Climate Smart Agriculture: What, Why, and How

Southern Rocky Mountain Ag Conference
Monte Vista, Colorado

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OFFICE of ENGAGEMENT

Colorado State University

Colorado Water Institute
A division of the Office of Engagement
Colorado State University

The Three Pillars of Climate Smart Agriculture

Talk Outline

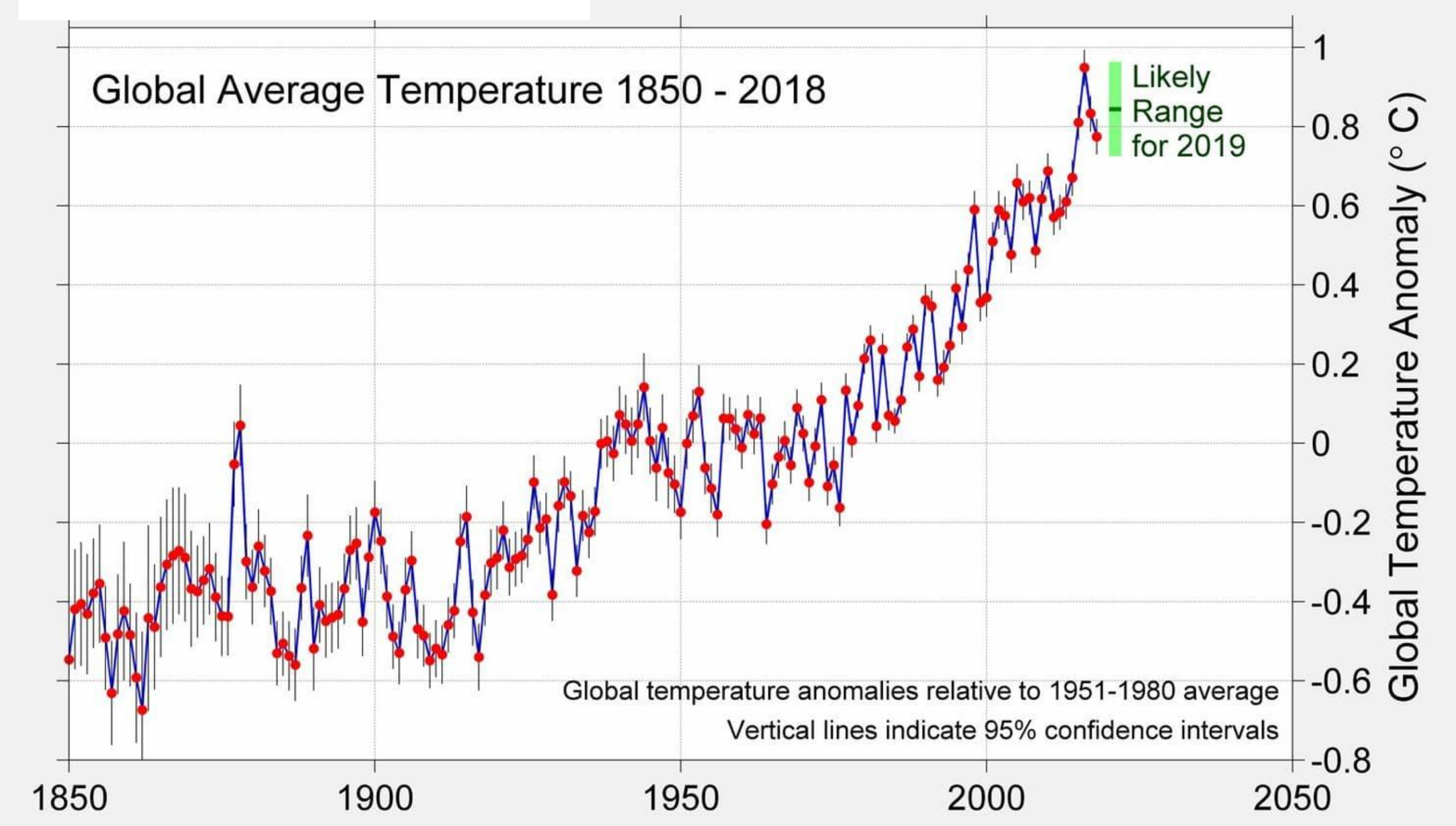
- Climate Events of 2018
- Colorado Agriculture Overview
- Climate Smart Agriculture: Why and What
- Impacts, Risks and Vulnerabilities to Ag
- Soil Carbon and Health
- Greenhouse Gas Mitigation of Ag
- Ending Comments
- Resources

You can put climate change on a t-shirt!

Climate and Environment

2018 was the fourth warmest year on record -- and more evidence of a 'new normal,' scientist group reports

By Chris Mooney
January 24 at 11:28 AM



Global warming will happen faster than we think

Three trends will combine to hasten it, warn **Yangyang Xu**, **Veerabhadran Ramanathan** and **David G. Victor**.

1. Continued High Emissions
2. Cleaner Air
3. Ocean Circulations

Nature, 2018

IPCC Special Report on Impacts of 1.5° C Warming

October 7, 2018

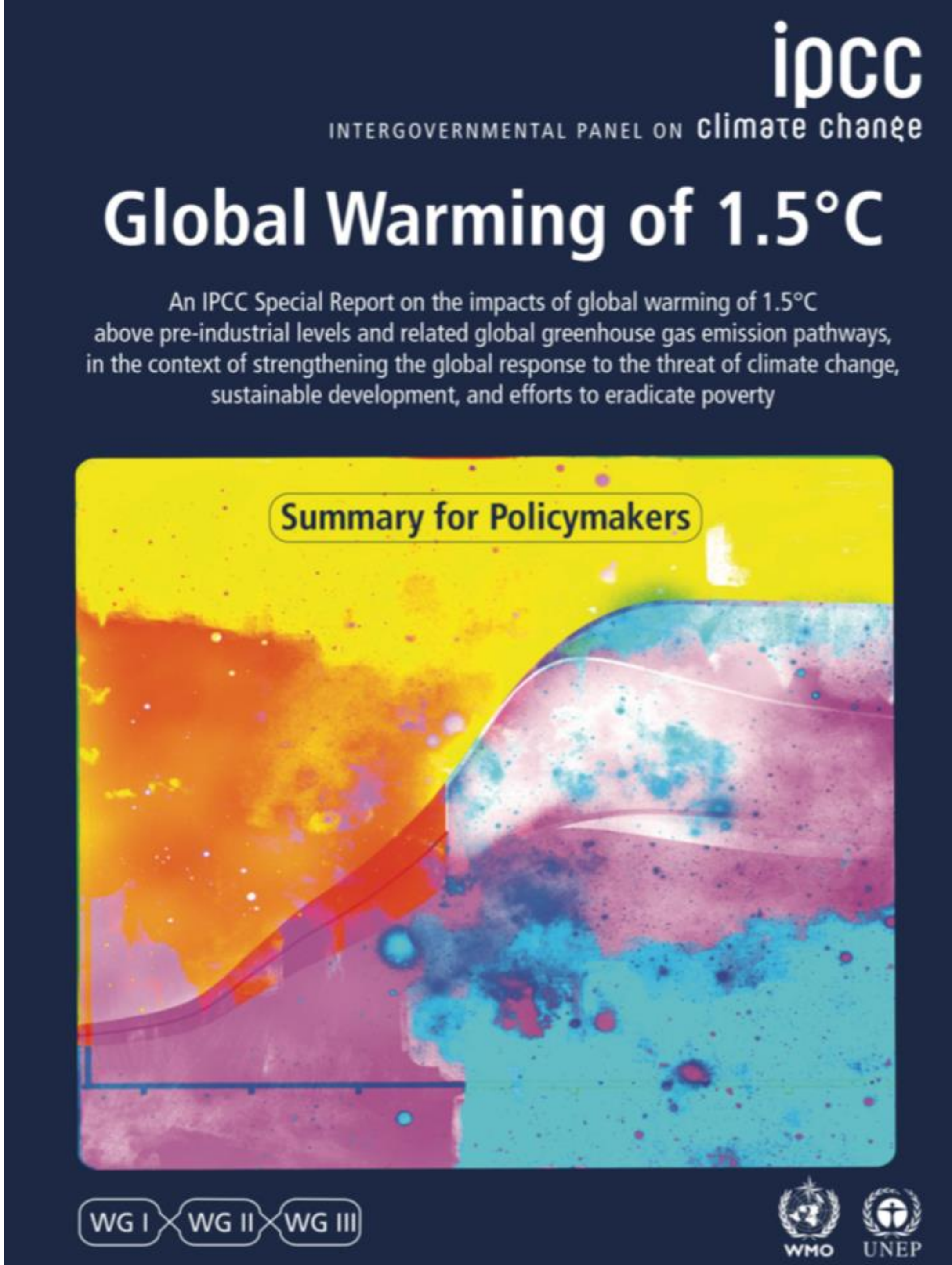
- 0.8° C warming already
- 1.5° C warming would be damaging
- 2.0° C could approach intolerable in places

- Current Promises to cut emissions lead to 3.5 ° C by 2100

- To avoid 1.5°C
    - Unprecedented actions needed
    - Steep Downward emissions by 2030
    - No historical analog to needed actions

- Takeaway 1: every 0.1° C warming is important. There is no ‘cliff’ beyond which is it ‘too late to act.’

- Takeaway 2: Focus on temperature obscures the most important goal. We must get to net 0 emissions as soon as possible. Negative emissions will become important.



4th National Climate Assessment

November 23, 2018

3 years in the making
400 co-authors
29 Chapters

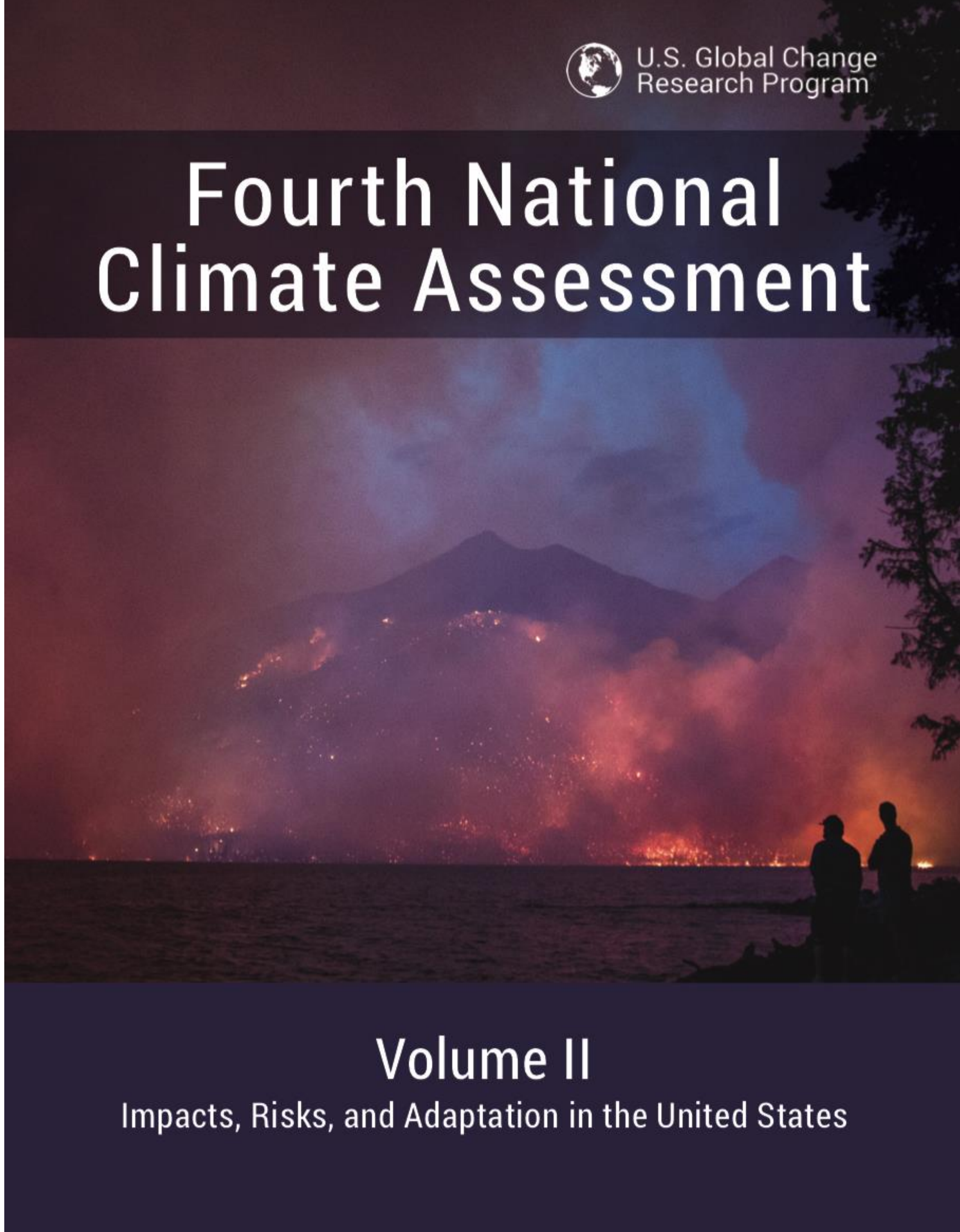
4 Major Findings (of 12)

- Impacts already being felt
    - Fires, Floods, Droughts, Hurricanes

- Future impacts will disrupt many areas of life

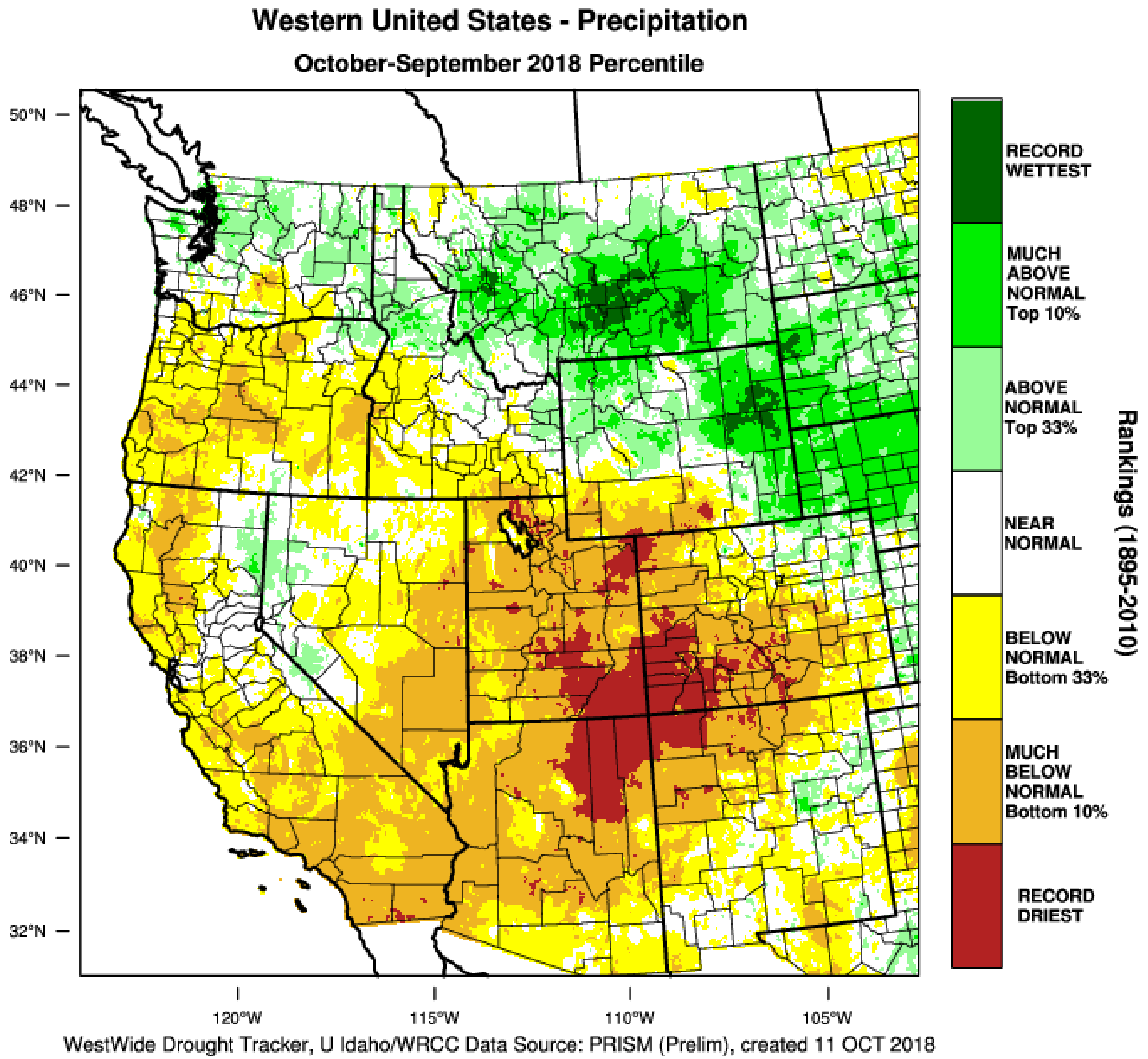
- Without substantial and sustained mitigation and adaptation, will cause growing losses to infrastructure, property and impede economic growth

