COLORADO SOIL HEALTH FUNDAMENTALS

PRIMER 11: PERENNIAL PLANTS

PRIMER 11 SUMMARY

The goal of the Colorado Soil Health Primer series is to demonstrate the core principles related to soil health management as practiced and researched within the boundaries of the State of Colorado. Colorado scientists studying the effects of management practices and the state's farmers and ranchers implementing and measuring the changes on the land participated in this project.

This series is not about instructing the exact tactics a farmer or rancher would need to improve soil health. The individual tactics and strategies must change from property to property — — or even field to field – depending on the goals of the land manager, and the available natural and financial resources. This series of information will give readers the resources to understand and evaluate practical and proven ideas to explore and adapt into a new or existing operation.

This primer showcases permanent crops, also known as perennial crops, which have unique growing systems that generally focus on goals multiple years out. These crops include one of Colorado's most historic perennial commodities, tree fruit, built on the enterprising, and stalwart spirits of Colorado's pioneers.

Perennial Crops Drive Soil Health

Permanent crop farmers in the Saving Tomorrow's Agriculture Resources (STAR) program are using innovative methods to monetize the native, perennial fruit and vegetative materials, while depositing significant environmental impact investments into the soil. This primer also explores perennial agriculture that has roots in the Midwest and is spreading westward, including Kernza grain and prairie strips.

Colorado grower Steve Ela illustrates the ingenuity of perennial systems nicely as he talks about trees and nutrient cycling, "It's like a smorgasbord," he said. "The tree can feed when it wants to. If the tree is hungry for some manganese, there it is. If not, something else in the system will use the nutrients."

Generally, Colorado growers choose permanent crops because they offer multiple value-added benefits, in addition to multiple soil health benefits, and are an attractive addition to the landscape. Return on investment

▲ *Source: Markus Spiske/Pexels.com*

(ROI) measurements are key in any grow operation, and these can be complicated by depreciation, capital infrastructure costs, weather events, and quality of life expectations. For the most part, perennial crops drive ecosystem health forward, and producers reap the benefits of fruit, fiber, or foliage.

COMMON TERMS

Cover Crops: The act of keeping the ground covered and maintaining living roots are two principles of soil management, and cover crops are a key tool to help farmers transition and measure the gains.

Pasture: Fields for grazing, wildlife passage or soil remediation are common across the state of Colorado.

Soil Biology: The life in the soil, from the smallest microbes to earthworms and dung beetles. The biology is responsible for helping break down organic matter and turning it into available nutrients for your crops.

Soil Chemistry: The ratios of elements in the soil are important and go beyond N-P-K.

Soil Health: The concept of maximizing an ecosystem's ability to feed soil microorganisms, leading to efficient nutrient cycling and turnover, which creates more nutrient availability for plants, increases soil water storage, and improves ecosystem sustainability and resiliency.

Soil Testing: The process of quantifying certain attributes of soil, including macro- and micro-nutrients, soil organic matter, cation exchange capacity, soil biology, water and/or air.

NRCS: The Natural Resources Conservation Service.

Source: Jim Ippolito & Megan Machmuller, Colorado State University

USDA-NRCS
Soil Management Principles

1. Limit disturbance
2. Keep soil covered
3. Strive for biodiversity
4. Maintain living roots
5. Integrate animals

▲ Perennial crops can offer an attractive part of the landscape, while also creating products from fruit, fiber, or foliage. *Source: Colorado Department of Agriculture and Jim Cox*

One of the tenets of soil conservation—living roots—give perennial systems unique advantages in their ability to restore soil. The lack of annual disturbance, combined with the annual growth of root systems, are two of those advantages, and as a result, perennial root systems have the capacity to drive past organic matter rich topsoil and dig deep into mineral rich subsoil.

Perennial roots can range anywhere from two feet to 12 feet in length. The sheer increased surface area of these roots creates more root exudates, which drives an increase in microbial associations, and thus, builds soils with increased available nutrients. Perennial rooting systems generate soil development in ways only duplicated by decades and even centuries of mineralization and erosion forces. This process of soil development is fast-tracked by the redistribution of sub-surface soil minerals, the restructuring of soil structure and aggregate formation, and the enhanced biological activity—all a result of root architecture.

