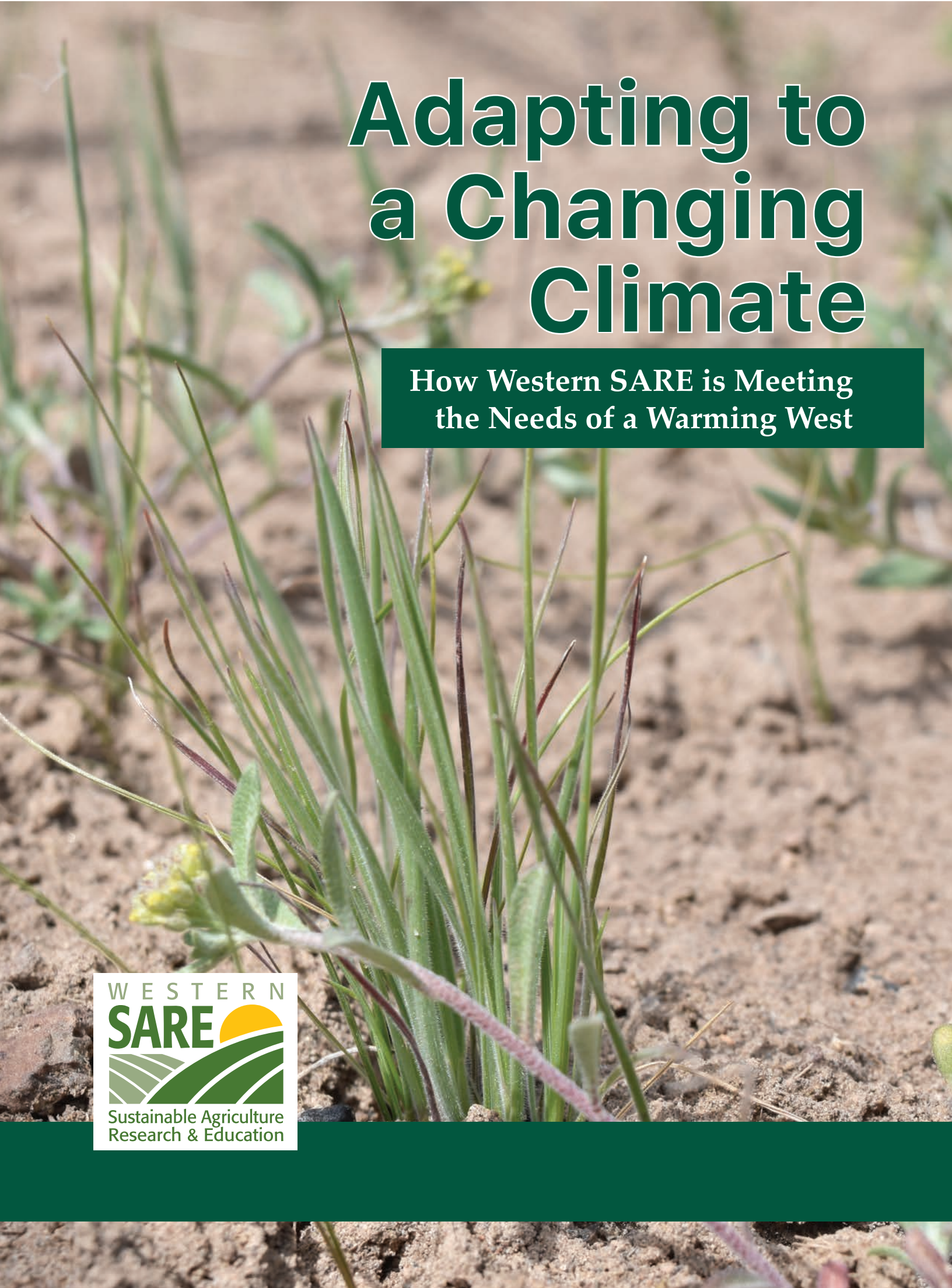

Adapting to a Changing Climate

How Western SARE is Meeting the Needs of a Warming West

WESTERN SARE
Sustainable Agriculture Research & Education

Adapting to a Changing Climate: How Western SARE is Meeting the Needs of a Warming West

Stories by:
Steve Elliott, Diane Nelson, Stacie Clary
Design by Steve Elliott

Western SARE
Clayton Marlow, Coordinator
cmarlow@montana.edu
Phone: 406-994-5161

Western SARE PDP Program
Jenna Meeks, Coordinator
jmeeks@sare.org
Phone: 970-556-3533

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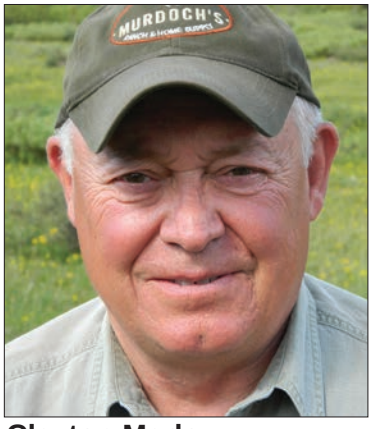
Responding to the Realities Faced by Western Producers

As an organization that serves the public and is overseen and staffed by people throughout the West, Western SARE can never be fully removed from the topics of public discourse or political debate.

And climate change is clearly on of those topics.

Thankfully though, Western SARE is not a political organization. We don't set policy or advocate for specific programs. Instead, we respond to the needs of Western farmers, ranchers and rural communities. We fund the critical research they tell us they need to be successful, sustainable stewards of the land.



Clayton Marlow
WESTERN SARE REGIONAL COORDINATOR

And more and more, and louder and louder, they tell us that climate change is here and hampering their ability to produce the food and fiber we all depend on.

Looking back through the grant proposals we've received and the projects we've funded, the trends are clear. Before 2005, the number of proposals focused on climate change was in the single digits annually. Between 2006 to 2016 it was in the teens. Since then, the number has grown into the 20s and 30s.

This report highlights just a sample of the innovative climate-related projects Western SARE has funded and research we've supported. As you'll see, it's as varied and diverse as the American West itself.

At Western SARE, we are grateful to be a key resource for agriculture in the West. We will continue to meet our Western farmers and ranchers where they are and respond to the needs they know better than anyone else, now and into the future.

Farms & Drought

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Drought

Climate change manifests many ways in the American West. The easiest to see are hotter days and warmer nights. Growers experience earlier springs and later falls, which can be both a boon and a challenge as they try to manage more generations of insect pests or more disease outbreaks during damp springs.

Weather extremes are another challenge of our changing climate. Storms are wetter or more infrequent – or both. Winter snow is heavier, deeper – or non-existent.

The enduring effect of climate change in the West – and the ever-present, pervasive threat to Western agricultural producers - is drought. We're getting hotter and dryer and the availability of water for everything from irrigation to lawn watering to even household drinking is no longer a guarantee in many parts of our region.

For Western agriculture to continue to thrive, farmers and ranchers will have to adapt to these water-availability challenges – and Western SARE will be a critical partner in seeking effective solutions.

Switching to Winter Crops Helps Grower Cope with a Warming World

For farmers, climate change isn't something to worry about down the road. It's here.

"Climate change is playing out on farms like mine every day, every season and in every extreme weather event," said Caitlin Hachmyer, who owns Red H Farm in Sebastopol, California. "Farmers are nimble and used to working with inclement weather, but the extremes and unpredictability are getting to be too much."

