COLORADO SOIL HEALTH FUNDAMENTALS

PRIMER 7: INSECT & WEED PROTECTION

PRIMER 7 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 is about how to think about agronomic weeds and pests from a soil health perspective. By common definition, weeds are plants in a commercial cropping system that are perceived as having more negative factors than positive factors. Usually that means that they grow aggressively in places where land managers, such as farmers, ranchers, and park supervisors, do not want them to grow. In practice, management tactics can vary significantly depending on the type of farming system employed - ranging from regular use of pesticides and herbicides to maintain an orderly monoculture field, to more natural systems that focus on maintaining soil biology, but might allow more biodiversity, including weeds, into their fields and pastures.

▲ Velvetleaf, a common weed in Colorado fields. *Source: Wikimedia Commons*

Many states, including Colorado, find it necessary to control both agronomic and invasive or "noxious" weeds. Noxious weeds include non-native weed species that tend to drink more water and crowd out the native weed species that provide a host of ecological benefits for the local ecology.

The common economic rationale to curtail the spread of aggressive weeds is that they are the cause of decreases in agricultural productivity, which a recent study says costs the USA around $20 billion each year. The spread of weeds — especially noxious weeds — may also increase the threat of wildfire, and unfortunately, some weed management strategies may increase the landscape's susceptibility to wind and water erosion.

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

▲ The Colorado potato beetle is one of the pests challenging Colorado farmers, and is resistant to most pesticides. *Source: Wikimedia Commons: Adámozphoto*

Weeds and pests can be a significant issue on any farm or ranch in Colorado and can cause damage to crops, forests, and the water supply. They are also often symptoms of deficiencies or excesses in the growing system that can be effectively managed by the land manager by repairing their soil and ecosystem health. Decades of herbicide and pesticide use have caused resistant strains of pests and weeds to become more dominant, so common management methods in Colorado include some use of biological, mechanical, and chemical applications.

Caitlin Fish owns Rabbitbrush Farms in Cortez, Colorado, and runs 70 Katadin ewes on dryland pasture while selling the lamb meat locally and the breeding stock nationally. She finds that inconsistent moisture drives the growth of aggressive weeds and pests in her pastures, but rotational grazing as a tactic helps.

"My biggest issue with weeds comes in my dryland pastures where it's harder to encourage growth of beneficial native grasses consistently with unpredictable and inconsistent moisture," said Fish, who uses electric fencing to manage her pastures and rotations. "The most unpalatable and aggressive weed to the sheep in this scenario is the tumbleweed (Russian thistle), and cheat grass (*Bromus tectorum*) once it gets a head on. The most palatable and desired grass mix for the dryland pastures is composed of smooth brome and crested wheat. In my irrigated pastures I use a mixture of orchard grass, fescue, and smooth brome. The biggest aggressive weed issue we have is Russian Knapweed, although the sheep love to eat it."

Yet, her livestock are a natural defense, Fish said.

"Right now, my hair sheep are the most important and crucial tool in helping to better my forage on a rotational basis on irrigated land. The sheep are browsers and while they do enjoy grass, they often tackle the Russian Knapweed, brush (rabbitbrush

and sage), Russian-olive trees, and other broadleafs like clover as fast or faster as they do the grass. I use Premier 1 sheep and goat net, rotating their grazing space every three to four days. The grass that is coming up behind the rotation is thicker, fuller, and by far is outweighing the weeds or less desirable species."

Timing is key to any type of grazing, she added. "Dryland is grazed preferably in the fall," Fish said. "While it would be more nutritious in the spring, the sheep and cows can decimate the pastures quickly. By allowing the fields to grow undisturbed through spring growth and again through monsoon season, the pastures are much healthier and productive."

Diversified commodity crop farmer Roy Pfaltzgraff, a third-generation farmer who owns and operates Pfz Farms in the southwest corner of Philips County in the northeast corner of the state, tries to manage his weeds and pests without the safety net of irrigation.

