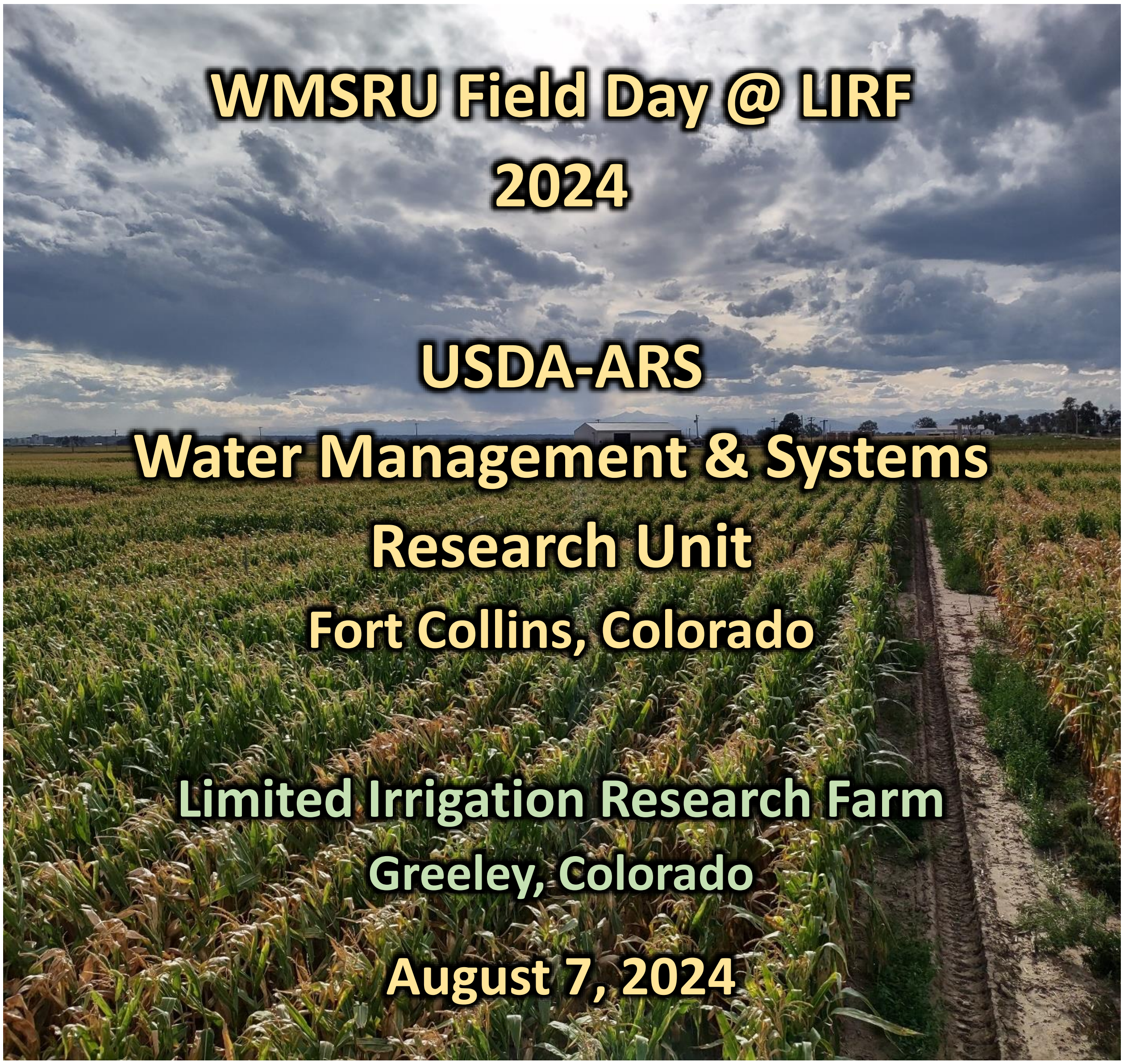
FIELD DAY THEME:
On-Farm Options to Handle Water Shortages



USDA Agricultural Research Service

Northern Water

Colorado State University

WMSRU Field Day @ LIRF – Booklet Contents

Contents

Mission Statement – WMSRU

Water is precious.

Our mission is to improve science & technologies underpinning regional and global challenges of increasing water scarcity in agriculture.

We work in areas *where rainfall is scarce*, from snow-fed mountain source waters to irrigated and dryland cropping systems.

We develop strategies to deal with changing climate, forest fire, competition for water, and the challenges of water scarcity.

Our research makes advances in plant trait networks, ecophysiology, remote sensing, micrometeorology, plant to watershed modeling, precision farming, irrigation management, and real-time decision support to bring economic value to stakeholders.

Limited Irrigation Research Farm (LIRF)

UAV Image (7/8/22)
Credit: Kevin Yemoto

Our Stakeholders and Partners

The Water Management & Systems Research Unit strives to build climate-smart agriculture and forestry systems in the western U.S. through research into drought-resilient dryland and limited-irrigation farming systems as well as wildfire and climate-resilient source-water forest ecosystems.

We work together with many agency, university, government, non-profit, and industry partners to research water issues that impact water-use stakeholders throughout the Rocky Mountain Front Range, the Western Great Plains, and water-limited regions throughout the world.

Hot Topics

- **Crops with water-efficient trait networks** are being studied that will provide both high yields and water-stress resilience in water-limited environments.
- **Precision irrigation research** at the **Limited Irrigation Research Farm** near Greeley Colorado uses Variable Rate Irrigation (VRI) systems along with sensors, monitoring, and modeling to apply irrigation when and where it is needed.
- **Wildfires in the western U.S.** are a huge threat to water supplies affecting rural and urban communities. Our research will measure and predict fire impacts, reduce fire danger, improve ecosystem health, and sustain urban and agricultural water supplies.
- **Climate-resilient, water-smart agricultural solutions** are being developed for precision agriculture and forest water-resource management using on-the-go sensors, remote sensing, big data, AI, and computer models.

Our Staff

Back: Jared Stewart, Joseph Michaud, Sean Gleason, Imun Known, Larry Wagner, Cam Caron, Chris Brackett, JD Miller, Ross Steward, Tyler Pokoski, Tim Green, Brendan Allen, Adam Mahood
Front: Louise Comas, Ryan Wells, Stephanie Polutchko, Kevin Yemoto, Huihui Zhang, Joy Angermueller, Kendall DeJonge, Alex Olsen-Mikitowicz, Kyle Mankin

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Kevin Yemoto, Engineering Technician

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Brendan Allen, Reagan Ames, Joy Angermueller, Mickie Barraza, Giovanni Borsari, Josh Brekel, Cam Caron, Sarah Culhane, Tyler Donovan, Naiara Doherty Garcia, Jordyn Geller, Madeline Guimond, Hugh McCurren, Alex Merklein, JD Miller, Shanthini Ode, Alex Olsen-Mikitowscz, Anna Pfohl, Stephanie Polutchko, Jack Reuland, Catherine Schumak, Megan Sears, Dan Spitzer, Subash Thapaliya

Field Day Agenda

2024 WMSRU Field Day @ LIRF
FIELD DAY THEME: On-Farm Options to Handle Water Shortages
Wednesday, August 7, 2024, 8:30 a.m. - 2:30 p.m.
Limited Irrigation Research Farm, Greeley, Colorado

8:30 Coffee & Donuts
In poster area. Provided by **Colorado Corn**.

8:30 Posters & Discussion with Researchers
Continuing throughout the day.

9:00 Field Tours & Demonstrations
1. Introduction & Tour Overview (Kyle Mankin – ARS)
2. Irrigation Scheduling using Evapotranspiration (ET) & LIRF's Variable-Rate Linear Sprinkler System (Kendall DeJonge, Tyler Pokoski, Ross Steward – ARS)
3. Remote Sensing for Irrigation Scheduling (Unmanned Aerial Vehicles & Satellites) (Huihui Zhang, Kevin Yemoto – ARS)
4. Drought Severity – What is the Point of No Return? (Sean Gleason, Jared Stewart – ARS)
5. Plant Traits for Drought Hybrids of the Future (Louise Comas, Joseph Michaud – ARS; Rubi Raymundo Carhuapoma – CSU)
6. Benefits of Monitoring Applied Water (Jon Altenhofen – NWCD)

11:00 Indoor Lightning Talks
1. Peter Goble (CSU): **Climate Projections & CoAgMet Network**
2. Dannele Peck (ARS): **Drought Preparedness & Decision Making**
3. Allan Andales (CSU): **S. Platte River Salinity Issues**
4. Jon Altenhofen (Northern Water): **Water Allocations & Ditch Sources**
5. Mary Guttieri (ARS) & Geoff Morris (CSU): **Breeding for a Drought-Resilient Wheat Crop**
6. Tim Martin (CSU): **CSU-TAPS – Testing Ag Performance Solutions 2024**

12:15 LUNCH… **BBQ**!
Provided by **Northern Water**.

1:30 Optional Round Table:
NRCS Colorado South Platte River Basin Conservation Effects Assessment Project (CEAP) Watershed Assessment Study
This is a new collaborative project between NRCS, USDA-ARS, and CSU to use monitoring, modeling, and experimentation to assess the influence of conservation practices on hydrology and water quality within the Colorado South Platte River Basin.

2:30 Wrap up

Field Tour Stop 1:
LIRF Water Research: On-Farm Options to Handle Water Shortages

Kyle Mankin
USDA-ARS, Water Management & Systems Research Unit (WMSRU), Fort Collins, CO

Welcome!

The USDA Agricultural Research Service (ARS) is a national research agency with 2000+ research scientists at 90+ sites around the US, like those in Greeley, Fort Collins, and Akron, Colorado. We are located at this many sites so that we can stay connected to and address regional issues to agriculture. Our local scientists work directly on these issues. When needed, we also mobilize expertise from our ARS network and others around the US. We are good collaborators and catalysts for action.

Based in Fort Collins, Colorado, WMSRU addresses western US water issues, especially where water is scarce. The scope of our research ranges from **mountain source-waters** (impact of fire on forest ecosystems and their delivery of water downstream) to **limited irrigation management** (increasing crop per drop, water productivity) to **dryland agriculture** (maximum net returns with minimal risk).