Caitlin Hachmyer tends the land at Red H Farm.

When Hachmyer founded Red H Farm in 2009, her land was often blanketed by cool, coastal fog. Now, she spends much of her summer dragging hoses from bed to bed beneath hot, dry, smoke-filled skies.

It's hard on her health, she says, but how can California farmers survive economically without producing crops in the summer and fall? Traditionally, those are the seasons when Western farmers sell their most lucrative fruits and vegetables. Sales of high-value crops like tomatoes are important to small, diverse farmers like Hachmyer who grows herbs and vegetables on her one-acre, agroecologically conscious farm.

But Hachmyer has a plan. With a $25,000 grant from Western SARE, Hachmyer is transitioning from labor-intensive summer crops to vegetables with a longer growing season and shelf life, like beets, onions and winter squash. That way, she can limit her fieldwork when temperatures are high and air quality is low.

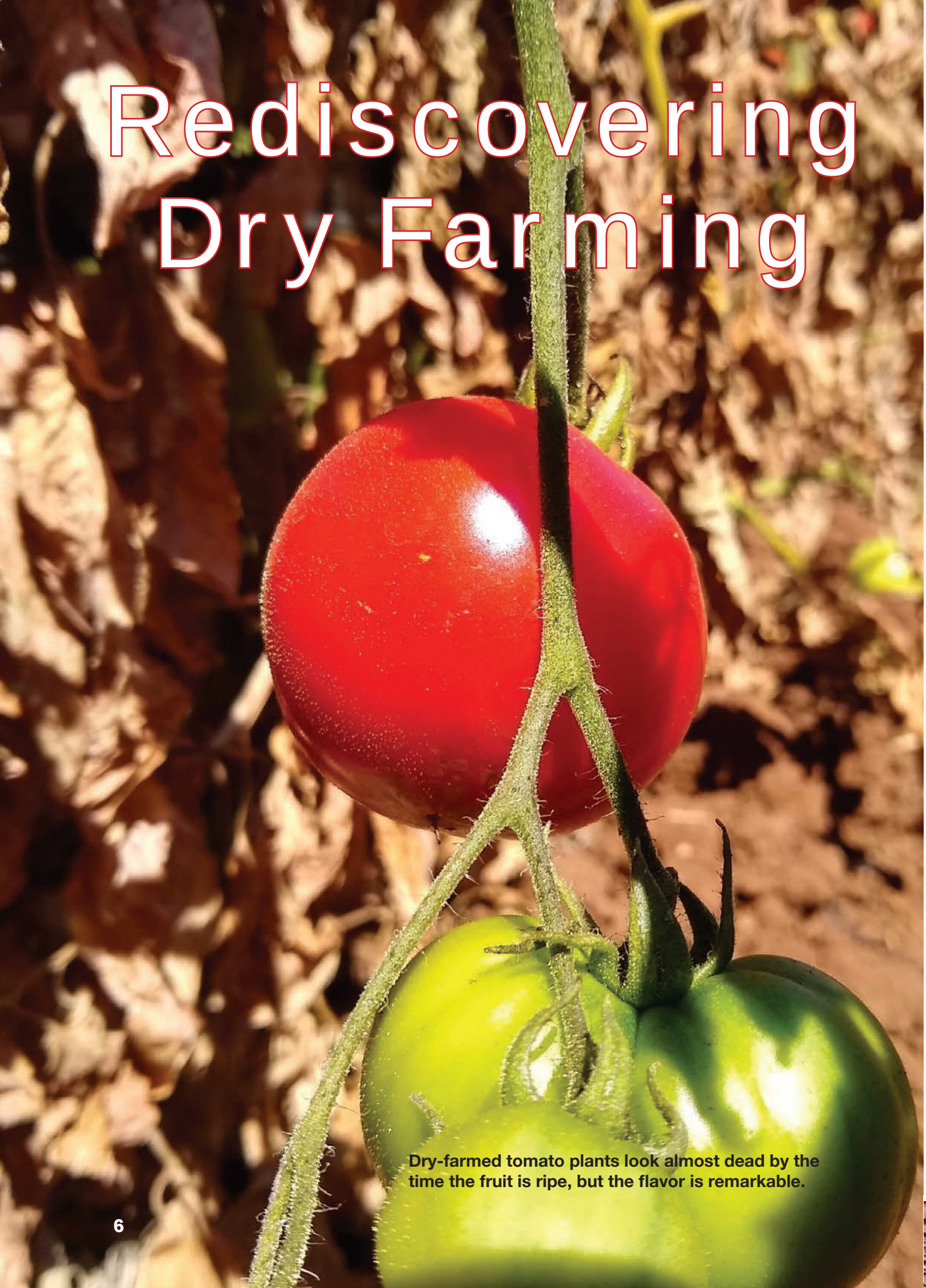
Root and other long-season vegetables can be less profitable, but Hachmyer hopes to offset that by selling enough to winter-only Community Supported Agriculture (CSA) subscribers. Most CSA plans are year-around, but Hachmyer is confident the community will support a winter-only bounty of cabbage, broccoli, beets and more.

"We're excited about the possibilities," Hachmyer said. "As we shift our growing season, we can expand to include radishes, arugula, lemon balm and lots of other crops. This could be a great way to feed the community while helping farmers adapt to climate change without sacrificing environmental stewardship, economic viability and quality of life."

As her farm switches from summer to winter crops, Hachmyer will measure how the transition impacts soil health, CSA-member satisfaction, economic viability and farmer well-being. Hachmyer, who teaches agroecology at Sonoma State University in addition to farming, will share her outcomes with a wide public audience including fellow scientists, educators and farmers. You can learn more about the project and subscribe to the winter CSA at **www.redhfarm.com**.

"The climate crisis is bearing down on us all," Hachmyer said. "Hopefully, by working together we can develop solutions to reduce farmer attrition as climate extremes worsen, and protect the health of our communities and our world."

Rediscovering Dry Farming



Dry-farmed tomato plants look almost dead by the time the fruit is ripe, but the flavor is remarkable.

Climate change poses a serious challenge to Western farmers. How do you grow crops profitably when rainfall and drought are becoming so unpredictable and extreme?

For some producers, dry farming may offer a way forward. Instead of relying on irrigation in the summer, dry farmers are finding ways to capture water from winter rains and store it in the soil long enough to harvest their crops.

The practice has its challenges. Dry-farmed produce tends to be smaller in size and yield, but the bounty is often longer lasting and exceptionally sweet. Supported by grants from the Western SARE program, researchers are helping dry farmers clarify which practices can potentially increase crop quality and yield while protecting limited water supplies.

For example, new research from Yvonne Socolar, a Ph.D. candidate from the University of California at Berkeley, is shedding light on how dry-farmed crops access nutrients and impact soil health. Socolar recently conducted on-farm trials with six dry-farm tomato growers located near California's Central Coast.

"Dry farmers are the experts in this system," Socolar said. "There hasn't been a lot of research into dry farming with vegetables, so it's exciting to study some of the issues these innovative farmers have already identified."

First up: Nutrient depth

In conventional farming, plant roots cluster close to the surface to access water and fertilizer added from above. Dry-farmed crops extend their roots further underground to pull moisture stored deeper in the soil. Socolar discovered that dry-farm tomatoes also draw most nutrients from two-to-three feet underground.

"It was so clear-cut, scientifically," she said. "We thought young plants might benefit from surface nutrients before they sent roots down to access moisture, but that doesn't appear to be the case. When farmers are trying to increase quality and yield, nutrients located at least two feet underground are what matter."