Weeds can lower production dramatically on a farm. Farmers must consider many tactics to control them, such as focusing on the timing of crop seeding and harvesting, the use of mechanical or biological methods of cultivation and weed control, and the targeted use of herbicides when conditions warrant. To Pfaltzgraff, that means using cover crops which offer competition to the weeds and help keep negative weed pressure to a minimum. Cover crops also help build soil carbon, which in turn helps hold moisture, which enhances soil health overall - a key objective of the STAR program.

"We are 100% dryland so no irrigation at all," Pfaltzgraff said. "We have to remember this is high desert and it is challenging to farm here. We do our best to improve our infiltration rates and keep the land covered to limit evaporation and erosion."

Current conditions are particularly troublesome for Pfaltzgraff: "This year is very bad. We have gotten 4.5-inches of precipitation in the last 13 months. We have been able to get crops up but are having problems maintaining them. They somehow are staying alive but we don't know how."

Weed Prevention

Using integrated pest management — commonly called "IPM," as a component of a weed control strategy, is a solution that works well with the STAR program. A fundamental factor in IPM is to understand the target pest's life cycle and natural enemies. An integrated pest management plan will help a producer optimize — and hence minimize — pesticide use. This is a best management practice for any type of chemical application.

To keep on top of weed control, a pest-specific approach is critical. Natural Resources Conservation Service (NRCS) State Conservation Agronomist Christine Newton suggests "having an IPM that uses the PAMS strategies (prevention, avoidance, monitoring and suppression) to manage and/or eradicate weeds. Also having a drought contingency plan and using adaptive strategies on managing livestock grazing in 'best case', 'average case,' and 'worst case' scenarios. By having a plan in place we can monitor production and cover and be proactive with weed management by preventing and avoiding weed infestations."

Creating a plan that specifically addresses a producer's landscape is key, Newton said, elaborating: "Plant genetics and resistant varieties, grazing management, conservation crop rotations, timing of planting and harvest dates, and establishing economic thresholds are all part of an IPM," Newton said. "Plans should be pest specific."

A soil health approach could incorporate IPM, and also focus on resilience of the overall production system. Farmers and ranchers who are measuring and testing their soil health can connect the dots between pests and weeds — and the deficien-

▲ Livestock can help manage weeds by grazing down the weeds in pastures, nutrient cycling in the soil, and helping transplant beneficial seeds. *Source: Colorado Department of Agriculture and Caleigh Payne*

▲ Keeping the ground covered is one way to help prevent weeds from taking over, and is a best practice in the state STAR program. *Source: Colorado Department of Agriculture and Daniel Harvey*

cies and excesses in their soil. A 2005 study showed potato beetle densities were generally lower in plots receiving organic manure soil amendments in combination with reduced amounts of synthetic fertilizers compared to plots receiving full rates of synthetic fertilizers, but no manure. Potato farmers like Brendon Rockey are having success with a biodiverse system that attracts beneficial insects, and, by increasing diversity in the field, creates a less hospitable area for the beetle.

A Historic Shift

Agricultural producers farm or ranch almost 32 million acres, and manage 7 million acres of the state's forests, accounting for more than 40 percent of the state's 66 million acres. About 57 percent of the state's surface acres are privately owned, including 87 percent of the Shortgrass Prairie in eastern Colorado.

Many of these prairie lands were historically plowed, grazed, logged, or developed during the last 200 years, changing the natural plant and animal communities that existed on the landscape before colonization by European settlers in the 1800s. This has shifted the balance of what ecologists call "classical linear succession and climax," favoring pioneering species that include noxious and aggressive weeds.

Cropping systems that regularly employ tillage perpetuate disturbance that triggers weedy annuals to germinate. Cover crops can provide cultural control by occupying space where annual weeds would try to grow. Soils can maintain seed bank stores for decades (if not longer), and any soil disturbance can trigger the growth of more aggressive plant species that have lain dormant in the soil for months or years.