- Quality and Quantity of water changing

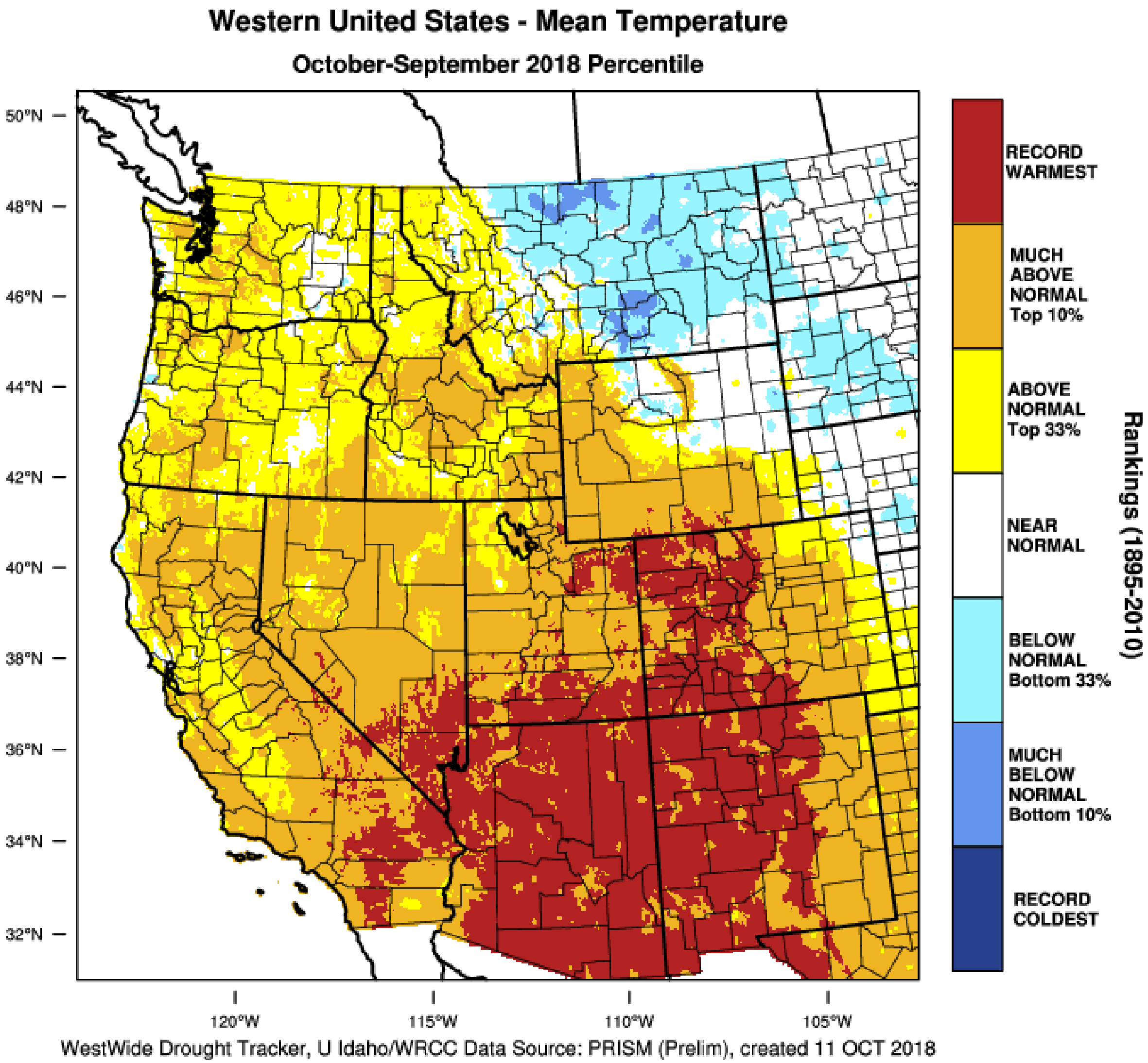


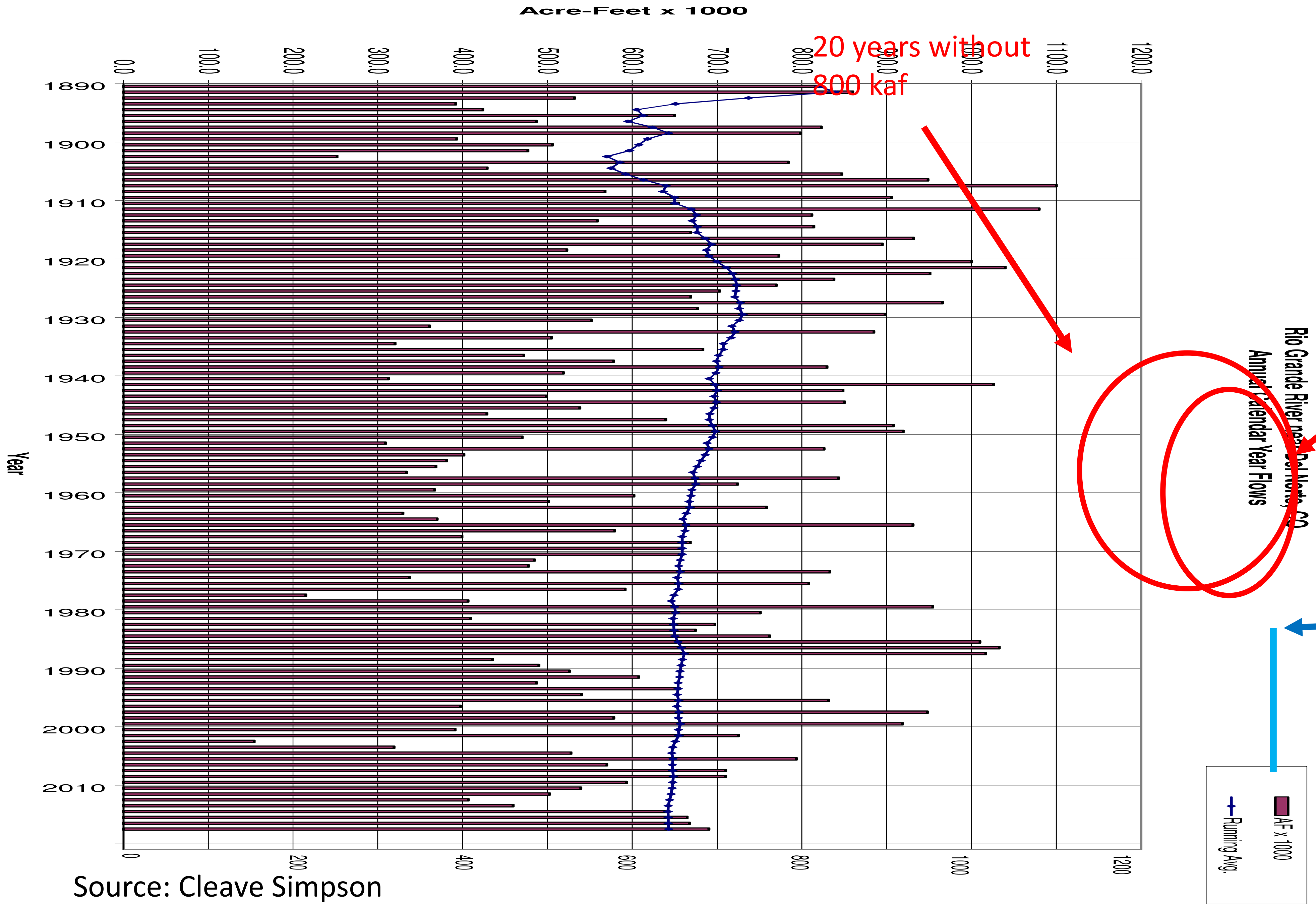
2018 was a brutal year for Colorado Agriculture

Lowest Precipitation on Record 4 Corners Area



Warmest Temps on Record in Many Parts of the State



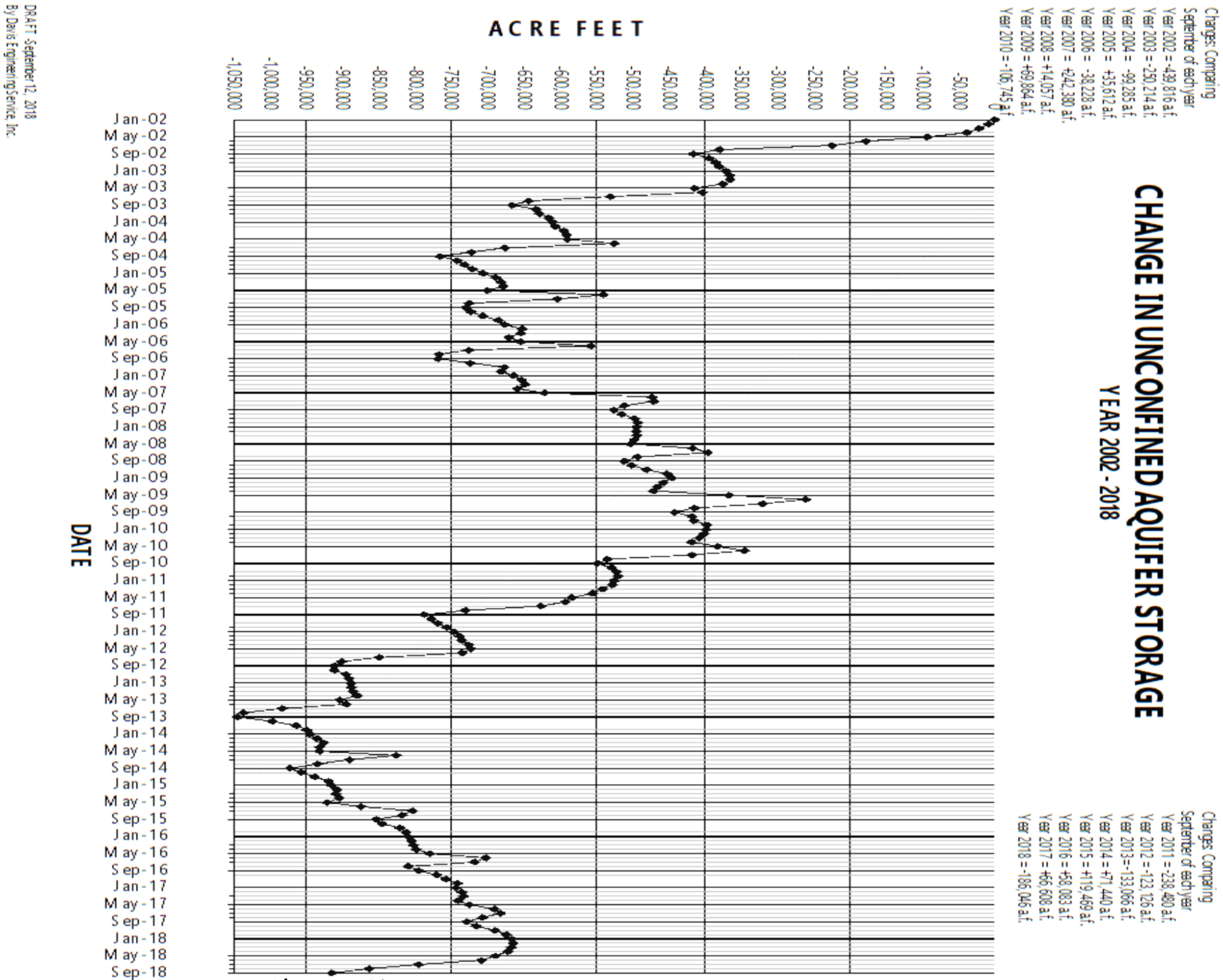


20 years without 800 kaf

10 Years without 700 kaf

285 kaf in 2018, estimated

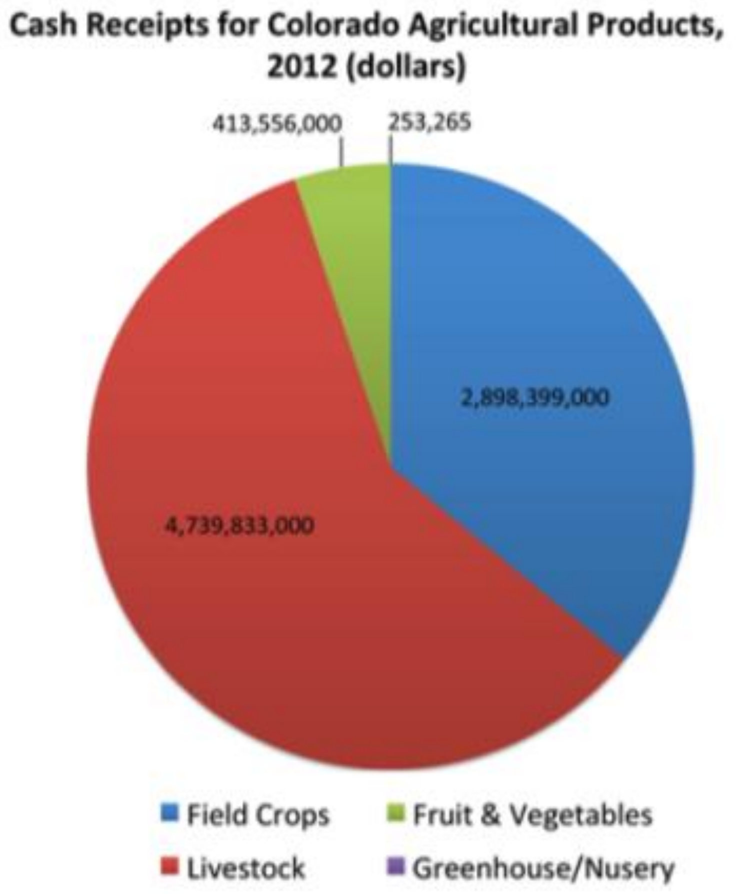
Source: Cleave Simpson



Source: Cleave Simpson

Colorado Agriculture

- Important to Colorado
  - 100% of Economy in many places
  - Huge Amenity Values elsewhere
- Climate Challenges
  - Too Much Water
  - Too Little Water
  - Heat
  - Fires
  - Odd Weather Patterns
- US Ag is ~10% of US Greenhouse Gas Emissions
  - Methane
  - Nitrous Oxide
  - Some CO2