Water starts as snowmelt and rainfall, is transported downstream, is used by agriculture and municipalities, and is discharged to receiving waters. Figure 1 captures the breadth and connection of water research important to agriculture in the western US. We work in all these areas.

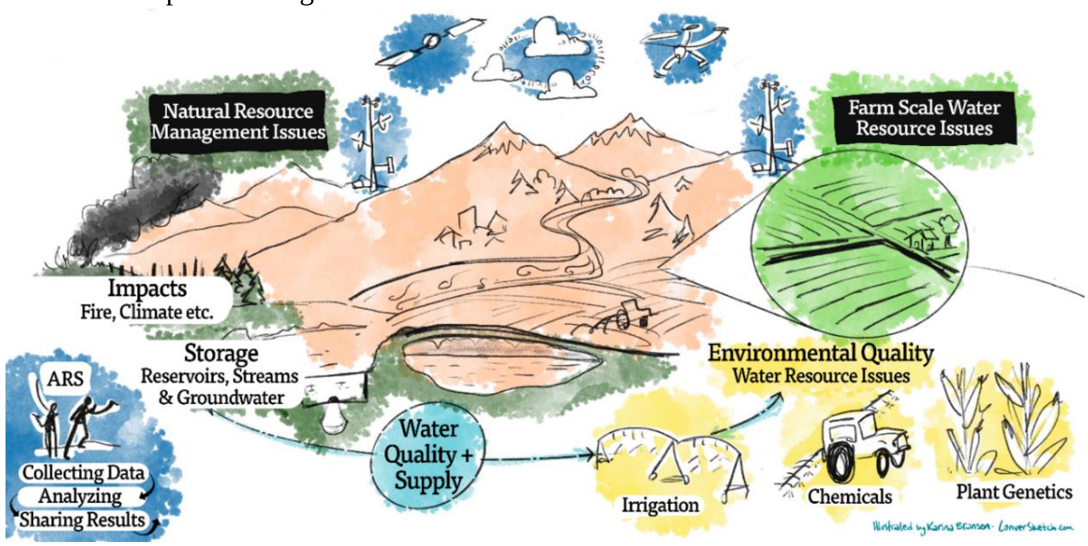


Figure 1. Water issues connect across agroecosystems and require transdisciplinary solutions (figure from Tsegaye et al., 2022; concept by Kyle Mankin). (Elias et al., 2023; https://doi.org/10.2489/jswc.2023.1220A)

Our Unit has more than a 100-year history with western water issues. Elwood Mead (after whom Lake Mead is named) was with Colorado Agricultural College (now CSU) from 1882-1888 and was USDA's Chief of the Division of Irrigation and Drainage Investigations from 1899-1907. The continuous chain of USDA water researchers linked to the WMSRU starts with Victor Cone (1911-1918) and Ralph Parshall (1913-1959, inventor of the Parshall flume), who led research on channel hydraulics.

Over the years, Unit research has evolved to span all aspects of western water:

- canal seepage (A.R. Robinson, 1951-1963),
- surface irrigation automation (Howard Haise, 1954-1974),

- evapotranspiration [ET] estimation (Marvin Jensen, 1959-1964),
- irrigation well design & water measurement (Gordon Kruse, 1957-1993),
- soil water movement (Roy Brooks, 1957-1967),
- pollution prevention (Harold Duke, 1967-2002),
- center pivot design & management (Dale Heermann, 1968-2005),
- remote sensing crop yield prediction (Heerman, Duke),
- physics of wetting/drying soils (Arnold Klute, 1971-1981),
- plant water uptake (Edwin Fiscus, 1976-1989),
- integrated agricultural systems research (Laj Ahuja, 1995-2015)
- variable rate herbicide management (Dale Shaner, 2001-2013),
- limited or deficit irrigation (Tom Trout, 2006-2015), and others.

Our current research has evolved to cover these critical topics:

- crop growth, development & functioning under stress (Louise Comas, 2011-present),
- limited irrigation management & crop ET modeling (Kendall DeJonge, 2011-present),
- remote sensing of crop water stress & ET (Huihui Zhang, 2014-present),
- crop physiological response to water stress (Sean Gleason, 2014-present),
- water & nutrient transport in agricultural fields & watersheds (Tim Green, 1998-present),
- soil health in dryland agriculture systems (Maysoon Mikha, 2003-present),
- forest ecology, restoration, & water impacts (Dave Barnard, 2019-present), and
- hydrology & modeling of agricultural crops, fields, & watersheds (Kyle Mankin, 2018-present).

Our Field Day theme this year is "On-Farm Options to Handle Water Shortages".

Western water law started with legal challenges over water and shortfalls in the Poudre River basin in Colorado. Colorado water law is complex, but generally states that water is appropriated (assigned to a user) by the State for a beneficial use with priority given to older original claims. Water Rights can be bought and sold, but only the amount "beneficially used". Surface irrigation return flows don't count towards the water used, nor does irrigated water seeping out of root zones.

Limited irrigation is one way to handle water shortages. Our research shows you can use 17% less water by strategically giving crops less water during specific developmental stages, such as late vegetative stages in corn. An additional benefit is that this comes with less leaf growth, and this limited-irrigated corn is more resilient (maintains yield) under late season water shortages.

Another way to handle water shortages is switching from irrigation to dryland cropping ("Buy and Dry"). This is more straight-forward but comes at a cost, both for the producer and society, with reduced crop production.

In some situations, "water savings" on farms can be leased to provide yet another source of revenue for producers, but documenting "tradable water savings" on real farms is tricky.

The Tour Stops all present research related to understanding crop water demands, managing irrigation water, measuring crop stress response, designing crops that are more resilient to water stress, measuring on-farm crop water use, and farm-scale water optimization. The Indoor Lightning Talks will start with understanding climate and the role of weather station networks, decision making under drought, salinity issues in the South Platte, water allocations and sources, and breeding for future crop hybrids. We hope you walk away with a more comprehensive understanding of agricultural water issues in our region and how our research is helping develop both source-water and ***on-farm options to handle water shortages***.

Field Tour Stop 2:
Irrigation Scheduling using Evapotranspiration (ET)

Kendall DeJonge, Tyler Pokoski, Ross Steward

USDA-ARS, Water Management & Systems Research Unit, Fort Collins, CO

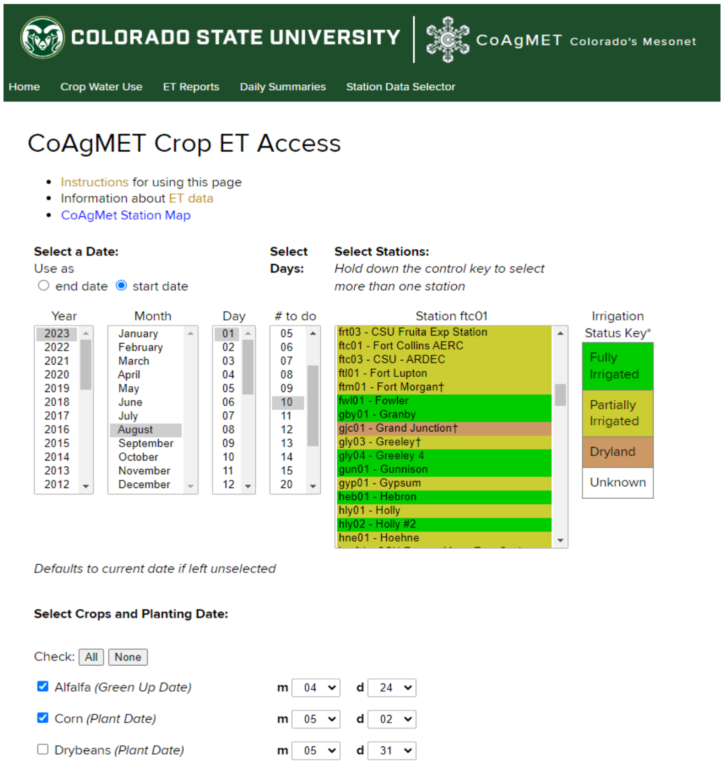
Estimating crop water use can be very valuable for water scheduling – if we can know how much water was *lost* through evapotranspiration (ET), we know how much water we need to *replace* through irrigation.

Crop ET is a dynamic process. Many rules of thumb exist, for example some say in peak corn growing conditions, such as when there is a fully grown crop in peak heat (July-August), a corn crop uses around an inch of rain every three days. That's not a bad rule, but there are tools out there for a more science-based approach.

Crop ET is determined by two main factors:

- **Environment** – using a standardized weather station from a network like CoAgMet, we measure temperature, humidity, solar radiation, and wind. Those ingredients help us calculate Reference ET (ETref, sometimes referred to as ETr or ETo), which is the ET over a consistent alfalfa or grass reference surface.
- **Crop status** – as leaves grow and intercept more light, more water is used by the crop. If there isn't available moisture in the soil, the crop will wilt, become hot, and use less water.