Farmers have various ways to deposit nutrients underground. Growing deep-rooted cover crops like rye and peas is a good way to enrich lower layers of land. Farmers can also plan ahead: The nutrients you add today can show up two feet below the surface in a few years (depending on rainfall or irrigation.)

Tilling is another way to uncover and apply nutrients deep in the soil. But aggressive tilling can disrupt fungal communities and accelerate decomposition of organic matter, which can hinder the soil's ability to hold water.

Fungal diversity in the field

Healthy soil is alive with billions of bacteria, fungi and other microorganisms that can provide nutrients for plants and help store water.

Socolar analyzed soil samples from dry farms and nearby irrigated and non-cultivated land. The dry-farm soil was especially rich in certain fungi that seem to be a signature of low-water farming, and those fungi were associated with higher tomato yields and better fruit quality.

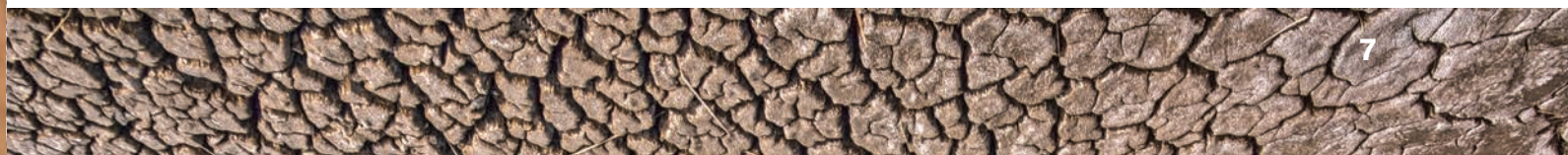
"So, rather than depleting the soil, farming with fewer inputs might actually sustain continued growth in dry-farm systems," Socolar said. "Perhaps when farming systems best align with the local conditions, it's good for farming and for the environment."

Boosting flavor and sustainability

Dry-farmed tomato plants look almost dead by the time the fruit is ripe, but the flavor is remarkable. Less moisture in the soil translates to lower water content, less dilution and more sweetness in the crop. The same is true of other popular dry-farmed crops like potatoes, squash and melons, which are the focus of other SARE-funded projects. Associate Professor Alexandra Stone from Oregon State University, for example, is working with tomato and melon growers in Oregon to expand knowledge and awareness of dry-farming practices among growers and consumers.

As Socolar notes, awareness is the key to farming in the face of climate change.

"It's a huge challenge for farmers to cope with water scarcity without jeopardizing their livelihoods," Socolar said. "Dry farming may be one answer. The practices appear to increase produce quality, support economic viability and promote water resilience."

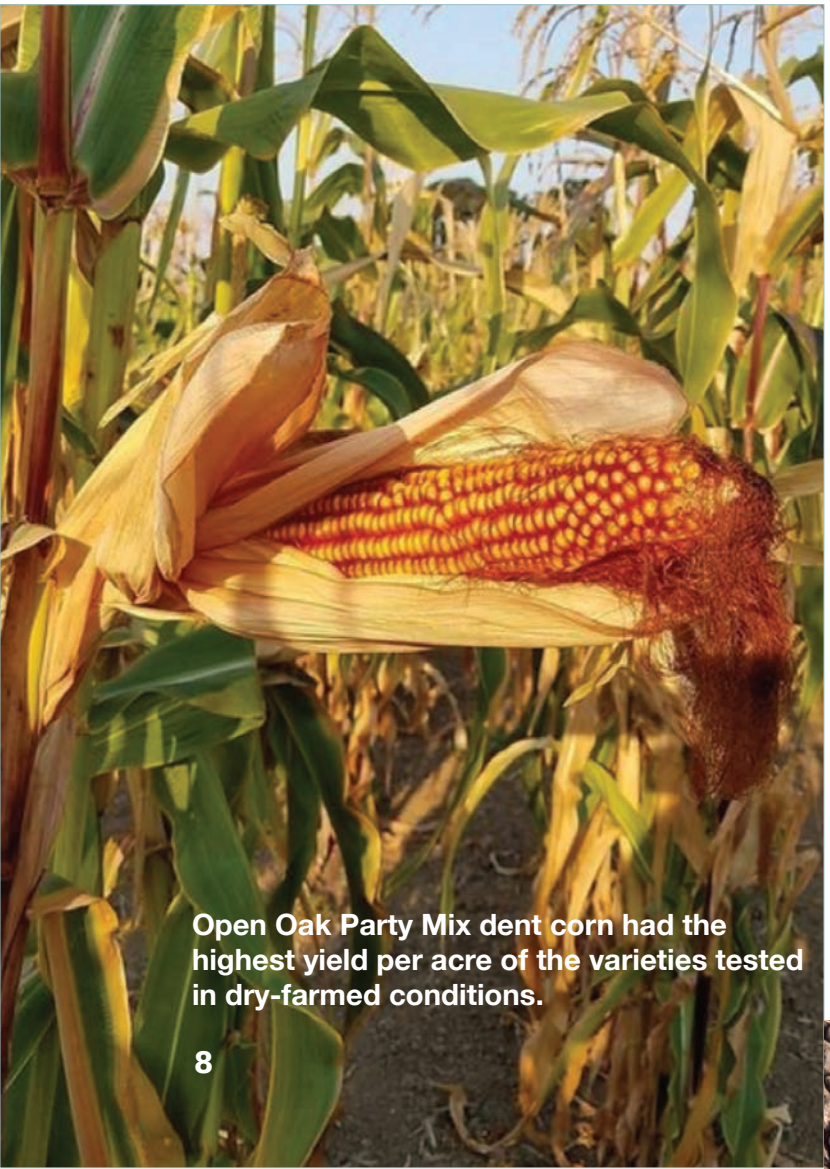


Researchers Work to Develop, Test Dry-Farm-Adapted Corn Varieties

As farmers and agricultural researchers work to adapt to changing climatic conditions, some are looking to future innovations, some are exploring past agricultural practices, and some are doing both.

In Western Oregon, a collaborative effort to establish and expand dry farming – growing crops without irrigation – is decidedly in the "doing both" camp.

"There is enough winter rain in Western Oregon to dry farm summer crops like corn, tomatoes and melons," explained Lucas Nebert, a research associate in the Department of Horticulture at Oregon State University. "The problem is that many commercial varieties of seeds for these crops haven't been dry-farm adapted."



Open Oak Party Mix dent corn had the highest yield per acre of the varieties tested in dry-farmed conditions.

So with a Western SARE Professional + Producer grant, Nebert started a corn breeding project to improve the ability of open-pollinated corn varieties to grow successfully during drought and in dry-farmed conditions. In the arid West, where summer rains are scarce, the vast majority of corn acreage is irrigated.

"Plants all around us survive the summer without irrigation, so why can't we have certain crops do the same?" he said. "What we're doing with the corn breeding project is nudging the varieties so they'll perform better in dry-farmed conditions."

A group of 11 mostly organic growers in the Willamette Valley planted the different corn varieties at multiple sites. Some had dry farmed before while others were trying it for the first time. Some tilled their fields while others used no-till practices. Their results:

First, soil composition is critical for successful dry farming, Nebert said. Sandy soils don't hold as much water, so are less suitable for dry farming.

The second most important factor in the successful trials was the variety of corn planted, with the more drought-tolerant varieties out-performing standard varieties.