Perennial plants often develop aerial growth habits that are beneficial in creating microclimates that cool down the soil, reduce evaporation moisture rates, and harness more solar energy. The vertical architecture of aerial perennial plant growth also has an advantage in capturing atmospheric moisture, while the rooting architecture of these plants creates a drought resilient soil profile.

Perennial canopy cover also creates beneficial microclimates, buffers the landscape from destructive winds, and can serve as a natural snow fence, or snow moisture catchment system.

Vanessa Harmony owns and operates Colorado Edible Forest, a fruit tree, shrub, and herbaceous perennial nursery that supplies landowners with perennial plant stock to restore habitat, build soil, and bear fruit on the Western Slope. Harmony speaks to Colorado's alkaline soils and some of the incentives for establishing

Perennial Species	Plant part used	Value-added product	Growth Habit
American Elderberry (*Sambucus canadensis*)	Flowers and fruits	Tea, dietary supplements, jam, wine, flavoring	Woody, deciduous, 5-12' tall and 6-10' wide at maturity
Nanking cherry (*Prunus tomentosa*)	Fruits	Fresh, jam, jelly	Woody, deciduous, 6-10' tall and 15' wide at maturity
Gooseberry (*Ribes hirtellum or Ribes uva-crispa*)	Fruit	Fresh, jam, jelly	Woody, deciduous, 5' tall and 6' wide at maturity

▲ *Source: Vanessa Harmony*

perennial plots, which include the long-term process of balancing alkaline soils through leaf litter integration in soil biology. Harmony also points out the increased biodiversity index that is supported through perennial plants' provision of habitat, nectar, and pollen. In the table above, she shared some of her favorite selections for value-added fruit bearing perennials that farmers in Colorado can work into agroforestry plans.

Ecosystem Benefits

Perennial production systems tend to work in tandem with other ecological cycles having influence on the land. Perennial root systems can both slow and spread the flow of water, for example, during extreme weather events. And after extreme weather, the soils of perennial systems generally hold that rainwater with greater efficiency.

Growth habits of many perennial cropping systems provide habitat and cover for mammals seeking cover and refuge. Relationships that occur due to the compositions of perennials encourage mycorrhizal growth and promote microbial health. And by virtue of their diverse array of perennial flowering and fruiting attributes, perennials tend to draw necessary pollinators and beneficial insects (as well as pest insects, which serve as a food source) to create flourishing and biodiverse habitat.

Perennial production systems are true embodiments of healthy soil management strategies as they maintain living roots and soil cover.

Colorado Peaches

Steve Ela is a fourth-generation farmer of Ela Family Farms, located in Hotchkiss on the Western Slope. Ela Family Farm is a certified organic fruit farm and encompasses 100 acres, 80 acres of which are in tree fruit production. The original family farm was located in Grand Junction and moved to Hotchkiss in 1987, and in 1990, Steve returned to the farm with a masters in soil science. Ela grows 14 varieties of peaches, three varieties of pears, 30 varieties of apples, six varieties of plums, several sweet cherry varieties, and heirloom tomatoes.

"The Colorado tree fruit industry is characterized not by continuous acreage of trees but by little pockets of trees," Ela said, "And probably the Palisade area has more continuous acreage than anywhere. It's a small industry but it's worth a lot of money. Millions and millions of dollars of fruit are grown here in Colorado and shipped all over the country. Ninety-eight percent of our fruit is sold in the Denver to Fort Collins area alone."

The farm was certified organic in 2004. The farm also houses a commercial kitchen to process off-grade fruit into apple sauces, jams, juices, and fruit butters. This underscores a valuable component of perennial crop production—the opportunity to create value-added products.

"You really can't grow tree fruit in Colorado," Ela said. "We are in the wrong climatic zone, except that there are these little pockets of microclimates here on the Western Slope, these little pockets, where we can cheat Mother Nature and have mild enough weather to grow the tree fruits."