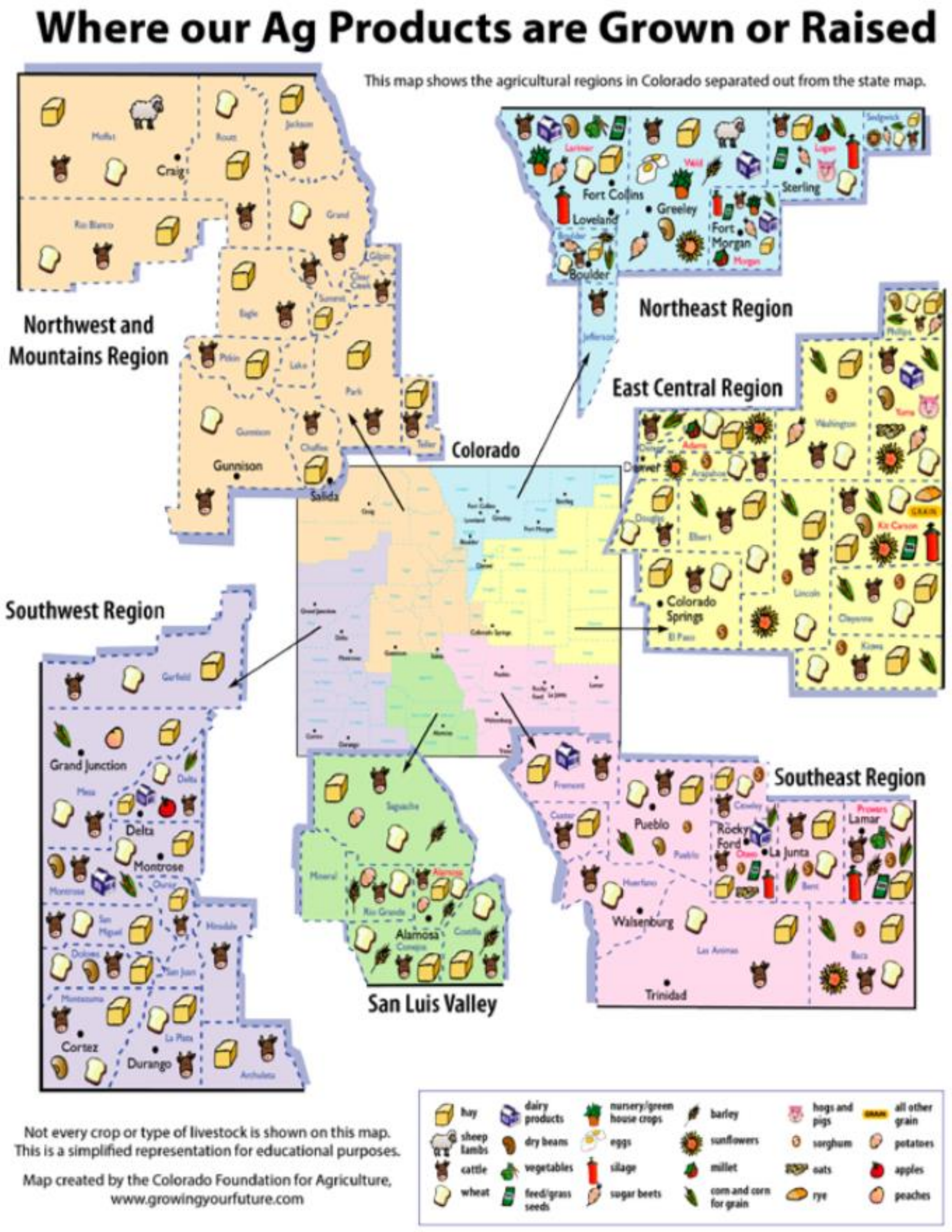


$8B / Year in Cash Receipts all Ag Products

Colorado Ag Products by Location

- Hay
- Sheep/Lambs
- Cattle
- Wheat
- Dairy
- Dry Beans
- Vegetables
- Grass Seeds
- Nursery
- Eggs
- Silage
- Sugar Beets
- Barley
- Sunflowers
- Millet
- Corn
- Hogs and Pigs
- Sorghum
- Oats
- Rye
- Other Grains
- Potatoes
- Apples
- Peaches

San Luis Valley: Wheat, Potatoes, Barley, Cattle, Alfalfa Carrots, lettuce, spinach, quinoa, cover crops, rye, canola, irrigated forage



Source: Colorado Foundation for Agriculture

Climate Smart Agriculture

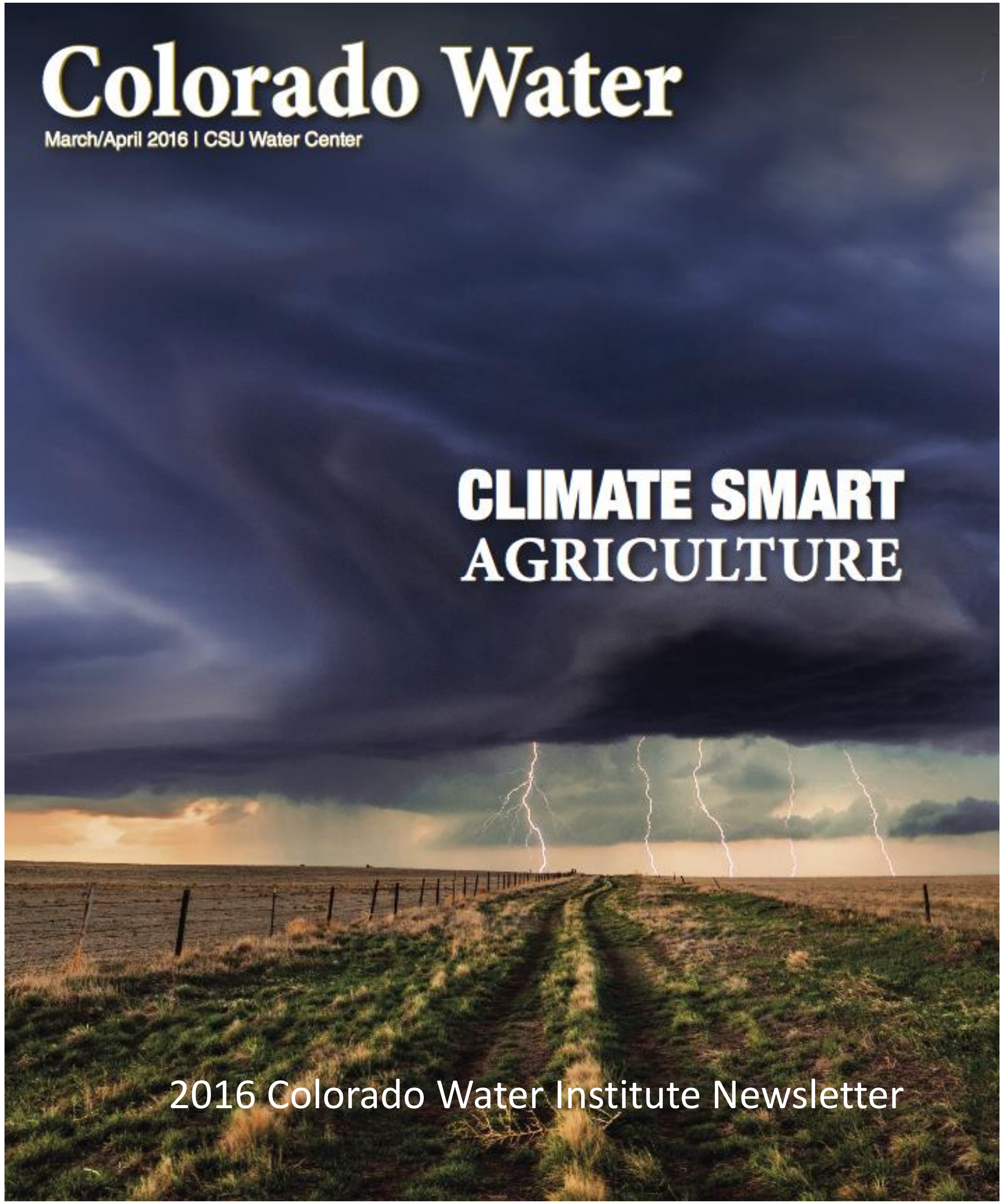
- What is it?
  - A framework for ag to handle/manage climate change
    - ~ 40% of the land surface
    - ~ 20% of Emissions worldwide, ~10% US
  - Adopted by CSU ~2016
  - Very much a work in progress

- 3 Pillars
  1. Sustainable Intensification

     Grow more food on same land base

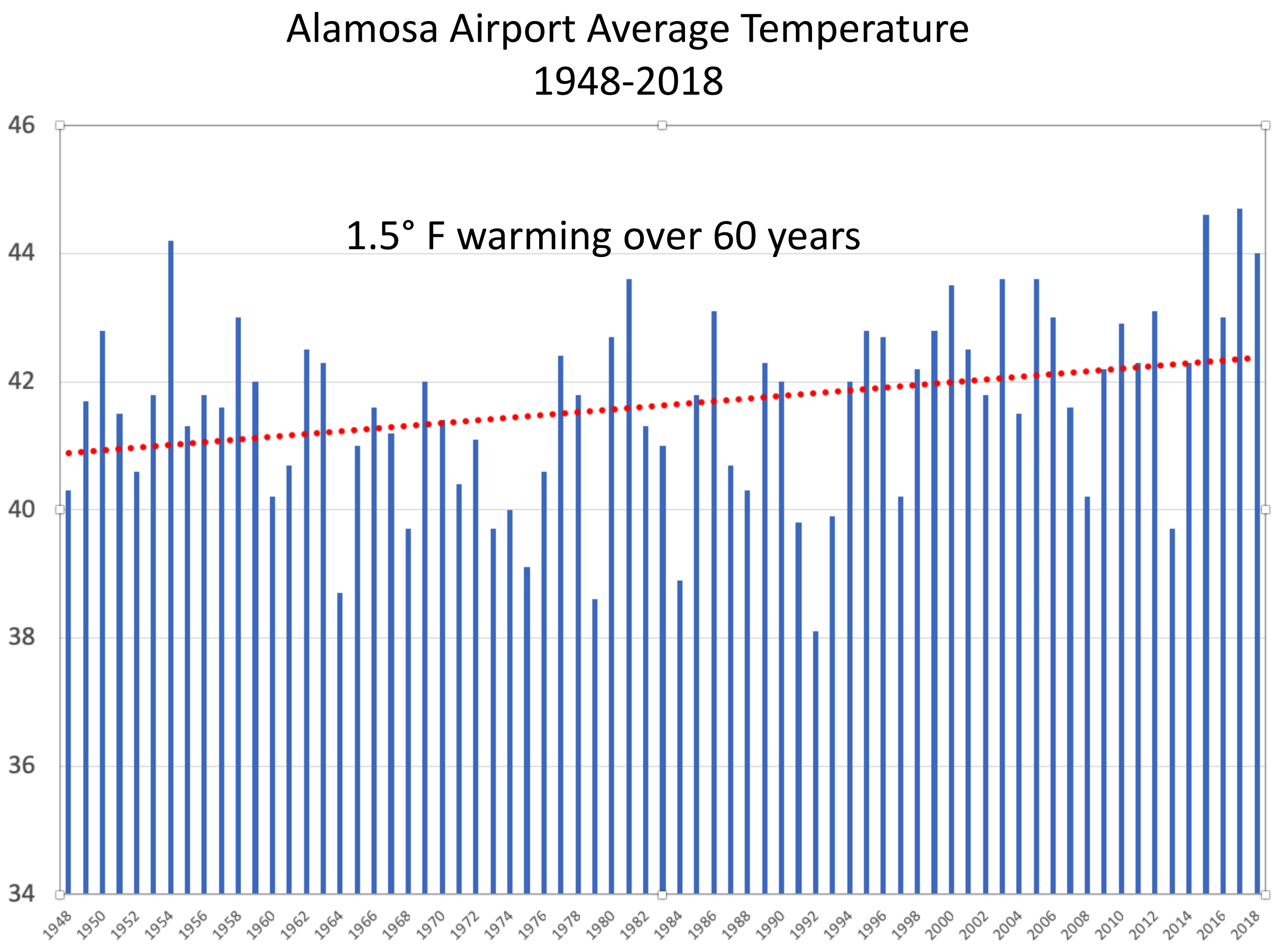
     9B people in 2050, 11B in 2100
  2. Adaptation to climate change

     Technology
     Farm Production Practices
     Farm Financial Management
     Govt Programs & Insurance
  3. Mitigation (Reduction) of Greenhouse Gasses



Why Climate Smart Agriculture at CSU?

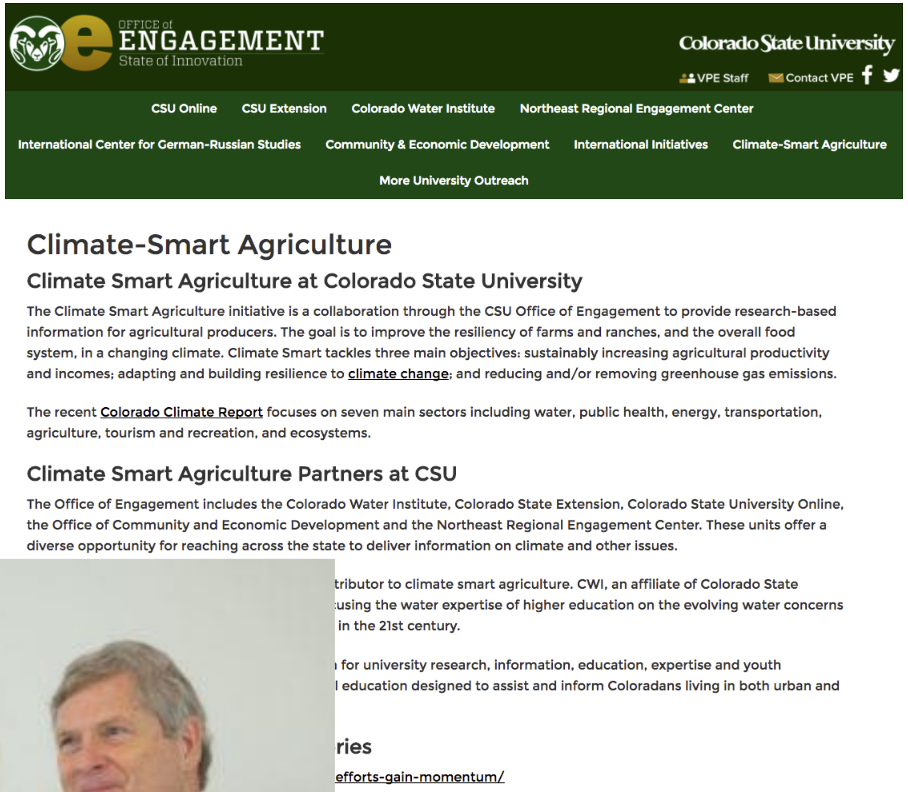
- 2016 Extension Listening Sessions
  - Pueblo, Akron, Adams County
  - Total of ~30 Agents
- Findings
  - Producers and Agents aware of climatic changes
  - But great reluctance to tie these changes to human actions
  - Agents want more information
  - Support for new CSU Climate Smart Ag Initiative



Alamosa temperature increase mirrors US and Worldwide increase

CSU CSA Activities

- CSA Web Page
- Interface with Governor's Staff
  - Colorado Department of Agriculture
- USDA Climate Hub Activities
  - E.g., GrassCast
  - Workshops
- Outreach
  - Western Dairy, Farm Bureau, Wheat Growers, Farm Show, etc
- Newsletters
- Online Courses
- Best Management Practices
- Conferences
- Drought Activities



CSU's CSA Webpage

Secretary Vilsack at CSU CSA Event

USDA Climate Hubs

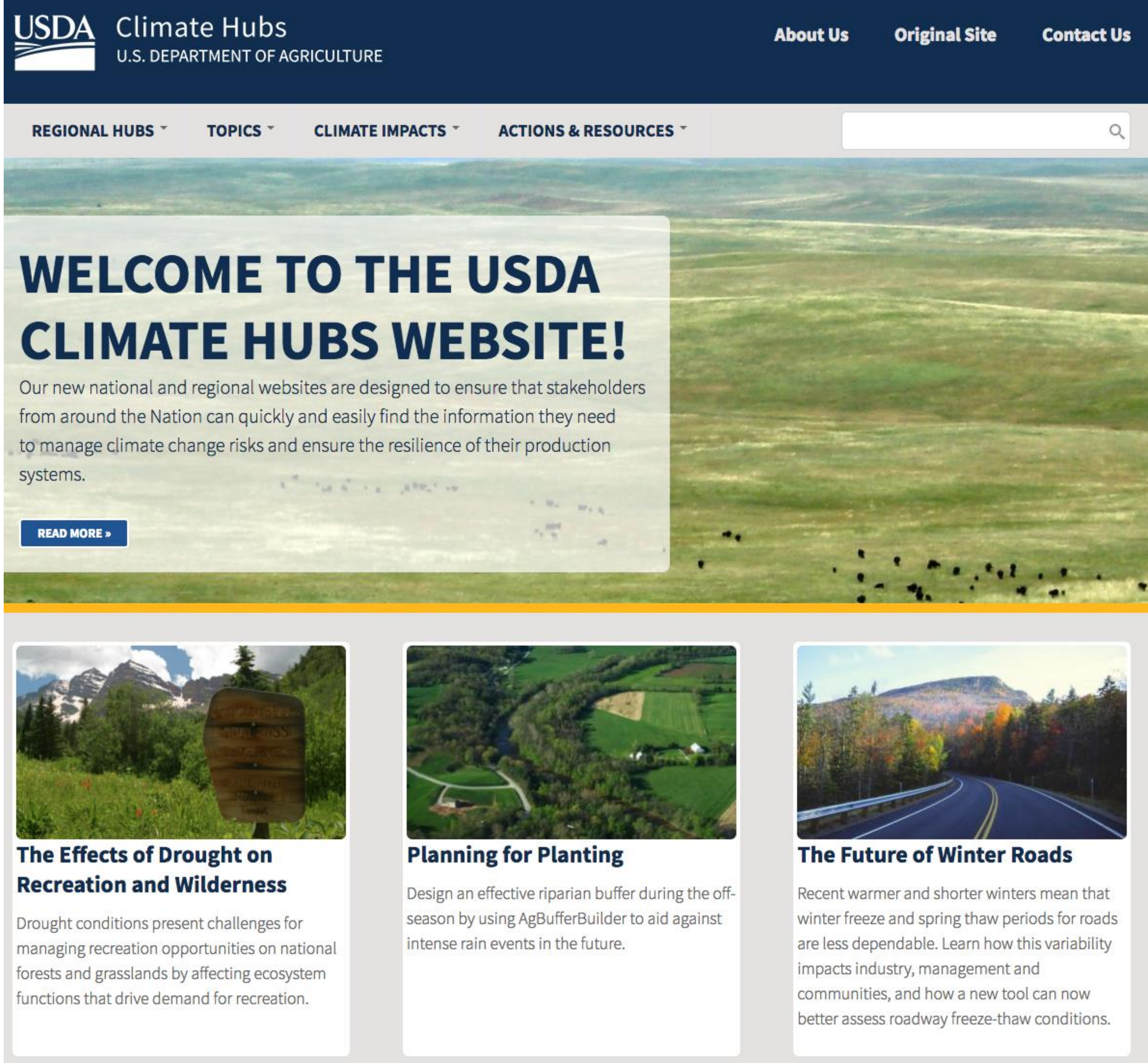
Established 2013 by Sec. Vilsack

Led by:
- ARS
- USFS

With help from USDA Agencies:
- APHIS
- NRCS
- FSA
- RMA

Mission:

Develop and Deliver science-based regionally specific information and technology that enables climate-informed decision making



Where are the Regional Climate Hubs located?