Tools like CoAgMet (www.coagmet.colostate.edu) are available to estimate your crop water use by choosing a nearby weather station, your crop, and planting date. All of the math is done in the background, but it can give you an estimate of how much water a healthy crop is using. Try it out! An example is below:



Crop Evapotranspiration in Inches

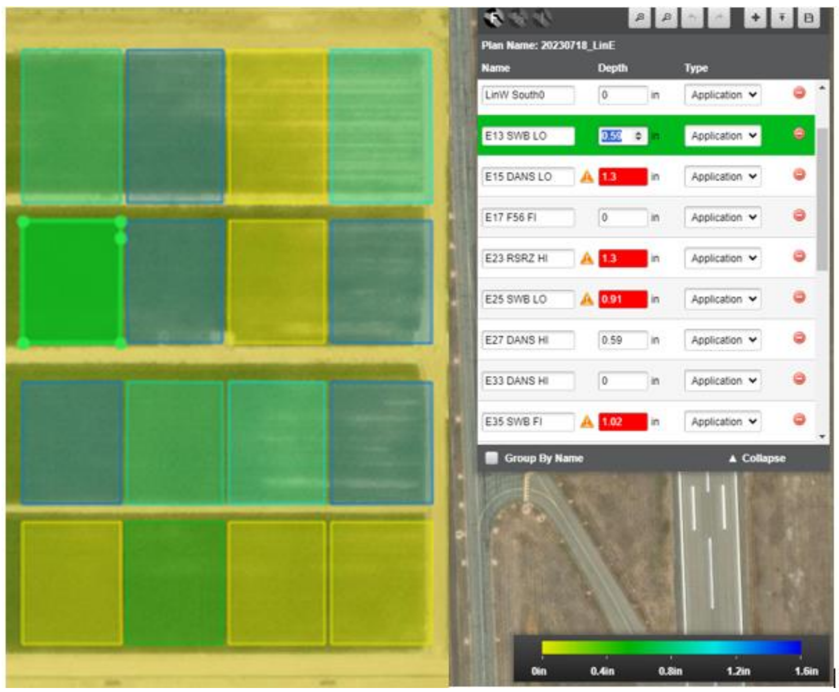
Date	Corn	ETr	ETo	Precip
08/01/2023	0.23	0.24	0.20	0.01
08/02/2023	0.26	0.27	0.22	0.01
08/03/2023	0.20	0.20	0.21	0.21
08/04/2023	0.24	0.25	0.21	0.00
08/05/2023	0.22	0.23	0.20	0.08
08/06/2023	0.15	0.15	0.14	0.02
08/07/2023	0.19	0.20	0.16	0.02
08/08/2023	0.22	0.22	0.19	0.00
08/09/2023	0.26	0.27	0.21	0.00
Sum	1.95	2.04	1.75	0.35
Average	0.22	0.23	0.19	0.04

These irrigation scheduling methods work well under well-watered crops. Estimating crop water use when crops are water stressed is much more complicated. Our current experiments look at several methods to estimate ET and make irrigation decisions under full and limited water. These methods include:

- Soil water balance (SWB), with frequent measurements of soil moisture
- Degrees above non stressed temp (DANS), with continuous canopy temperature measurement
- Remote sensing and root zone model (RSRZ), which integrates remote sensing measurements with a crop model
- Energy balance (EBAL), with an energy balance model to estimate ET
- FAO-56 crop coefficient method, which is what CoAgMet uses

Our linear variable rate irrigation (VRI) system was manufactured by Lindsay Irrigation (Zimmatic), installed in 2021, and has now fully replaced the previously existing surface drip irrigation system. The linear consists of 4 spans that irrigate 15 acres. The system has individually controlled nozzles on 5-ft spacing. Using FieldNet software, we can define customized irrigation zones and write prescriptions to apply specific amounts of water to each plot, depending on the needs of the experiment. This system has increased the farm flexibility and research capabilities. It is also very applicable and recognizable to farmers.

The primary onsite well pumps groundwater from a depth of ~50 feet, at a peak rate of ~500 gpm. The well water can then be used to supply some on-farm canals for siphon tube irrigation, as well as the majority of the farm, which is under various pressurized irrigation systems: ground sprinkler, linear sprinkler, and subsurface drip. For the pressurized systems, the booster is set at a desired pressure for the irrigation type, and flow is regulated to maintain the setpoint pressure. A backflow flush filtration system is required to keep sediment out of the pressurized systems, as well as maintain operating pressure.



Field Tour Stop 3:
Unmanned Aerial Vehicle (UAV)-Based Remote Sensing for Yield Prediction and Irrigation Scheduling

Huihui Zhang, Kevin Yemoto

USDA-ARS, Water Management & Systems Research Unit, Fort Collins, CO

Leveraging advanced UAV technology, the scientists at WMSRU in Fort Collins, CO, have exploited the potential of remote sensing to monitor dynamic crop conditions throughout the growing season. By capturing high-resolution RGB (Fig. 1a), multispectral (Normalized difference vegetation index, NDVI, Fig. 1c), and thermal (Fig.1d) imagery, we can derive critical information on crop health, stress, and yield potential. These insights empower farmers and agronomists to make informed irrigation decisions and optimize resource allocation.

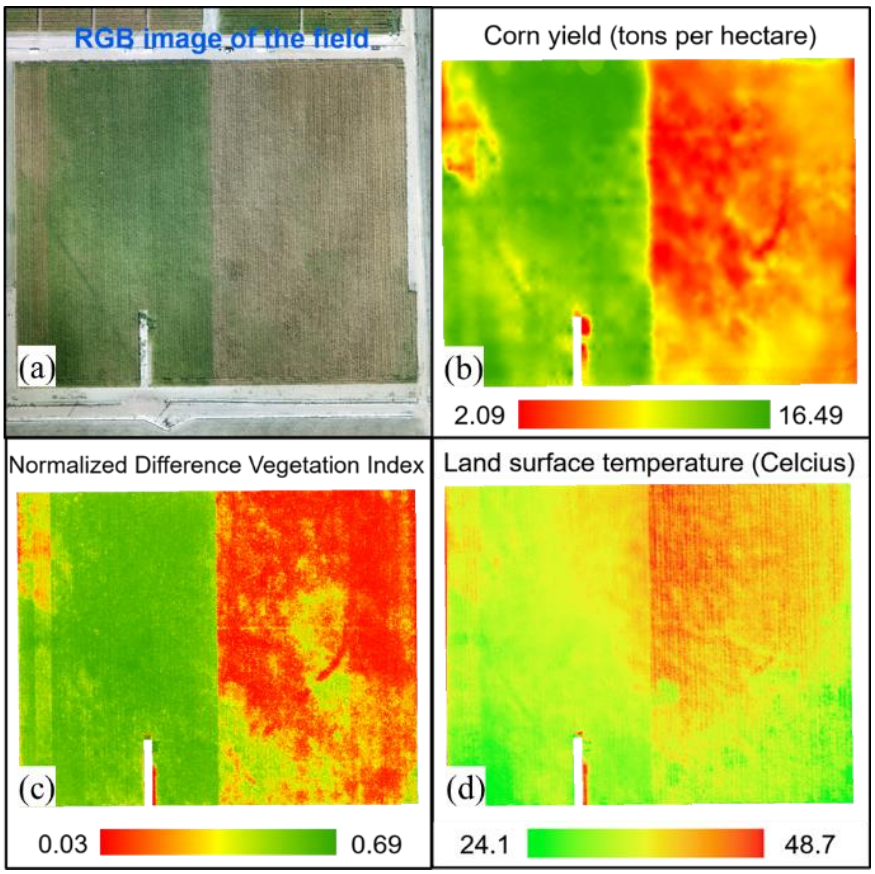


Figure 1. Study site, RGB (a), yield map (b), Normalized Difference Vegetation Index (NDVI) (c), and thermal imagery indicating surface temperature (d) taken by a UAV imaging system on Sept 16, 2022.

Yield prediction: We compared the performance of yield prediction models using various UAV-based data types: ref (multispectral), RGB, RGB+thermal, and ref+thermal imagery. The analysis included both fully irrigated and deficit-irrigated corn fields during the 2022 growing season.

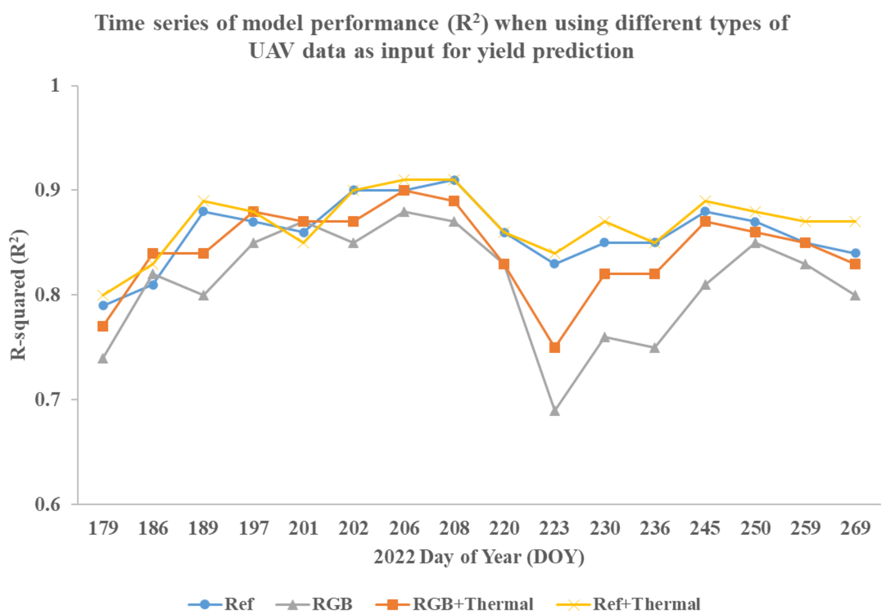


Figure 2. Time series of model performance when using different types of UAV imagery data as input for yield prediction at different crop growing stages from 6/28-9/26/2022.

Irrigation scheduling: NDVI-derived leaf area index was integrated into the crop model to optimize irrigation scheduling. Compared to the FAO56 method, this approach (CMRS) decreased irrigation water by 12% while incurring an 8.4% yield penalty in 2022.

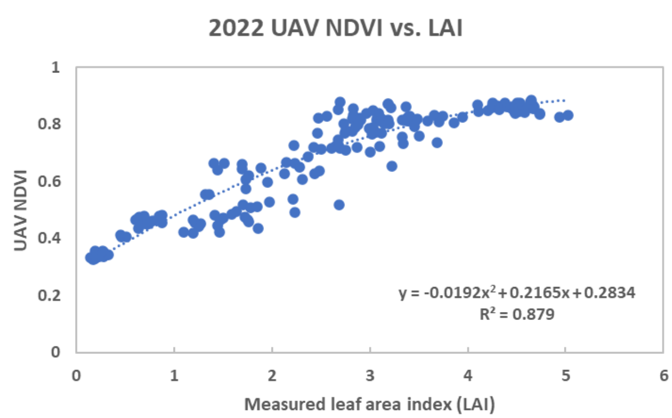


Figure 3. UAV NDVI is highly correlated to the measured leaf area index.

