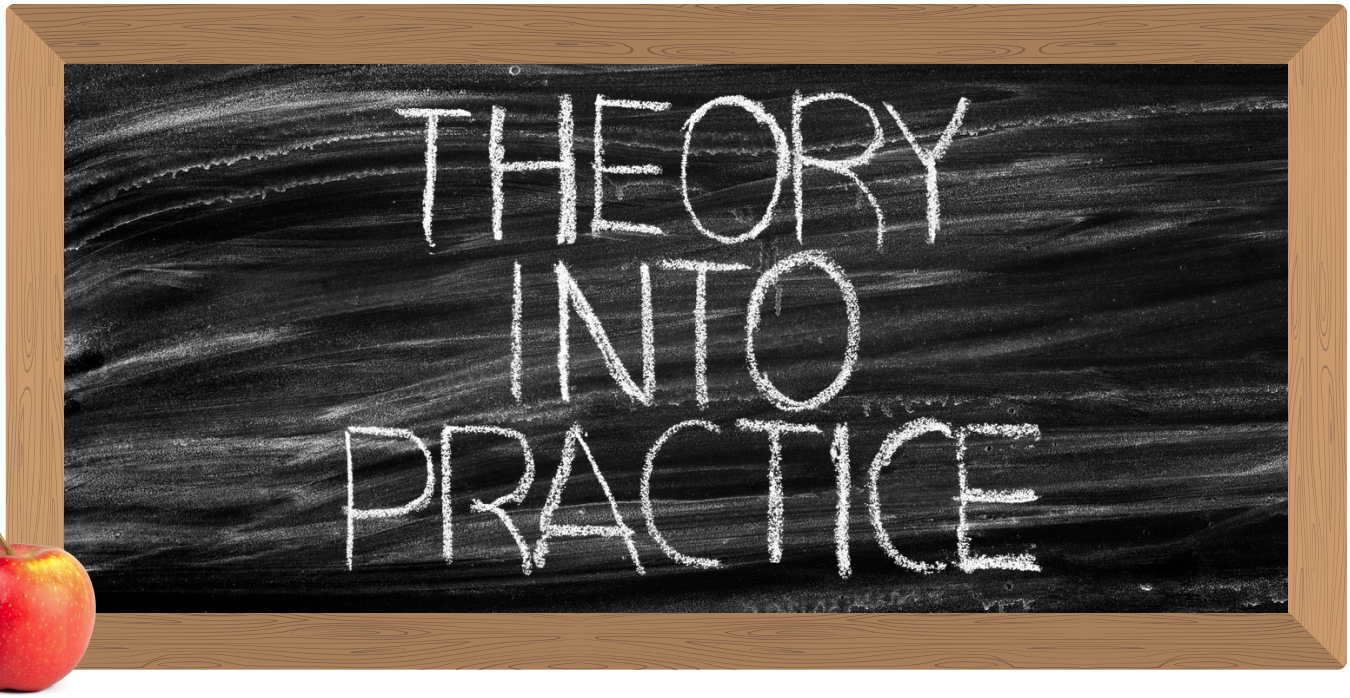
TWO COMPONENTS

01 *Curriculum*

- Lesson content shaped around soil health and the carbon cycle provides a conceptual foundation of why carbon farming is important.

02 *Practice*

- Practical, hands-on application that complements the concepts covered in the classroom.
- These practices might include learning gardens and long-term experiments.
- In conjunction with the material absorbed through classroom learning, participating in these educational practices empowers students with the necessary knowledge to begin capturing carbon themselves.



Educational programming should focus on carbon farming as **both an element of a curriculum** that covers the carbon cycle and soil health, **AND a practice** by setting up a plot for an observational carbon farming experiment or other hands-on applications such as a learning garden.

Curriculum Examples

The following selections come from lessons that are currently implemented and active within a curriculum.

These lessons are an example of how this content can be embedded within an already-existing program. These are ways to convey the subject matter of carbon farming and soil regeneration as a component of a larger unit such as environmental programs, an earth science module, or a plants and gardening project -- which most education centers have in some variety. Some are readily set up for this, and some might have a less-robust environmental science curriculum, but seeing a tangible example of successful implementation will inspire and equip educators in any system to begin incorporating this content into their programs.

For some school systems, the development of a robust environmental education program is well within their means. However, others may not have the necessary infrastructure in place, making a full program inaccessible.

The following are examples of effective ways to convey the content, as well as strategies to effectively implement that content into a curriculum or education program.

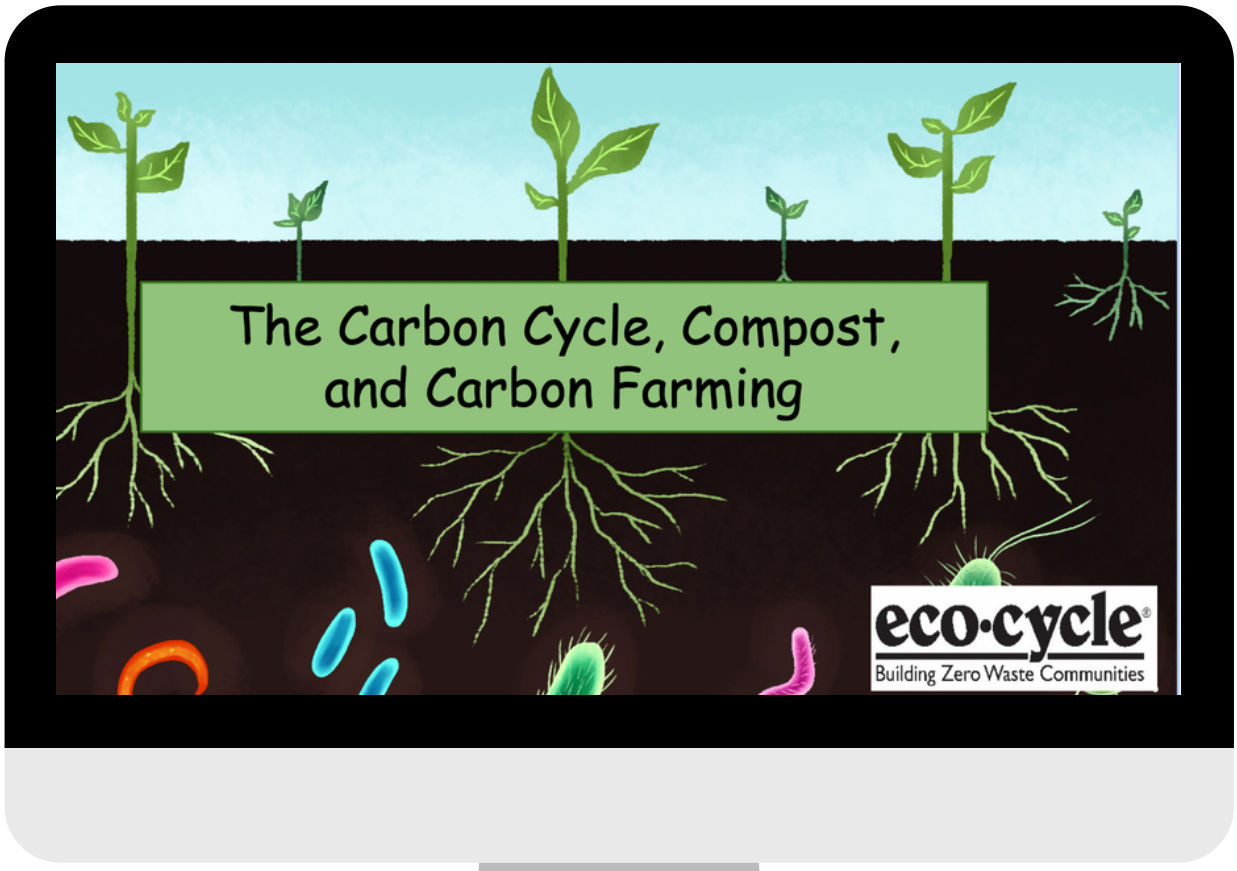
Elementary School:

The Carbon Cycle, Compost, and Carbon Farming

Eco-Cycle's Environmental Education Program in Boulder, CO

This lesson example effectively demonstrates how to take more advanced topics such as soil health, carbon sequestration, and the carbon cycle, and distill them down into pieces that children from kindergarten through fourth grade can understand. This involves not only simplifying complex ideas, but also relating them to concepts that students of these ages are already familiar with.

Click below for the lesson plan!



Elementary School Continued

KEY POINTS from The Carbon Cycle, Compost, and Carbon Farming by Eco-Cycle of Boulder, CO.[21]

01 **Start by explaining what a cycle is:**

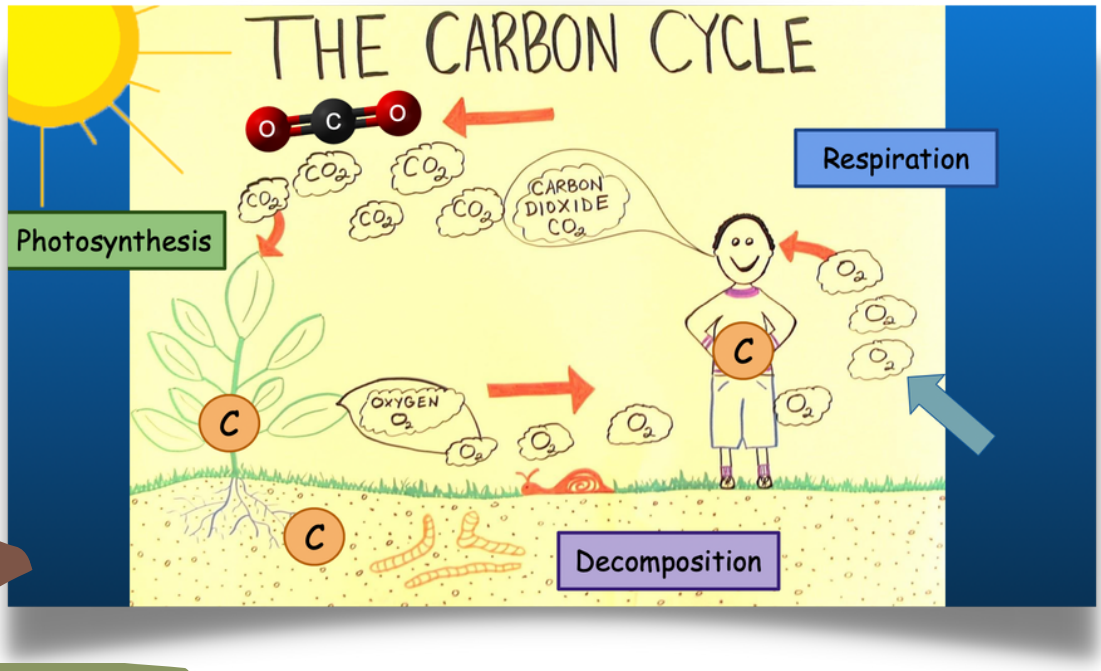
"A process that has no waste, no end, or beginning." Cycle = Circle.

PRO TIP

Give examples of cycles that the kids would know: sunrise and sunset, the water cycle, the nutrient cycle. These can happen within a day, or over the course of several years or even centuries! It's important to understand these because they help keep everything in our world in balance.

02 **Then, introduce the carbon cycle:**

Carbon is: a building block of nature, plants and animals (give examples), wood that was once a tree, even rocks, are all made of carbon. It is in the air we breathe. We inhale oxygen, exhale carbon dioxide. (But what do trees and plants "breathe??" What do they exhale? We need each other!)



PRO TIP

Introduce or review photosynthesis and respiration, depending on class level & familiarity.