Ela describes the unique growing conditions found in the high-altitude, mostly arid region: "Western Slope tree fruit production is very diverse," he said. "Many people know about Palisade and Palisade peaches; there are tops of mesas where there is very good air drainage, and there are some canyons where there's some benches with some sweet little spots down by Cortez."

Ela elaborates on the importance of air-drainage in tree production: "One thing with tree fruits is, everything in moderation. Trees don't like big jumps in temperature, and they certainly don't like it in the spring when everything is in bloom. If we get cold nights in the spring that freeze the blooms, that's obviously not good. And likewise in the fall, we don't want cold snaps while we still have fruit on the trees. You take the chance of freezing the fruit on the trees before they have a chance to form a pit. So people, honestly, I think by trial-and-error, found these spots where microclimates create a space where there is warmer weather at night and usually that is moderated by airflow. In Palisade, for example, at night, as the cold air sinks and comes off the mountains: it goes through one of the canyons upstream of Palisade and that air gets compressed and warmed up and so as that air comes out of the canyon, it is warmed up, so that's kind of a nice, little spot."

He describes Ela Family Farms location as sitting on the top of a mesa. And so, as the cold air comes through,

▲ Only a small number of Colorado growers live in regions where fruit trees can thrive. In 2019, the industry had a banner peach crop. In 2020, it was almost all destroyed by a hard freeze. *Source: Colorado Department of Agriculture and Jim Cox*

it slides past the farm and sinks down to the river below. Ela says that the two-mile difference results in an eight- to 10-degree night temperature differential. He is quick to add that this geographic buffer is not infallible, and that they have experienced a number of frost years where crops have been damaged by snaps in temperature.

Ela shared how fruit-trees demonstrate phenotypic variability and how this affects crop planning:

"Trees grow differently," he said. "Some are smaller and wispy, and some are bigger and stouter. Some have draping limbs, and some are upright. All trees have different structures, and so they have different frost sensitivity. Of the 14 varieties of peaches we grow, some are hardier than others, and this is something we just know from experience."

The very nature of fruit tree production as a perennial system means there will be healthy soil regeneration. Steve expands more on how his management systems contribute to an overall balanced cycle,

"By and large, we will plant a tree and plant the cover crops and that is a system that will be in there for 20 years," he said. "My background is in biology, geology, and soil science and so I'm fascinated by ecology and systems and that is what really fascinates me. As an organic grower, you don't try to solve things with just one solution. I'm always going to think big picture and long term. I don't want to do anything that is going to screw up the systems long term in a way that we can't rebound from. That sentiment translates into our cover crop program. We integrate them (the trees and the cover crops) and they all work together: for flowers, for refugia (creating a comfortable spot for beneficial species (which assumes some pest species), for soil erosion, for organic matter, and for long term health."

Pioneers and Peaches

"We are a tight knit industry," Ela said.

Ela described the family legacy behind Western fruit production: "Almost all farms are family farms, even one of the biggest farms in Palisade is family owned by fourth-generation kids. We just aren't huge mega corporations. Growers generally share information with each other."

Joyce Sexton was a Grand Junction native, and also secretary of the Colorado State University Orchard Mesa Research Center in the 1990s. Before her passing in 1997, she curated a historical survey of fruit production in Mesa County, and also chronicled the inception of fruit growing on the Western Slope.

She documented that the region's agriculture industry paralleled the development of water irrigation systems, which began in 1882 and diverted water from the Colorado

River through a set of canals to support a much larger region of farmers, growers, and towns. According to Sexton, the first Mesa County orchards were established in the late 1800s, and included apples, peaches, cherries, plums, and grapes. Throughout the next few decades, through trial and error (as Ela mentioned), growers figured out where the best soils and microclimates were situated by testing hundred-acre plantings. They survived and learned from crop failures due to weather events. In spite of some of these challenges, "In 1909, the apple crop in Mesa County totaled 1,400 rail cars, which was nearly double that of the previous year," Sexton wrote. Fruit production continues to be a strong industry in Colorado, with 2021 yielding 10,700 tons of fresh peaches to market and grossing $24.5 million in peach (fresh and processed) sales.