"In parts of the country, markets for dry farmed produce already exist," he said. "In Coastal California, dry farmed tomatoes and dry farmed melon are sought-out, valued commodities. In the Willamette Valley, there is more drought stress so those same varieties don't do as well here. We have to develop varieties that can be dependable and successful in our dry farmed conditions."

Other early lessons from the corn trials: no-till and shallow tillage were also more successful than deep tilling, because tillage allows moisture to escape the soil.

Dry farmed yields weren't as high as fields that

Testing Shade Cloth for Water Reduction in Peonies

Farmers often install shade cloth to reduce water use when growing fruits and vegetables. Can it work with flowers, too? A cut-flower farmer in Utah is exploring the possibilities.

Britin Van Brocklin, owner of Cherry Petals Flower Farm in Kaysville, Utah, received a $9,000 grant from Western SARE to test whether shade cloth could help reduce water use in peonies without limiting their beauty or bounty.

"Peonies can sometimes be grown in the shade, but it affects their bloom," Van Brocklin explained. "I'm going to install shade cloth to some of our peonies after they bloom to see if that reduces water use as compared to a control group."

Starting this June, Van Brocklin installed shade cloth above a test group of blooming peony plants. Throughout the growing season, she will apply one inch of water per week to her control group, and half that amount to the shaded group.

"My hope is that the shaded plants will perform as well as the peonies receiving twice as much water," she said. "I think these results could help many small farmers produce peonies while using less water."

A wide range of flowers flourish on Cherry Petals Flower Farm. Van Brocklin suspects these findings could also apply to many other flower varieties.

"I started with peonies because they tend to be more drought resistant," she said. "But I think shade cloth could allow a lot of flowers to grow taller with less water, especially those that thrive in dryer, cooler growing conditions."

were irrigated, but as Nebert explained, "dry farming isn't a yield-maximizing strategy." Instead, it's an options-maximizing strategy for a grower who doesn't have an allotment of irrigation water one season or has their allotment cut during drought conditions.

"Also, there are a lot of costs associated with irrigating," Nebert said. "Equipment, moving pipes, weeding. We found that it took half the time to weed dry-farmed fields and that's significant because organic farming has weed problems. With lower weed pressure, dry farming doesn't require as much labor."

Beyond developing dry-farm-adapted seeds, Nebert and others involved with the Oregon State University Dry Farming Project are mapping the state of Oregon to find areas where dry farming can work. Based on soil and precipitation maps, a dry farming overlay will show where producers could turn to this cropping system.

Nebert also received a Western SARE Research to Grass Roots grant for a dry farming acceleration project, helping growers try dry farming for the first time.

Dry-farmed Oxacan green corn is being used commercially to make green masa and tortillas.

Water sensors and connection help farmers face drought

For some farmers, reducing water use isn't an option. It's a mandate.

"When drought is especially severe, they shut off irrigation to farmers in our region," explained Katie Swanson, who grows vegetables on seven acres in Klamath Falls in south central Oregon. "We have to get creative to find ways to adapt and conserve water."

Swanson secured a $30,000 grant from Western SARE to explore whether low-till practices can help conserve water on small-scale farms east of the Cascades. She learned that yes, in many cases low-till and no-till practices can save water. But even more important, she discovered the value in providing farmers connection and new tools.

"The farmers became more intentional and observational in their irrigation practices because of this study," Swanson said. "They felt empowered because they helped design the project and were given water sensors, technical support, and compensation for their time. We all struggle with water issues in our isolated region, and working together on this project helped us feel less alone."

Five small-scale farmers from eastern and central Oregon participated in the year-long study, which began in 2022. Each farmer prepared one control plot and two test plots using the low-till or no-till practices of their choice. Farmers selected which annual vegetable or herb they wanted to study, but each of their plots had to contain the same crop and receive the same amount of water. Throughout the season they measured how much water was available to their crops using water-tension sensors installed at different depths in the soil.

Water tension indicates how hard a plant is working to extract water from the soil. A low reading means the plant root is getting all the water it needs while a high reading signals that a plant is exerting a lot of energy to find moisture in the soil.

Interesting findings

In general, plots prepared without tilling held the most moisture. The study also suggested that no-till farming is more feasible for single-season crops rather than those that require many quick successions.

One finding was especially surprising: Water tension readings were remarkably low across the board until August, meaning water was readily accessible to crops.

"Farmers realized that early in the season crops don't need as much irrigation as they had assumed," Swanson said. "That's a big takeaway because now they can provide irrigation based on actual water needs, not just based on standard practices or when the soil looks dry."

Water sensors can also provide farmers more peace of mind late in the season when irrigation is limited or completely shut off.

"When you only have so much water, where do you put it?" Swanson asked. "These new tools can help farmers prioritize and make those hard choices."

Swanson held meetings, organized tours, and helped produce a video so farmers could share their findings throughout the region. She also worked closely with several advisors from Oregon State University Extension Service. She's hopeful this new network of small farmers can support each other as well as farmers throughout the West.

"Small vegetable farmers east of the Cascades are not often heard from at large statewide gatherings," she said. "Farmers in our region have accumulated important adaptive strategies in our extreme climate that can be useful to others as we face continually more extreme weather. Together, we can become more resilient."

Can Kernza Be a Wheat Alternative?

While some growers and researchers are experimenting with drought-adapted varieties of existing crops, others are testing more substantial shifts in practices. One of those shifts is from annual grain crops that have to be replanted every year to perennial grains that produce a crop year after year without replanting.

In eastern Wyoming, a Western SARE-funded project has dryland wheat growers experimenting with Kernza, a perennial intermediate wheatgrass that can be harvested for grain like wheat or used for forage to feed livestock.

Ph.D. students Hannah Rodgers and Alex Fox are working with University of Wyoming Professor Linda Van Diepen to see if Kernza can be viably grown in a region that's just not hospitable.

"Eastern Wyoming is the harshest of the harsh regions to practice dryland agriculture," Rodgers said. "Many farmers here do a wheat-fallow rotation where they're only growing one crop every other year and often they face crop failures. One grower told us he expects to get a good crop just two of every 10 years."

Because of those pressures, many farmers in the region are abandoning their crops and switching to cattle grazing, or enrolling in the U.S. Department of Agriculture's Conservation Reserve Program where they're paid to plant species that improve environmental health and quality, often perennial grasses.

"The current model of 'let's farm marginal lands until the soil health is so degraded we have to abandon them' is not the best," Rodgers said. "We know that right now Kernza can't compete with wheat yields, but could it outcompete these other land-use options?"

The team is also measuring soil-health benefits from planting Kernza instead of wheat-fallow, and looking at other potential environmental benefits, including capturing carbon from the atmosphere and storing it in the earth.

"In general, planting anything to perennials instead of annuals will have major benefits in terms of carbon sequestration," Fox said. "Because you're not tilling, you cause a lot less disturbance and allow more stable forms of carbon to build up in the soil like they do in a native prairie."

In eastern Wyoming, Kernza is being studied as an alternative to wheat-fallow and other land uses in the dry environment.

And because Kernza's roots can extend some 10 feet deep underground, about three times deeper than most wheat varieties, that carbon storage is more permanent and environmentally beneficial. It also makes the crop better suited to water-insecure areas.

"We're getting a lot of questions from growers in northeast Colorado where they are worried about losing access to irrigation water and are looking for more drought-tolerant, deeper-rooted crops," Fox said. "The USDA Agricultural Research Service in Fort Collins has a large Kernza research division and we've been able to feed some information from our study into that larger research project."