Elementary School Continued

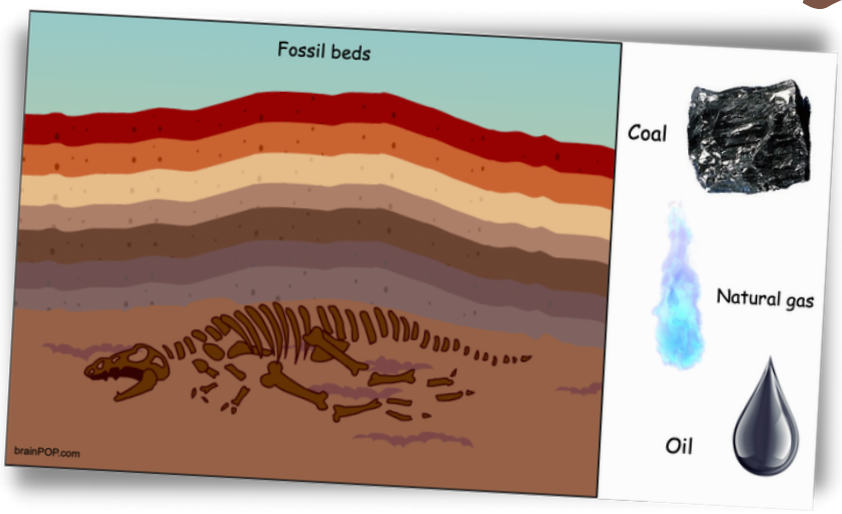
KEY POINTS from The Carbon Cycle, Compost, and Carbon Farming by Eco-Cycle of Boulder, CO.

03 Next, connect to related concepts:

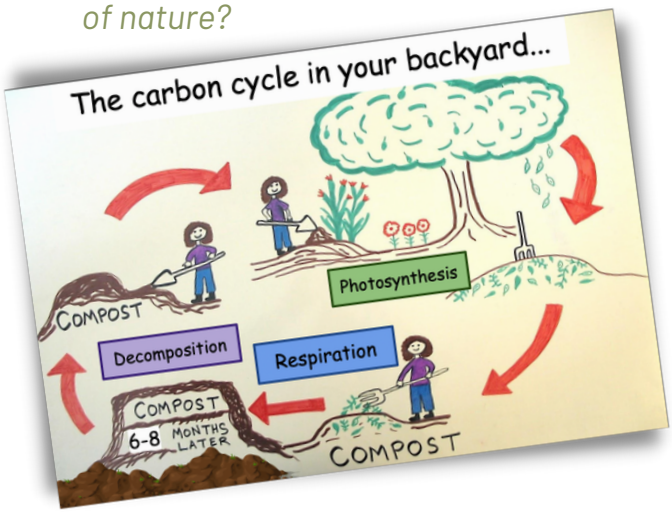
What happens after organisms die? Do they go back into the dirt? This process is called "decomposition." All of these things together are parts of this larger cycle that connects different parts of nature.

Other concepts relating to the carbon cycle:

- Decomposition
- Respiration
- Photosynthesis
- Weathering
- Emissions
- Fossilization



Fossils buried and stored underground contain lots of carbon. Consider the connection between fossils and fossil fuels. Humans burn fossil fuels for energy, which releases carbon. *This is a big way that humans affect the carbon cycle. Do you think this affects the balance of this cycle within the larger system of nature?*



PRO TIP

Carbon sinks: when carbon is released into the atmosphere, it has to go somewhere!

- Atmosphere
- Ocean
- Topsoil

Lead to composting, as a way to help rebuild the topsoil and keep the nutrients from organic matter breaking down.

04 Finally, define carbon farming:

A practice of caring for the land in a way that increases organic matter in the topsoil, by applying compost. This stores more and more carbon in the soil over time, which decreases the amount of carbon stored in the atmosphere.

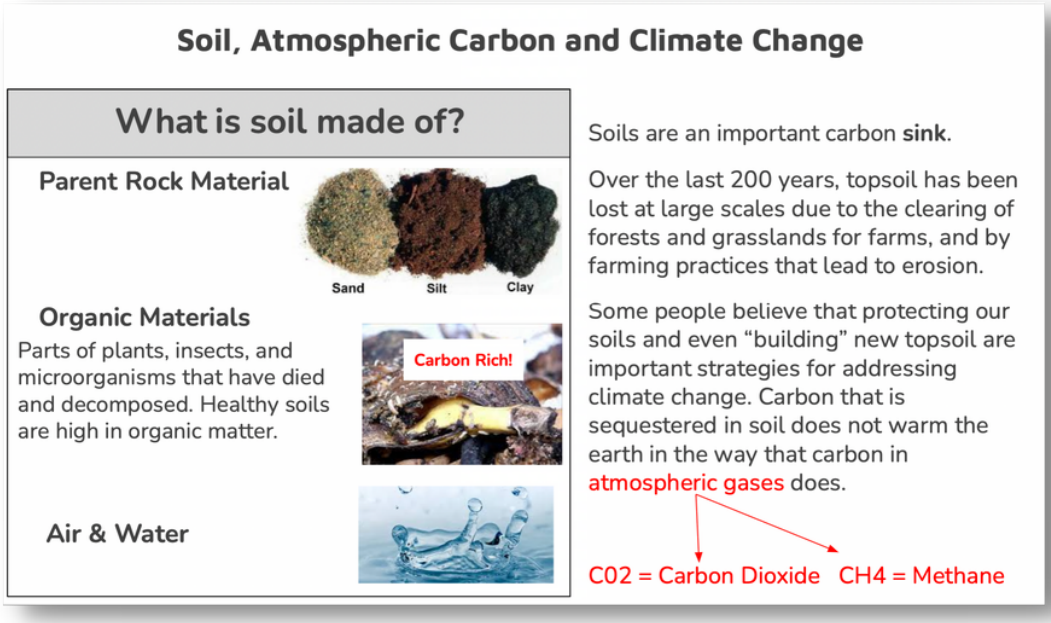
Middle School:

Round & Round it Goes

The Freeman Environmental Education Center in Ann Arbor, MI

The Ann Arbor Public Schools Environmental Education program focuses on experiential learning through lessons and field trips based in the natural environment. This lesson for 5th graders contains much of the same concepts as Eco-Cycle's for elementary students, but with more advanced vocabulary. It combines ideas like "sequestration" and "carbon sink" to soil health, and dives into organic matter and microorganisms.[22]

Below we will highlight a few key points within the lesson where there is an opportunity to "plant the seeds" for the concept and practice of carbon farming.



Soil, Atmospheric Carbon and Climate Change

What is soil made of?

Parent Rock Material

Sand Silt Clay

Organic Materials

Parts of plants, insects, and microorganisms that have died and decomposed. Healthy soils are high in organic matter.

Carbon Rich!

Air & Water

Soils are an important carbon **sink**.

Over the last 200 years, topsoil has been lost at large scales due to the clearing of forests and grasslands for farms, and by farming practices that lead to erosion.

Some people believe that protecting our soils and even "building" new topsoil are important strategies for addressing climate change. Carbon that is sequestered in soil does not warm the earth in the way that carbon in atmospheric gases does.

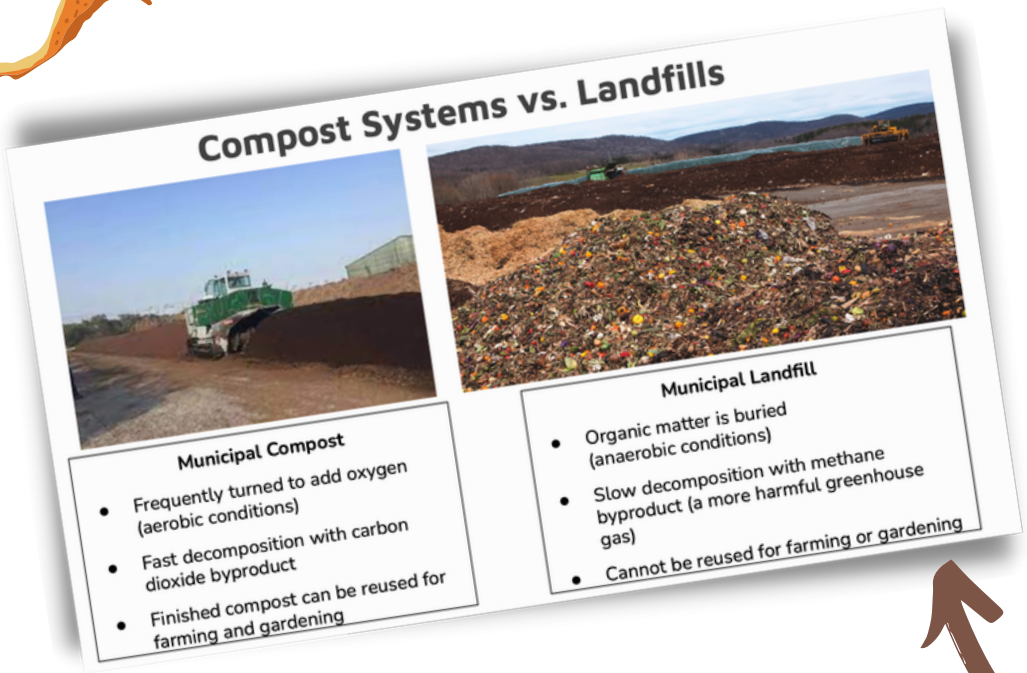
C02 = Carbon Dioxide CH4 = Methane

PRO TIP

When covering soil composition, connect this to the elements that contribute to healthy soil. Find the lesson plan here!

Middle School Continued

Continued key points from Round & Round it Goes by The Freeman Environmental Education Center in Ann Arbor, MI.

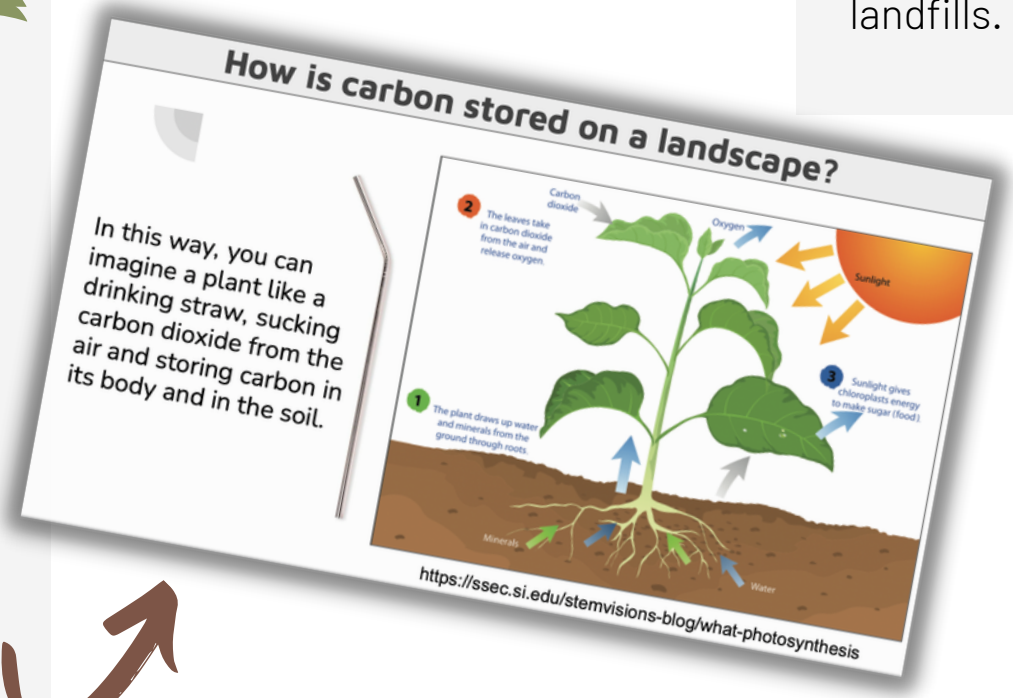


PRO TIP

When introducing compost systems, highlight how closing the loop of the organic matter cycle creates a place for nutrients to go which in addition to helping mitigating the emissions from organic waste in landfills.

PRO TIP

While explaining carbon storage, emphasize that drawing carbon down into the soil is called "carbon sequestration," and that carbon farming is when we do this intentionally.



Middle School Continued

Continued key points from Round & Round it Goes by The Freeman Environmental Education Center in Ann Arbor, MI.