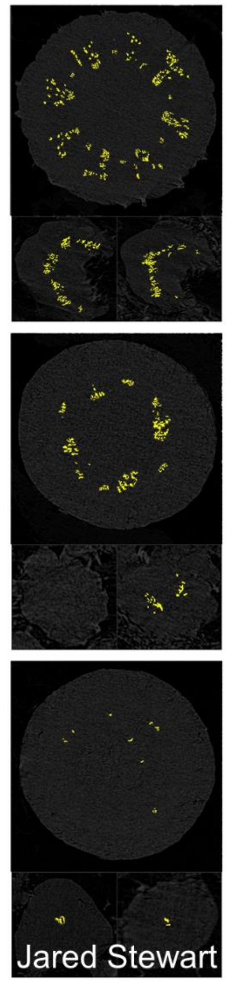
Year	Method	Irrigation amount (inch)				Yield (bu/ac)	Irri Water Saving (inch)	Yield Reduction
		V8-V17	VT-R3	R3-Harvest	Total			
2022	FAO56	7.04	5.04	5.24	17.3	249		
	CMRS	5.51	3.43	6.22	15.2	228	2.13 (12.3%)	8.4%
	Precip	0.47	1.06	0.67	2.2			

Field Tour Stop 4:
Drought Severity – What is the Point of No Return?

Sean Gleason, Jared Stewart

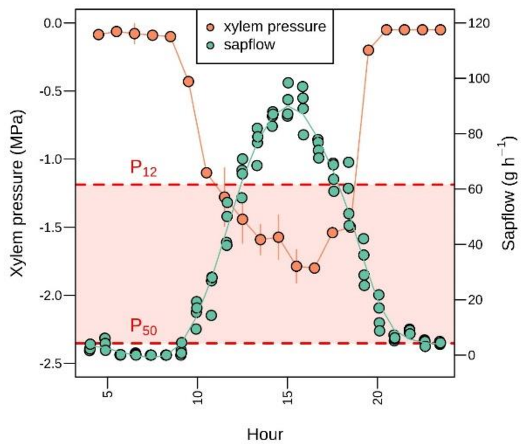
USDA-ARS, Water Management & Systems Research Unit, Fort Collins, CO

Crop improvement programs aim to increase yield per unit resource consumed, e.g., light, space, nutrient, and water. Plants grow by exchanging large volumes of water for atmospheric CO_2, and as such, crop growth and grain yield is supported primarily through this important exchange. However, the water-CO_2 exchange rate is costly – with crop species losing/"spending" between 260 to 1140 grams of water per 1 gram of atmospheric CO_2 taken in.



This considerable expense arises directly from the exposure of wet, internal cellular surfaces to the dry atmosphere, a condition necessary for the uptake of CO_2 into plant photosynthetic cells. An important implication of this system is that large volumes of water must be transported long distances through plant conductive tissues (roots, stems, leaves), explaining why natural selection has favored highly efficient water transport systems in crop species.

High growth rates are therefore usually closely aligned with: 1) the capacity of the root system to access soil water, 2) the capacity of the vascular system to deliver this water to the canopy, where it is converted into sugar and eventually grain, and 3) the ability of photosynthetic machinery to convert this water into plant tissues and grain. Taken together, the performance of crop plants depends not on single traits (e.g., leaf traits, root traits, photosynthesis traits) to provide efficient performance, but rather on "networks" of plant traits, working together in a coordinated fashion.



At this stop on the tour we provide an overview of the science underpinning the ability of crop species to achieve high rates of growth in both fully watered and water-limited environments. We also discuss how these scientific concepts are being used to improve crop species, and also how basic plant science will make crops grow faster in the future.

Field Tour Stop 5:
Plant Traits for Drought Hybrids of the Future

Louise Comas, Joseph Michaud, Mickie Barraza

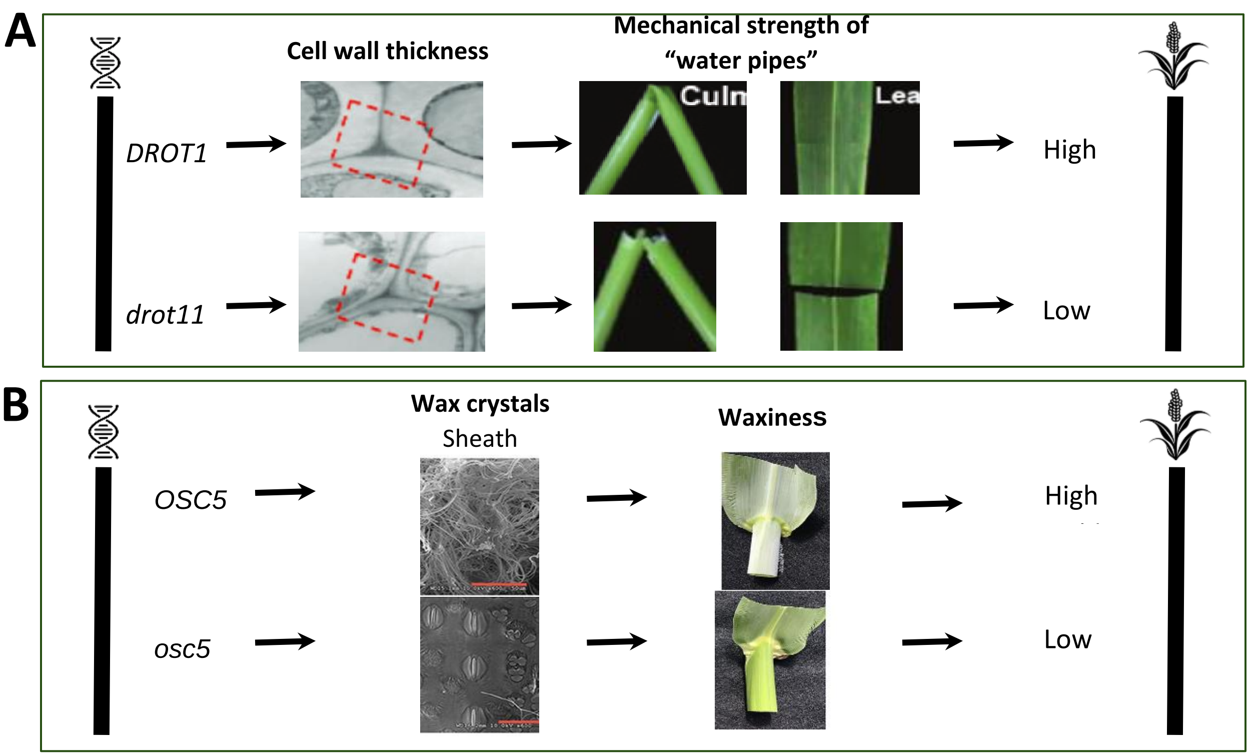
USDA-ARS, Water Management & Systems Research Unit, Fort Collins, CO

Rubí Raymundo Carhuapoma

Colorado State University, Fort Collins, CO

The location of the Limited Irrigation Research Farm (LIRF) at nearly the peak of the rain shadow from the Rocky Mountains makes it ideal for testing the contribution of plant traits for increased crop productivity under limited water. We have two collaborative experiments between the USDA-ARS and CSU this field season, one in wheat and one in sorghum, that were set up to identify which traits and trait combinations are most likely to improve hybrids of these crops for semi-arid environments.

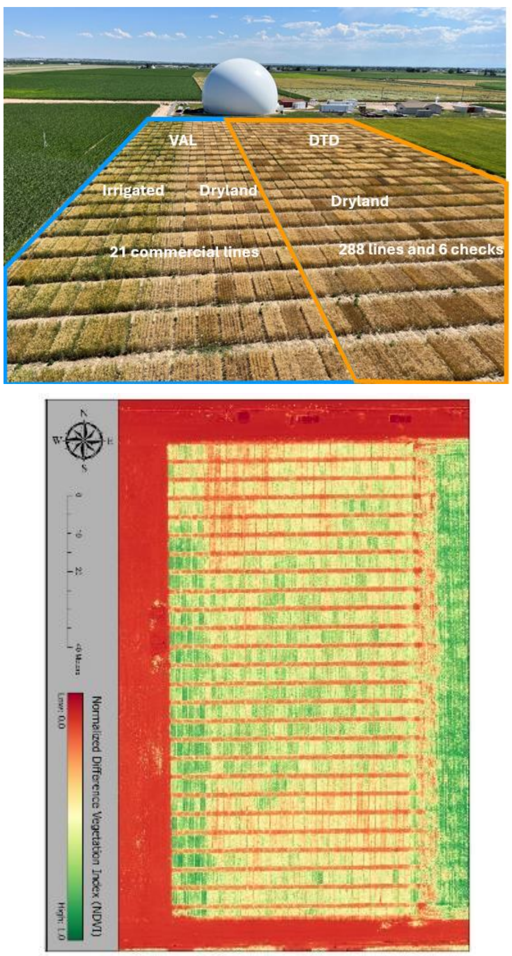
In our sorghum experiment, we used a new approach where we developed a list of traits that could improve plant growth under limited water. We identified genotypes with and without these traits from their genetic sequences, taking advantage of the newly sequenced genome of sorghum. Traits included increased photosynthetic capacity (PEP carboxylase), the thickness of structural roots, vascular cell wall thickness (strength of "water pipes" in plants, Fig. A), and leaf cuticular wax thickness, plus others.



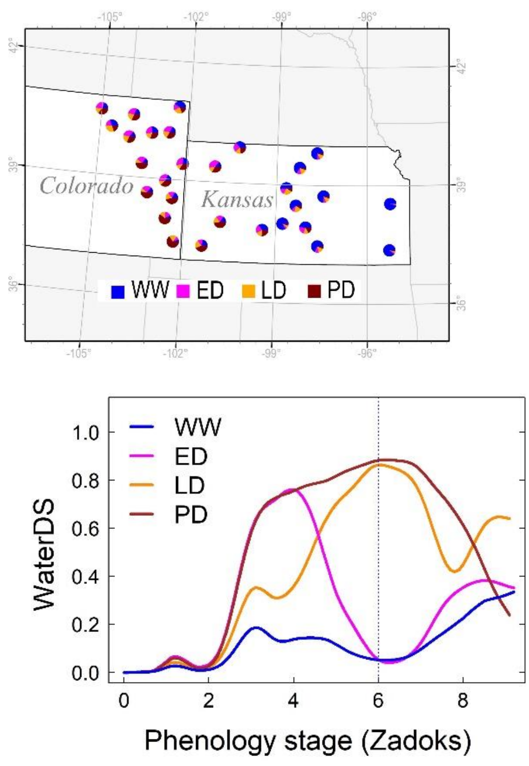
Genotypes with and without these traits are planted in the field. We are testing the ability of these genotypes to keep their stomata open and continue to function under limited water, along with scoring functional aspects of their roots, their cell wall and wax thickness. At the end of the season, we will also collect samples from their shoots and roots to see how much they grew and their root distribution. If we confirm that these traits contribute to greater productivity of the plants under limited water, the geneticists on our team will be able to breed those genes into new hybrids.