Danelle Peck

Windy Kelley

Colorado is in Northern Plains Region but Southwest and Southern Plains Hub may also be useful

What do the Climate Hubs do?

Research and Science Information Synthesis

- Provide periodic regional assessments of risk and vulnerability to production sectors and rural economies. This includes writing portions of or contributing to the National Climate Assessment prepared by the United States Global Change Research Program (USGCRP).
- Support applied research and development and innovation partnerships for risk management and climate change response.
- Work closely with extension organizations, universities, technical service providers, and the private sector to be a source of user-friendly information developed from a wide variety of sources.

Tool Development, Technology Exchange, and Implementation Assistance

- Deliver science-based agriculture, forestry, and land management tools and strategies for responding to impacts of a changing climate such as drought, extreme weather events, and changing growing seasons.
- Improve access to usable regional data and climate change projections and forecasts in support of risk management and climate adaptation planning.
- Provide coordinated technical support to supplement USDA agriculture and land management program delivery, especially to underserved and vulnerable communities, tribes, and individuals.

Stakeholder Education, Outreach, and Engagement

- Provide outreach and education to farmers, ranchers, and forest landowners on science-based risk management.
- Educate natural and agriculture resource managers on the latest understanding of climate science and the effects of climate change on working lands.
- Engage with our stakeholders and partners in innovative and interactive ways to help lower the barriers to adaptation, manage risk, and enhance rural productivity.

Overview Document for the Northern Plains Climate Hub

Climate Overview
- Past and Future

Cropping and Grazing Systems
- Risks
- Vulnerabilities
- Adaptation Strategies

Greenhouse Gasses Emissions Profile and Mitigation Opportunities

USDA Northern Plains Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies

Photo Credit: David Augustine, ARS

Authors: Justin Derner (ARS), Northern Plains Hub Lead; Linda Joyce (Forest Service) Northern Plains Hub; Rafael Guerrero (NRCS), Northern Plains Hub; Rachel Steele, National Climate Hubs Coordinator

Northern Plains Climate Hub
USDA ARS, Natural Resources Research Center
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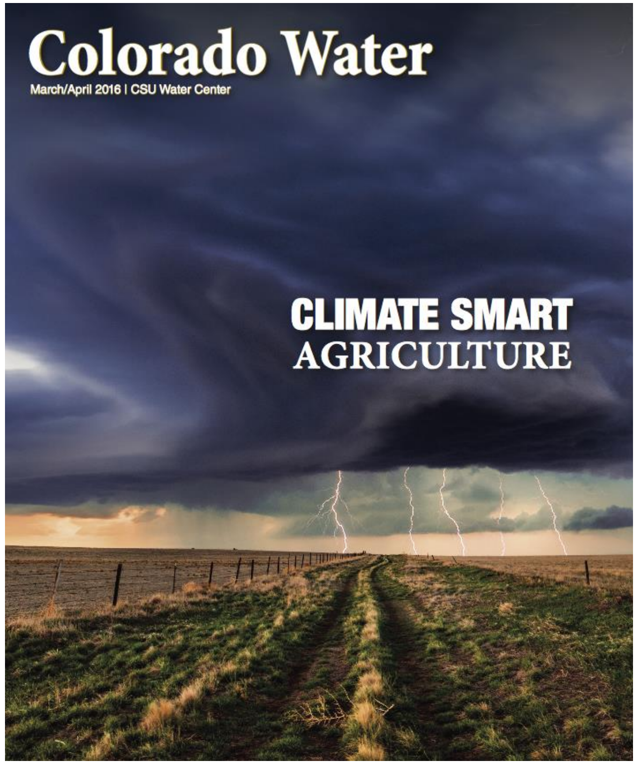
May 2015

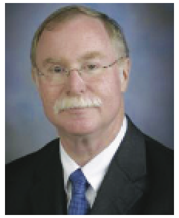
Contributors: Our thanks to Juliet Bochicchio, RD; Wendy Hall and Marlene Cole, APHIS; Sharon Hestvik, RMA; Aaron Krauter, FSA; Dana Coelho and Trey Schillie, Forest Service; Michele Schoeneberger and Gary Bentrup, National Agro-forestry Center (Forest Service); Sharon Papiernik, Ann Heckart, and Lee Panella, ARS; and David Buland, Elise Boeke, Joyce Swartzendruber, Neil Dominy, Ted Alme, Jeffrey Zimprich, and Dennis Kimberlin, NRCS. We acknowledge ICF International for their contributions to the Greenhouse Gas Profile.

Edited By: Terry Anderson, ARS.

Climate-Smart Ag Newsletter - 2016



Editorial LOU SWANSON



I am writing this note at a hotel in downtown Beijing—one of the global posterchildren for the ecological crises and the political, economic and social complexities for addressing climate change. Here, all of your senses vividly register the consequences of human activity on the atmosphere, water, and soils. The Chinese government is feverishly ramping up efforts to mitigate pollution, including nitrate and chemical associated with their agricultural practices. At the end of last year a remarkable event occurred in Paris. After over twenty years of discussions, one failed agreement, and five major scientific assessments involving thousands of scientists, 195 countries agreed to reduce their emissions of carbon to avoid harmful climate change. One hundred ninety-five countries actually agreed to recognize our common dependency on our planet.

Over my career, including as a Peace Corps Volunteer in western Tunisia, I have watched the climate change issue unfold with major impacts on the ground and have watched the science of climate dynamics mature. Concerns about the future resiliency of agriculture, in Colorado and globally, have led the Office of Engagement to undertake a new initiative on Climate Smart Agriculture to help producers plan for a future with a changing climate and the resulting social and economic adaptations. The goal of this initiative is to reduce the vulnerability of agriculture to a changing climate, including

Features— Climate Smart Agriculture

On the cover: Akron, Colorado
Photo by Bryce Bradford

Ralph Parshall, one of Colorado's water leaders and an internationally-celebrated member of the CSU faculty, gave a speech in 1957 at the Rotary Club in Fort Collins where he talked about how greenhouse gases emitted by humans could change the climate. Climate has since grown to be a significant international concern. Courtesy of Water Resources Archive, CSU Libraries

Ralph Parshall's speech to the Rotary Club in 1957 about climate change

Reagan Waskom & Dennis Ojima
Article

Short, Simple Introduction to Ag Impacts and Adaptation Opportunities

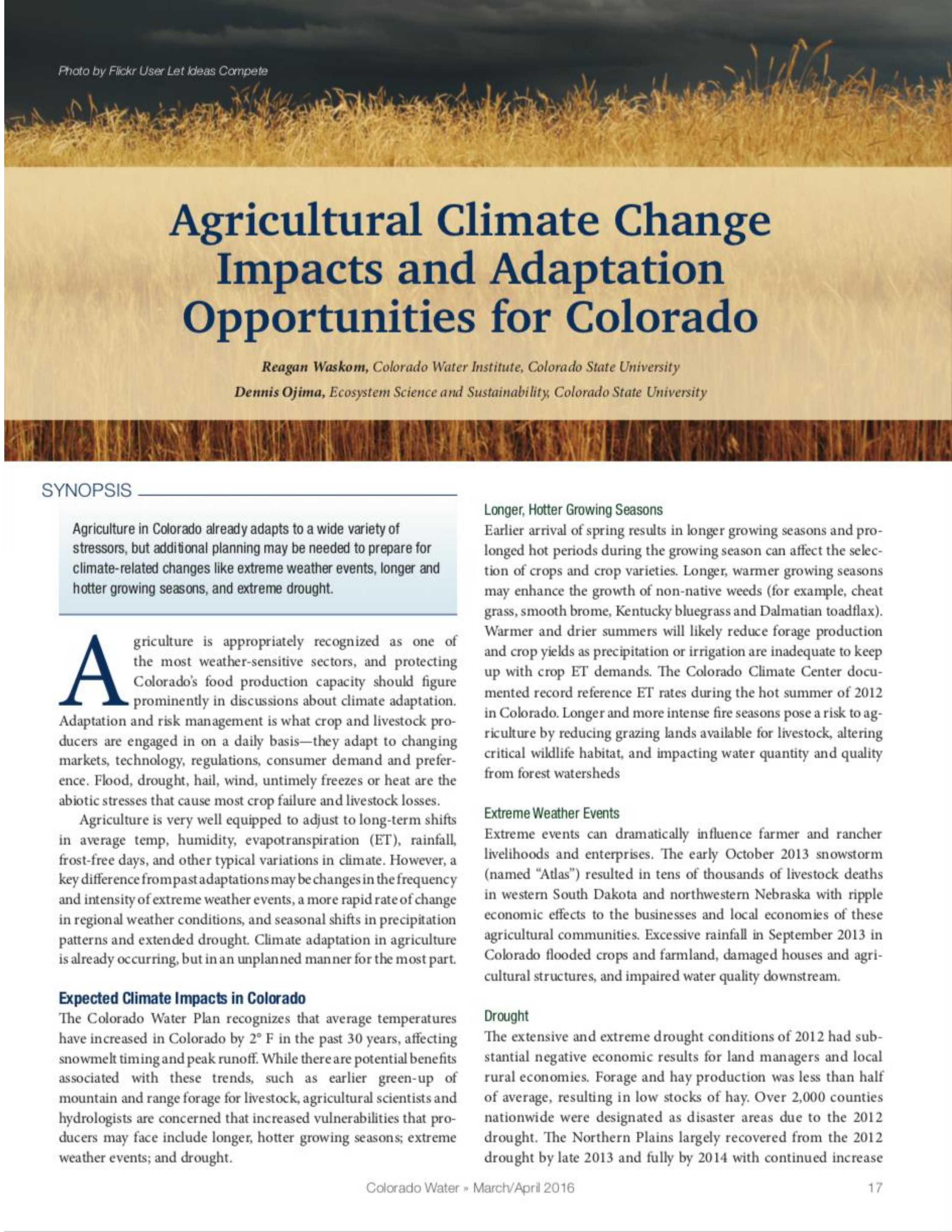


Photo by Flickr User Let Ideas Compete

Agricultural Climate Change Impacts and Adaptation Opportunities for Colorado

Reagan Waskom, *Colorado Water Institute, Colorado State University*
Dennis Ojima, *Ecosystem Science and Sustainability, Colorado State University*

SYNOPSIS

Agriculture in Colorado already adapts to a wide variety of stressors, but additional planning may be needed to prepare for climate-related changes like extreme weather events, longer and hotter growing seasons, and extreme drought.

Agriculture is appropriately recognized as one of the most weather-sensitive sectors, and protecting Colorado's food production capacity should figure prominently in discussions about climate adaptation. Adaptation and risk management is what crop and livestock producers are engaged in on a daily basis—they adapt to changing markets, technology, regulations, consumer demand and preference. Flood, drought, hail, wind, untimely freezes or heat are the abiotic stresses that cause most crop failure and livestock losses.

Agriculture is very well equipped to adjust to long-term shifts in average temp, humidity, evapotranspiration (ET), rainfall, frost-free days, and other typical variations in climate. However, a key difference from past adaptations may be changes in the frequency and intensity of extreme weather events, a more rapid rate of change in regional weather conditions, and seasonal shifts in precipitation patterns and extended drought. Climate adaptation in agriculture is already occurring, but in an unplanned manner for the most part.

Expected Climate Impacts in Colorado

The Colorado Water Plan recognizes that average temperatures have increased in Colorado by 2° F in the past 30 years, affecting snowmelt timing and peak runoff. While there are potential benefits associated with these trends, such as earlier green-up of mountain and range forage for livestock, agricultural scientists and hydrologists are concerned that increased vulnerabilities that producers may face include longer, hotter growing seasons; extreme weather events; and drought.

Longer, Hotter Growing Seasons

Earlier arrival of spring results in longer growing seasons and prolonged hot periods during the growing season can affect the selection of crops and crop varieties. Longer, warmer growing seasons may enhance the growth of non-native weeds (for example, cheat grass, smooth brome, Kentucky bluegrass and Dalmatian toadflax). Warmer and drier summers will likely reduce forage production and crop yields as precipitation or irrigation are inadequate to keep up with crop ET demands. The Colorado Climate Center documented record reference ET rates during the hot summer of 2012 in Colorado. Longer and more intense fire seasons pose a risk to agriculture by reducing grazing lands available for livestock, altering critical wildlife habitat, and impacting water quantity and quality from forest watersheds

Extreme Weather Events

Extreme events can dramatically influence farmer and rancher livelihoods and enterprises. The early October 2013 snowstorm (named "Atlas") resulted in tens of thousands of livestock deaths in western South Dakota and northwestern Nebraska with ripple economic effects to the businesses and local economies of these agricultural communities. Excessive rainfall in September 2013 in Colorado flooded crops and farmland, damaged houses and agricultural structures, and impaired water quality downstream.