In classical succession there is a linear progression from one state of vegetative growth to a climax state. In Colorado that series of steps will vary depending on the topography and region.

The Eastern Shortgrass Prairie

The State of Colorado's Biodiversity Scorecard, developed jointly by Colorado State University, the Natural Heritage Program Colorado, and the Nature Conservancy, notes that Shortgrass Prairies are the most threatened landscape in the state, a resource that has been diminished by almost half in

the last century. Eighty percent of Colorado's native amphibians and reptiles occur in the eastern Shortgrass Plains, which contain the highest amount of at-risk animal species in the state.

The majority of the grain farming and much of the state's cattle ranching lies in this region of short prairie grasses and sandy, silt rich soils. Massive droughts in the 1930s drove farmers and ranchers away from the land, only to return as precipitation numbers climbed back to historical levels. The renewed and prolonged current drought period began around 2000, with average annual precipitation numbers dropping sometimes much lower than the previously expected 12 to 18 inches.

Weeds and Pests: Prevention Tactics

The STAR program's emphasis on soil health practices encourages a range of tactics to prevent weeds and pests. For example, planting certified seed can help reduce pest loads, as does sampling pest populations to monitor whether/when they pose an economic threat to crops. As is well known, pests — like the potato beetle — can develop resistance to pesticides and focusing on improving the ecosystem to favor beneficial insects is a proven tactic to help reduce the need for pesticides.

Some producers use the knowledge that they have learned over their farming careers to create a hybrid approach to weed and pest management. For Jared Kerst, a fifth-generation farmer who owns and operates Rivendell Farms, a regenerative sod farm, and Plus Lazy K, a holistically managed beef operation in the Spring Valley of Glenwood Springs, managing weeds took a change in mindset.

"A legacy of 'weeds' has been one of the primary drivers in our push for changing management practices," Kerst said. "We have employed myriad 'BMP' and 'IPM' strategies to manage weeds on the farm for years. Recently, however, I have shifted to a mindset of focusing on managing for desired plant communities and not *against* others, since I have observed that despite many battles won, we have been losing the war. Biological, mechanical, and occasionally chemical interventions are still employed to target problematic species but suppression efforts are taking a back seat to ecosystem promotion."

Many farmers are now focusing on increasing the health of the soil and providing pollinator and insectary plots.

Pfaltzgraff on the Eastern Plains raises hard red winter wheat, barley, millet, grain sorghum (milo), and hay on his family farm, using practical and cost-effective soil conservation methods. Growing grains always comes with its share of weed issues.

"We have problems with Palmer Amaranth and Puncturevine," Pfaltzgraff said. "[For] the amaranth, we have purchased a weeder that uses electricity to kill the plants that are taller than the crop. With the Puncturevine we have gotten some insects that are supposed to attack it — but it takes time and is slow, so I am thinking about adding pollinator strips to our fields on the end rows where compaction is the worst."

Electro-weeding works for Pfaltzgraff and some of his neighbors. "The electro-weeder, as we have come to call it, works well for what it was designed for. As long as the weeds are at least 6 inches taller it does a good job on broadleaves. Drier and multi-stemmed weeds not as much but that is expected. We have done a couple circles for other farms and they have been pleased with what they have seen. The sugar beet farmer asked us to come back again in a week to do a second pass to get the short weeds. It kills Palmer Amaranth very well, as well as musk thistle or sunflowers. It isn't as good on larger Russian thistle plants because of all the stems. Definitely have to be careful with fire danger, but we have a plan for that so nothing serious has happened."

Palmer Amaranth, which can grow up to seven feet high and produce a million seeds, threatens corn and soybean production (in the southern states, cotton producers spend upwards of a $100 million a year to keep it out of their fields). Combines can spread this seed across fields, and, once detected, it is recommended to eradicate it as quickly as possible because of its prolific seed production habit.