In our wheat experiment (Drought Trait Discovery, DTD), we are screening germplasm (~350) from the Wheat Genetic Resources Center carrying gene introgressions from wild wheat ancestors. In this initial three-year pilot experiment, we identify introgression lines with improved performance under drought (Fig. C) and prevalent drought stress patterns (Fig. D). To select which line can grow with the least stress under limited water and produce the most grain, we measure plant stress and water use of the genotypes via traditional and high throughput phenotyping. We completed the second of three years of this study in July of this year, and the analysis indicates we should target the late drought managed stress for future screening. Once we identify the genotypes of interest, a second phase of experiments will identify the traits that contribute to their greater productivity under limited water. This research is a collaboration between the USDA-ARS in Kansas, CSU, KSU, and the USDA-ARS in Fort Collins. Water scarcity is one of the main factors limiting winter wheat productivity in dryland regions of the US. Improving water productivity in genotypes for these regions is one of the critical solutions to increasing productivity in these regions.

C Screening wheat introgression lines under water stress (dryland).



D Prevalent drought stress patterns in Kansas and Colorado.



Well-Watered (WW); Early Drought (ED); Persistent Drought (PD), Late Drought (LD)

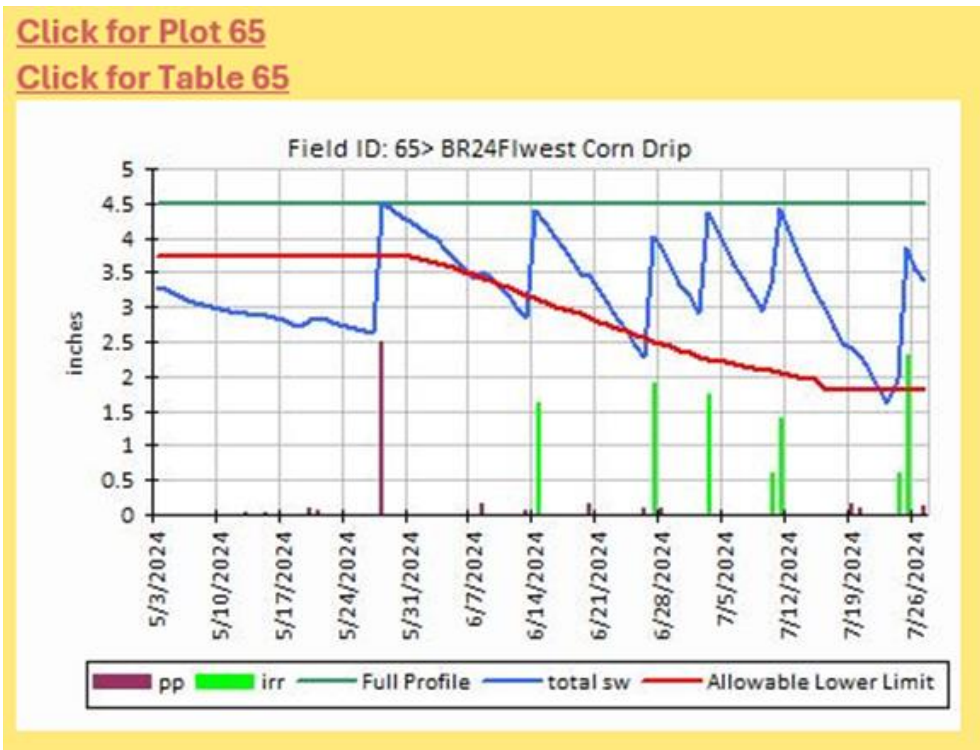
Field Tour Stop 6:
Benefits of Monitoring Applied Water

Jon Altenhofen, PE

South Platte Special Project Manager, Northern Water (Northern Colorado Water Conservancy District), Berthoud, CO. jaltenhofen@northernwater.org, 970-622-2236

Monitoring of water supply and comparing to water demands (crop consumptive use, or evapotranspiration, ET) improves water efficiency and helps deal with water shortages from droughts and climate change. ET data (inches per day) is readily available from local weather stations. With the addition of in-field monitoring, demonstrated at LIRF, a farm-specific ET can be determined, which can help producers determine farm specific consumptive use estimates for deficit and fully irrigated fields.

Smart phone apps, computers and websites (CSU) can give real-time access to the data as shown in water balance graph in the graph shown here (contact Jon at Northern Water if interested).



Water supply to a farm can be easily monitored by flowmeters, flumes, counting siphon tubes, ditch company deliveries, sprinkler nozzle flow rates, etc. Irrigation water supplies come with constraints for farmers, such as enough water supply (gpm/acre) to meet the ET demand (inches/day).

The table with my Indoor Lightning Talk (Farm Water Supply Required to meet ET at a given Efficiency) is useful in understanding this supply constraint and making changes. Also, root zone salt build-up issues and leaching requirements (i.e., supply 15% more than ET) need water supply measurements.

Indoor Talk 1:
Climate Projections & CoAgMet Network

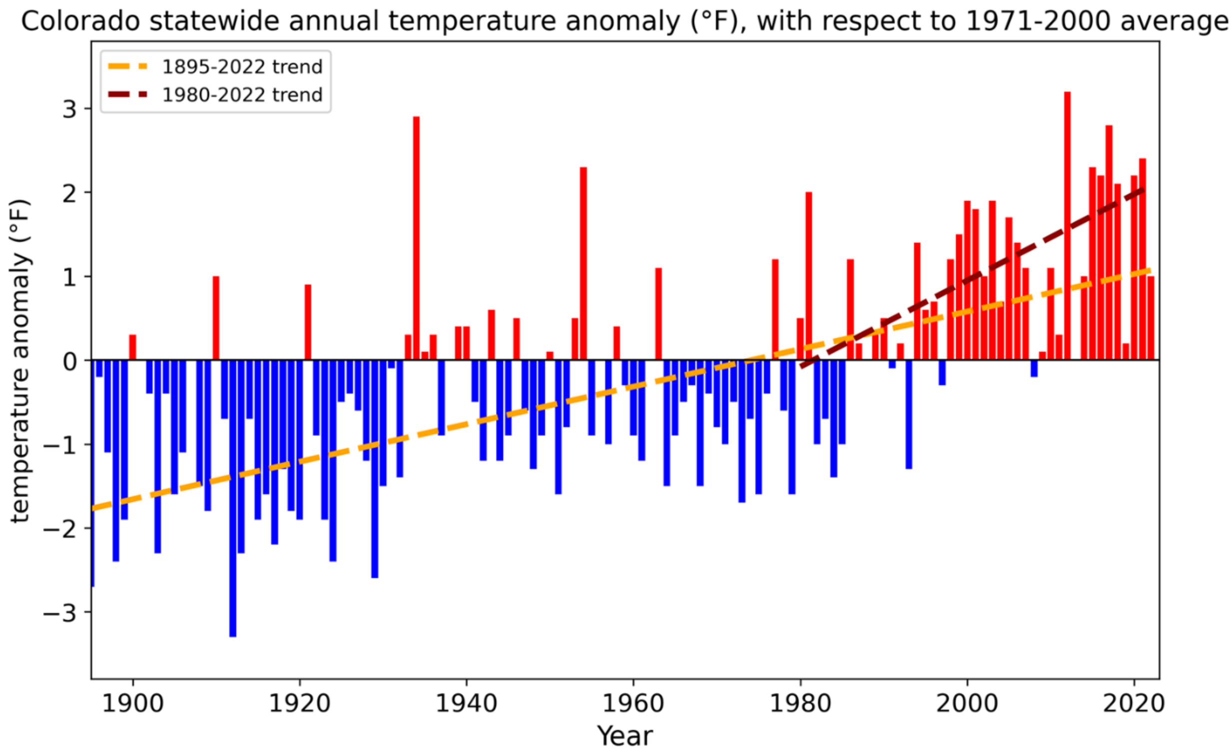
Peter Goble

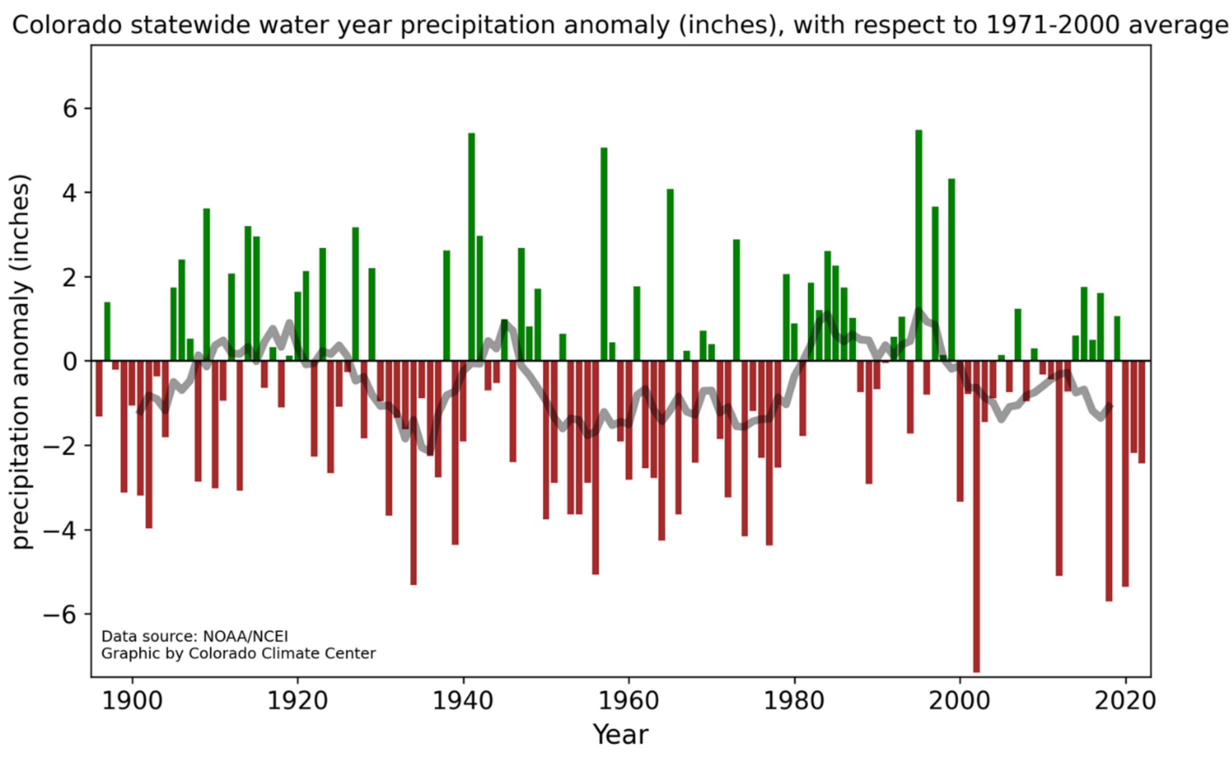
Climatologist, Colorado CoCoRaHS Coordinator, Colorado Climate Center, CSU.