Drought

The extensive and extreme drought conditions of 2012 had substantial negative economic results for land managers and local rural economies. Forage and hay production was less than half of average, resulting in low stocks of hay. Over 2,000 counties nationwide were designated as disaster areas due to the 2012 drought. The Northern Plains largely recovered from the 2012 drought by late 2013 and fully by 2014 with continued increase

Colorado Climate Change Vulnerability Study

2014 CSU + CU Study
+ Colorado Energy Office

Climate Overview

Sectors

- Ecosystems
- Public Health
- Energy
- Water
- Transportation
- Agriculture
- Recreation

Type of Crop
Climate Impact
Key Vulnerability

	Climate Impact	Key Vulnerabilities
Field Crops	• Rising temperatures	• Crop yields vulnerable to reductions due to heat stress
	• Increasing frequency and severity of drought	• More frequent losses of crops, forage, and soil
	• Earlier onset of spring; longer growing seasons	• Crops vulnerable to increased weeds and pests due to longer growing season
	• Potentially reduced streamflow	• Production losses due to irrigation shortages
	• Increased CO_2 levels	• Crops potentially affected by weeds encouraged by CO_2 fertilization
	• Extreme weather events	• Continued losses of crops, facilities (structures, ditches, equipment)
Fruits and Vegatables	• Earlier spring thaws	• Fruit crops vulnerable to frost damage worsened by early budburst
	• Increasing frequency and severity of drought	• Increased potential for water shortages occurring simultaneously with higher crop water demand
	• Reduction streamflow, especially in late summer	• Reduced production due to limited irrigation supply, increased water prices
Livestock	• More favorable conditions for pathogens	• Cattle vulnerable to lower weight gain and other health problems due to higher temperatures
	• Increasing temperatures	• Loss of weight and animal health in higher temperature; increased costs of facilities
Green Industry	• Extreme weather events	• Damage to facilities and products
	• Potential reduction in streamflow	• Loss of production due to water use restrictions

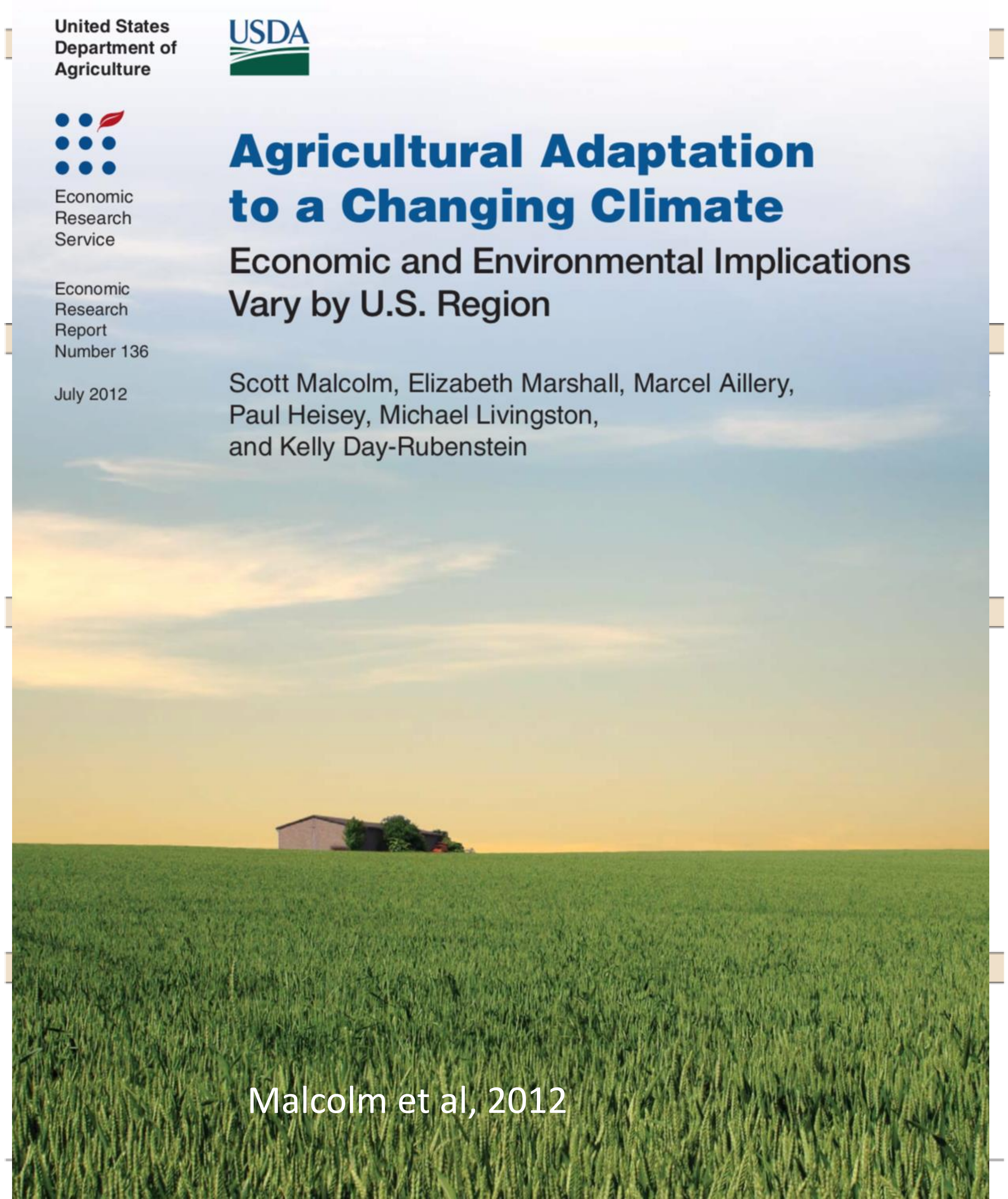
Agricultural Adaptation Options

Technology
- New cultivars
- Weather and Climate Information
- Water Management Innovations

Government Programs and Insurance
- Ag Subsidy and Price Support Programs
- Private Insurance

Farm Production Practices
- Diversify crop and livestock types
- Alternative Fallow and Tillage
- Irrigation
- Timing of Operations (plant/harvest)

Farm Financial Management
- Crop Insurance



Malcolm et al, 2012

Key Drivers

Adaptation Strategies → Farm Production Practices

Farm Financial Management

Farm Infrastructure

Technological Developments

Govt Programs and Insurance

Climate Variability

Soil Degradation

Pests

Droughts

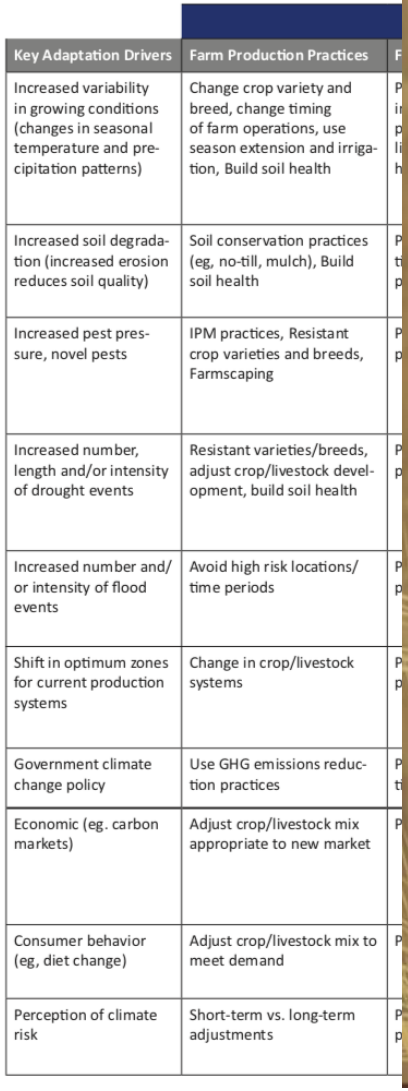
Floods

Govt Policy

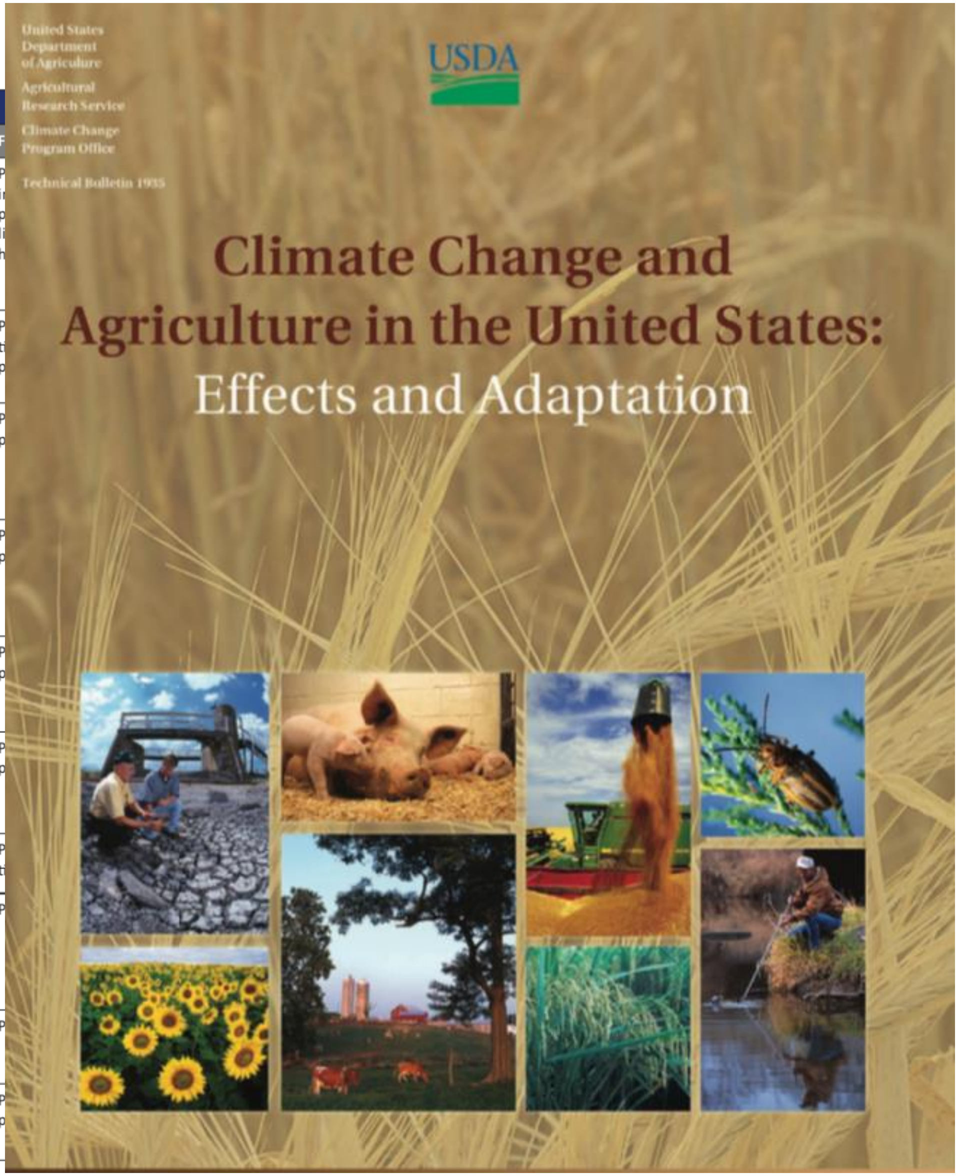
Economic (e.g. Carbon Markets)

Consumer Behavior (diets)

Perception of Risk



Key Adaptation Drivers	Farm Production Practices
Increased variability in growing conditions (changes in seasonal temperature and precipitation patterns)	Change crop variety and breed, change timing of farm operations, use season extension and irrigation, Build soil health
Increased soil degradation (increased erosion reduces soil quality)	Soil conservation practices (eg, no-till, mulch), Build soil health
Increased pest pressure, novel pests	IPM practices, Resistant crop varieties and breeds, Farmscaping
Increased number, length and/or intensity of drought events	Resistant varieties/breeds, adjust crop/livestock development, build soil health
Increased number and/or intensity of flood events	Avoid high risk locations/time periods
Shift in optimum zones for current production systems	Change in crop/livestock systems
Government climate change policy	Use GHG emissions reduction practices
Economic (eg. carbon markets)	Adjust crop/livestock mix appropriate to new market
Consumer behavior (eg, diet change)	Adjust crop/livestock mix to meet demand
Perception of climate risk	Short-term vs. long-term adjustments



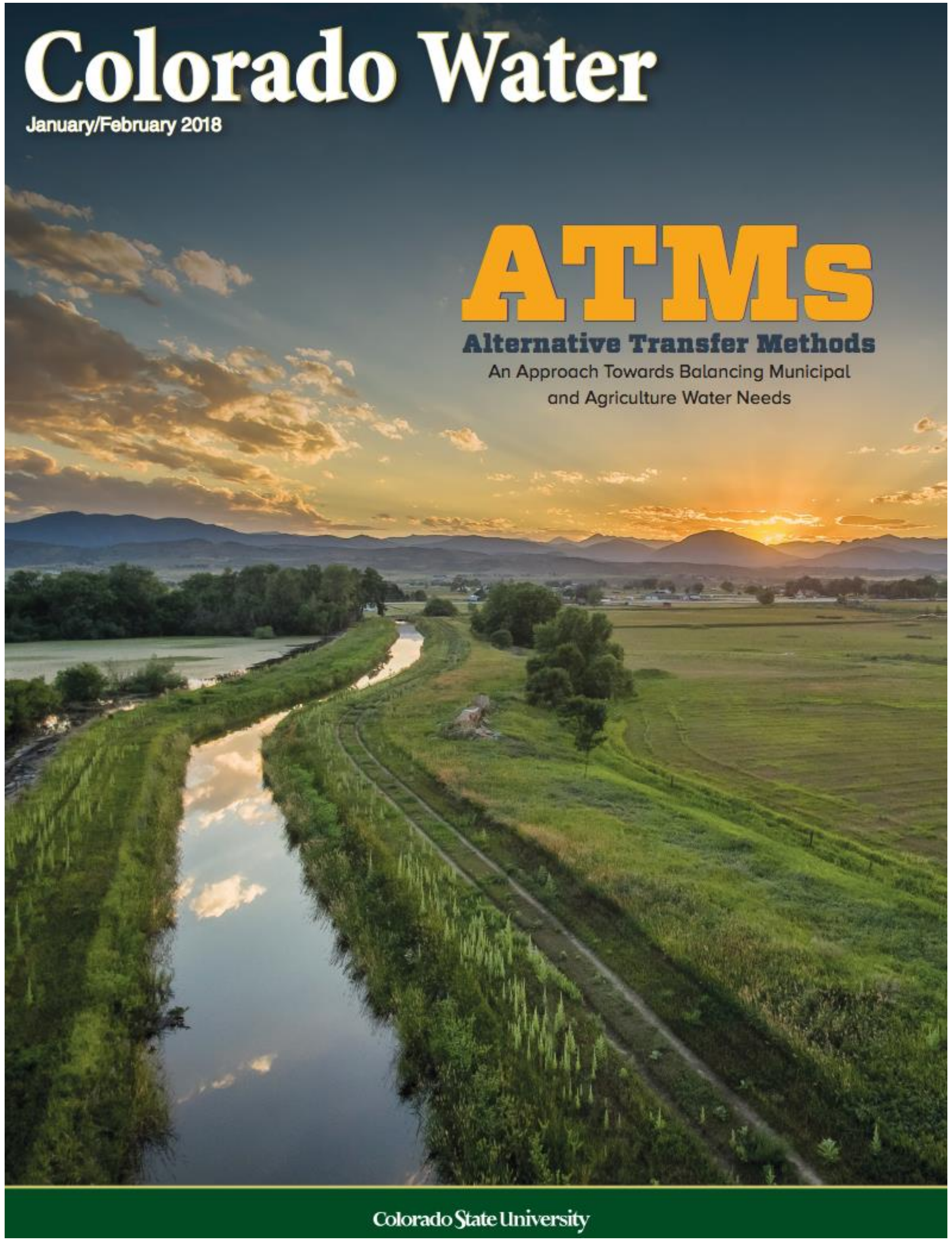
Alternatives to Permanent Fallowing

- Provide a Literature Review of what we know about
  - Deficit Irrigation
  - Rotational Fallowing
  - Crop Switching
  - Irrigation Efficiency

- Colorado River Basin Focus
  - Upper Basin Agriculture very different from Lower Basin

- Purpose:
  - Provide Information to policy makers, NGOs, producers and others on alternatives to permanent fallowing
  - CSU not advocates for/against

- Meetings held
  - Grand Junction
  - Tucson
  - Washington, DC



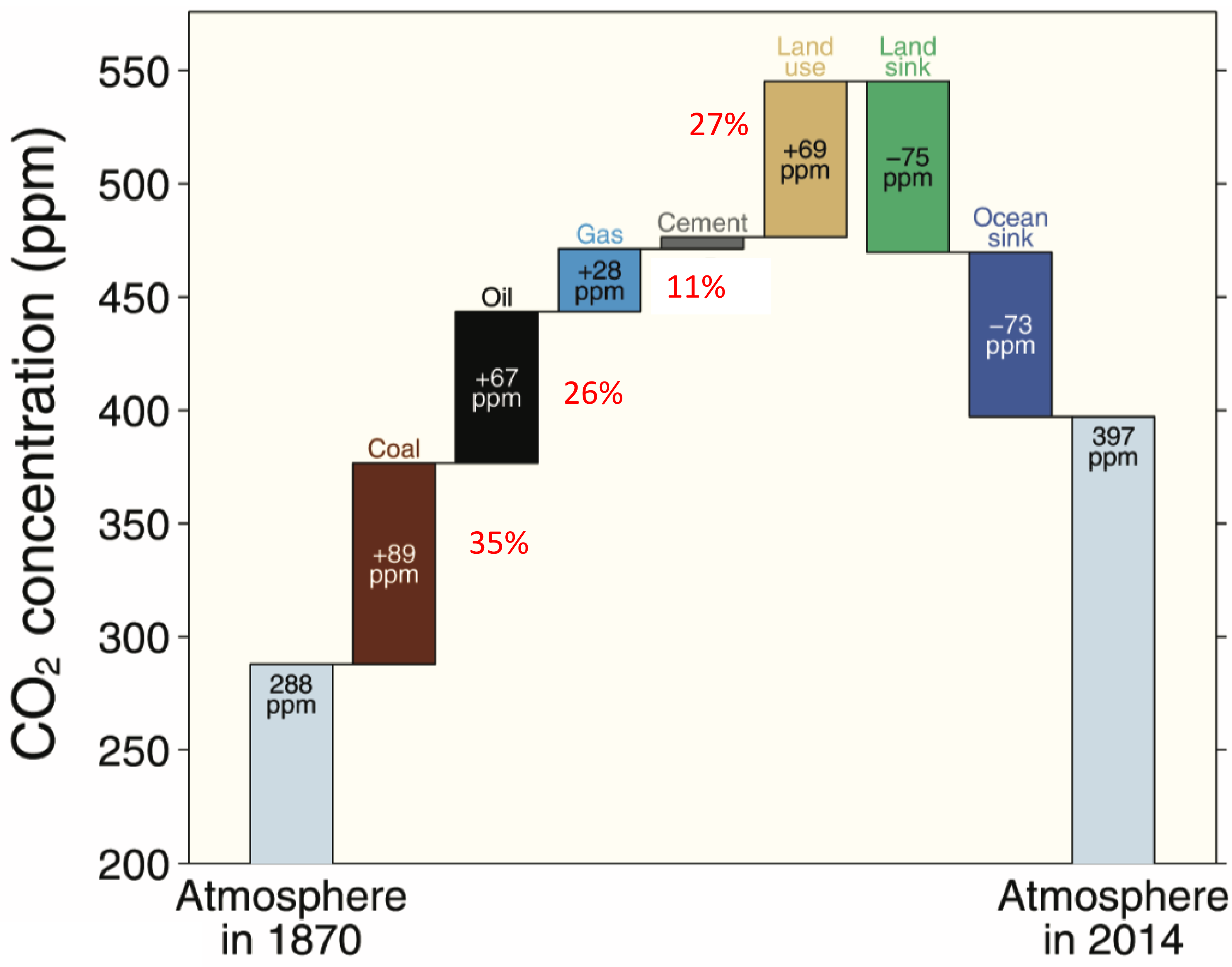
Agricultural Contribution to Atmospheric C02 Increases