In these examples, notice how The Freeman Center starts by covering curriculum content through background information on the carbon cycle, composting, and soil health, followed by an introduction of their own Carbon Farming Project. This exemplifies how "programming" is a combination of curriculum content as well as a practical component.

See page 19 for how to set up a carbon farming plot

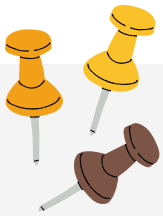
Creating a carbon farming plot could be done on various levels: by a single classroom, a grade level, or a school-wide project as part of community outreach. While this is not time- or money-intensive, there might be various unique limitations that each type of group would need to navigate.

The first step is to systematically familiarize students with foundational content and terminology:

- The Carbon Cycle
- Soil Health
- Composting

Program Implementation

Adjacent to developing the curriculum content itself, is identifying how to successfully implement the program into an existing educational structure. This section provides guidance on how to effectively begin to navigate that process, drawing attention to differences in structures and presenting strategies to use.



Identify at what level decisions regarding curriculum are made

In most cases, there are state-level standards to adhere to, while giving regions or districts "local control" over instructional methods and implementation.[23] This could be at the district level, a school system, or sometimes even an individual school or teacher will have that autonomy for how the content is sequenced, integrated, and delivered into learning modules. Each area's practices are different. Starting with the school board is a good place to get comprehensive information at once. Or, search the Department of Education website for the state - keep reading for examples of what this might look like, and how to navigate those types of resources.

START BY:

Consulting the regulations or educational standards for your state

Whether you are a curriculum developer, educational director trying to start a robust environmental education program, or a teacher trying to incorporate the content into your own lesson plans, the process begins at your state's academic regulations or educational standards.

Program Implementation

For lesson planning and sequencing, it might be as easy as finding where state standards coincide with key concepts from the lesson content itself, and embedding some of the content from the example lessons above into that particular learning module.

By showing that these lessons help meet state-wide standards, one has a case for the importance and effectiveness of incorporating these topics. From there, it is only one step further to set up carbon farming plots as a tangible, hands-on practice of the principles that are covered.

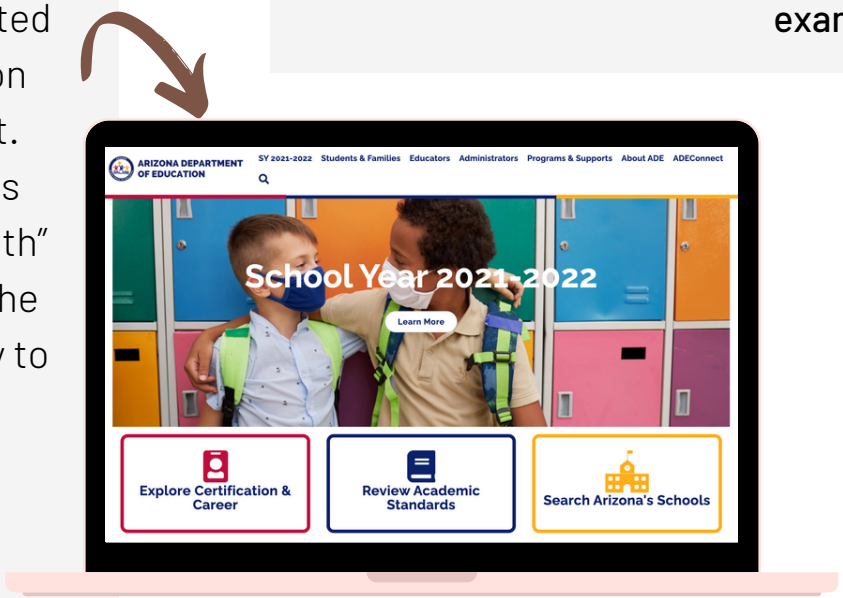
PRO TIP

When looking to integrate lesson plans on carbon farming into a larger curriculum, it is important to first be familiar with the particular academic practices for the state.

Oftentimes, *statewide academic standards* will be clearly indicated on the Department of Education website for the state or district. Sifting through these standards for key words such as "soil health" or "carbon cycle" may provide the creative constraints necessary to weave modules and activities throughout the already-established standards that a curriculum must meet.

CASE STUDY

For an educator in Colorado, a direct and effective way to help incorporate lessons like these into a science curriculum is to consult the Colorado Academic Standards for science at a particular grade level. On the next page we will review a successful example.



CO Academic Standards

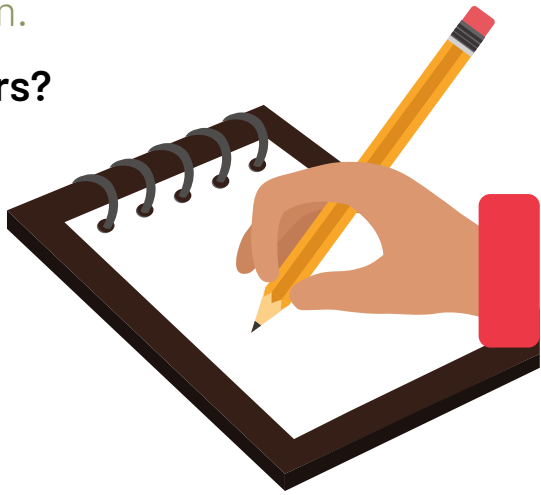
Denver Urban Gardens

A case study of successful lesson building and implementation alongside state academic standards

Denver Urban Gardens operates "more than 180 community gardens in the Denver Metro area, including 70 school-based community gardens."[24] In addition to other trainings and certifications available to communities, they also provide educational resources and programming for schools. This allows students to experience hands-on learning amidst their regular curriculum.

What resources does D.U.G. provide to educators?

- Trainings, resources, and research findings
- Workshops for educators
- 'Healthy Bodies, Healthy Gardens' curriculum[25]



Programs by D.U.G.

- Garden to Cafeteria
- Youth Farm Stands
- Healthy Seedlings Nutrition Program

How does D.U.G. develop curriculum and lesson content?

D.U.G. has a curriculum that they developed to cover content that is in line with their mission. By keeping these in mind, they create ease of implementation into the programs of the schools or education centers who need to meet these standards. They are a prime example of an organization that creates content that they want to see integrated into programs to enhance students' learning, and simultaneously eases the burden on traditional educators within a school system.

Case Study Continued

A CLOSER LOOK: the 'Healthy Bodies, Healthy Gardens' curriculum

This curriculum seeks to "build a bridge between the school garden and the classroom."[26] These lessons are developed and aligned with the state academic standards in Colorado, and are sequenced in accordance with topics that are seasonally relevant.

This curriculum has one lesson called "Worms are our friends," where students learn about composting, decomposition, and the **red wiggler worms** that help in the process. These worms are commonly used in **vermicomposting**, or composting done by worms, and are the same type that Eco-Cycle uses to decompose food scraps and make its signature MicrobeBrew compost tea!

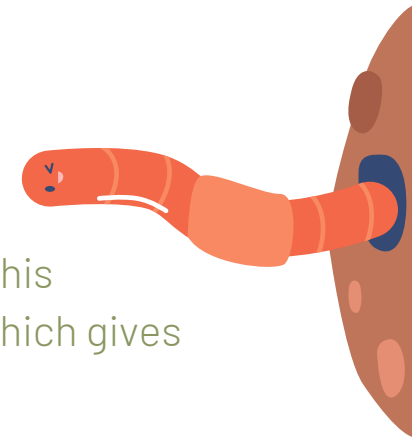
This lesson is relevant because there is emphasis on the importance of soil health and carbon content, creating a path to further connect the topics of the carbon cycle and carbon farming into the lesson.

This program focuses on making the connection between garden activities and the curricular components set by the state that teachers have to meet.

Their lessons are built around the standards, and this is clearly indicated on the lesson overview spreadsheet. You can gain access to these materials here using your email address and providing more information about the capacity at which you interact with students.

Case Study Continued

LESSON PREVIEW: "Worms are our Friends"
'Healthy Bodies, Healthy Gardens' curriculum



Note that the Colorado Academic Standards within this lesson are clearly indicated. DUG also summarizes this information in their Lessons at a Glance spreadsheet, which gives the teacher flexibility as to how to sequence them.

The lessons are written with grades 1-5 in mind, but contain recommendations at the end to tailor towards learning objectives for middle or high school.

DUG DENVER URBAN GARDENS

Worms Are Our Friends

Healthy Bodies, Healthy Gardens Curriculum

Objectives
Students will learn about Red Wiggler worms, composting and decomposition.

Standard Connections
Colorado 2020 Academic Standards
Science: Life Science

GR.1 – S.2 – GLE.1	All organisms have external parts that they use to perform daily functions.
GR.2 – S.2 – GLE.2	A range of different organisms lives in different places.
GR.3 – S.2 – GLE.1	Organisms have unique and diverse life cycles.
GR.4 – S.2 – GLE.1	Organisms have both internal and external structures that serve various functions.
GR.5 – S.2 – GLE.2	Matter cycles between air and soil and among plants, animals and microbes as these organisms live and die.

Total Time – 60 minutes

Materials
- Worm Bin/Container (wood or plastic)
- Newspaper (black and white only)
- Red Wiggler worms
- Fall leaves
- Food scraps (old bread, egg shells, fruit and vegetable peels, coffee grounds, etc. Do not use meat, fat, dairy, junk food or citrus)
- Magnifying glasses

Vocabulary

cocoon	cold-blooded	compost	erosion
fertilizer	hatch	improvement	invertebrates
moisture	oxygen	recycle	vermicomposting

Background for Teachers
Red Wiggler worms, which are used for worm composting, consume their weigh each day in raw organic material, live about one year, do NOT turn into two worms when cut in half and take only six weeks to grow from hatchling to adult. See the Worm Composting 101 resource sheet for more detailed information on how to care for your worm bin. This is a great follow up lesson to *The Rotten Truth*.

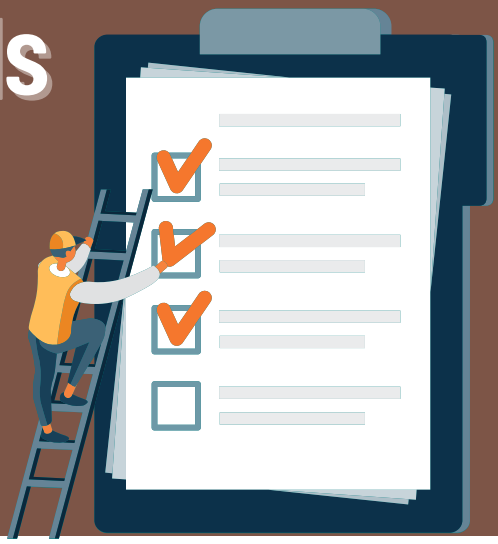
KEY POINTS

- Interacts with learning objectives through hands-on application
- Enhances content that teachers would already be using
- Encourages students to make mental note of new vocabulary
- Materials used include a magnifying glass, to encourage students to observe closely, and intentionally. It enables a search for something new, and not just the things they recognize

MI Academic Standards

A Closer Look

An example of how statewide academic standards are a connection between larger frameworks and specific curriculums



Michigan's standards, which are developed alongside National Research Council's Frameworks, provide guidelines for school districts to consult while developing and implementing curriculum.

The science academic standards document from the Michigan Department of Education states:

"Standards are performance expectations for students. They are not curriculum and they do not specify classroom instruction. Standards should be used by schools as a framework for curriculum development with the curriculum itself prescribing instructional resources, methods, progressions, and additional knowledge valued by the local community. Since Michigan is a "local control" state, local school districts and public school academies can use these standards in this manner to make decisions about curriculum, instruction, and assessment."[27]

Recorded history, as well as chemical and geological evidence, indicates that human activities in agriculture, industry, and everyday life have had major impacts on the land, rivers, ocean, and air.

By the end of grade 5. Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. For example, they are treating sewage, reducing the amounts of materials they use, and regulating sources of pollution such as emissions from factories and power plants or the runoff from agricultural activities.

By the end of grade 8. Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.

From the National Academies Press Framework for K-12 Science Education [28]

Additional Resources & Tips

Colorado Alliance for Environmental Education (CAEE)

This is an example for educators that wish to look outside the scope of traditional, district-oriented education so that they might expand their potential reach.