Both researchers acknowledge that, all things being equal, Kernza isn't an economically viable option to replace wheat yet, but that ongoing development of the grain could change the equation in the coming decades.

Using Less Water by "Stacking" Conservation Practices

There's a reason so many of the climate-related projects funded by Western SARE focus on water.

"In Utah and much of the West, water scarcity is the number one issue when it comes to the future of agriculture," explained Matt Yost, an Agroclimate Extension Specialist at Utah State University. "The pressure on water systems is just intense."

Not surprisingly, access to sufficient water was listed as one the top information needs in a 2022 Western SARE needs assessment of cooperative extension educators.

Yost's role at Utah State is to help agricultural producers deal with water scarcity in comprehensive, long-term ways. He's now received two Western SARE Research and Education grants to study stacked water conservation practices.

"The goal is to look at several of the most promising options for optimizing water use," he said. "We'll look at them individually, and also look at suites of practices and test these combinations for a long time."

Duration is an important part of the research. One shortcoming of most earlier irrigation studies is their short duration, Yost explained.

"There are many long-term studies on fertilizer and tillage, but most irrigation studies are just for a few years," he said. "There's a huge need to look at irrigation, crop and soil practices all combined and to see what the repeated effects of these practices are over 15 years or more."

As you would expect from research seeking comprehensive, long-term solutions to drought in the West, the practices being studied can best be described as "all of the above." They include:

- Deficit irrigation
- Drought-tolerant crops
- Efficient sprinkler packages
- Alternative crops
- Precision irrigation management

Yost's team of researchers and cooperators in Utah and Idaho has produced fact sheets for many of these topics, each focused on the individual benefits growers might realize from adopting them, but work continues to identify and document the best combinations of practices. But even before that is complete, Yost's research is having real on-the-ground impacts.

"The research into different sprinkler types came at a perfect time," he explained. "Utah was in a mega-drought and the state made massive investments in water optimization. There was $70 million in federal relief money put toward optimization projects, and in the last legislative session, the state earmarked another $200 million to help growers optimize their water use."

And with fresh research results, growers didn't have to guess or decipher marketing hype about what kinds of irrigation improvements to make and there was a large conversion to low-elevation precision application, or LEPA systems, with state grants paying half the costs and growers finding matching

Combinations of conservation practices could provide long-term irrigation savings.

funding for the rest.

"Many of the advanced sprinkler technologies could produce similar yield with 25 percent less irrigation than the conventional sprinkler at 100% irrigation," Yost said. "This was a good sign that these irrigation systems might be a way to save water. The tricky part is that the sprinklers did not always do this and we are working on better understanding when and where they consistently save water."

An additional focus of Yost's first SARE project was studying zonal irrigation systems – center-pivot irrigation setups that can turn individual sprinklers on and off anywhere during the rotation so it isn't slices of the circle that get more or less water, but individual rows or pockets of the field. One focus of the new grant is to transfer the zone-irrigation approach to the more common, accessible and affordable sector irrigation. Sector irrigation can speed up or slow down to adjust the amount of water applied as the sprinklers complete the circle. (Picture a pie with different slices receiving more water than others.) This capability is available on almost all pivots in the Western United States.

The team has six new trials of sector irrigation underway, with two locations in Utah and four in Idaho. And while Yost believes variable-rate, sector-based irrigation can save significant amount of water, it's going to be just one part of the all-of-the-above solution.

"We have also been testing alternative crops such as teff and sorghum sudangrass," Yost said. "These crops require less irrigation than alfalfa and corn and were also often able to withstand the 25 percent irrigation reduction with the low-elevation sprinklers. We are just starting to test some different pasture grass varieties, Italian ryegrass, hybrid rye, and some other alternative crops and will have more information on them in the future."

The project team also launched an Irrigation Technology Cost/Benefit Analysis Calculator online that lets growers compare various options to see what practices could be the most cost-effective to implement and have the biggest water savings. (See the calculator at **extension.usu.edu/crops/tools/irrigation-technology-cost-benefit-calculator**)

"We're collecting massive amounts of data and analyzing each practice individually and then all the combinations of practices," Yost said. "Where multiple practices do have water-saving benefits, we'll update the fact sheets and the online calculator to show those combined benefits."

Promoting Water Recycling in Nurseries

One way to use water more efficiently is to use it twice. That's the idea behind a Western SARE Professional Development Project grant in Utah to promote water recycling in the state's nursery industry.

"I came here from Michigan and it's a common practice to recycle water in nurseries there and on the eastern seaboard," explained Utah State University Assistant Professor Shital Poudyal, who is in the Plants, Soils and Climate Department. "Many nurseries have retention ponds and they recycle their water and use it to irrigate again, both to benefit the environment because the runoff from a nursery has a lot of agrochemicals, and to reduce overall water usage."

In Utah the practice hasn't been widely adopted, in part because runoff helps maintain the Great Salt Lake, which before last winter had been shrinking alarmingly due to the years-long drought.

"While we want water to flow into the Great Salt Lake, we also want clean water going into the lake," Poudyal said. "Nearly 50 percent of waterways in Utah are impaired or contaminated and retaining water laden with agrochemicals can reduce that impact."

The basic concept is pretty straight forward.

"Take a basic container nursery production," Poudyal explained. "Usually it's outside and the plants are irrigated. So the idea with water recycling is to slope the land and have a big retention pond that's lined with some impermeable substance so you can capture the irrigation water there to reuse it. In this project we're trying to do demonstration projects of this model with Progressive Plants Nursery near Salt Lake City and a big tree nursery in southern Utah."

While the general engineering of capturing irrigation runoff isn't complex, there are several factors to plan for before the water can be safely reused. If high concentrations of pesticides are present in the captured water, they may have to be diluted or otherwise remediated before the water can go back on plants.

"If the water needs treatment, we can build a simple bioreactor containing something that absorbs or adheres to those pesticides and promote microbial action. Microbes feed on pesticide and degrade them. Something as basic as wood chips can be a bioreactor material," Poudyal said. "We send the water through bioreactors at different flow rates so the pesticides degrade and then the water goes to a clean pond or in the case of nursery, they would just reuse it back on the plants."

Plant diseases like *Phytophthora* are an even bigger concern when reusing nursery irrigation water, and it's one of the areas Poudyal's project addresses. Aimed at an audience of professionals in the nursery, water conservation, state government and extension arenas, the project will organize a series of workshops presented by topic-area experts. The idea is that at the end of the two-year effort, Poudyal's project will have trained a number of professionals who can train and assist individual nurseries in implementing future water recycling programs .

"We'll have a disease expert and water recycling expert talk about how we can sample the retention pond for diseases and the best ways for a nursery or landscaper to reduce the impact of diseases from recycled water," Poudyal said. "We already had a talk about the viability of water recycling system for nursery industry. Important questions remain – what needs to be done? Does it even work? What does it cost and when can you get a payback?"

Future workshops – all of which will be recorded and posted to YouTube – include monitoring and mitigating agrochemicals, monitoring and treating diseases, Utah-specific rules and regulations, using smart sensors and controllers to automate irrigation, and even a session on marketing to explore if recycling water can be a selling point for nurseries.

"The idea is for all the stakeholders involved in water conservation to have this knowledge so they can take it and give it back to their community," Poudyal said.