In 2023 the Colorado Climate Center and Lukas Climate completed a synthesis of the observed and projected climate impacts across the state of Colorado. This report can be found at climatechange.colostate.edu. Today Peter will give a brief overview of this report, touching on the observed and projected changes to Colorado's temperatures and precipitation, water cycle, and weather hazards and extremes. This chat will integrate data collected from the Colorado Agricultural Meteorological (CoAgMET) Network. CoAgMET is a network of over 90 agricultural weather stations around the state that is managed by the Colorado Climate Center, and used by producers, agricultural researchers, and extension.

Climate variable/event	Recent trend	Projected future change	Confidence in change
Average Temperature	Warmer	Warmer	*Very high*
Annual Precipitation	Lower	Uncertain	*Low*

Climate variable/event	Recent trend	Projected future change	Confidence in change
Spring Snowpack	Lower	Lower	*Medium*
Runoff Timing	Earlier	Earlier	*High*
Annual Streamflow	Lower	Lower	*Medium*
Summer Soil Moisture	Lower	Lower	*High*
Evaporative Demand	Higher	Higher	*Very High*


Colorado statewide annual temperature anomaly (°F), with respect to 1971-2000 average
1895-2022 trend
1980-2022 trend
temperature anomaly (°F)
3
2
1
0
−1
−2
−3
1900
1920
1940
1960
1980
2000
2020
Year


Colorado statewide water year precipitation anomaly (inches), with respect to 1971-2000 average
precipitation anomaly (inches)
6
4
2
0
−2
−4
−6
Data source: NOAA/NCEI
Graphic by Colorado Climate Center
1900
1920
1940
1960
1980
2000
2020
Year

Indoor Talk 2:
Drought Preparedness & Decision Making

Dannele Peck

Director/Agricultural Economist, USDA-ARS, Northern Plains Climate Hub, Fort Collins, CO

USDA Northern Plains Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

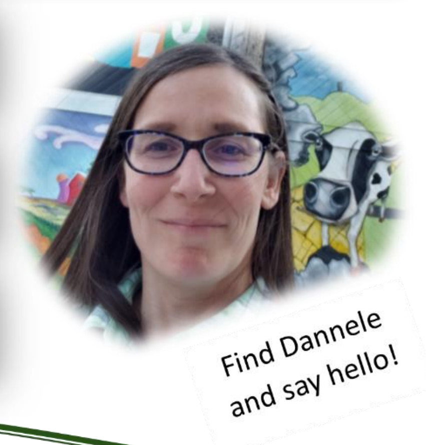
Vision:
Robust and healthy agricultural production and natural resources under increasing **climate variability and change...**

Through **science-based, region-specific information and technologies** that enable **climate-informed** decision-making.

Outreach, convening, and training
Facilitating engagement and exchange

Science and data syntheses
Translating and delivering relevant information

Tool/tech co-development
Supporting climate-informed decision-making



USDA Northern Plains Climate Hub
U.S. DEPARTMENT OF AGRICULTURE

1. Drought *Adaptation & Preparedness*

bit.ly/3WwpRSq

COLORADO CLIMATE-SMART COMMODITIES PROJECTS

27 Projects | 36 Major Commodities | 112 Practices | $797.45 M Federal Funding*

DAIRY & LIVESTOCK | ROW & ENERGY CROPS | FRUIT, VEGETABLE & SPECIALTY CROPS | FORESTS & AGROFORESTRY

Colorado High Plains Irrigation Practices Guide

Water Saving Options for Irrigators in Eastern Colorado

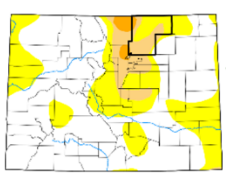
bit.ly/3WJCsDb

2. Drought *Monitoring*

NATIONAL DROUGHT MITIGATION CENTER NDMC UNIVERSITY OF NEBRASKA

Drought Impact Reporter

bit.ly/3WO69C3



U.S. Drought Monitor Virtual Workshop August 14, 8-10am MT

bit.ly/3WKWPzJ

3. Drought *Response & Recovery*

USDA

Disaster Assistance Discovery Tool

Learn about USDA disaster assistance steps.

1 STEP ONE LOSS OR DAMAGE

2 STEP TWO WHEN

bit.ly/3Wwpc3o

Prevented Planting for Irrigated Acreage

bit.ly/3WMGrPa

RMA

USDA is an equal opportunity provider, employer, and lender.

Indoor Talk 3:
Breeding for a Drought-Resilient Wheat Crop

Mary Guttieri[1], Geoff Morris[2]

[1]Research Geneticist, USDA-ARS, Hard Winter Wheat Genetics Research Unit, Manhattan, KS.
[2]CSU

10,000 Years Ago… (more or less) "a Miracle Happened."
The ancient ancestor of durum wheat hybridized with the ancient ancestor of goatgrass to create what became bread wheat.

Wild Emmer – *Triticum dicoccoides*

What was lost?
Weedy Habits: Shatters, tightly adhering glumes, indeterminate flowering
Weedy Adaptation: Resistance to diseases and insects. Tolerance to head and drought.

Recovering Useful Traits

***Step 1:* Build Germplasm**

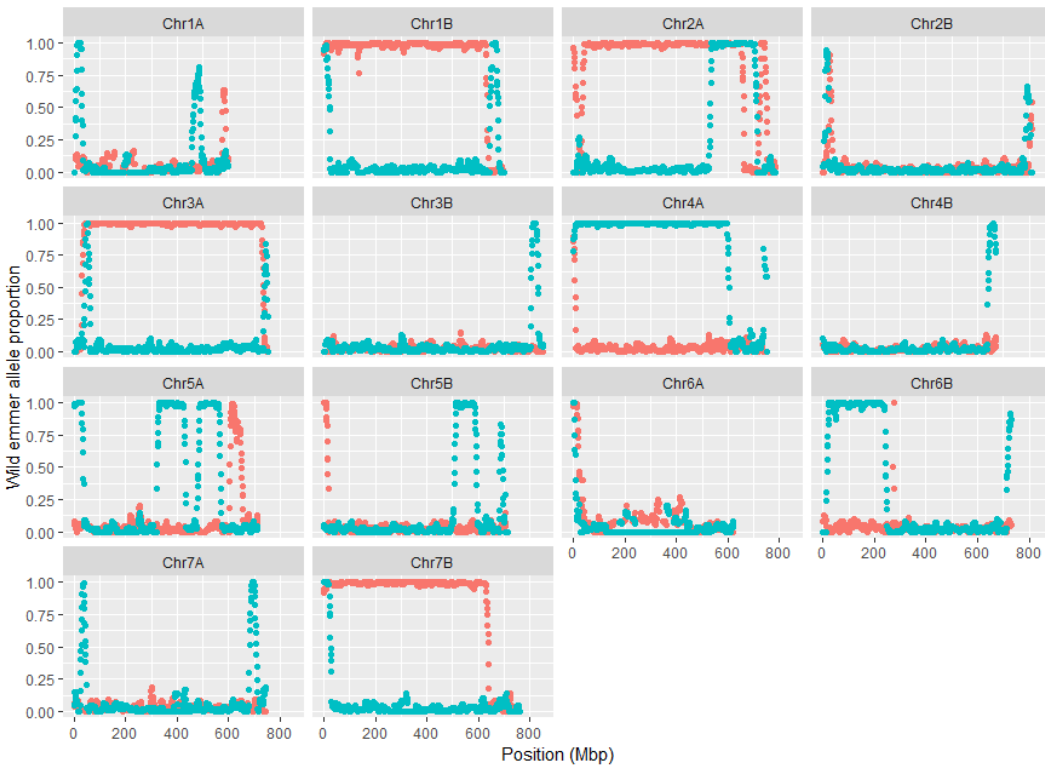
a. Cross bread wheat to a diverse set of wild emmer (or *Ae. tauschii*)
b. Cross bread wheat to the hybrids – 25% wild, 75% cultivated
c. Self-pollinate five generations to produce true-breeding progeny

***Step 2:* Test Germplasm**

Disease resistance – Wheat stem sawfly resistance – Coleoptile lengths – High Temperature Tolerance – Quality

Drought Tolerance – Collaboration – Colorado State University, Scientists in Water Management & Systems Research Unit