- While they are Colorado-based, CAEE is comprised of mostly non-profit organizations that do education work with youth and their principles and practices can be referenced by anyone. They work with open space departments with counties, nature centers, and develop programming.
- They provide the verbiage to make the case for Environmental Education & its inclusion in K-12 science curriculums. This makes them a useful resource for educators who do not have the infrastructure within their school system to initiate implementation of a carbon farming program.[29]

- In this case, options might include advocating for environmental education within their sector of impact by using this type of argument, or simply seeking resources outside the scope of traditional public schools or academies with which to consult and collaborate with as a means of extra-curricular programming.

Navigate the system by framing curricular content intentionally:

Emphasize that the content proposed to be integrated represents an essential part of the academic standards, helps meet them, and is beneficial to teachers, developers, and students alike.

Potential Challenges

01 Geographic variance

It can be challenging to navigate the education system to incorporate curriculum elements because of the vast differences in structure, standards and enforcement, and even political influences which vary by region and even between districts. Additionally, different areas have different landscapes, soil content and prevalence which has implications for carbon farming itself.

02 Limited bandwidth of teachers

This is why organizations like the Freeman Center in Ann Arbor Public School District is so crucial to content becoming widespread. Part of the reason they exist is to help alleviate the burden placed on teachers. Their entire environmental education program is based on field trips, a model that many programs follow. For these types of organizations, it is often helpful for the teachers to receive any outside lesson content before the trip or class visit occurs. This encourages and empowers teachers to engage with the extra content without feeling overwhelmed to have to develop or pursue it themselves.

03 Garnering support & resources from administration

For grade school teachers, for instance, who are passionate about nature and environmental education, they might receive initial verbal support from other teachers or administrators when presenting their ideas. But, this does little if it is not followed or reinforced by action to facilitate implementation of the material. Navasota Independent School District in Texas is an underfunded, remote school district that has a high turnover rate. A few teachers had personal interest in starting a school gardening program, the kind of thing that would be a perfect candidate for the carbon farming project. However this fizzled down throughout the year because of the lack of resources and followthrough to implement the project.

One elementary school teacher noted that he thought access to the necessary resources was perhaps the most important factor, but that a 3rd party educational center or organization that travelled to different schools to do hands-on activities or field trips might greatly aid in removing this barrier.

Potential Challenges

04 School and district culture, the "Hidden Curriculum"

When a curriculum is designed primarily around standardized, end-of-year testing, it can be difficult to incorporate purpose-driven programming (and hands-on practices) that might not directly correlate with testing. Without acknowledging these hidden norms, it can be difficult to incentivize both teachers and students to engage with new material that contributes to overall learning and curiosity of the students.

Awareness of the existing "hidden curriculum" is one of the barriers to implement programming into an established curriculum, as identified by the Association for Supervision and Curriculum Development. Approaching curriculum implementation and development with emphasis on the process itself is key in ensuring that the learning content is at the center.[30]

RESOURCE

8 Barriers to Curriculum Design from ASCD

05 Remote learning & uncertainty

Most educators have dealt with at great length in the age of COVID-19, but many did not have the external support that they needed. The lessons from the Freeman Center and Eco-Cycle's educational department that are included here were developed during this time, and contain content that was delivered primarily through virtual learning platforms.

This type of adaptation, which many educators did successfully, is just the beginning of the measures that educators can take to ensure that students and teachers can continue engaging with the lesson content and each other in a meaningful way.

STRATEGIES

Additional measures beyond translating content to a virtual platform:

- Interactive at-home activities done together during school hours
- Delivery of project materials to students at home
- Inclusion of parents to facilitate more in-person engagement for students

Potential Challenges

CASE STUDY

One Teacher's Gardening Program in a Texas Public School

Charla is a retired 2nd grade math & science teacher, who spoke to us about her experiences creating and implementing a year-long gardening project for her classroom. She found a program called the Junior Master Gardener's program which had a plethora of resources and lesson tools.[31] Using these tools, she implemented the material into the given curriculum for her public school.

- *Check out their resources here:*

At times, connections between the gardening program and lesson plan were clear, other times, she had to designate time in the day for an activity. She acknowledged the limitations and bandwidth of individual teachers, but she noted there are always scheduling adjustments teachers must work around such as field trips and assemblies.

PRO TIP

Use take-home activities (coloring sheets, visuals, etc.) to prompt familiarity from students, and avoid an "island effect" of an isolated new topic

TAKEAWAY

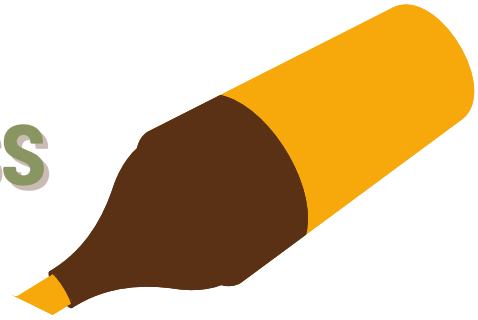
This kind of program is much more intensive than the carbon farming project, which requires only a set up and two soil amendment applications throughout the year. The rest of the program is shaped around observation, which takes minimal time and resources, but gradually builds on itself to indicate results.

TAKEAWAY

The carbon farming project within a school or classroom is a great way to draw connections between curriculum and real-world applications through practice. It takes minimal time and effort on the part of teachers, making it a great option for those educators who recognize the importance of practical applications, but might be hesitant about (or experience a lack of) time, support, resources, or energy to undertake something more intensive.

Strategies for Success

Caretakers' involvement makes it a community



Designate weekly stewards for monitoring the plot and adding to an Observation Journal with notes and pictures: pairs of students, or a student and their parent (or caretaker) for younger grade levels

Provide take-home activities: they help reinforce material and expose parents to learning concepts

Connect with the Parent Teacher Organization (PTO) to find the involved, passionate parents who are good at finding volunteers

Utilize field trips as learning vessels that engage students AND parents

- Parents want to take off work and be involved with their child's school, and field trips usually need chaperones.
- This kind of school day with a central event is a perfect opportunity to implement and set up a carbon farming plot at the school, or hold a demonstration of what to do and what's next.
- From here, it's an easy transition right into "parents -- do you want to do this at home? Here's a kit to take home, an info packet or QR code to videos, the materials you'll need," and so on.

Benefits of Implementation

Implementing these programs and incorporating these concepts into curriculum provides numerous benefits, including adding that necessary practical component.

REMEMBER

In order to resonate with and impact students, classrooms, and the larger community, lessons learned through classroom education need to be reinforced by a practical application of the subject matter - especially if it is being introduced for the first time to students.

The concept of carbon farming is one that is newer and developing in many sectors, including education. Many educators already seek to incorporate more environmental and sustainability concepts into their curriculum, but oftentimes at first, the practical application of these lessons seems to require more in terms of both materials and time. The guidance and resources help by identifying program guidelines and starting points for implementing the practice of carbon farming.

The Community Carbon Farming project combines what teachers seek to include in their classrooms with a practical application element that is feasible in terms of time and resources. It provides a stage to take the concepts of soil health and the carbon cycle, and apply them on a scale that ties everything together, making it tangible for the students.

Benefits of Implementation

Many teachers want to provide more hands-on activities linked to lesson content. Yet resolving to develop and maintain a school or learning garden, or care for and tend to plant species, etc., might be a daunting task that requires more time and energy than is available.

Participating in the carbon farming project requires minimal time and upkeep.

After the initial training and set up of plots (appx. 3 hours), there are a few applications of soil amendments to the test plot during the year. Everything else is gathering evidence through observation. This makes the project a great option for any classroom - whether to complement an existing garden, or as a stand-alone project.

REMEMBER

Carbon farming is easy, quick to set-up, and low maintenance!

Schools provide inclusivity

To be an individual participant in the Community Carbon Farming Project, one needs to have access to a yard or turf that they are able to create plots and apply compost. Many individuals and families do not have this.

Having a school-based project that multiple students and their families can participate in helps to overcome that barrier to access, and conveys the educational content to close the knowledge gap in an interactive way.

NOTE

Carbon farming in schools promotes inclusivity

ENTREPRENEURS

Introduction

This section of the toolkit is intended for those looking into entrepreneurial roles that aid in closing the loop between food waste and carbon farming resources.

Where do entrepreneurs fit into carbon farming?

An entrepreneur in the zero waste industry is participating in carbon farming simply by diverting waste streams. When food waste and other organic materials break down in landfills, the anaerobic conditions cause the release of various greenhouse gases, most significantly methane. Methane is 25 times more impactful than CO2 in increasing the greenhouse effect. Reducing organic waste in landfills reduces the impact of that waste by reducing methane emissions. By creating compost from that waste, it is also possible to draw carbon down into the soil. Entrepreneurs can increase not only their profitability but also their inputs and future customers through strategic community engagement.

Eco Cycle's carbon farming initiative, and programs like it, are a great way for entrepreneurs to showcase the value they bring to the community, the importance of reducing waste and emissions, and the potential benefits of compost application. Interviews with compost entrepreneurs suggest that building relationships with local communities builds community trust, increases initial customers purchasing compost hauling services, and thereby improves the total quantity of compost as well as provides a ready-made database of potential consumers.

Keys to Business Success

Carbon farming is an opportunity to help ecosystems by reducing greenhouse gas emissions from waste and improving soil health. Entrepreneurs can also benefit: earn a living, create jobs, and stimulate small communities

01 Develop partnerships

There is much to navigate in starting a business. Many successful composting facilities and haulers begin by renting small plots of land on neighbors' farms or other agricultural sites. This can also allow for proof-of-concept testing, ensuring the feasibility of the business before vast expenditures of time and resources.

02 Build local support

Many of the challenges confronting composters can be alleviated by cultivating relationships with the communities in which they operate. Building ties with individuals enables entrepreneurs to gauge interest in compost or potential opposition while building community trust and support. Specific tips for community engagement occur on page 87 of this toolkit.

03 Turn enforcers into allies

State and local regulations pertaining to composting vary, but wherever you live, there is some sort of regulation regarding waste disposal. Contacting these organizations and enforcement agencies early on is key to understanding your local rules and will inform what is or isn't feasible. This will also introduce you to these enforcers outside of the context of enforcement, enabling you to build relationships which can be hugely beneficial later on.

Keys to Business Success

04 Know your competitors

Zero-waste facilities and haulers earn money in several ways, and each of these cash flows faces potential competition. Main competition sources are waste haulers, the convenience factor, and a lack of awareness

Waste haulers

Trash is a utility for which residents already pay, and the inconvenience of having to actively separate waste and pay for additional composting waste services should not be underestimated. Cost concerns can be combated by demonstrating the value that compost brings to communities and strengthening ties with the community.

Convenience

There is no denying that simply tossing all waste into the same container is easy. This means that asking residents to buy a separate bin, inform themselves as to what can or can't go into a compost bin in their area, and actively separate that waste into the appropriate bins every time is a real challenge. Residents must see the value of waste diversion to buy into composting.

Lack of awareness

Residents must be willing and able to separate garbage and organic waste and put that organic matter into appropriate bins. This can be more of a challenge than it seems, as lack of awareness or concern for separating waste is common. Many residents don't have access to (or don't realize they have access to) composting pick-up, and disposing of it improperly leads to compost contamination.

Keys to Business Success

05 Distinguish yourself

The best way to succeed in business is to make sure you are the best at what you do. Here are some of the ways a composting entrepreneur can best distinguish themselves from their competitors.

Compost quality

Keeping your compost heap at ideal conditions and contaminant free is essential. It is also worth considering your feedstock and which nutrients will be dominant in your compost as a result of these feedstocks. This will ensure you match the compost to the end-users' needs.

Certifications

There are many certifications in composting. The following examples will help you to stand out amongst competitors:

- The U.S. Composting Council (USCC) awarded certifications
  - Certified Compost Operations Manager (CCOM)
  - Certified Composting Professional (CCP)
  - STA Certified Compost
- More information on compost certifications can be found here

Compost amendments

One fantastic way to ensure your product is unique and provides added value is by implementing different compost *amendments*. More information about different amendments and their uses can be found on the following page.