Contributions to CO2 increases from 1870 "Pre-Industrial" to 2014

Key contributors to the increase:

Land Use: = 27 %

Coal = 35 %
Oil = 26 %
Gas = 11 %



Soil Carbon / Health

- ”Living Epidermis of the Planet”

- Plants, Animals, Microbes in soil
- Largest Temporary Storage of Water
- $4T in agricultural products yearly

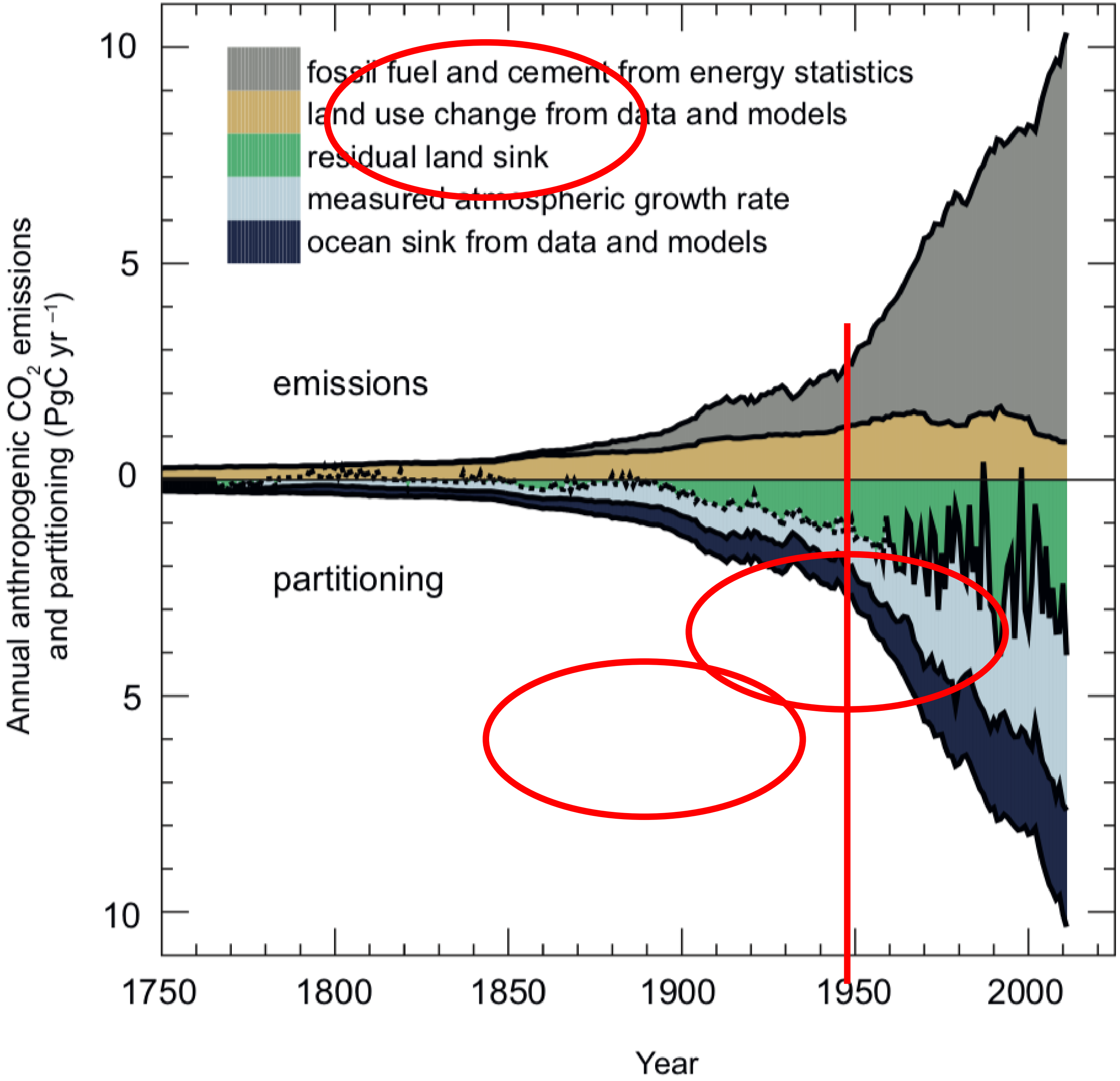
- Huge, Dynamic Carbon Reservoir
  - 2-4x size of atmospheric carbon
  - critical part of carbon cycle

- Cultivation ‘ignited’ vast store of carbon
  - ~ 130 Billion Tons of Carbon Lost
  - = 25% of total emissions since 1850

- Soils have been fundamentally altered
  - ‘Domesticated’ soils

- Up until mid-20th century biomass burning and cultivation carbon loss exceeded fossil fuel emissions

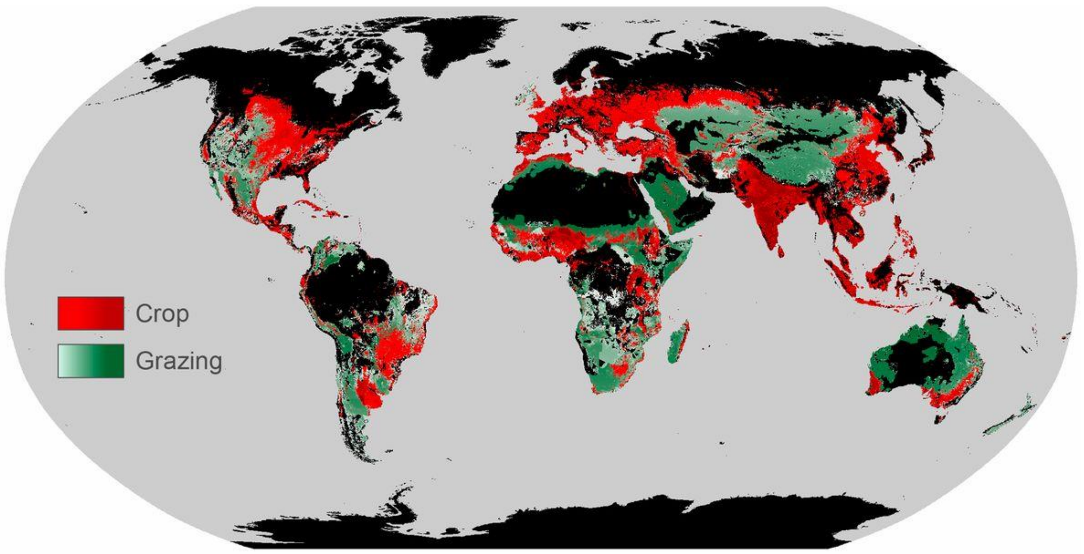
C02 Sources (above 0) and Sinks (below 0)



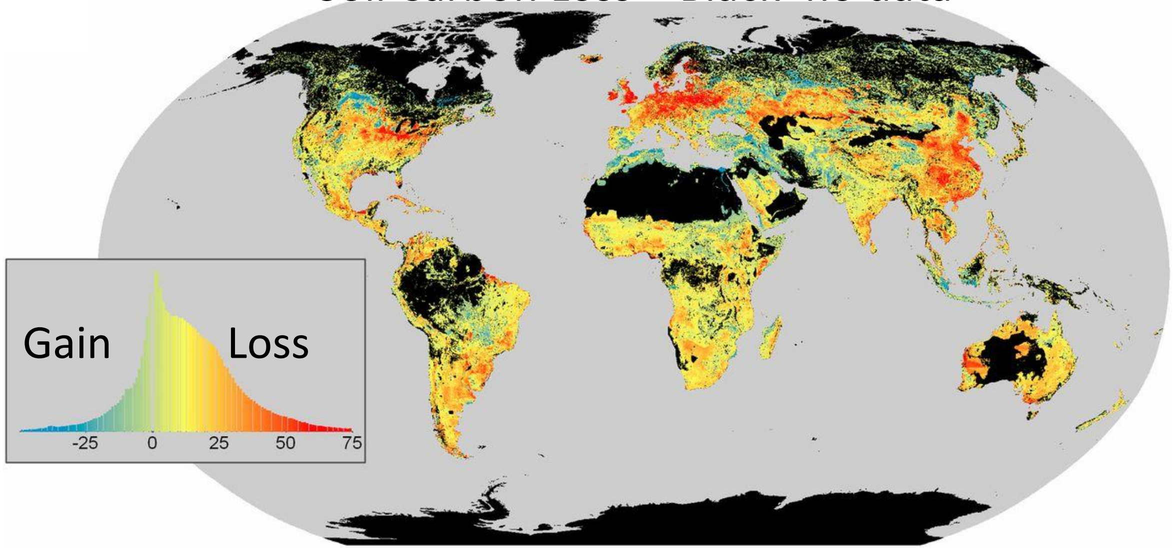
Soil Carbon / Health

- Soil Carbon
  - 0.5 to 4% naturally
  - helps to holds water
  - provides nutrients from decomposition
  - provides structure to soil
- Original Loss from Northern areas, now equator
- Possible to recover some of lost carbon
  - 1.3 GtC/year max (15% total GHG emissions)
- Difficulties
  - Measurement, retaining SOC
- Erosion is big problem
  - water is biggest culprit but also wind
  - with cover crop, less erosion possible
  - water preferentially moves lightest, carbon-rich top soil

Crop and Grazing Areas



Soil Carbon Loss – Black=no data



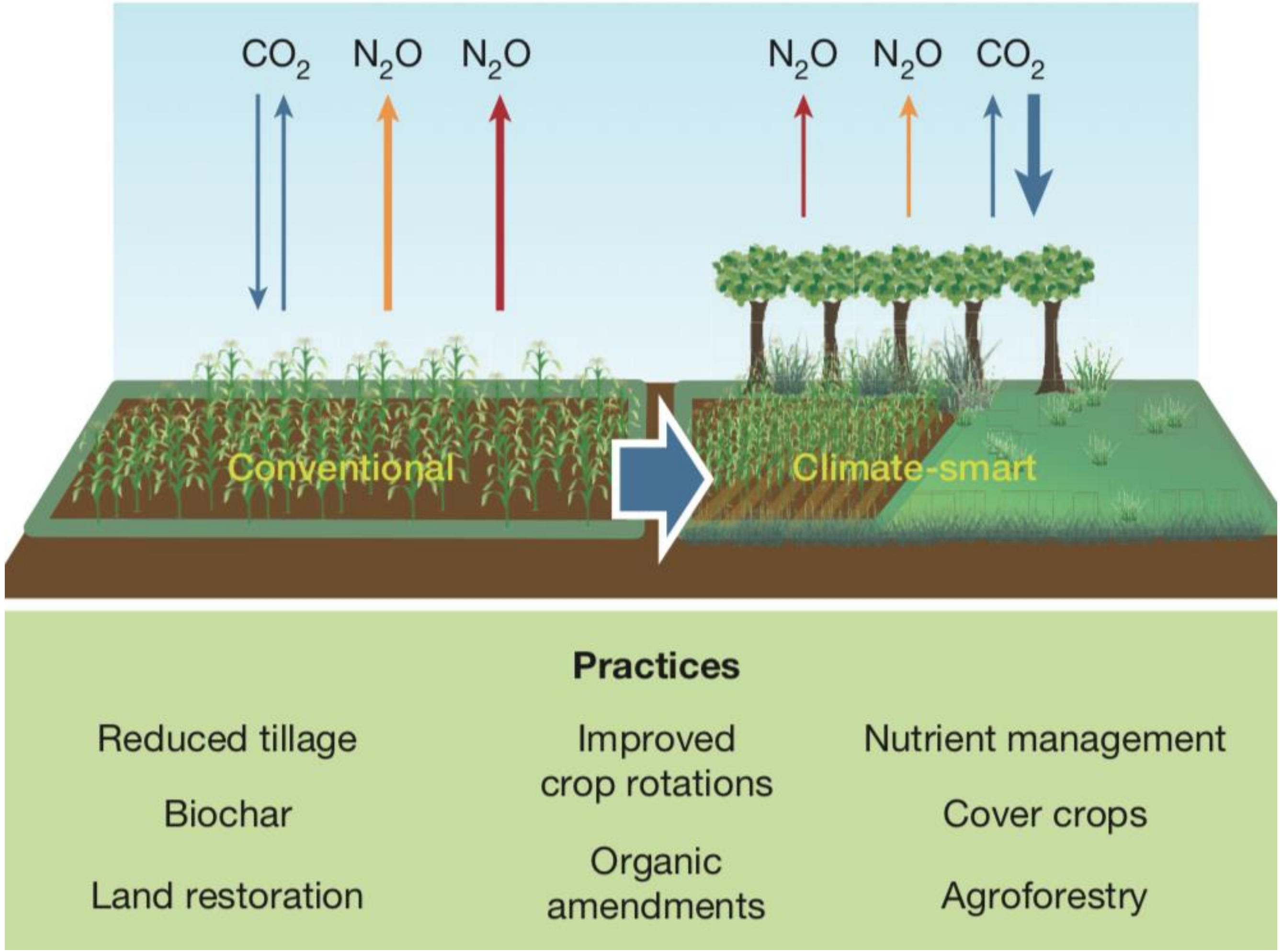
Soil Health Benefits

- Science not always clear that increased soil carbon will provide a yield benefit
  - Fertilizer can offset low soil carbon

- But clear yield benefits to
  - Tubers
  - Cereals

- Other Benefits
  - Soil structure
  - Water holding
  - Micro nutrients
  - Carbon sequestration

- How to increase soil carbon ?
  - Less tillage
  - Leave residues on surface
  - Cover crops (where water)
  - Crops with more roots (new crops?)
    - grasses especially good
  - Improved crop rotations
  - Amendments/Biochar