FIRE

Forests in the West face stress due to rising temperatures and changes in timing and amount of precipitation. The impacts of this stress can result in increased susceptibility to wildfires, insect outbreaks and disease. Past forest-management practices can also create additional burdens as they often result in a lack of species diversity and overly dense stands that further decrease forest resilience, according to Kirk Hanson, director of forestry with the Northwest Natural Resource Group.

The number of large fires between 1984 and 2015 doubled in the Western United States due to these changing climate conditions and forest producers, farmers, ranchers, rural homeowners and agricultural communities are all experiencing increasing levels of risk from wildfire.

Western SARE has responded by funding projects to increase forest producers' understanding of climate threats, to train forest producers in management techniques to address those challenges and to guide agricultural professionals in practical, proven strategies for risk reduction, wildfire preparedness, disaster response and recovery.

Preparing For Dry Decades

Courses Focus on Keeping Forests Healthy and Productive

Thinning a dense Douglas fir stand.

To help forest producers prepare for and adapt to climate change, the Northwest Natural Resource Group is leading six workshops and planning 80 site visits to individual forest producers. They anticipate that 175 forest owners and managers will have increased understanding of climate threats to forest health and management techniques to address those challenges.

These forest owners and managers will be provided with four key strategies to increase their forest stand's resilience: stand release, young-stand thinning, commercial thinning and fire-hazard reduction.

Kirk Hanson, director of forestry for the group, identified two common forest-management misconceptions to overcome.

"It is incorrectly believed that previously clear-cut forests thrive best when left alone to recover and that intensive monoculture timber production is the only economically viable choice for forest owners seeking income from their land," said Hanson.

Hanson expects that with more understanding of good management practices, forest owners can maintain commercial production of timber even in the face of climatic disruption and increase the provision of ecosystem services, such as watershed protection, salmon and wildlife habitat and carbon storage – all while increasing the likelihood of robust timber yields.

The organization's current Western SARE Research to Grassroots project connects forest producers with the results of previously funded research on seedling release and young-stand thinning and disseminates the technical expertise the Northwest Natural Resource Group brought together in other SARE-funded projects on climate adaptation. This information will enable forest producers to change their manage-

The Northwest Natural Resources Group hosts a forestry tour for small woodland owners.

ment practices to better protect their resources for both economic production and conservation.

Seedling Release and Thinning

After timber harvest, forest producers often struggle to establish new trees on their land. Seedlings face competition from invasive plants and native shrubs; increasingly limited resources, such as light, nutrients and water; as well as hotter and drier summers. According to Hanson, there are options for reducing competition for resources, such as stand release, which entails removing encroaching vegetation when the plantation is young, or pre-commercial thinning, which entails removing some of the trees altogether as the plantation ages. Thinning overcrowded young stands is crucial for reducing competition for limited soil moisture, in particular during later summer months.

The group compared conventional and unconventional seedling release and young-stand thinning options with six producer-partners. Case studies for four trials were developed and disseminated as well as six fact sheets. Additionally, the resource group hosted a series of webinars and field tours and created a video titled *Tips on Managing Young Alder and Douglas Fir Stands in Your Forest*. Lessons relating to costs, labor, working with contractors, timing and effectiveness improved producer education and by the end of the project, the group held 100 consultations with forest producers.

Climate Adaptation Training for Foresters

The group earlier received funding to train professional foresters and natural resource managers in Oregon and Washington to help woodland owners prepare for and adapt to climate change.

In 2019, three full-day workshops attended by over 140 participants covered climate adaptation topics. An educational series of 12 videos, geographically tailored to Washington or Oregon audiences, was released online and shared with a network of 3,500 foresters and landowners. The resource group wrote and released a white paper on climate adaptation strategies for natural resource managers, wrote and released a management plan template and shared a series of three case studies describing climate adaptation issues on the ground. All can be found at **nnrg.org/climateadaptation/**.

Topics covered in the workshops, white paper, and videos include:

- Climate-change projections for the Pacific Northwest
- Likely effects of climate change on forest ecosystems in Oregon and Washington
- Climate adaptation strategies for Pacific Northwest forests
- Tools to inform management decisions
- Resources to refer to and share with clients

Smoke from a wildfire darkens the skies over Sonoma, California.

Training Growers to Farm Through Wildfire

To assist producers and agricultural communities in California facing increased frequency and intensity of wildfires, the Community Alliance with Family Farmers (CAFF) is using Western SARE grant funds to train agricultural professionals on wildfire disaster preparedness, response and recovery.

The alliance's new training course, *Farming Through the Wildfire Season,* will guide agricultural professionals in learning practical, proven strategies for risk reduction, wildfire preparedness, disaster response and recovery. The course uses multimedia resources and a workbook which supports self-assessments and activities designed for farm and regional-level analyses. The workbook was developed by CAFF's partner, Farmer Campus.

After completing the training, ag professionals will be able to tailor a Wildfire Resilience Plan for producers' businesses.

"As California's farmers are increasingly confronted with wildfires, direct farm losses, smoke and ash health hazards, lost markets and time, evacuations and power outages become more likely," said Amber Schatt, CAFF's Wildfire Resilience Specialist. "This training gives agricultural professionals the knowledge and tools needed to help their clientele become more resilient against wildfires."

In addition, agricultural professionals in high-risk Western regions will be invited to attend workshops on how to use the curriculum in their communities and on key aspects of wildfire readiness. The project is part of CAFF's larger Wildfire Resilience Program, which includes a library of videos, podcasts, fact sheets and more that is updated quarterly.

See the material at **caff.org/wildfire-resilience-program/**

PACIFIC ISLANDS

While the impacts of climate change are felt around the globe, nowhere is the threat more real than to island communities that may literally disappear beneath rising seas.

Beyond flooding driven by sea-level rise, Hawai'i and America's Pacific Island Territories also face additional climate-related threats, including more frequent and destructive typhoons, heat waves, coral bleaching, endangered fish stocks, imperiled fresh water supplies, drought, and as tragically seen in Maui, wildfire.

Farmers on the islands, who already faced unique challenges, are now adapting to these new realities through training efforts sponsored by Western SARE and others.

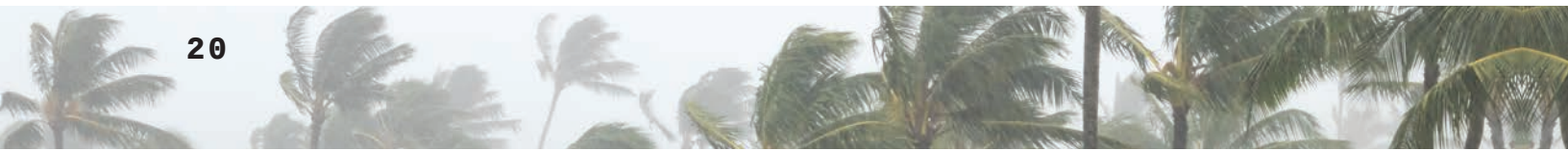
Preparing for the Coming Storm

Forums for Farmers and Ag Professionals

Pacific Island residents face strong and immediate threats from climate change, given that they live on low-lying atolls or islands in a period of rising sea levels. The islands are responsible for very little of the globe's greenhouse emissions but are facing the direct impact of worldwide warming.

To adapt to these changing conditions, farmers and ag professionals are seeking increasing efficiencies to reduce stress on local resources and dependence on imports, as well as climate-change mitigation. With Western SARE funding, ag professionals and researchers increased the capacity to tackle these challenges on a region-wide basis.