Puncturevine is a summer annual forb that is native to Europe. It spreads in a prostrate form that can create a thick mat cover. It is a serious competitor to crops, as it can draw up moisture from deep in the soil, and the sharp seeds can harm humans, tires, and even livestock if the seed is found in hay. The seed can get into sheep's wool, which then decreases its market value. The most successful biological control of the vine is the use of two weevil types, *Microlarinus lareynii* and *Microlarinus lypriformis*. These weevils feed on the seeds and stems of the plant and are commonly shipped together in containers of 100 to 200 adults.

Canada Thistle is an aggressive non-native colony-forming perennial weed that can reduce corn crops by 80 percent.

Field Bindweed is another persistent weed in Colorado fields, and has arrow shaped leaves on twining stems, white or pink trumpet shaped flowers, and a long taproot that, along with the abundant seeds that remain viable in the soil for years, makes eradication difficult after establishment. It is important for farmers to locate and treat areas of infestation as soon as possible in order to get ahead of their expansive growth pattern.

Velvetleaf, another pervasive corn crop weed, has heart shaped, alternate leaves that grow around 5 inches wide, and yellow flowers that form the seed pods. It grows on the edges of fields, and quick shading and early tillage help to manage this weed.

Nathan Raymer and his family farm about 5,000 acres of wheat, millet, and milo in the New Raymer area, which is situated in the northeastern plains. He notes that Kochia is their biggest weed hassle. "We're having to go to avenues like Paraquat and different chemistries to try and get in front of the resistant

weeds," Raymer explained.

Ron Meyer, Colorado State University Extension Agronomist, noted that several weeds have developed herbicide resistance and that many previously useful control methods are minimally effective after field establishment.

"Herbicide resistant Kochia and Palmer Amaranth are currently challenging for eastern Colorado farmers," Meyer said. "Glyphosate controlled them a few years ago, but has no activity on both those weeds today. As a result, the two control methods are tillage and pre-emergent herbicides. After either of these emerge in crops, very little control is available."

Colorado State University scientists note that more than 50 percent of Kochia is resistant to triazine and ALS herbicides. It has a long, reddish stem, with narrow leaves alternately attached. Its seeds are spread by dead windblown plants tumbling in fields in the fall.

Conclusion

With mechanical, chemical, and biological options to control weed pressure and noxious plant proliferation, Colorado producers have much to think about and many decisions to make.

Creating a map of a producer's landscape can help with many management decisions, including setting up crop and grazing rotations, and designing access roads and fencing. Surface water maps, or contour maps, from a local GIS department, and soil maps, available from a local NRCS office or at the Web Soil Survey website at https://websoilsurvey.sc.egov.usda.gov, can also help with the land management decision-making process.

There are many Colorado producers who are gaining experience in soil health-based weed and pest control tactics, and as the STAR program grows and evolves, there will be even more data on strategies that can be successfully implemented to help our agricultural producers manage weeds and pests.

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▲ Palmer Amaranth in a soybean field. *Source: United Soybean Board*

Colorado Noxious Weeds (including Watch List), effective October, 2020 (Alphabetized by scientific name)

List A Species

Camelthorn (*Alhagi maurorum*)
Giant reed (*Arundo donax*)
Elongated mustard (*Brassica elongata*)
Flowering rush (*Butomus umbellatus*)
Yellow starthistle (*Centaurea solstitialis*)
Squarrose knapweed (*Centaurea virgata*)
Meadow knapweed (*Centaurea x moncktonii*)
Rush skeletonweed (*Chondrilla juncea*)
Common crupina (*Crupina vulgaris*)
Hairy willow-herb (*Epilobium hirsutum*)
Cypress spurge (*Euphorbia cyparissias*)
Myrtle spurge (*Euphorbia myrsinites*)
Japanese knotweed (*Fallopia japonica*)
Giant knotweed (*Fallopia sachalinensis*)*
Bohemian knotweed (*Fallopia x bohemicum*)
Orange hawkweed (*Hieracium aurantiacum*)
Hydrilla (*Hydrilla verticillata*)
Dyer's woad (*Isatis tinctoria*)
Purple loosestrife (*Lythrum salicaria*)
Parrotfeather (*Myriophyllum aquaticum*)
African rue (*Peganum harmala*)
Mediterranean sage (*Salvia aethiopis*)
Giant salvinia (*Salvinia molesta*)
Tansy ragwort (*Senecio jacobaea*)
Medusahead (*Taeniatherum caput-medusae*)