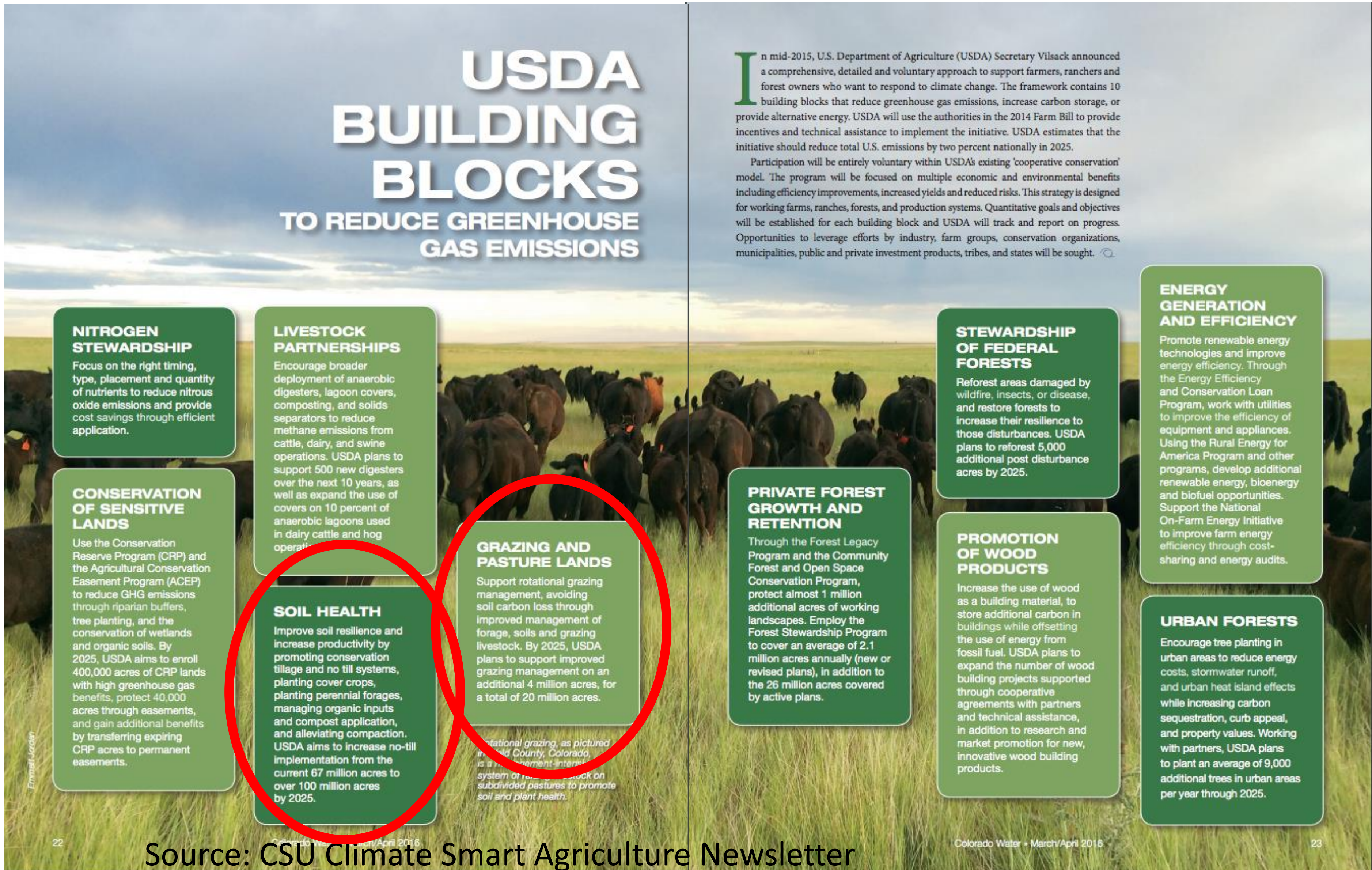


Climate Smart Practices can reduce GHG emissions and improve soil health

Paustian et al., 2016

Climate Smart Agriculture: GHG Mitigation

- US Agriculture GHGs are ~10% of US Total Emissions
- USDA Building Blocks were part of US Paris Pledge to reduce GHGs
- Built on existing NRCS programs
- Status Unknown


USDA BUILDING BLOCKS TO REDUCE GREENHOUSE GAS EMISSIONS

In mid-2015, U.S. Department of Agriculture (USDA) Secretary Vilsack announced a comprehensive, detailed and voluntary approach to support farmers, ranchers and forest owners who want to respond to climate change. The framework contains 10 building blocks that reduce greenhouse gas emissions, increase carbon storage, or provide alternative energy. USDA will use the authorities in the 2014 Farm Bill to provide incentives and technical assistance to implement the initiative. USDA estimates that the initiative should reduce total U.S. emissions by two percent nationally in 2025.

Participation will be entirely voluntary within USDA's existing 'cooperative conservation' model. The program will be focused on multiple economic and environmental benefits including efficiency improvements, increased yields and reduced risks. This strategy is designed for working farms, ranches, forests, and production systems. Quantitative goals and objectives will be established for each building block and USDA will track and report on progress. Opportunities to leverage efforts by industry, farm groups, conservation organizations, municipalities, public and private investment products, tribes, and states will be sought.

NITROGEN STEWARDSHIP
Focus on the right timing, type, placement and quantity of nutrients to reduce nitrous oxide emissions and provide cost savings through efficient application.

CONSERVATION OF SENSITIVE LANDS
Use the Conservation Reserve Program (CRP) and the Agricultural Conservation Easement Program (ACEP) to reduce GHG emissions through riparian buffers, tree planting, and the conservation of wetlands and organic soils. By 2025, USDA aims to enroll 400,000 acres of CRP lands with high greenhouse gas benefits, protect 40,000 acres through easements, and gain additional benefits by transferring expiring CRP acres to permanent easements.

LIVESTOCK PARTNERSHIPS
Encourage broader deployment of anaerobic digesters, lagoon covers, composting, and solids separators to reduce methane emissions from cattle, dairy, and swine operations. USDA plans to support 500 new digesters over the next 10 years, as well as expand the use of covers on 10 percent of anaerobic lagoons used in dairy cattle and hog operations.

SOIL HEALTH
Improve soil resilience and increase productivity by promoting conservation tillage and no till systems, planting cover crops, planting perennial forages, managing organic inputs and compost application, and alleviating compaction. USDA aims to increase no-till implementation from the current 67 million acres to over 100 million acres by 2025.

GRAZING AND PASTURE LANDS
Support rotational grazing management, avoiding soil carbon loss through improved management of forage, soils and grazing livestock. By 2025, USDA plans to support improved grazing management on an additional 4 million acres, for a total of 20 million acres.

Rotational grazing, as pictured in ...ld County, Colorado, is a ...nagement-intens... system of ...ck on subdivided pastures to promote soil and plant health.

PRIVATE FOREST GROWTH AND RETENTION
Through the Forest Legacy Program and the Community Forest and Open Space Conservation Program, protect almost 1 million additional acres of working landscapes. Employ the Forest Stewardship Program to cover an average of 2.1 million acres annually (new or revised plans), in addition to the 26 million acres covered by active plans.

STEWARDSHIP OF FEDERAL FORESTS
Reforest areas damaged by wildfire, insects, or disease, and restore forests to increase their resilience to those disturbances. USDA plans to reforest 5,000 additional post disturbance acres by 2025.

PROMOTION OF WOOD PRODUCTS
Increase the use of wood as a building material, to store additional carbon in buildings while offsetting the use of energy from fossil fuel. USDA plans to expand the number of wood building projects supported through cooperative agreements with partners and technical assistance, in addition to research and market promotion for new, innovative wood building products.

ENERGY GENERATION AND EFFICIENCY
Promote renewable energy technologies and improve energy efficiency. Through the Energy Efficiency and Conservation Loan Program, work with utilities to improve the efficiency of equipment and appliances. Using the Rural Energy for America Program and other programs, develop additional renewable energy, bioenergy and biofuel opportunities. Support the National On-Farm Energy Initiative to improve farm energy efficiency through cost-sharing and energy audits.

URBAN FORESTS
Encourage tree planting in urban areas to reduce energy costs, stormwater runoff, and urban heat island effects while increasing carbon sequestration, curb appeal, and property values. Working with partners, USDA plans to plant an average of 9,000 additional trees in urban areas per year through 2025.

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Source: CSU Climate Smart Agriculture Newsletter

Existing NRCS Conservation Practices that build soil carbon

Table 2

Soil carbon sequestration rates under USDA Natural Resources Conservation Service (NRCS) conservation practices for cropland (adapted from Swan et al. [2015]).

Climate Change Mitigation Building Block	NRCS Conservation Practice Standard Number	NRCS Conservation Practice Standard	Atmospheric/soil benefit ($Mg\ C\ ha^{-1}\ y^{-1}$)
Soil Health	327	Conservation cover (ac) – retiring marginal soils	0.42 to 0.94
	328	Conservation crop rotation (ac)	0.15 to 0.17
	329	Residue and tillage management, no-till (ac)	0.15 to 0.27
	329A	Strip till (ac)	0.07 to 0.17
	329B	Mulch till (ac)	0.07 to 0.18
	330	Contour farming (ac)	0.07 to 0.19
	332	Contour buffer strips (ac)	0.42 to 0.94
	340	Cover crop (ac)	0.15 to 0.22
	345	Residue and tillage management, reduced till (ac)	0.02 to 0.15
	386	Field border (ac)	0.42 to 0.94
	393	Filter strips (ac)	0.42 to 0.95
	412	Grassed waterways (ac)	0.42 to 0.96
	585	Strip-cropping (ac)	0.02 to 0.17
	601	Vegetative barriers (ft)	0.42 to 0.94
	603	Herbaceous wind barriers (ft)	0.42 to 0.95

Chambers et al., 2016

Existing NRCS Conservation Practices that build soil carbon

Table 3

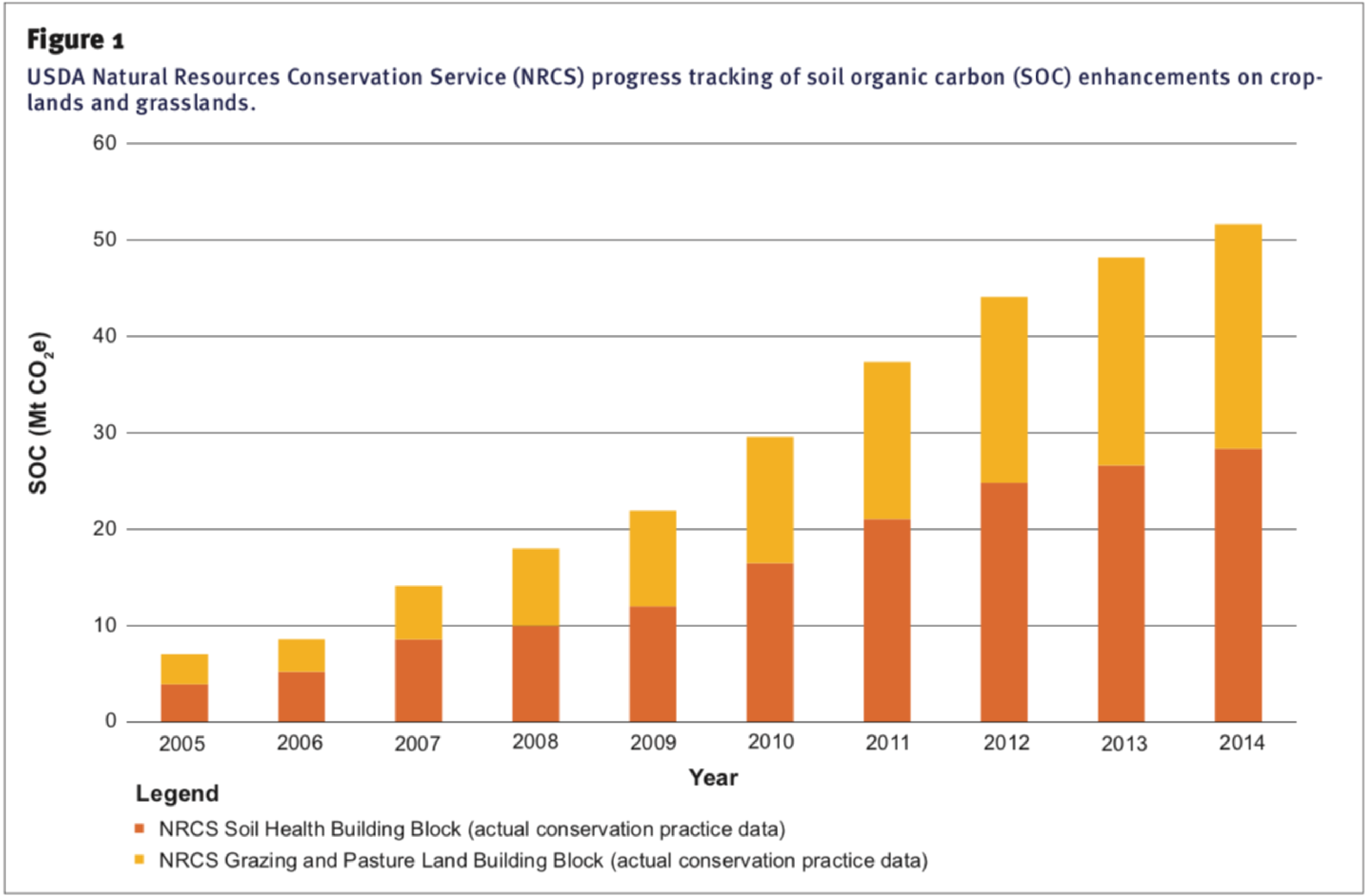
USDA Natural Resources Conservation Service (NRCS) atmospheric-beneficial grazing and pasture lands and degraded lands conservation practices (adapted from Swan et al. [2015]).

Climate Change Mitigation Building Block	NRCS Conservation Practice Standard Number	NRCS Conservation Practice Standard	Atmospheric/soil benefit (Mg C ha^{-1} y^{-1})
Grazing and Pasture	512	Forage and biomass planting (ac)	0.02 to 0.17
	528	Prescribed grazing	0.17 to 0.44
	550	Range planting	0.22 to 0.35
Degraded Lands Restoration (Not an official mitigation building block)	342	Critical area planting (ac)	0.66 to 1.28
	453	Land reclamation: landslide treatment (ac)	0.49 to 1.28
	543	Land reclamation: abandoned mine lands (ac)	0.67 to 1.28
	544	Land reclamation: currently mined lands (ac)	0.27 to 1.28

Chambers et al., 2016

Proposal for US to join 4 Parts per Thousand Global Soil Initi

If fully implemented, practices would offset 50% of US Ag GHG emissions



Ag Best Management Practices Compilation

- CSU Professor Jim Ippolito lead
- Compiling list of BMPs for Ag
  - Ranching – Casey Shawver
  - Field Crops – Dustin Diaz
- Rollout
  - Summer 2019

Climate Smart Ag Online Courses

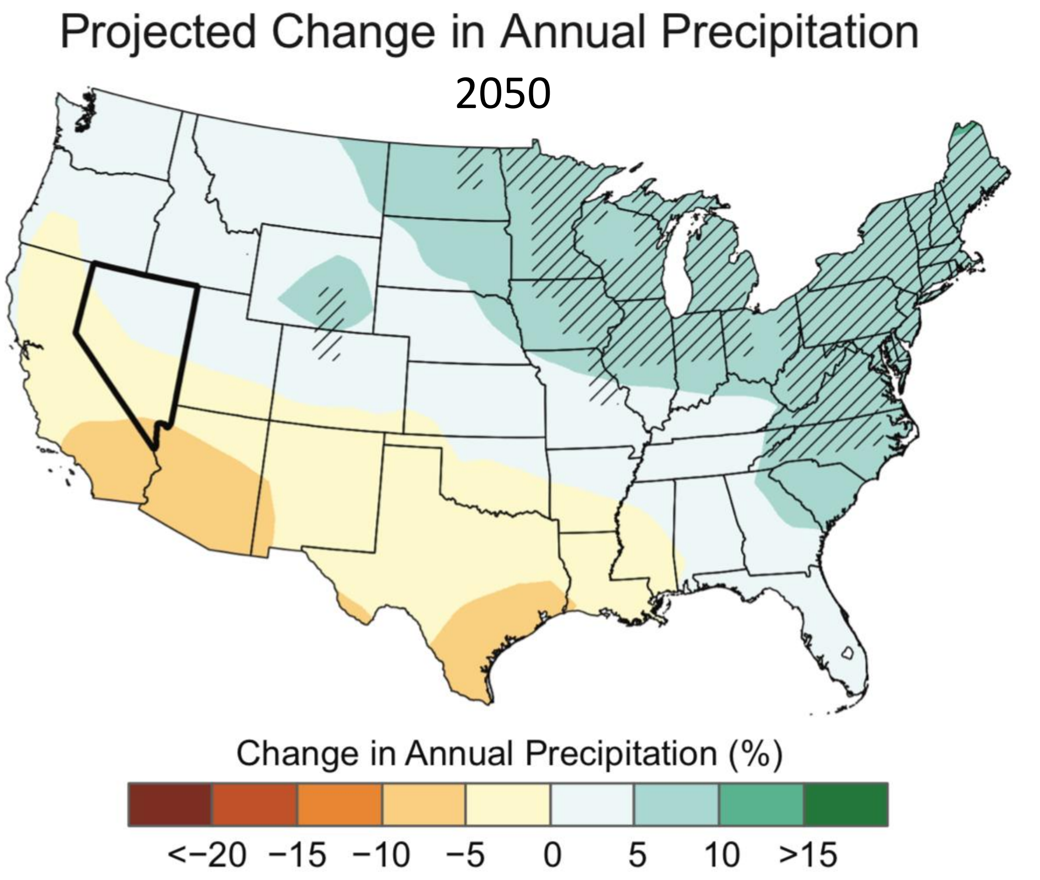
- Target: Extension Agents and Producers
- Format: Short Mini-courses
- Topics
  - Colorado's Climate - Doesken
  - Climate Change Basics - Denning
  - Climate Change and the Water Cycle – Udall
  - Agriculture Impacts and Adaptation - Udall
  - Agricultural GHG Mitigation - Paustian
  - Climate Change Myths – Udall
- Late Spring 2019 Rollout