Compost Amendments

There are many different forms of amendments that can be added to compost. These can be anything, whether organic or inorganic, added to compost to enhance nutrient availability or address some other need.

Below are some of the major compost amendments that we recommend in order to best distinguish your final product.

BIOCHAR

The USDA defines *Biochar* as "black carbon produced from biomass sources [i.e., wood chips, plant residues, manure] for the purpose of transforming the biomass carbon into a more stable form (carbon sequestration)."[32] Biochar can be easily produced by burning fuels like wood or straw at low temperatures for long periods of time and covering the fire in a way that restricts most oxygen, leading to the processes of *pyrolysis* and *carbonization*.

Studies show biochar "can effectively improve quality and reduce ecological risks of compost," decrease emissions of methane and ammonia from compost, and improve soil quality.[33, 34, 35]

MANURE

Manure leads to an ultra nutrient-dense compost product that comes at little cost if sourced from neighboring organic livestock farms. Scientific studies have shown that the use of manure as an amendment can improve crop yields and soil carbon, and when paired with biochar, can reduce methane and other harmful impacts while maximizing nutrient availability.[36] Producers can go the extra mile with cow manure by creating Biodynamic Preparation 500, which studies have shown can further increase soil fertility.[37]

Compost Amendments

BOKASHI

Bokashi is a Japanese word roughly defined as "fermented organic matter." In composting, the Bokashi method involves an effective microorganism (EM) inoculated substance, like wheat bran, molasses, or even fermented beer grains. This inoculant is layered with food scraps in a sealed container, removing as much oxygen as possible, allowing the mixture to ferment.[38]

This fermentation allows for the composting of difficult to compost materials, like animal waste, fats, and oils. It has also been linked with reducing soil pathogens and improving microbial life.

MYCORRHIZAL INOCULANT

Mycorrhizae are fungal roots, but this description does not come close to the full story.

Most plants on earth have symbiotic relationships with fungi and mycorrhizae, the former bring energy and sugars down into their roots, making it available to the mycorrhizae, while the mycorrhizae break down nutrients in the soil and make them bioavailable to the plants. Mycorrhizal inoculants are a powerful compost amendment.

Case Study

Table to Farm
Durango, CO

A zero-waste entrepreneur on the frontier of climate change

Nestled in the mountains of La Plata County lies the city of Durango, Colorado. Durango is in the midst of the Animas River valley, yet its climate influences also include the nearby San Juan and Needles Mountain ranges as well as arid desert plains to the near west.

This unique combination of climates means Durango experiences varied weather conditions, however climate change has led to an increase in both the frequency and intensity of weather events like droughts and floods. The Durango community is resilient and progressive, and residents have voted for climate actions such as 100% renewable energy by the year 2050.

The area is also home to around 1,100 farms totaling roughly 550,000 acres in agricultural production. This means that Durango's resilience will be tested as residents experience the effects of climate change. [39]

In 2016, Table to Farm founders David Golden and Emily Bowie saw a lack of waste reduction options in their community. Their mission was to empower the community of Durango to divert organic waste out of landfills. This mission continues today through the work of Monique DiGiorgio and Taylor Hanson. We spoke with DiGiorgio about the business of composting and the challenges she and her team are working to overcome.

Case Study Continued

Who is Table to Farm?

A for-profit compost enterprise diverting food waste into compost

- Table to Farm operate as both a hauler and composting facility, bringing residents' kitchen food & lawn scraps to their facility where it is processed and sold as compost.
- Currently a Class 2 composting facility working through the Class 3 permitting process, Table to Farm also takes glass recycling and is experimenting with potential uses for crushed glass in landscaping and elsewhere.

Challenges

- The ability to scale up
- Understanding local regulations and permitting processes
- Managing feedstock to ensure a nutrient-balanced final compost
- Wildlife management
- Effects of local temperature conditions on decomposition

"Getting off the ground was the easy part, but once you begin to grow, the financial considerations, feedstock management, and logistical hurdles start to add up!"

Contamination

Not all "compostables" are equal! Biodegradable products can be climate-specific. Corn-starch based forks might break down easily in humid regions, but in arid climates those forks won't fully decompose - becoming contaminants.

Contaminants (fruit stickers, tea bags, etc.) are anything that don't properly decompose - if not removed they could ruin a whole batch of compost. Some contaminants result from carelessness, but often a lack of awareness and misinformation is the culprit. DiGiorgio speculates this could become a larger issue if scaling-up zero waste initiatives at regional levels makes composting mandatory, causing some residents' motivation to meticulously peel stickers from fruit or decipher local compost regulations to plummet.

Costs

The national average costs to consumers for composting businesses are ~$29 per month. For motivated participants who value waste diversion, the direct impact on real climate solutions is more than worth that cost.

Awareness

DiGiorgio emphasized simple messaging centering around efficiency, respecting local and global ecosystems, and minimizing waste.

Place within the Carbon Farming Network

The basis of Eco-Cycle's Carbon Farming initiative asks participants in carbon farming to apply small amounts of compost to their lawns. This creates a need best filled by local composting enterprises.

Why Local?

- Purchasing compost from local businesses means less emissions affiliated with transporting large volumes of fertilizer or mass-produced composts long distances. The benefits of supporting local don't end there, it also allows for transparency and communication between consumers and producers. Also, from a business perspective, buying local creates jobs, builds community, keeps money in local economies, and local businesses donate to community causes "at more than twice the rate of chains."[40]

Where do businesses fit in?

- As a zero-waste entrepreneur, finding consumers is key to financial solvency and long-term success. Carbon Farming provides a niche of buyers who are motivated enough to take real meaningful action against climate change. They show that to do so they are willing to pay for compost at least once, which means a large base of compost consumers. Engaging this community around the importance of waste reduction and the power of compost can create lifelong customers.

Scaling Operations

Bringing carbon farming to the masses through strategic community engagement efforts

Recommendations

One of the largest obstacles in expanding zero-waste infrastructure and programs is NIMBYism. NIMBY - short for "Not in my backyard" - is a simple way of stating that while many people are in favor of expanding these programs, they prefer not to live near the infrastructure itself. Much of this comes down to mistaken preconceptions about potential odors, unpleasant sights, and pests. To scale-up these zero-waste facilities and carbon farming in any meaningful way requires combating the NIMBY concerns by shifting paradigms.

SHIFTING THE PARADIGM

A paradigm shift is "an important change that happens when the usual way of thinking about or doing something is replaced by a new and different way."[41] While this term might not be new, most of us have likely experienced an attempt at shifting a paradigm in one way or another.

When it comes to expanding zero-waste infrastructure, it is essential to shift these paradigms based on misconceptions to best enable waste diversion to scale up and build the infrastructure needed to facilitate zero-waste food systems.

Shifting the narrative and reducing misconceptions requires effective community outreach. Whether it's cold-calling, sending newsletters or knocking on doors, cultivating relationships with communities is essential. Not only this, but homeowners may change and new neighborhoods emerge in areas around composting sites, therefore this community outreach is work which is never truly done.

Scaling Operations

As each community is different, no one method of engagement will work everywhere. However, these are some tested methods:

- **Carbon farming**
  - Carbon farming itself can be an important method of community engagement, as it showcases the power of diverting organic waste and brings motivated individuals into the fold of a nation-wide system. This creates a network of individuals who will spread the realities of composting and its importance, thus fighting misconceptions and helping to shift the narrative.

- **Be proactive**
  - Bring in as many community members as possible through town halls, surveys, and other functions. This establishes trust and builds relationships with people who might soon have composters' fates in their hands by way of policy and ballot initiatives.

- **Demonstrate value**
  - Composting is an important climate change solution, but it does not need to be politically divisive. Keeping the conversation centered around reducing waste, lowered costs, lawn health, and benefits for farmers is a good way to bring people from all backgrounds to the table.

- **Reap the rewards of partnerships**
  - Community events at local farms who use or contribute to compost is a great way to link waste reduction with food, in a way that's fun and delicious for people of all ages and demographics.

- **Other opportunities**
  - Farmers' markets or meet and greets, which allow people to put a face to the business and deepen bonds while gaining trust.

IMPORTANT RESOURCES

Navigating waste management regulations & permitting processes is essential to zero-waste entrepreneurs sustainable success

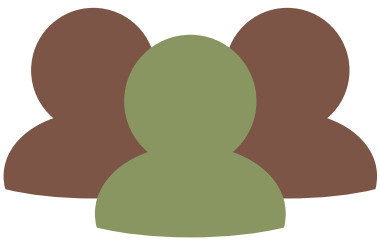
Colorado's overall regulatory guidelines for composting facilities come from the Colorado Department of Health and the Environment, found here.

Compost Tipsheet by ATTRA
Digestible one-page overview of compost

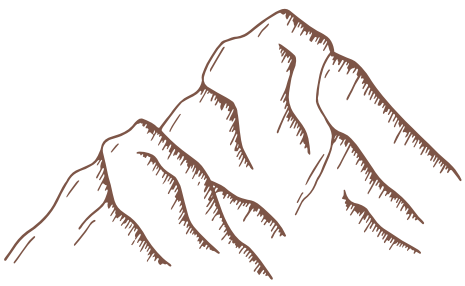
Compost Manufacturing Alliance
Provides an acceptance standard for compostables

EPA Overview of Composting and Facts & Figures
Dives deeper into compost

Colorado Farm to Market Licensing Information
Outlines licensing requirements



Composting Council
Provides key resources for compost manufacturers



Boulder, Colorado Circular Economy Report
Contextualizes a circular economy

MUNICIPALITIES

Introduction

This section of the toolkit is not only for those working in local government, but for any groups - public, private, or nonprofit - looking to enact change at a larger scale, specifically at the municipal level.

Carbon farming can be a valuable tactic for municipalities in achieving net zero carbon and zero waste sustainability goals. While cities are increasingly adopting climate and sustainability action plans, many of these proposals exclude the opportunity for additional carbon sequestration through collaborative land and waste management practices.

The following pages will address these opportunities related to municipal carbon farming, showcase examples of planned or existing practices today, and highlight trends for large-scale soil carbon sequestration in the future.

Opportunity One

Transform municipal organic waste into a carbon farming resource

As previously identified in the toolkit, compost application is one of the most effective and easiest ways to apply carbon to your soil. But to have an adequate supply of finished product (compost), you need ample supply of raw materials (organic waste).

According to the USDA, Americans waste between 30-40% of their food supply.[42] Instead of going to the landfill to anaerobically decompose and release methane into the atmosphere, wouldn't it be better to turn all that waste into a carbon farming resource?

Municipalities have the unique opportunity to act as large scale purchasers and suppliers to compost facilities in efforts to decrease net greenhouse gas emissions and organic food waste.

Case Study:

Compost access in Boston, Massachusetts

Boston is getting creative to promote compost practices and diversion of organic waste within the community

Boston's Public Works department has developed a program that subsidizes at-home compost buckets, picks up yard waste, and provides composting resources and information on city websites.

Recently, the city has launched a pilot project to collect food scraps for composting via conveniently placed drop-off locations. Project Oscar (named after the Sesame Street character) has compost bins currently operating in five locations around Boston, and city officials are seeking advice from the community through open forums and outreach events regarding where to install additional bins.[43]

- Lacking residential compost collection, these bins provide residents convenient access to their commercial compost facility.

- Inviting the community into the decision making process allows for enhanced chance of program success, with community members more likely to utilize the bins once installed.

- Since implementing residential compost pickup may be cost-prohibitive in some areas, Project Oscar bins are a great example of small scale projects that can have huge impacts on community access.

Case Study Continued

Profitable compost production for carbon farming not only requires an increased supply of organic waste diverted from the landfill, but also demand for finished compost product.

Municipalities may act as institutional purchasers of compost, where they can use it in a variety of public works and land use projects such as those outlined in the Marin County Climate Action Plan.