**Scientific name is correct here, and the Administrative Rule will be updated during thenext cycle (2022)*

List B Species

Absinth wormwood (*Artemisia absinthium*)
Diffuse knapweed (*Centaurea diffusa*)
Canada thistle (*Cirsium arvense*)
Bull thistle (*Cirsium vulgare*)
Chinese clematis (*Clematis orientalis*)
Common teasel (*Dipsacus fullonum*)
Cutleaf teasel (*Dipsacus laciniatus*)
Dame's rocket (*Hesperis matronalis*)
Black henbane (*Hyoscyamus niger*)
Hoary cress (*Lepidium draba*)
Dalmatian toadflax, broad-leaved (*Linaria dalmatica*)
Dalmatian toadflax, narrow-leaved (*Linaria genistifolia*)
Eurasian watermilfoil (*Myriophyllum spicatum*)
Bouncingbet (*Saponaria officinalis*)
Common tansy (*Tanacetum vulgare*)

List B Addendum

Jointed goatgrass (*Aegilops cylindrica*)
Mayweed chamomile (*Anthemis cotula*)
Plumeless thistle (*Carduus acanthoides*)
Musk thistle (*Carduus nutans*)
Wild caraway (*Carum carvi*)
Spotted knapweed (*Centaurea stoebe ssp. micranthos*)
Spotted x diffuse knapweed hybrid (*Centaurea x psammogena*)
Houndstongue (*Cynoglossum officinale*)
Yellow nutsedge (*Cyperus esculentus*)
Russian-olive (*Elaeagnus angustifolia*)
Leafy spurge (*Euphorbia esula*)
Perennial pepperweed (*Lepidium latifolium*)
Oxeye daisy (*Leucanthemum vulgare*)
Yellow x Dalmatian toadflax hybrid (*Linaria vulgaris x L. dalmatica*)
Yellow toadflax (*Linaria vulgaris*)
Scotch thistle (*O. tauricum*)
Scotch thistle (*Onopordum acanthium*)
Sulfur cinquefoil (*Potentilla recta*)
Russian knapweed (*Rhaponticum repens*)
Salt cedar (*T. chinensis*)
Salt cedar (*Tamarix. ramosissima*)
Scentless chamomile (*Tripleurospermum inodorum*)
Moth mullein (*Verbascum blattaria*)

List C Species

Common Scientific
Velvetleaf (*Abutilon theophrasti*)
Common burdock (*Arctium minus*)
Downy brome, cheatgrass (*Bromus tectorum*)
Chicory (*Cichorium intybus*)
Poison hemlock (*Conium maculatum*)
Field bindweed (*Convolvulus arvensis*)
Quackgrass (*Elymus repens*)
Redstem filaree (*Erodium cicutarium*)
Halogeton (*Halogeton glomeratus*)
Common St. Johnswort (*Hypericum perforatum*)
Wild proso millet (*Panicum miliaceum*)
Bulbous bluegrass (*Poa bulbosa*)
Perennial sowthistle (*Sonchus arvensis*)
Johnsongrass (*Sorghum halepense*)
Puncturevine (*Tribulus terrestris*)
Common mullein (*Verbascum thapsus*)

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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.

COLORADO Department of Agriculture Conservation Services Division

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SAVING TOMORROW'S S.T.A.R. AGRICULTURE RESOURCES