Dr. Clay Trauernicht, University of Hawai'i, Dr. Patricia Fifita, Oregon State University, and Dr. Nat Tuivavagali, College of Micronesia-FSM, built on existing curriculum and the success of previous climate forums developed by the College of Tropical Agriculture and Human Resources at the University of Hawai'i to create Climate Forums for Pacific Island Cooperative Extension Service faculty. Trauernicht, Fifita and Tuivavagali facilitated two-day climate forums on Pohnpei and Chuuk.



Smart-Farming Training on Micronesia

To support small-scale agriculture, College of Micronesia Research Assistant Rickyes Ikin and his team provided hands-on "Smart Farming" climate-focused trainings to backyard farmers throughout Pohnpei, Micronesia.

The trainings demonstrated simple climate-change adaptation measures such as composting, sheet-mulching, cover cropping, intercropping and the use of climate-tolerant varieties. Backyard farming increases the availability of healthy local foods and has the potential to reduce imports which use a large amount of fossil fuels and leave residents vulnerable to shipping difficulties. The use of recycled items such as coconut husks, containers and tires holds the soil and provides better conditions for the growing plants.

The trainings proved to be very popular and successful, according to Extension Agent Engly Ioanis.

"We have more backyard farmers than ever," Ioanis said.

At the forums, 85 farmers and ag professionals addressed the "long-term sustainability, diversity, and cultural value of ancestral food systems as well as the opportunities that new crops and technologies present for increasing food security and the wellbeing of the people of Chuuk and Pohnpei who are at the frontline of climate change impacts."

Presentations and facilitated discussions centered around questions such as:

- What is your understanding of climate change and climate vulnerability and resilience in the Federated States of Micronesia and the Pacific and how does it relate to your work?
- What existing resources can we use? What resources need to be developed?
- What are our options to respond to climate change within cooperative extension programs? What are examples of cooperative extension programs where climate information is relevant?
- How can we improve extension programs with climate-related information?
- How can weather services link to local knowledge and farmers? How does indigenous and scientific knowledge of climate and weather compare with each other?
- How can local knowledge help inform climate-smart agriculture and adaptation?

Participants broadened their knowledge and developed calls to action needed to address and mitigate climate-change impacts on local agricultural systems. Sixty-ninety percent of project participants reported a high level of knowledge of climate-change impacts on agriculture after the workshops.

At the different workshops, 50 to 70 percent of participants indicated they felt confident to communicate about climate change after attending the forums and 40-60 percent indicated they would incorporate materials and topics into their work and educational activities.

One participant stated, "I found this workshop to be helpful as a person without an agriculture/science background. I will be using what I've learned with my work with youth and people in the communities."

In response to the climate forums, a project website at **www.pacificclimateexchange.org** was developed to provide regional overviews and project and farmer spotlights across various Pacific Islands. This site gathers both island-specific and regionally relevant climate information, resources and mitigation strategies to support cooperative extension programs in the Pacific.

Promoting Agroforestry Across the Pacific Islands

Agroforestry – the planting, protection and integration of trees into agricultural systems – has provided Pacific Islanders food, fiber, medicine and materials for generations. These systems also can contribute to climate-change mitigation through improved soil fertility and health, improved water quality, biodiversity protection, ecosystem health, reduced soil erosion and carbon sequestration.

However, many native agroforestry trees have been removed for monoculture production, creating pastures and urban space all while the Pacific Islands were being affected by an intensified frequency and strength of cyclones.

Over the course of 12 years, Craig Elevitch, director of Agroforestry Net and a Hawaiian farmer, developed a series of Western SARE-funded projects to provide practical information for agriculture professionals and farmers in the Pacific Islands.

By 2016, Elevitch observed an increased interest in receiving information about these traditional agroforestry systems. In addition, a 2015 survey at the "Creative Agroforestry for Food Production in Farm, Home, and Community Landscapes" workshop, part of a funded Western SARE project, showed that agroforestry design was the highest priority for further education among agricultural professionals and farmers.

"There was a deepening sense of the necessity to shift from commercial forestry to local food systems," Elevitch said. "Earlier projects may have been ahead of their time, but we were building a knowledge base and awareness, along with learning how to create a curriculum."

In response to the increased interest, Elevitch received funding for a Professional Development Program project.

The project built upon six previously funded projects and brought together people with expertise in agroforestry, forestry, soil science, agronomy, ethnobotany, plant science, commercial enterprise development and wildfire management to couple with critical input from producers. The result was the creation of the first-ever manual on design and management of agroforestry systems in the Pacific Islands, a 40-page publication entitled *Workbook for Agroforestry Design for Regenerative Production.*

"The content of the agroforestry design manual was developed through dialog with numerous producers at the outset and during the initial stages of this project," said Elevitch.

The well-received workbook covers six steps in the design process: goals and skills assessment, site assessment, planting configuration, species selection, scheduling and financial analysis.

The publication was shared in workshops for extension, Natural Resource Conservation Service, government agencies, non-governmental organizations and other agricultural professionals. The original goal was to have 200 people attend three workshops to use the manual for their own personal design and gain expertise using hands-on exercises. In total, 320 people attended the six workshops – in Guam, Saipan, Pohnpei, Marshall Islands, Oahu and Kauai.

Elevitch continues planting food forests and training and research on regenerative agroforestry around the globe. He has created his own food forest on an acre of land on the Big Island, using only regenerative practices and no inputs since 1995.

"It's necessary to see nature as your source," he said. "We are a participant in nature, not its dominator. This supportive role, in contrast to an extractive role, reconnects us to our humanity."

Rangeland

Rangeland dominates Western landscapes. These vast areas of open land are home to countless native plant and animal species, and are the economic backbone for many rural, ranching communities.

Western rangelands are also under dire threat from a climate that's growing hotter and drier. Drought stresses the native plant communities and leads to more frequent and destructive wildfires, which in turn make the land more vulnerable to invasive plants like cheatgrass and medusahead. Those species are more fire-prone, which amplifies the cycle.

As a leading supporter of ranching research, Western SARE actively funds projects focused on preserving Western rangeland and research to keep ranching economically and ecologically viable.

Can Compost Help Rangeland Weather Drought?

Rangelands throughout the West are important to the world's human, economic and environmental well-being. They nourish livestock and offer many ecological benefits such as keeping weeds in check, providing water storage and carbon sequestration, and supporting habitat for grassland plants, animals and birds.

Rangelands are especially vulnerable to drought because they are rainfall limited. Drawing from findings in other agricultural systems, researchers want to know if compost can also help rangelands stay healthy and productive and several are working to find out.

"Previous studies has shown that compost can support soil health and plant productively on agricultural crop land, but we don't know as much about how compost might benefit soil health on rangeland," said Ava-Rose Beech, an ecology Ph.D. student at the University of California at Davis. "I want to examine compost's potential for increasing rangeland resilience to prolonged drought and water scarcity by boosting soil health. This can help ranchers assess the ecological and economic benefits of this climate-smart land-management practice."

Ava-Rose Beech collects soil samples.

Beech began her work this summer, supported by a $30,000 grant from Western SARE. She will sample soils from several ranches in northeast California that have previously applied compost amendments, measuring soil microbial health. Healthy soil is alive with billions of microbes and other organisms that provide nutrients for plant growth, detoxify potential pollutants, store water and provide habitat for soil microbial communities to diversify and flourish.