The table below shows numerous carbon sequestration approaches, including compost application, and accompanying estimates of sequestration potential:

Carbon Sequestration Approach	Total Potential Acres	Sequestration Factor (MTCO2e/acre/year)	Sequestration Potential (MTCO2e/year)	Sequestration Lifespan
Riparian restoration	5700	9.16	52,212	20
Compost on rangelands	60,217	1.49	89,723	20
Compost on croplands	407	1.18	482	6
Compost on vineyards	195	4.4	860	1
Hedgerow planting	267	1.49	399	34
Prescribed grazing	101,496	0.005	507	10
Range planting	28,271	0.502	14,192	10
Silvopasture	17,254	1.48	25,486	80
Windbreak/shelterbelt	852	1.48	1,263	80
Critical area planting	353	1.9	671	10

Source: Marin County Climate Action Plan 2030

Spreading compost across rangelands, croplands, or other public lands has tremendous potential for soil carbon sequestration and restoration of depleted soils over long periods of time.

Case Study:

Zero Waste and Compost in Boulder, Colorado

Using food waste as a carbon farming resource on county managed land

Tim Broderick is a Senior Sustainability Strategist with Boulder County, Colorado. Tim is developing a program in which the county buys compost to apply on municipal land for carbon farming and soil restoration co-benefits.

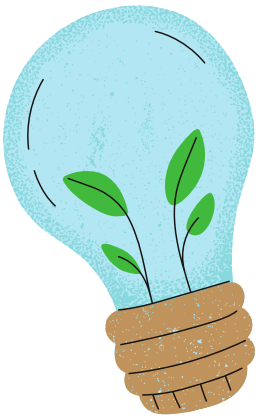
Working closely with Colorado State University's compost application study, the county wanted to find a way to support sustainable and regenerative agriculture practices. The project "evolved up and out" to include compost application on land such as golf courses, residential lawns, riparian zones, and under city trees.

In 2020, Boulder County was a first-ever recipient of the Community Compost and Food Waste Reduction Projects grant, funded by the USDA through its new Office of Urban Agriculture and Innovative Production.[44]

Key Insights

When discussing widespread application of compost on municipal lands, Tim offers key insights for city professionals looking into piloting similar projects:

01 Not all ecosystems store carbon in similar ways



For example, warm, humid regions have longer growing seasons, absorbing more carbon dioxide and transferring greater amounts of carbon into the soil than in drier, arid based climates.

It is important to understand the goal of carbon farming is not only to sequester carbon, but to provide a robust and healthy soil ecosystem that is replenished through the application of compost.

02 Initial costs for a municipal composting project

Equipment

- Plastic contamination is often an issue, which eliminates the ability of application to lands that require high quality compost, such as those in organic agricultural production.

Planning

- Logistics costs involve pick up and transfer of materials and labor to operate, manage, and spread compost.

Extensive community outreach

- Working with communities to better understand where and what type of compost projects to pursue is recommended for long term success.

Key Insights

03 Make use of financial resources

At the county level, there are opportunities using incentives, resources, and grants to promote the production and utilization of high quality compost, but you cannot force people to adopt such practices.

04 Engage the community

Future carbon farming projects need to be designed in a way that engages community members from the start; using easily digestible terminology that both informs and validates, preventing confusion and misinformation around compost or the development of local zero waste infrastructure.

Opportunity Two

Utilize partnerships to create support networks for carbon farming

To close the loop between waste and resource, it is necessary for governmental departments to work together and gain influential partnerships to ensure multilateral success of municipal carbon farming.

Municipalities have the opportunity to utilize partnerships to create an interdepartmental network of support for carbon farming practices.

Case Study:

California's Healthy Soils Initiative

A multilateral approach to better soil management

California's Healthy Soils Initiative is a collaboration of state agencies and departments to promote the development of healthy soils on California's farmlands and ranchlands.[45]

- The program is funded through the state's cap and trade proceeds, and has received additional funding through the California Drought, Water, Parks, Climate, Coastal Protection and Outdoor Access for All Act of 2018.

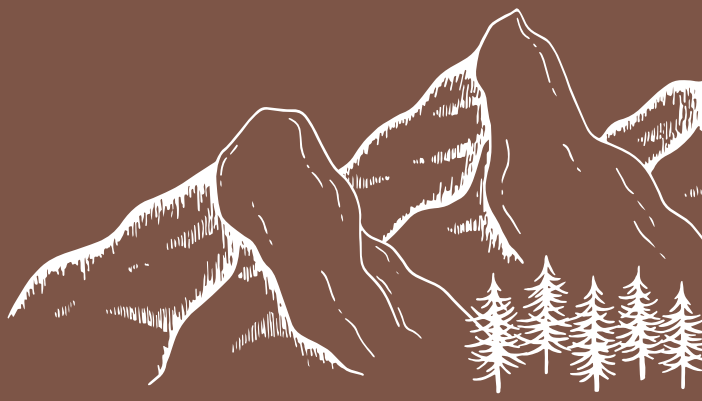
- The Healthy Soils Program has partnered with the USDA's National Resources Conservation Service, with incentives payouts aligning with the federal Environmental Quality Incentives (EQIP) Program. [46]

- If that's not enough collaboration for you, in 2019 the California Department of Food and Agriculture (CDFA) partnered with the University of California Agriculture and Natural Resources to fund and provide individualized assistance to farmers in preparing and submitting applications to the Healthy Soils Program.[47]

A vast network of connections are being utilized across the state and federal levels for success of the project.

Case Study:

Building Collaboration on the Front Range



Efforts to bring soil health support to Colorado

New efforts are underway for a program like California's Healthy Soils Initiative to be developed in Colorado. We spoke with Dan Matsch of Eco-Cycle, our project partner and nonprofit organization dedicated to zero waste solutions, to gain his perspective on the state's current efforts to develop and connect a Soil Health program with a Statewide Organics Management Plan.

The Colorado Department of Public Health and Environment is investing in an organics management plan that would promote compost use on Colorado soils to "advance carbon reduction through carbon storage."[48]

The Soil Health Program will be operating under the Department of Agriculture with the aim to foster responsible stewardship of soils. It is intended for these two state departments to work together and share resources for achieving overlapping goals.

Dan discussed how coordination between government agencies has traditionally been lacking, but strong collaboration between soil health and organics management at all levels is imperative for success. While much work is left to do in developing such plans, this initiative is a big step for Colorado soil health and cross-collaborative municipal action.

Opportunity Three

Local Role in a Global Emissions Problem

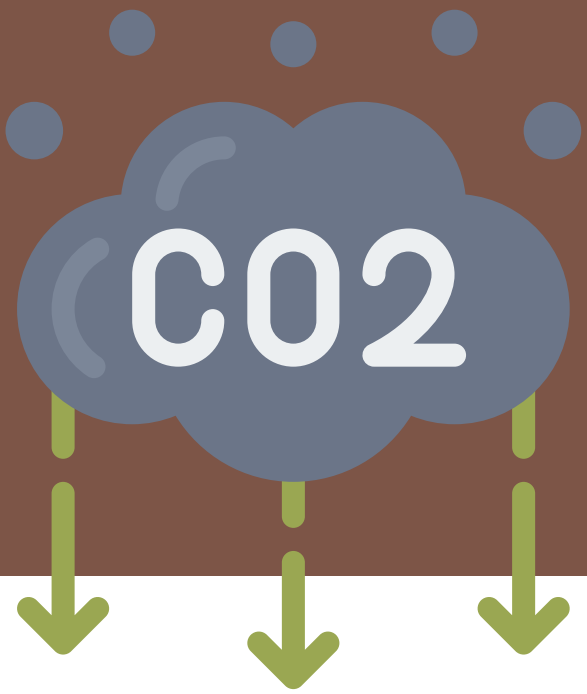
Large scale change is made up of many smaller actions. **If the global community wants to see a cleaner, healthier planet, individual localities are responsible for aligning with that vision.**

Local municipalities have the opportunity to participate in large scale research projects with less bureaucratic red tape than regional or national governance. Carbon farming projects may include such activities as application of compost, repair of riparian zones, reforestation, urban forestry, utilizing cover crops, or conversion to no-till agricultural systems.[49]

Case Study:

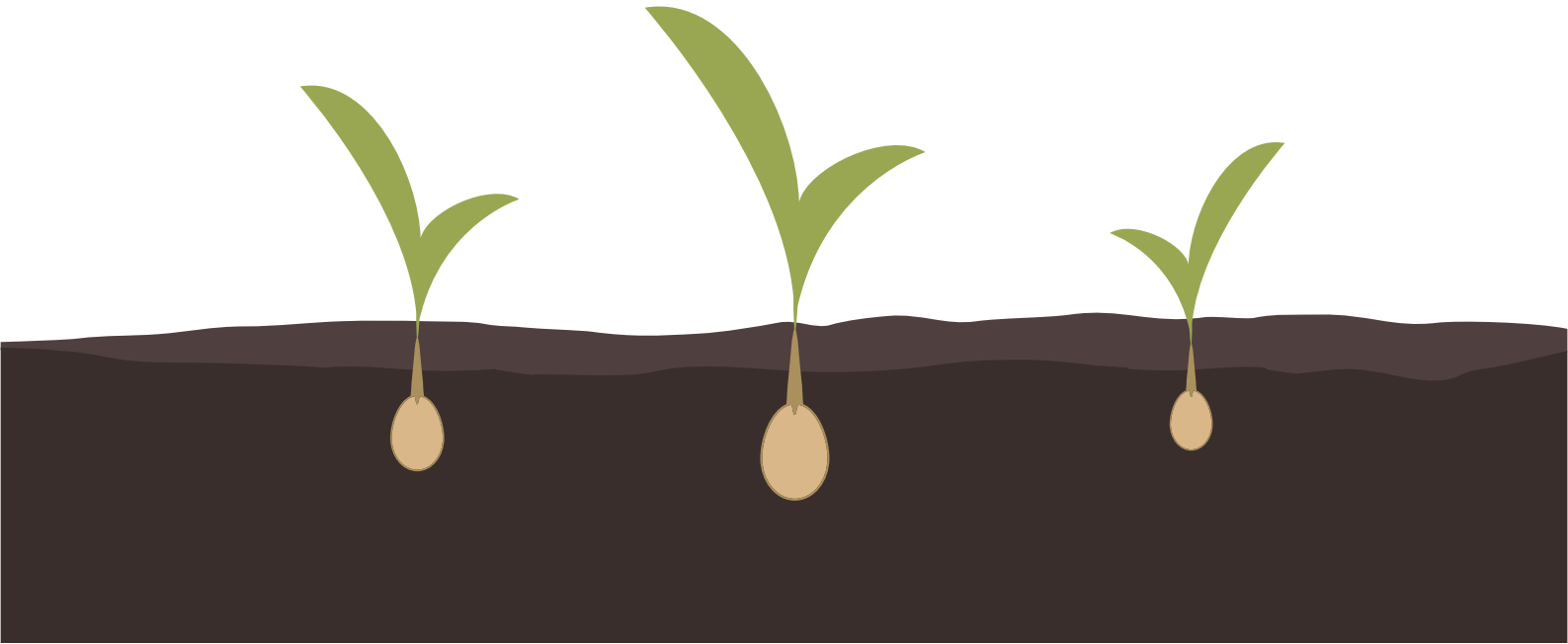
Urban Drawdown in Boulder, Colorado

Using local levers to address a global problem



Brett KenCairn is a Senior Policy Advisor for the City of Boulder and Director of the Urban Drawdown Initiative. Brett is responsible for guiding the city on its participation in carbon sequestration projects.

His perspective is that we need to view ourselves as "carbon managers". He says, "Carbon farming is all about a cycle of managing four things: carbon, water, nutrients, and plants". Humans are still learning which practices are the most effective at fixing carbon in regional soils. But we do know that as more carbon is sequestered into the soil, the more water the soil is able to retain. This is a very big draw for soil managers, especially in arid and drought prone regions such as the American West.



Case Study Continued

When discussing carbon farming projects with the public, Brett knows to frame the benefits to fit more tangible goals that the audience can relate to: water management, transpiration and cooling capacities, climate resilience benefits, fire mitigation. "Carbon farming for the sake of carbon emissions is too abstract for most", Brett says, "we need to manage carbon back into the earth's living systems" to reap the associated benefits.