Couple with DNA Sequence Information



Develop Mechanistic Understanding – Collaboration with Plant Physiologists

***Step 3:* Develop Commercial Cultivars with Targeted Traits from Weedy, Wild Relatives**

Use test germplasm to breed targeted traits into competitive cultivars

Use DNA information for selection

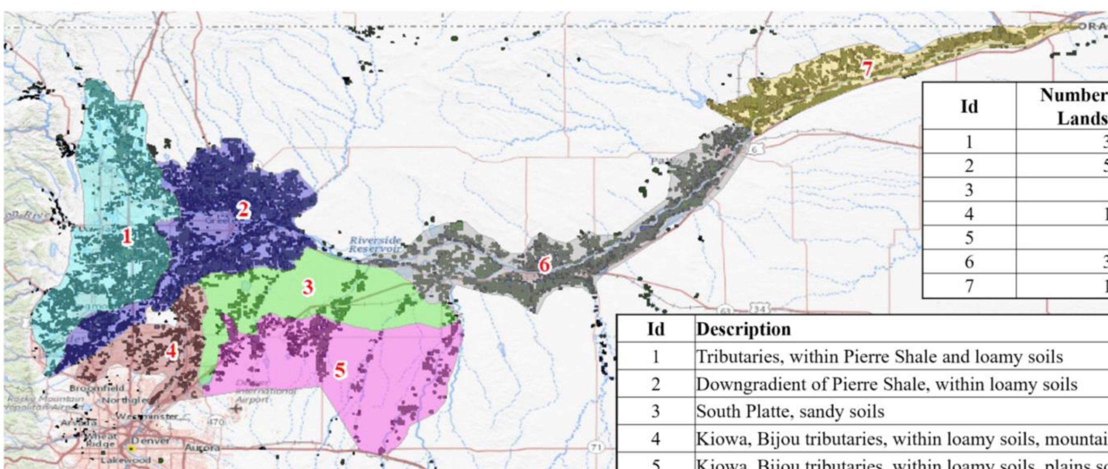
Indoor Talk 4:
South Platte River Basin Salinity Study

Allan Andales

Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO

The South Platte River Basin (SPRB) is the most populous and agriculturally productive Basin in Colorado and is affected by salinization. Soil and water salinity refers to the total dissolved salts (ions, charged particles or compounds) that can cause water stress, reduced crop yields, and non-ideal soil conditions. There is some evidence that soil and water salinity in the SPRB is increasing with time and with downstream distance from the headwaters.

The South Platte Salinity Stakeholder Group was formed in 2020 to facilitate regional dialogue and coordination of activities addressing the salinity issues. Coordinated by the Colorado Water Center, it represents agricultural, municipal, water supply, water treatment, and research interests in the South Platte River and its tributaries from Waterton Canyon to the Colorado/Nebraska state line. Efforts are underway to understand the extent and severity of soil and water salinity in the SPRB. In 2023, a team of researchers collaborating with the Stakeholder Group began installing groundwater monitoring wells and conducting soil salinity surveys along the SPRB. Below is a map of the SPRB with seven (7) regions delineated. To date, approximately twenty wells and adjacent irrigated fields in regions 2, 6, and 7 have been identified for long-term monitoring of groundwater salinity and soil salinity, respectively. The team is working with the Colorado Division of Water Resources, Northern Water, USDA-NRCS, and other members of the Stakeholder Group to identify existing data sources and monitoring locations for surface and ground water salinity. The long-term goal is to enable planning for targeted applications of treatment and remediation technologies and practices at identified salinity hot spots within the SPRB.



Id	Number of Irrigated Lands in Region
1	3,736
2	5,355
3	252
4	1,003
5	853
6	3,048
7	1,583

Id	Description
1	Tributaries, within Pierre Shale and loamy soils
2	Downgradient of Pierre Shale, within loamy soils
3	South Platte, sandy soils
4	Kiowa, Bijou tributaries, within loamy soils, mountain source
5	Kiowa, Bijou tributaries, within loamy soils, plains source
6	South Platte, bedrock source is Cretaceous (marine)
7	South Platte, bedrock source is Tertiary (terrestrial)

For more details, scan the QR code or follow the URL:
https://watercenter.colostate.edu/south-platte-salinity-stakeholder-group/

Indoor Talk 5:
Municipal / Agricultural Collaboration for Water Leasing from Deficit Irrigation

Jon Altenhofen

South Platte Special Project Manager, Northern Water, Berthoud, CO

jaltenhofen@northernwater.org, 970-622-2236

Successful and long-term leasing must be economically incentivized for farmers and cities assured of a reliable supply. Deficit irrigation causes water stress, and the reduced ET (just as with fallowing) can be leased to cities. Monitoring a farmer's water supply and demand and crop response can maintain yield with less ET. This can help with farmer response to droughts, and/or the saved water from reduced ET can be leased to cities through approved Colorado water supply plans and Water Court augmentation plans.

This could be an alternative to cities buying farms and drying them up permanently. However, the key aspect of transferring surface water out of a ditch system to a city is the maintenance of historic return flows (Augmented Deficit Irrigation)—this maintenance is the foundation of Colorado water law and the doctrine of prior appropriation.

At LIRF, we stress grain corn crops to the maximum extent and look at various practices that could maintain the yield, such as drought tolerant varieties, plant population, plant row spacing (twin-row vs. 30-inch row) and irrigation amount and timing as a function of irrigation system whether sprinkler or surface/furrow irrigated. Managing water stress involves (1) avoid it (start with full soil water profile), (2) tolerate it (variety and row spacing), and (3) control/recover from the water stress (irrigation frequency and amount).

The economic benefits to farmers for changing irrigation practices must be positive and incentivized—net profits should be maintained or enhanced through any leases that must be based on current $ per bushel corn prices. The economics is critical for farmer interest/participation, and the USDA-ARS mission area of Research, Education and Economics (REE) is recognized by all that collaborate at the Greeley LIRF facility.

Water Supply Formulas (see next page)

inches = cfs x hours / acres
cfs = gpm / 450
cfs = cubic feet per sec
gpm = gallons per minute

FARM WATER SUPPLY REQUIRED
TO MEET ET
AT A GIVEN EFFICIENCY

GPM per Acre
(Based on Continuous Flowrate per Acre)

ET, inch/day	% IRRIGATION EFFICIENCY 20	30	40	50	60	70	80	90
0.05	4.7	3.1	2.4	1.9	1.6	1.3	1.2	1.0
0.10	9.4	6.3	4.7	3.8	3.1	2.7	2.4	2.1
0.15	14.1	9.4	7.1	5.7	4.7	4.0	3.5	3.1
0.20	18.9	12.6	9.4	7.5	6.3	5.4	4.7	4.2
0.25	23.6	15.7	11.8	9.4	7.9	6.7	5.9	5.2
0.30	28.3	18.9	14.1	11.3	9.4	8.1	7.1	6.3
0.35	33.0	22.0	16.5	13.2	11.0	9.4	8.2	7.3
0.40	37.7	25.1	18.9	15.1	12.6	10.8	9.4	8.4
0.45	42.4	28.3	21.2	17.0	14.1	12.1	10.6	9.4
0.50	47.1	31.4	23.6	18.9	15.7	13.5	11.8	10.5

NOTES:

(1) GPM = Gallons per minute (=cubic feet per sec X 448.8)
Above table based on continuous flowrate; if ditch delivery was for 3 out of 7 days then multiply ditch delivery rate by 3/7 to get reference continuous rate for above table.

(2) ET = EvapoTranspiration from ET weather station / ET instruments (inch/day).
Use a daily value for ET which represents a high ET day OR an average net value.

(3) % IRRIGATION APPLICATION EFFICIENCY:
Flood irrigation (furrow/border) is 30% to 70%
Sprinkler is 70% to 90%

(4) Equation for above table: GPM / Acre = (ET / .eff) * 18.8571

EXAMPLE:

(1) For a daily ET of 0.35 inch/day and an efficiency of 50%, 13.2 GPM per Acre required.
160 acres would require 2,112 GPM
1,000 GPM would supply 76 acres

If your GPM per Acre is greater than the value in the above table then you do not have to irrigate continuously.

If your GPM per Acre is less than the value in the above table then you do not have enough water and your crops will go into water stress.

Indoor Talk 6:
CSU-TAPS (Testing Ag Performance Solutions)

Tim Martin

Executive Director, Irrigation Innovation Consortium, CSU, Fort Collins, CO.

TAPS is a growing season length farming contest and research framework, designed to uncover how producers' management leads to profitable and input-use efficient outcomes.

In TAPS, competitors (individuals or teams) are tasked with selecting a corn hybrid, seeding rate and crop insurance and making irrigation and nitrogen management and marketing decisions through the growing season.

Team decisions are implemented on 3 randomized plots in the same field where crops are irrigated with a variable rate system. CSU-TAPS is hosted at a Colorado State University research farm in Fort Collins.

Contacts:

- Omer Izrael, CSU-TAPS program manager (Omer.Izrael@colostate.edu)
- Amy Kremen, IIC Associate Director (Amy.Kremen@colostate.edu)
- Tim Martin, IIC Executive Director (Timothy.Martin@colostate.edu)

For more information, go to the CSU-TAPS website at: https://www.irrigationinnovation.org/csu-taps

Roundtable: NRCS South Platte River Basin Conservation Effects Assessment Project (CEAP) Watershed Assessment Study

Kyle Mankin[1], Ryan Wells[1], Pete Kleinman[1], Erik Wardle[2], Troy Bauder[2]
Colorado CEAP Watershed Project Team, Fort Collins, CO. [1]USDA-ARS. [2]Colorado Water Center, CSU

What is a CEAP Watershed Assessment Study?

(https://www.nrcs.usda.gov/publications/ceap-watershed-2021-WatershedAssessmentStudiesNetwork.pdf)

Following passage of the 2002 Farm Bill, which significantly increased funding for conservation programs, U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), USDA Agricultural Research Service (ARS) and other USDA agencies created the Conservation Effects Assessment Project (CEAP) in 2003. The goal of CEAP is to measure the effects of agricultural conservation practices and develop the science-base for managing agricultural landscapes for environmental quality. The CEAP Watershed Assessment Studies, a partnership between NRCS, ARS, and numerous other federal and university partners, quantify the effects of conservation practices on water quality, water availability, and soil health within small watersheds. Field and watershed studies also help build understanding of the processes that are influenced by or that drive conservation practice effects.