Fruits and Berries

The impressive, regenerative soil health building virtues of perennial systems stand apart from annual systems in their potential to restore ecological integrity, to balance dysregulated systems, and to provide long-term return on investments in time, energy, labor, and inputs.

Botany provides us with classification systems for the fleshy fruits filled with seeds that we generally categorize as berries. Raspberries, for example, technically belong to the group known as aggregate fruits, and strawberries belong to the botanical group, accessory fruit. No matter what we call them, strawberries, raspberries, and other small fruits fill a niche for Colorado's diversified, specialty crop producers.

Tim and Claudia Ferrell own and operate Berry Patch Farms, a certified organic vegetable and fruit farm in Brighton, and they know all about the nice niche that perennial fruits can offer farmers.

"We have started using a reservation system when cherry picking season comes around," Claudia said. "It's that popular and the reservations sell out. Tim's cherry trees (the pie variety) are a well-known, local favorite. He has some trees that are over 15 years old and still producing, and says that his 10-year-old trees are amazing producers, and cherries are his highest grossing crop."

Along with pick-your-own cherries, strawberries, raspberries, and blackberries, the Ferrells grow a diverse mix of vegetables for a CSA, direct to consumer, and the retail market.

"The raspberries though," Tim shares, "They really do well here in Colorado. Once they take off, they are easy, and they produce like gangbusters—and they remain productive for about 10 years."

The Ferrells amend the soil with chicken manure before establishing bare root stock. Fruit bearing beds are irrigated with double drip tape under plastic, and Tim points out that this system is very effective at suppressing weed pressure. Tim also notes that, "With climate change, we need to be open to doing new things, and going with what the plants want."

Agroforestry

The vast tracts of Colorado's remaining natural spaces are working examples of perennial systems. Colorado's distinct biomes are knit together across the landscape and include many native berries and fruit producing shrubs and trees.

Agroforestry, at its heart, attempts to mimic nature, through the incorporation of trees and shrubs into agricultural landscapes with little need for external inputs. Agroforestry programs may establish trees to serve as saturation buffers and nutrient filters; some farms integrate fruit-bearing perennial trees and shrubs into existing row-crop plans, while other farmers focus heavily on permaculture systems.

Jerome Ostenowski is the director and founder of the Central Rocky Mountain Permaculture Institute (CRMPI) and has managed intensive perennial systems for 30 years. Permaculture, as an agricultural lineage, is described by Osentowski as a

▼ Peaches also attract tourists to the Western Slope region. *Source: Mark Stebnicki / Pexels.com*

design science that strives to mirror natural processes and patterns and result in more resilient agricultural systems.

Ostenowski makes a living on one-acre of high-altitude permaculture, perennial production. He is the author of The Forest Garden Greenhouse and hosts a permaculture course that has been running for 30 years. On his one-acre site, Ostenowski established a multi-story, edible forest garden structured as a seven-layer forest. Canopy architecture, nutrient cycling, and symbiotic relationships between the different plants all work in concert to create dynamic stability.

For example, the apex story in this system includes large fruit and nut trees, and then moves down to dwarf fruit trees and then drops down to the shrub story (currants, berries). The system then drops to herbaceous perennials and annuals, such as yarrow, mountain bee balm, or comfrey and then lowers to root crops, such as radish or carrots. The ground level story includes ground covers like Oregon grape holly, and then the vertical layer consists of climbing vines.

As climate change necessitates that farmers find new ways to build soil health and make a profit, agroforestry and permaculture design offer different ways to think of maximizing the use of the space on the land, diversify crops, and create symbiotic ecosystems that fight pests and weeds.

Prairie Strips

Prairie strips are a nascent approach to precision perennial integration within row crop production in Colorado—but have been implemented and studied in the Midwest—and specifically in Iowa, for well over a decade. Prairie strips are long, wide patches of native, perennial prairie vegetation that have been strategically planted and cultivated to diversify otherwise homogeneous crop production, prevent leaching, reduce erosion, and boost biodiversity and water quality. Researchers at Iowa State University estimate that a managed field converted to 10 percent prairie strip plots demonstrates, "a four-fold increase in plant diversity, a doubling in bird species (with a three percent increase in abundance), 40 percent less water runoff and 95 percent less soil loss."