Brett hopes to design a carbon farming project next year, one that spends local resources on local benefits and helps develop necessary infrastructure that is lacking in most places.

The project is still in the early stages of development, but Brett knows that equity needs to be central in planning these efforts. Some concerns we discussed surrounding equity include:

- Increased engagement with decentralized and community based composting in urban agriculture,
- Utilizing urban forestry to capture carbon and reduce heat-island effect in at-risk and underserved communities, and
- The need for workforce engagement equity and community based equity throughout the design and implementation of every carbon farming project.

Looking Ahead

Incentivizing carbon farming practices: Payments for ecosystem services

Many policy makers and economists are planning for a future in which land management practitioners can be financially incentivized to implement carbon farming techniques.

Payments for Ecosystem Services (PES) are incentives offered to farmers or landowners in exchange for managing their land to provide an ecological service.[50]

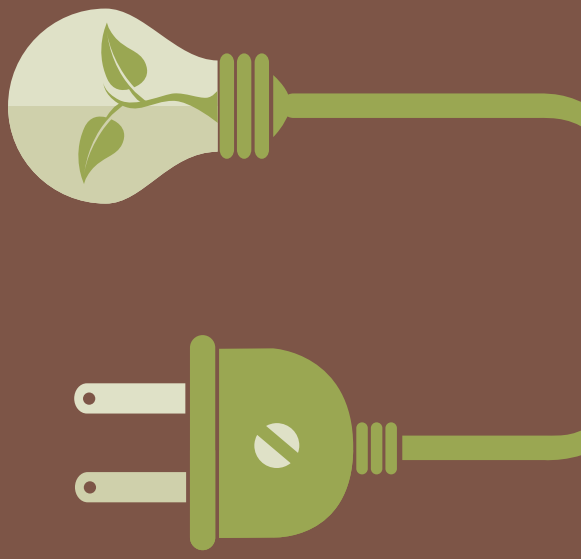
PES is gaining traction as a climate adaptation strategy, particularly within the development context. Payments could provide an income buffer and a source of income diversification, aiding in building community resilience to climate shocks.

In developing the structure of PES schemes, it is important to note the system must be rooted in the local context, with communities taking ownership of the process and money being kept in the local economy.

Case Study:

4CORE Offset Fund

Creating a market for offsetting greenhouse gas emissions



The 4 Corners Office of Resource Efficiency (4CORE), based in Durango, Colorado has developed **an offset fund that requires minimal management and provides reductions of greenhouse gas emissions in the local community.**[51]

Through a website, buyers can voluntarily purchase credits to offset their carbon dioxide emissions. This money goes into a fund that 4CORE uses to install efficiency upgrades in lower income households, decreasing total greenhouse gas emissions in the community.

Something of this structure, or one like a revolving loan program, are very simple schemes and easily replicated at the municipal level.

Case Study:

PES in San Miguel County

A pilot program for a local PES scheme that is linked with soil health initiatives

A former county commissioner started the project as a **copy of the Marin County carbon farming initiatives in California.** When the project grew in sophistication, Chris Hazen was brought in to lead the scheme's development. We spoke with Chris about the structure and development of his PES.

Overseen by the Parks and Open Space department, the county pays producers for utilizing certain soil management practices (like carbon farming), with payments reflecting the federal EQIP program.

Chris is also one to emphasize the broader benefits of this project. It is not just about carbon, but about all ecosystem benefits, including the benefit of human capital.

A local municipality implementing this program provides an opportunity for trust and relationship building between land practitioners and government officials, trust that can go a long way in collaboration to achieve mutual goals of community and ecosystem resiliency.

Carbon Markets

Municipalities are increasingly engaging in a specific type of payment for ecosystem service called Carbon Markets.

Marin County, California's Climate Action Plan states "*the partnerships, models, and necessary experience [for carbon farming] are in place already. The initiative needs to increase implementation funding to launch an expansion of the existing carbon farming work in Marin County*".[52] The plan identifies possible funding sources in the commercial offset market or a locally developed offset market.

Carbon markets, also referred to as Emissions Trading Schemes (ETS), are developed to place a cost on the amount of greenhouse gas emissions a particular firm produces, thus disincentivizing the practice.

The emitting firm buys "credits" for the amount of emissions produced, usually measured in tons of carbon dioxide equivalents. Under this scheme, the money spent on purchasing credits goes to fund an entity who has sequestered that amount of carbon from the atmosphere.

Carbon Markets

When developed in an equitable manner, these markets move capital away from greenhouse gas emitters toward projects that provide carbon management and environmental restoration practices, such as carbon farming.

The Growing Climate Solutions Act passed by US Congress in June 2021 allows the USDA to establish technical assistant providers and a third-party verification program to "help reduce entry barriers into voluntary environmental credit markets for farmers, ranchers, and private forest landowners".[53]

This act has the potential to allow for standardization of both voluntary and compliance markets by developing the knowledge base and verification needed to grow emissions trading at large.

Carbon Markets

A critical piece for large scale functioning of carbon markets is the establishment of an accurate and standardized price on carbon, one that accounts for the full ecological and social ramifications of carbon emissions.

Carbon credits today are priced too low to provide significant incentive for land managers, ranging dramatically from $2 - $40 per ton of carbon dioxide equivalent.

On his first day in office, President Joe Biden established an interagency working group to develop an appropriate "Social Cost of Carbon" to better conduct cost-benefit analyses regarding emissions actions.[54]

The Biden Administration has since set an interim social cost of carbon at $51 per ton, which is only expected to rise with more research and policy development.

Carbon Markets

Local municipalities engaging in PES and carbon markets help to create demand for the regulations and standardizations needed for responsible development of these services.

Increased participation in carbon farming projects allow for greater research into monitoring and evaluation practices necessary to scale such projects, one day giving carbon farmers a fair and worthy price on carbon.

Much work is required to create a standardized monitoring, reporting, and verification framework for carbon sequestration that prevents risk of "greenwashing", double counting of credits, or poor environmental integrity.[55]

Much speculation exists around the long lasting efficacy of carbon markets, but it is a large step in the direction towards incentivizing the nature based solutions needed to both restore depleted soils and aid in greenhouse gas sequestration.

COMMUNITY ENGAGEMENT

Overview

Climate change and ecosystem degradation can feel overwhelming to individuals who wish to contribute to solutions but are unsure where to begin. Carbon farming provides on-the-ground, easy to implement solutions for engaging the community in soil carbon sequestration. Community carbon farming projects allow for collective action and a sense of purpose while achieving improvements to air, water, and soil ecosystems.

Objective

In this section of the toolkit we will provide recommendations for engaging various sectors of the community in carbon farming, as a muti-sector approach is necessary for long-term success.

How to Engage Individuals

Emphasize how participants are contributing to a climate solution and making a difference--this is the number one reason we have found community members to participate in carbon farming.

Emphasize the direct benefits for participants' own lawn (greener, healthier grass).

Make carbon farming a digestible and understandable process so that interested individuals know they are capable of participating.

Emails and other forms of touchpoints with participants keeps them engaged--participants want to hear from you and why their participation is important!

Ensure you have strategically timed email reminders sent to interested community members that sign up to learn more--people will lose interest if they do not hear from you quickly.

- Set up an auto-reply email for participants as soon as they sign up that highlights next steps, what to expect, action steps, and an annual schedule
- Send an extra reminder email two weeks post sign up to ensure participants have begun the process of carbon farming.
- Send a seasonal auto email reminder to participants to apply compost when the time comes.
- Send an annual auto email reminder to participants to take soil samples.
- Send seasonal newsletters to participants to get them excited about carbon sequestration research, lab results, etc.

How to Engage Individuals

Assign a designated point person for participants to reach out to with any questions that arise as they go through the process of carbon farming.

Provide individuals with recommendations of where to get compost and where to send lab samples so that they have the resources to begin.

Share a clear timeline and calendar of events with participants so that they know when they should be doing what (when to apply compost, when to take lab samples, etc.).

Participants want to see the results! Educate participants on how to understand their lab results and try to share community soil sequestration results in a digestible form when they are available.

Utilize social media to spread the word! Other ways to spread the word could be tabling at events, hosting documentaries, etc., get creative!

We have found that the number one reason people do not follow through with carbon farming is because they do not believe they have the free time--when in reality carbon farming is an extremely low time commitment and very easy. Emphasize this!

Ask current participants to reach out to 3-5 others to share their experiences and the ways in which they have seen it benefit their lawn.

How to Engage People in Education Systems

For teachers who already have their own additional lesson content but want to get administers on board with a carbon farming program, garner support laterally between other teachers while also looking to their school district and policymakers.

For parents and community members, network between each other to establish ways to support teachers as they embark on their carbon farming journey; let teachers know the specific ways you can contribute when suggesting the project.

For municipalities or administrators who wish to implement carbon farming within their public school system, ensure to ask teachers about their own interests and potential resources they might need.

For students and parents who want to see these topics represented, research local Department of Education standards and engage faculty through student-run organizations.

No matter who you are, be certain that lessons on carbon farming would enhance current curriculum with a hands-on component, and be prepared to respond to skepticism by volunteering your own efforts.

Through observation, education professionals can see that this added practice is not time intensive, is low maintenance, and benefits teachers *and* students with fresh activities and materials.

How Entrepreneurs Can Engage Consumers

Emphasize the impacts of waste reduction. From the climate impacts of reduced emissions and improved soil health to the financial impacts of reduced costs compared to fertilizers and other lawn amendments, carbon farming and reducing waste creates tangible, meaningful benefits for everyone involved.

Showcase the uses of compost through community partnerships. Local organic food is a delicious way to feel the tangible impacts of compost!

Carbon Farming itself is a great way to raise awareness, combat misconceptions, and cultivate a loyal customer base for compost.

Never stop! Many of the biggest challenges facing carbon farming revolve around misconceptions, most of which will likely never fully disappear. Over time, cities change, and their communities change along with it. The best way to safeguard a business from bad information is to continuously make oneself available to the community, answering any concerns as they arise and keeping neighbors involved.

How Municipalities Can Engage the Community

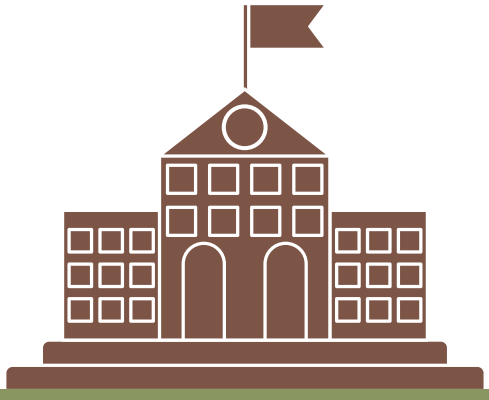
Municipalities can engage their residents in composting and carbon farming by providing necessary materials and resources such as:

- Household compost bins
- Information workshops
- Hosting educational material on municipal websites

Engagement needs to be robust and include various members of the community, particularly those historically marginalized by past planning decisions.

- Human capital and local capacity building can provide strong benefit to the community.
- Accessible and valid information will help prevent misinformation surrounding new projects or infrastructure plans.
- Creative collaboration between the public, soil scientists, compost facilities, and public lands is essential in developing a successful support network and advocacy for carbon farming activities.

Frame carbon farming benefits in terms that people relate to, like water retention and soil health, rather than the abstract notion of carbon sequestration.



CONCLUSION

Conclusion

Carbon farming is a key intervention in tackling major climate issues before us. Through carbon farming, participants:

Reduce greenhouse gas emissions from landfills

Reduce wasted nutrients and re-use them in a more circular food system

Improve lawn, garden & soil health through nutrient rich compost

Through the implementation of carbon-farming, participants around the country and even the planet can build momentum towards shifting food systems to a more circular economy.

Conclusion

Sequester carbon from the atmosphere and into the soil

Improve ecosystem health, soil water retention, and reduce erosion potential

See the direct impact of their action improve the local community

A circular food system leads to reduced emissions from waste, more equitable and just distribution of food to ensure everyone has enough to eat, and healthier soils and thus agricultural systems. These impacts cannot be overestimated in supporting the long-term health of our planet.