"Soil is incredible," Beech said. "It's where it all starts, and can really make a difference in forage productivity, carbon sequestration, water-holding capacity and drought resilience."

Beech will also survey ranchers in California to better understand some of practical, social and financial barriers to applying compost on rangeland in California.

In a similar study at Colorado State University Extension, Range Management Specialist Retta Bruegger is working with ranchers to assess whether compost can improve carbon sequestration in soils on several pastures in western Colorado. Supported by a $50,000 SARE grant, Bruegger will conduct field trials alongside ranchers to measure compost's effect on grass productivity, plant special composition, soil organic matter and carbon sequestration.

Like Beech, Bruegger hopes her data can help ranchers make informed decisions about whether applying compost is right for their land.

"Rangeland is so important to the environment, food security and rural livelihoods," Beech noted. "By working directly with ranchers, we can better understand both the limitations and benefits of applying compost to this critical resource that is especially vulnerable to climate change."

Restoring the Land with an Eye Toward the Future

Post-fire seeding efforts seek to improve rangeland resilience in the Great Basin.

Massive wildfires are on the rise throughout the West, reshaping plant communities and endangering native grasses that are a key source of forage for livestock. Reseeding with locally sourced seed is a common rangeland restoration strategy, but climate change raises an interesting question: What's the best way to heal the land when its future environment might not look like its past?

"Maybe we also need to look to environments with climate patterns that may be more in keeping with what future conditions might bring," said Lina Aoyama, a Ph.D. candidate from the University of Oregon. Funded by a grant from Western SARE, Aoyama is exploring ways to improve post-fire reseeding efforts and promote resilient rangelands in the Great Basin, which includes most of Nevada, half of Utah and sections of Idaho, Wyoming, Oregon and California.

Land managers in the Great Basin usually reseed burned rangeland with native grasses that grew in the area before the fire, which is the common approach to land rehabilitation. Aoyama wondered how native-grass cultivars bred in different environments would compare with local seeds when grown under simulated drought conditions.

To evaluate performance, Aoyama grew locally sourced seeds alongside native-grass seeds from two other climates, one that was hotter and drier and another that was cooler and wetter. She grew the seeds in three controlled environments: One with ambient rainfall, one under moderate drought conditions and another under severe drought conditions.

Under moderate drought conditions, which forecasters predict will occur more frequently in the Great Basin, seeds from drier and hotter regions and from cooler, wetter regions performed better than the locally sourced seeds.

"The seeds employed different strategies, but they both out-performed the local native-grass seeds in moderate drought," Aoyama said.

Under severe drought conditions, virtually none of the samples performed well.

Aoyama's takeaway: Variety gives post-fire seeding the best chance to succeed.

"It's good to hedge your bet," she explained. "Seeds from various climates provide greater genetic diversity and more strategies to adapt when faced with stressful growing conditions."

In the short run, it won't be easy for land managers to buy large quantities of native-grass seeds from multiple climates. Aoyama hopes that, in the future, projects like these can help expand seed availability and support evolving restoration strategies.

The Quest: Create Low-Emission Cattle

As cows digest grasses and other cellulose-rich plants, microbes in their large first stomach – the rumen – break down the feed, releasing the potent greenhouse gas methane as a natural fermentation byproduct. Research is ongoing into seaweed and other additives to traditional forages to reduce methane production, creating low-emission feeds.

But what if you created low-emission cattle as well?

Like a fuel-efficient car, a low-emission beef cow would use fuel – in this case feed – more efficiently, converting it into muscle readily and minimizing methane emissions over the life of the animal.

Animal genetics are complex and genetic selection tools haven't advanced to that point yet. But research is being done into understanding how genetics effects methane emissions.

Ashley Schilling, a doctoral student with Colorado State University's AgNext program, is working on a Western SARE-funded project that examines how animal genetics and grazing practices effect both emissions and performance.

"There has been extensive research into the impact feedlot systems have in the environmental footprint of beef cattle, but when we look at a grazing environment we actually don't know as much about grazing animals," Schilling explained. "And the majority of a beef animal's life is spent in a grazing environment."

Her project compares two sets of genetically distinct steers – one group sourced locally within Colorado, the other imported from Nebraska – in a production environment. Both were grazed at the USDA-ARS Central Plains Experiment Range during the 2022 summer grazing season.

The local steers originate from a similar short-grass steppe ecosystems as the experiment station, while the Nebraska steers originate from a tall grass prairie ecosystem.

"We were able to measure methane emissions in grams per head per day and weighed the steers every 28 days to calculate the average daily gain," Schilling said. "Then we calculated methane emissions intensity, or the grams of methane per kilogram of average daily gain."

What she found was the local steers emitted more methane but they also had a greater average daily weight gain so their overall emissions intensity was significantly lower than the steers from Nebraska.

"So we started thinking about the factors that might have played into that," she said. "Why were they more efficient?"

This is where things get tricky from a scientific standpoint.

Were the local steers simply eating more? In a feedlot, that would be easier to measure but in a pasture it's more complex. There are halters being developed to measure bite rate and may in the future provide some data on grazing consumption, but Schilling's future research will use a titanium dioxide tracer to estimate feed intake.

"Another thing we thought would be interesting to look at is potential microbiome difference between the two groups of cattle," she said. "Are these local cattle already acclimated and prepared with the right microbes to digest that local forage more efficiently compared to the cattle brought from a different ecosystem? Maybe the microbes in the Nebraska cattle just took a little bit of time to adjust. We don't know that yet."

They also don't know if the emissions intensity difference measured in the pasture will remain consistent when the steers go to a feedlot for finishing the last part of their growth.

Research steers in the shortgrass steppe pasture at Colorado's Central Plains Experiment Range. Steers from the region had lower methane emissions intensity than those imported from a tall grass prairie ecosystem in Nebraska.

But as her Ph.D. and Western SARE research progress, Schilling will be able to answer some of those questions and help Western ranchers and the Colorado State AgNext program reduce the climate impact of raising beef cattle.

"AgNext is a new initiative at CSU and our main mission is to identify and scale innovations that will foster the health of animal agriculture but also the ecosystems in which we produce animal agriculture – while also considering the economic and social impacts of those innovations," Schilling said. "It's allowing us to address some of the critical challenges facing animal agriculture."

Methane emissions will continue to be one of those challenges, and genetic selection may be one element in overcoming it.

"I think as we move forward in this space and talk about genetics, it's not always going to be about maximizing what we have but optimizing it," Schilling explained. "When we talk about maximizing, we're talking about growth, getting bigger. And we know that as animals get bigger, they're going to eat more and they are going to emit more because as they eat more they ferment more so logically it makes sense they would emit more."

But by changing the focus to optimizing growth rather than maximizing it, producers benefit by raising more efficient cattle in their individual and unique production environments which should translate into environment benefits from the lower emissions intensity of those animals.

"It's a way to get more by using less," Schilling said. "I think optimization will be critical. And we need to remember it is not going to be a silver-bullet approach that overcomes this challenge, but rather a silver-buckshot approach. It won't be one strategy that will work for everyone producing beef, but rather many different strategies catered uniquely to each producer."

Western SARE
Montana State University
207 Linfield Hall
P.O. Box 172840
Bozeman, MT 59717-3120

Western farming practices are adapting

For detailed information about the projects featured in this report – or any SARE-funded project – search our database by state, crop, project type, farming practice or keyword. Visit https://projects.sare.org/search-projects/