Kernza

In 2003, The Land Institute in Salina, Kansas, began a breeding program to research an intermediate, perennial wheatgrass (Thinopyrum intermedium), a cousin to annual wheat. The grain from this wheatgrass is known as Kernza. Kernza is presently used in the livestock fodder market and is in the beginning stages of "research plot to farm field" adoption, as well as finding a niche space in brewing, malting, and milling markets.

Kernza displays remarkable drought tolerance, weed suppression, and robust root system development—all of which make this relatively new crop an interesting and potentially viable addition to the grain industry in Colorado. Crop trials are currently underway at Colorado State University's Western Colorado Research Center in Fruita, and at select farm plots in Grand County. Historic drought in Colorado necessitates innovative solutions in the agricultural industry and so proven approaches, such as utilizing a drought-tolerant, perennial grain, will be much anticipated by producers statewide.

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Endnotes

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The STAR program was originally developed by Champaign County Soil and Water Conservation District (CCSWCD) in Illinois and is now also administered in four other states: Colorado, Indiana, Iowa, and Missouri. The Colorado STAR Plus program grew out of a stakeholder process launched by the Colorado Department of Agriculture and other partners in 2019 that was facilitated by the Colorado Collaborative for Healthy Soils, involved more than 250 stakeholders and resulted in passage of HB21-1181 and SB21-235, which authorized and funded the launch of a state soil health program based around STAR. This state stimulus funding and additional grant funding received from the Gates Family Foundation, Colorado Department of Public Health and the Environment, Colorado Water Conservation Board, NFWF, and NRCS have enabled the launch of the first round of the STAR Plus program.

Getting Involved with Colorado STAR

In the summer of 2021, legislation was passed in the Colorado House of Representatives funding the Agricultural Soil Health Program for 2022. The Colorado Soil Health Program is built around the framework of an Illinois program called STAR, which stands for Saving Tomorrow's Agriculture Resources. STAR was developed to be a free resource for farmers and ranchers, helping them evaluate their current land practices, and particularly focusing on nutrient and soil loss. The STAR program encourages best soil health practices, and rewards producers with recognition, a high rating, and a field sign. While the STAR rating system is a useful metric for farmers to measure their own conservation efforts, it is also a tool for consumers interested in a farmer's soil health practices.

The program was originally created in the Champaign County Soil & Water Conservation District in 2017, with the assistance of the Illinois Department of Agriculture, as a means to facilitate specific environmental and agricultural goals that were outlined in the state's Nutrient Loss Reduction Strategy. Colorado, as well as Iowa and Missouri, have adopted this program framework.

Best management practices for agricultural land use have been developed since the 1930s by the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS). The STAR program utilizes these best practices, and also relies on a panel of experts, including university researchers and scientists, to establish appropriate ranking systems based on different resource factors. STAR Plus is an additional level of producer support that "facilitates capacity building by providing matching state funds towards the cost of these projects and activities within each district". This means that the state provides technical and financial assistance to producers over the course of three years, through grants and services like soil testing that are facilitated through the state's conservation districts.

Any farmer or rancher can visit the STAR website and fill out these forms in order to receive this rating. The first 100 participants in a year also receive a free soil test.

To participate, the only requirement is that the farmer or rancher fill out a form to the best of their knowledge, describing their farm practices in detail for a specific field chosen by the producer. The forms include questions about cropping practices, tillage regimes, fertilizer and nutrient applications, and other management practice information. The producer then receives a STAR rating from 1-5 that demonstrates their incorporation of the five principles of STAR: Soil Armor, Minimize Soil Disturbance, Plant Diversity, Continual Live Plant/Root, and Livestock Integration in their cropping system. Earning five stars in a field means that a farmer or rancher is implementing all five soil health principles on that field, while earning one star means that they are following only one.

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