Earlier plot and field scale studies have documented that conservation practices improved water quality at the edge of a field, but water quality improvements in a watershed have been difficult to observe in large streams and rivers. CEAP efforts are innovative in that they identify more effective conservation practices, enhanced monitoring designs and more accurate simulation models. New understandings of the interactions between conservation practices and novel comprehensive conservation planning approaches help define which fields or areas within a field need conservation practices and what practices can be combined together in a field or watershed to improve water quality.

There are 24 active watershed studies at 19 locations in the US (Figure 1). Research findings from these studies and the associated improved simulation models along with the newly developed conservation practices and assessment tools contribute towards more effective conservation strategies to address goals and document outcomes for the USDA Mississippi River Basin Healthy Watersheds Initiative, the Great Lakes Restoration Initiative, the Chesapeake Bay Watershed Initiative, the Lake Champlain Basin Initiative, and local source water protection efforts.

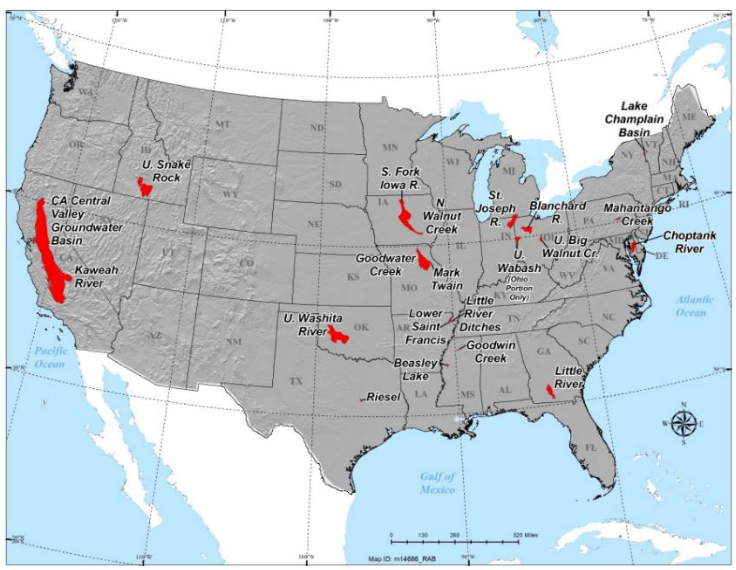


Figure 1. Active CEAP watershed sites. The newest S Platte River Basin CEAP study in NE Colorado is not shown.

For more information on CEAP:

Moriasi DN, Duriancik LF, Sadler EJ, Tsegaye T, … Osmond DL. 2020. **Quantifying the impacts of the Conservation Effects Assessment Project watershed assessments: The first fifteen years**. *JSWC*, 75(3), 57A-74A. https://doi.org/10.2489/jswc.75.3.57A

Colorado South Platte River Basin (SPRB) CEAP Watershed Assessment Study

The Colorado South Platte River Basin (SPRB, Figure 2) encompasses all the water conservation concerns facing western agriculture. Western water management systems, which include complex, legally constrained distributions of water between agriculture and other end users, is an area where management practices and improved decision support systems can play a critical role in agriculture's evolving use of water resources.

Agricultural water conservation concerns begin in the forested headwaters of the Rocky Mountains, where management to mitigate wildfire burn impacts on hydrology and water quality (Figures 3, 4) ensures that downstream water users have reliable supplies of water that match the quantity, quality and timing of availability that they require.

Agriculture within the SPRB includes irrigated, dryland and range production, requiring diverse conservation strategies that must be integrated to address the region's water resource issues. USDA's rangeland efforts apply key priorities from CEAP's previous recommendations for grazinglands, following a participatory, collaborative approach. On irrigated cropland, efficient delivery of water and nutrients are essential to managing diminishing water availability for agriculture. Dryland conservation efforts include alternative cropping strategies and precision conservation, all framed under the risk of severe water limitation.

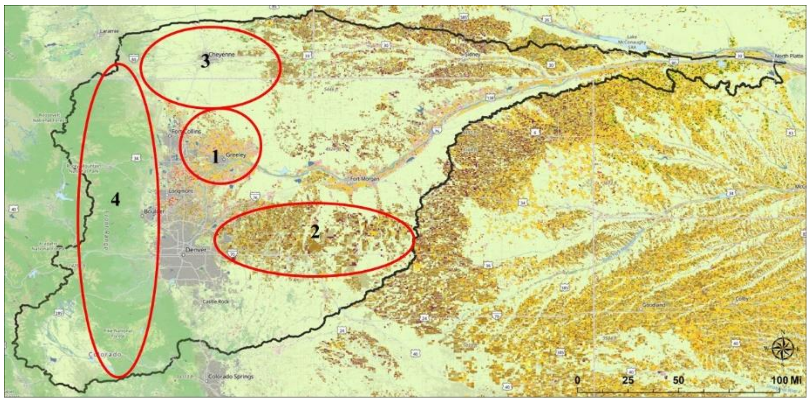


Figure 2. SPRB CEAP study area showing generalized regions of 1) irrigated agriculture, 2) dryland agriculture, 3) rangeland, and 4) forested headwaters (2023 NASS).

For this project, collaborative research by USDA-ARS, Colorado State University and their partners will use monitoring, modeling, and experimentation to examine the influence of conservation practices on water quantity and water quality (nutrients and sediments) within the Colorado SPRB.


Figure 3. Smoky sunset due to the Alexander Mountain Fire near Bellvue, CO on July 31, 2024.

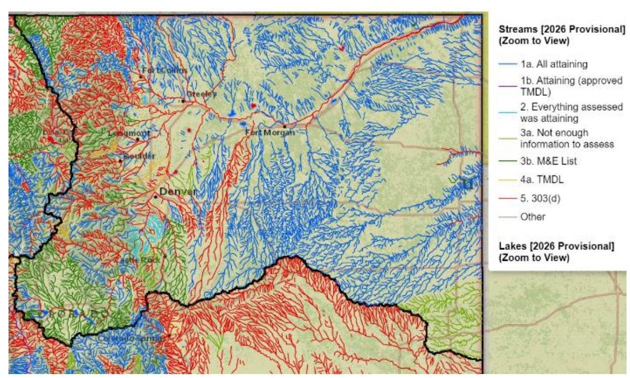


Figure 4. Stream segmentation and level of impairment for SPRB (CDPHE).

Poster (Other WMSRU Research):
Wildfire and climate change amplify knowledge gaps linking mountain source-water systems and agricultural water supply in the western United States

Dave Barnard[1], Tim Green[1], Kyle Mankin[1], Kendall DeJonge[1], Chuck Rhoades[2], Stephanie Kampf[3], Jeremy Giovando[4], Mike Wilkins[3], Adam Mahood[1], Megan Sears[1,3], Louise Comas[1], Sean Gleason[1], Huihui Zhang[1], Steve Fassnacht[3], Daren Harmel[1], Jon Altenhofen[5]

[1]USDA-ARS, Water Management & Systems Research Unit, Fort Collins, CO

[2]US Forest Service, Rocky Mountain Research Station, Fort Collins, CO

[3]Colorado State University, Fort Collins, CO

[4]Ice Engineering Group, Cold Regions Research & Eng. Lab, Eng. Research & Dev. Center, Hanover, NH

[5]Northern Colorado Water Conservancy District, Berthoud, CO

Water resources from seasonal snowpack and rainfall in high elevation mountains are an essential freshwater source in many semi-arid regions. However, these areas are increasingly impacted by a changing climate and disturbance such as wildfire, resulting in streamflow volumes that are variable and difficult to predict. This difficulty is especially impactful to agricultural producers who rely on snowmelt and streamflow forecasts for crop selection and irrigation planning. The future of sustainable food production in the western United States depends on a reliable and predictable water source, but little research has been done to link together mountain source-water systems and agricultural water supply forecasting. In this paper we review how source water systems function and are impacted by disturbance and climate change, and relate these topics back to water supply management and forecasting, and on-farm decision making for agricultural production. Improved understanding of how mountains source waters and agricultural end users are linked will improve forecasting ability and improve food production.

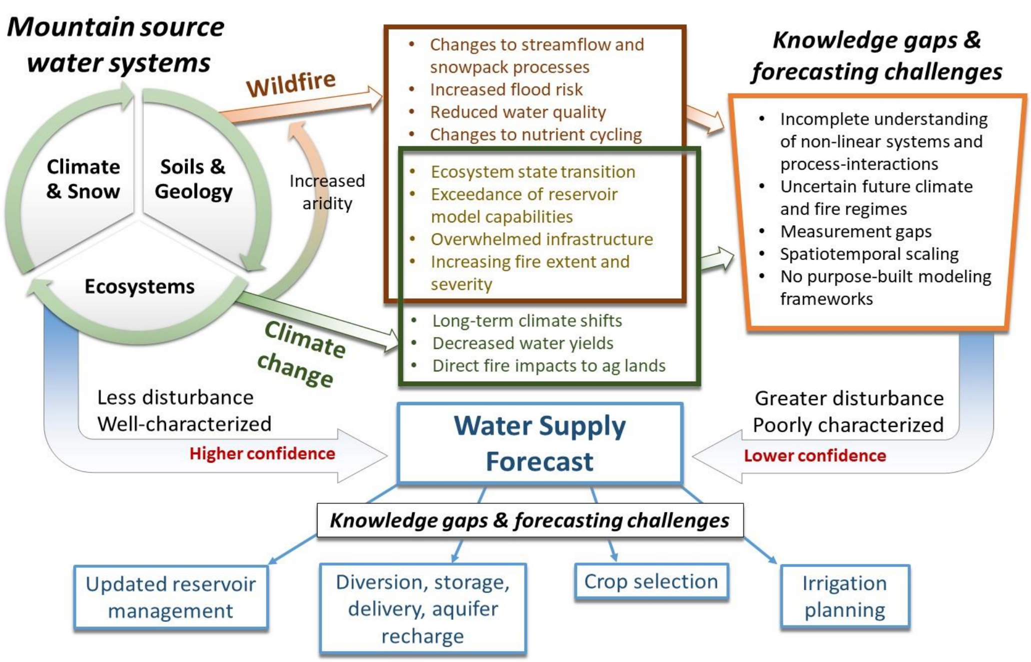


Figure 1: Conceptual diagram of mountain source water system functioning and water supply forecasting including complications due to the impacts of climate change and wildfire.

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