Conclusion

Interventions and engagement currently happen - and must continue to spread - through motivated individuals, within education centers, entrepreneurial enterprises, and at municipal levels.

Individuals

When individuals make the connection between their own backyards and carbon sequestration, they want to share it with others. Participants are drawn to adopt their own carbon farming practices because they feel empowered as a direct part of a climate solution. Carbon farming's ease and low-costs make it accessible to many people.

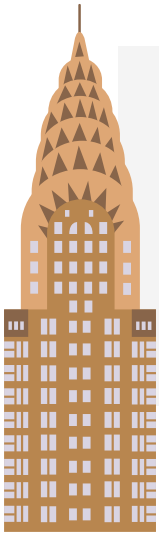
Education Centers

Education centers connect students and their families with the community. When students learn about carbon farming in the classroom, they introduce those concepts back to their families at home. Incorporating lessons and activities about carbon farming into existing curriculum is essential.

Entrepreneurs

Entrepreneurs are essential in carbon farming networks - they produce the necessary compost. These groups often report large community support for the idea of composting, waste reduction, and improving soil health--but as soon as plans to implement new infrastructure begin, concerns arise about ugly aesthetics, pests, or powerful odors. These concerns don't match the reality of an operational composting facility, combating this misinformation is integral for scaling up composting and therefore carbon farming operations.

Municipalities



Carbon farming is a valuable tactic for municipalities with sustainability goals, especially as a means of reducing emissions and waste. Municipalities have the unique ability to enact supportive policy, providing resources and networks for establishing and expanding carbon farming initiatives within their communities. Policy makers should find ways to engage groups like farmers and landowners around carbon farming to best create new systems for mutual benefit.

Acknowledgements

The University of Colorado Boulder Masters of the Environment Eco-Cycle Capstone Project would not exist as it does today without the guidance and support from our partner Dan Matsch of Eco-Cycle and our capstone advisor Taber Ward.

We would also like to thank those individuals who dedicated their time and shared their expertise:

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Acknowledgements

CU Boulder Indigenous Land Acknowledgement

We honor and acknowledge that the University of Colorado's four campuses are on the traditional territories and ancestral homelands of the Cheyenne, Arapaho, Ute, Apache, Comanche, Kiowa, Lakota, Pueblo and Shoshone Nations. Further, we acknowledge the 48 contemporary tribal nations historically tied to the lands that comprise what is now called Colorado.

Acknowledging that we live in the homelands of Indigenous peoples recognizes the original stewards of these lands and their legacies. With this land acknowledgment, we celebrate the many contributions of Native peoples to the fields of medicine, mathematics, government and military service, arts, literature, engineering and more. We also recognize the sophisticated and intricate knowledge systems Indigenous peoples have developed in relationship to their lands.

We recognize and affirm the ties these nations have to their traditional homelands and the many Indigenous people who thrive in this place, alive and strong. We also acknowledge the painful history of ill treatment and forced removal that has had a profoundly negative impact on Native nations. We respect the many diverse Indigenous peoples still connected to this land. We honor them and thank the indigenous ancestors of this place.

Acknowledgements

Climate Justice

Our work addresses the pressing problem of atmospheric carbon content by way of sequestering that carbon using regenerative soil health practices. Our intention is that this would help alleviate the environmental stressors caused by carbon emissions which BIPOC communities feel the effects of most intensively.

We recognize that environmental racism and oppression occurs when BIPOC marginalized communities are disproportionately affected by climate change. As stated by the First National People of Color Environmental Leadership Summit, one of the principles of Environmental Justice "mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things." All people have the right to clean air, water, and soil, but this right is most often infringed upon within BIPOC communities.

Glossary

Aerated Static Pile Composting - Aerated static pile composting produces compost relatively quickly (within three to six months). It is suitable for a relatively homogenous mix of organic waste and work well for larger quantity generators of yard trimmings and compostable municipal solid waste (e.g., food scraps, paper products), such as local governments, landscapers, or farms. This method, however, does not work well for composting animal byproducts or grease from food processing industries. In aerated static pile composting, organic waste mixed in a large pile. To aerate the pile, layers of loosely piled bulking agents (e.g., wood chips, shredded newspaper) are added so that air can pass from the bottom to the top of the pile. The piles also can be placed over a network of pipes that deliver air into or draw air out of the pile. Air blowers might be activated by a timer or a temperature sensors.

Biochar - So-called "black carbon" produced from biomass for the purpose of transforming it into a more stable form for the purpose of carbon sequestration.

Colorado Department of Public Health and the Environment - Abbreviated CDPHE

Linear Economy - Of all the materials we extract globally, only 10% ends up in products. The rest is wasted along the supply chain or dispersed into the environment, before it even reaches the hands of consumers. Even then, 80% of products end up in our waste system within six months, where they have little chance of ever returning to products again (Girling, 2011). Out of all of the materials that leave the global economy each year, only around 10% is recycled into new products, while the rest ends up in an incinerator or landfill (Haas, Krausmann, Wiederhofer & Heinz, 2015).

Circular Economy - The alternative to a linear economy is a circular economy, one in which everything we depend on for our health and well being is carefully preserved. This includes preserving the value of products, but also the natural capital of the environment on which we depend. It goes beyond simply recycling, to redesigning our economic system as one that is regenerative and resilient.

Carbon Farming - Diverting organic waste from landfills in order to improve soil health & potential carbon storage capacity.

Carbon Sequestration - The act of drawing carbon dioxide out of the atmosphere and storing it elsewhere. In a zero waste economy, carbon is usually sequestered into soil.

Carbon Dioxide (CO_2) - The most abundant and important greenhouse gas.

Glossary

Carbon Dioxide Equivalent (CO2e) - A way of standardizing the effects of an emission on the greenhouse effect. This is calculated by multiplying the Global Warming Potential (GWP) of a gas by its climate impact relative to CO2.. Some principal gases in greenhouse emissions and their CO2Es include:

- 12x Methane
- 114x Nitrous oxide
- 270x Hydrochlorofluorocarbons (HCFCs)
- 3200x Sulphur hexafluoride

Carbon Market - A carbon market or greenhouse gas trading system is a method for reducing carbon dioxide (CO2) and other greenhouse gases by putting a price on releasing carbon.

Class 1 Compost Facility - A class one composting facility is one that composts only type 1 feedstocks and has less than 50,000 cubic yards of feedstocks and in-process material onsite at any one time (finished compost does not count towards this total) *or* Composts only source separated organics and/or food residuals generated onsite together with other compatible materials as defined in Section 1 of these regulations, with the following limits: 1. A total volume of no greater than 5,000 cubic yards of source separated organics onsite at any one time (finished qualified product does not count toward this total); and 2. A composting area of two (2) acres in size or less; or (C) Composts at the site of generation or on agriculturally zoned property owned by the generator using only agricultural waste generated onsite together with other compatible materials as defined in Section 1 of these regulations and does not meet one of the general exemptions or conditional exemptions in Sections 14.1.3 or 14.1.4

- Class 2 - A facility that composts Type 1 feedstocks and manure and has less than 50,000 cubic yards of feedstocks and in-process material onsite at any one time (finished compost does not count toward this total).

- Class 3 - Any facility composting type 3 feedstocks. Additional permitting required to become a class 3 facility, including an Engineering Design and Operations Plan (EDOP) for the facility approved by the Department and the local governing authority, and a Certificate of Designation from the local governing authority.

Climate Action Plan - strategic framework for measuring, planning, and reducing greenhouse gas (GHG) emissions and related climatic impacts

CMA – Compost Manufacturers Alliance

Glossary

Compostable vs Biodegradable

- *Compostable* is organic material that can, through the process of decomposition, be turned into nutrient-rich soil or fertilizer. Composting itself is the process of returning your organic waste, leaves, grass clippings, banana peels, coffee grounds, and the like back to nature, so that it can eventually be reused as compost.
- *Biodegradable* means that an item can be disintegrated into its base elements by bacteria, fungi, or some other biological process. Biodegradation is just the process of nature breaking down materials into their component parts. Most fruits, vegetables, and other plant-based foods are biodegradable, in that if you buried them in your backyard without a proper composting setup, they would eventually biodegrade.

Contaminant - unwanted material. Physical contaminants of compost include glass, plastic, and stones, and chemical contaminants include trace heavy metals and toxic compounds

Drawdown - Another term for sequestration, drawdown refers to bringing atmospheric greenhouse gases (usually CO2) and storing them in soil, thus mitigating greenhouse effect while improving topsoil health.

Feedstock - Organic materials which, as the input, becomes compost through the process of decomposition. Feedstocks are usually referred to as "green" or "brown".

- Green Feedstocks - High in nitrogen, green feedstock refers to things like food waste, manure, and grass clippings.
- Brown Feedstocks - High in carbon, brown feedstock refers to things like wood chips, dry leaves, and branches.
- *Feed stocks are also sorted by the CDPHE into different 'types' in order to simplify regulations. Those types are as follows:*
    - Type 1 - Vegetative waste, & other materials determined by the Colorado Department of Public Health and the Environment to pose a low risk to human health and the environment.
    - Type 2 - Animal waste, manure, source-separated organics, food residuals and food processing vegetative waste.
    - Type 3 - Biosolids, mixed solid waste, processed solid waste and sludges and food processing residuals not covered in Type 2, fats, oils, greases, dairy manufacturing wastes, dissolved air flotation (DAF) skimming, paunch and any other compostable material not covered in Type 1 or Type 2.

Prohibited Wastes - Composting facilities may not accept asbestos or asbestos containing materials, infectious waste, hazardous waste, polychlorinated biphenyl waste or lead acid batteries.

Glossary

In-Vessel Composting - In-vessel composting can process large amounts of waste without taking up as much space as the windrow method and it can accommodate virtually any type of organic waste (e.g., meat, animal manure, biosolids, food scraps). This method involves feeding organic materials into a drum, silo, concrete-lined trench, or similar equipment. This allows good control of the environmental conditions such as temperature, moisture, and airflow. The material is mechanically turned or mixed to make sure the material is aerated. The size of the vessel can vary in size and capacity. This method produces compost in just a few weeks. It takes a few more weeks or months until it is ready to use because the microbial activity needs to balance and the pile needs to cool. (*Also see - windrow composting, aerated static pile composting.)*

BPI - Biodegradable Products Institute, a certification for compostable and biodegradable products and materials.

Greenhouse Gas (GHG) - a gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons.

Greenwashing - the process of conveying a false impression or providing misleading information about how a company's products are more environmentally sound.

Paris Agreement - The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. Importantly, the agreement does not outline any specific requirements for member nations to adapt in meeting their goals, the Paris accord is more of a non-binding agreement to move towards these goals than a specific commitment.

SSO – Separate Sourced Organics - the system by which waste generators segregate compostable materials from other waste streams at the source for separate collection.

Transfer Station - a building or processing site for the temporary deposition, consolidation and aggregation of waste. Transfer stations vary significantly in size and function.

Glossary

Windrow Composting - Aerated or turned windrow composting is suited for large volumes such as that generated by entire communities and collected by local governments, and high volume food-processing businesses (e.g., restaurants, cafeterias, packing plants). It will yield significant amounts of compost, which might require assistance to market the end-product. Local governments may want to make the compost available to residents for a low or no cost. This type of composting involves forming organic waste into rows of long piles called "windrows" and aerating them periodically by either manually or mechanically turning the piles. The ideal pile height is between four and eight feet with a width of 14 to 16 feet. This size pile is large enough to generate enough heat and maintain temperatures. It is small enough to allow oxygen flow to the windrow's core. Large volumes of diverse wastes such as yard trimmings, grease, liquids, and animal byproducts (such as fish and poultry wastes) can be composted through this method. (Also see - in-vessel composting, aerated static pile composting.)

Zero Waste Circular Economy - An innovative economic model that aims to keep products and packaging in use and infinitely recycled to prevent them from ever becoming waste.