Climate Smart Ag Course Format

- Course composed of 5-12 'modules' or 'weeks'
- Each Module
  - Video Lecture (5-10 minutes)
  - Reading(s) (30-45 minutes)
  - Possible Quiz
  - Total Time each Module under 1 hour
  - Short Test
- End of Course Exam
  - ~20 Questions

Closing Thoughts

- Climate Change is here, and it is a really big deal
  - San Luis Valley will have higher temperatures and less water
- Agriculture is both…
  - a cause of climate change and,
  - is impacted by climate change
- Agriculture can also help solve climate change
  - By reducing GHG emissions (N20, Methane especially)
  - By pulling Carbon (CO_2) out of the air
- Soil Health has a role
  - Adaptation Role – Yield, Structure, Water Holding, Nutrients
  - Can help with sequestering carbon, too
- CSU has a duty to help Colorado Agriculture…
  - Adapt to the coming changes
  - Reduce Ag's impact on climate change
- Climate Smart Agriculture is CSU's first, tentative steps to help
  - Colorado Ag is Diverse, Complicated
  - Education is the first step, but much more needed
  - But we can't do it alone
  - We need your help, too



San Luis Valley will see less precipitation

National Climate Assessment, 2018

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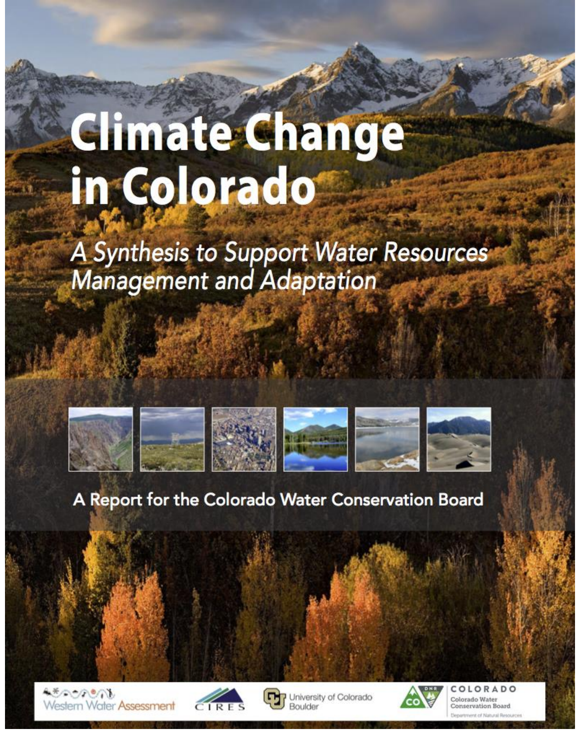
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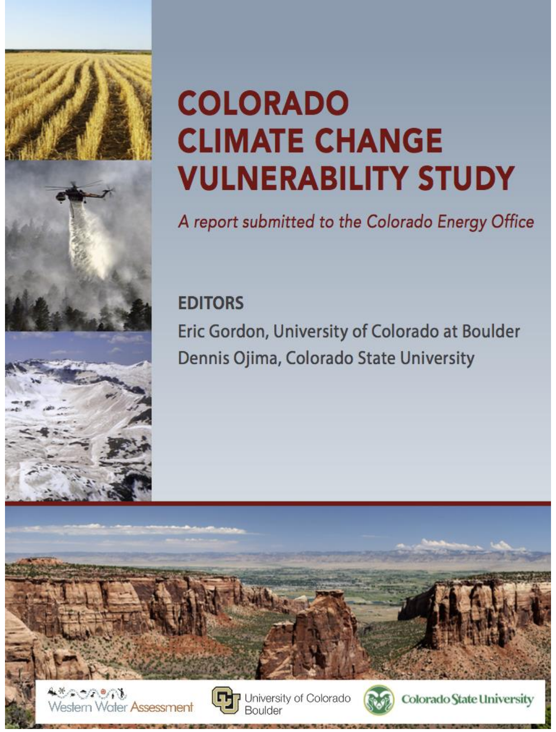
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EDITORS
Eric Gordon, University of Colorado at Boulder
Dennis Ojima, Colorado State University
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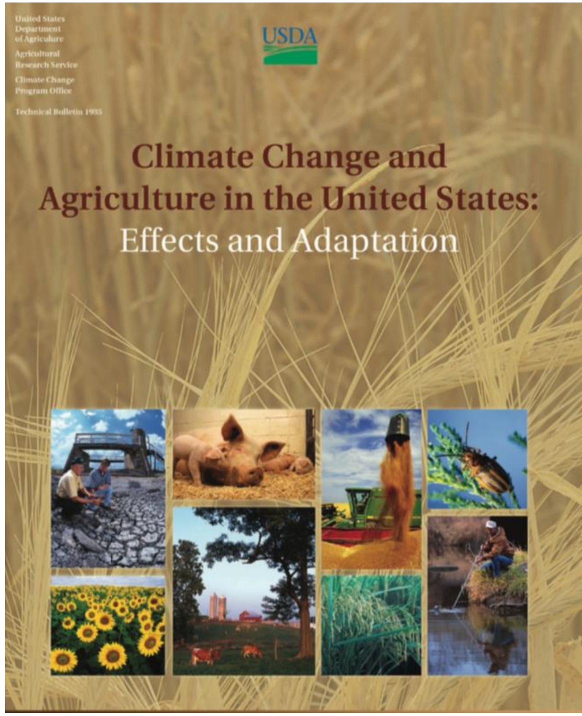
University of Colorado Boulder
Colorado State University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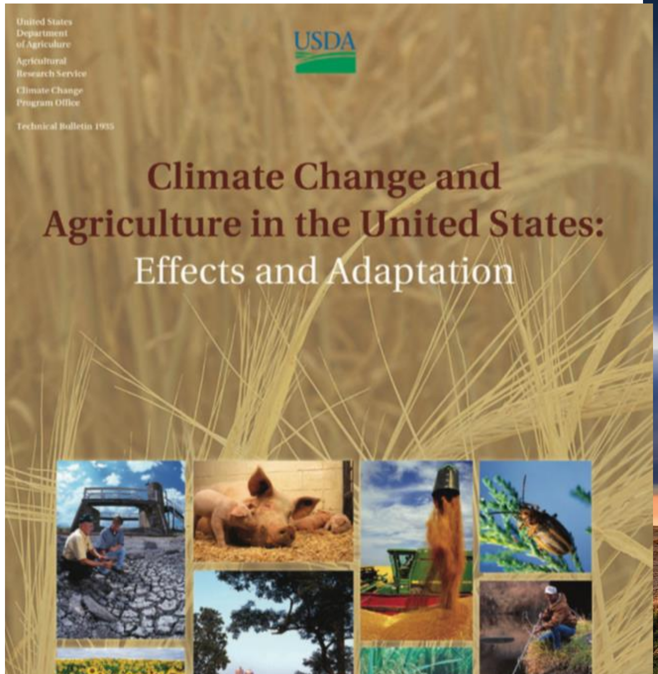
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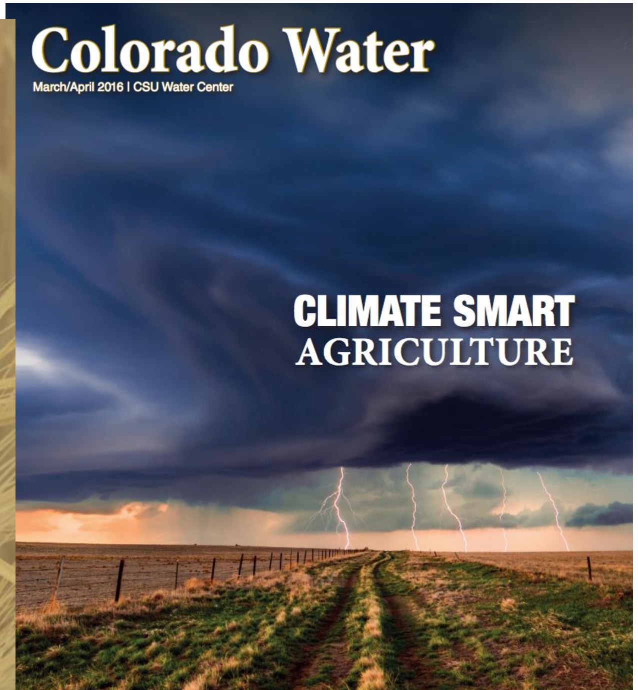
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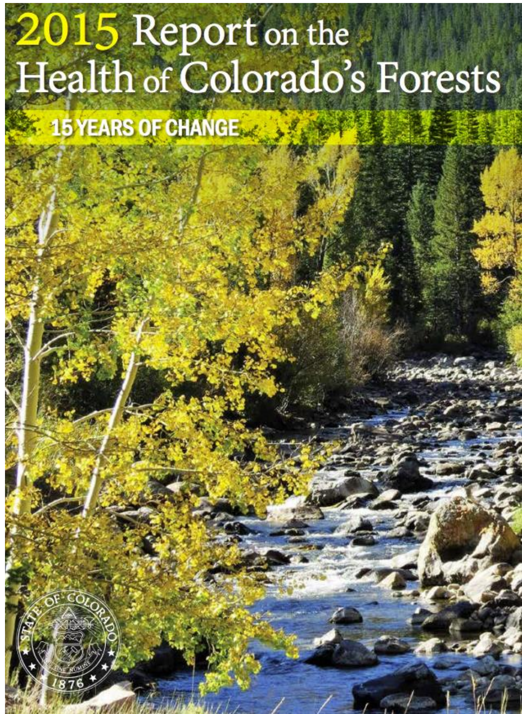
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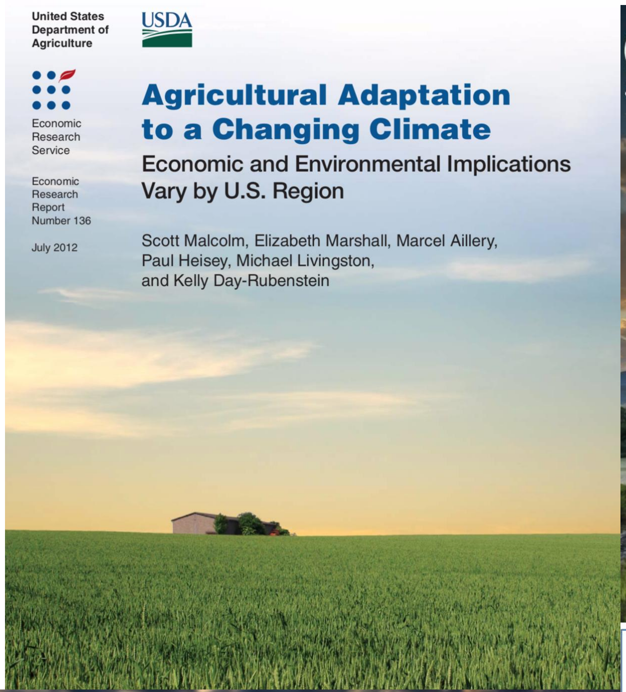

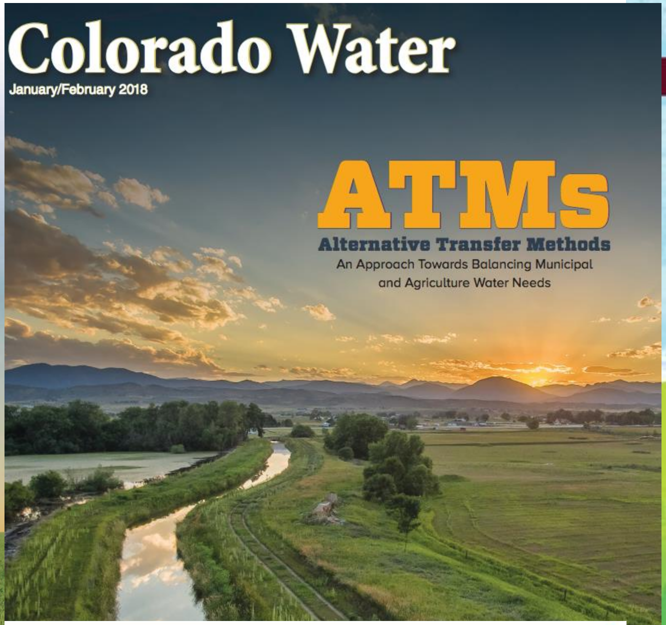

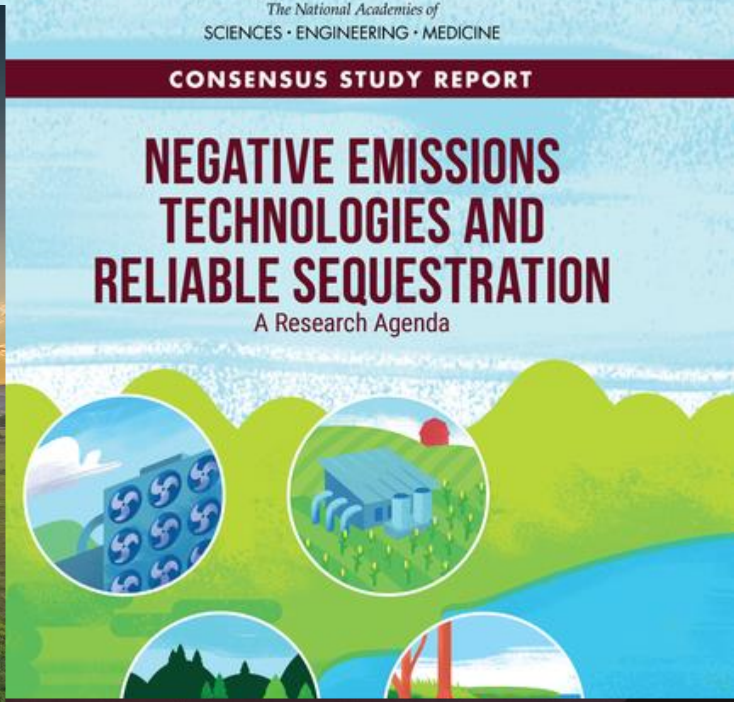

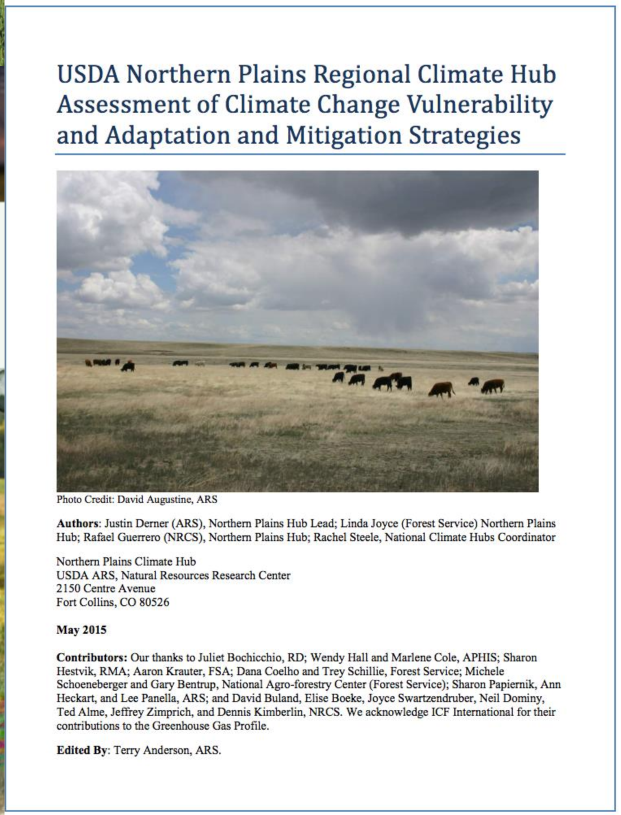

USDA Northern Plains Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies

Photo Credit: David Augustine, ARS

Authors: Justin Derner (ARS), Northern Plains Hub Lead; Linda Joyce (Forest Service) Northern Plains Hub; Rafael Guerrero (NRCS), Northern Plains Hub; Rachel Steele, National Climate Hubs Coordinator

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May 2015

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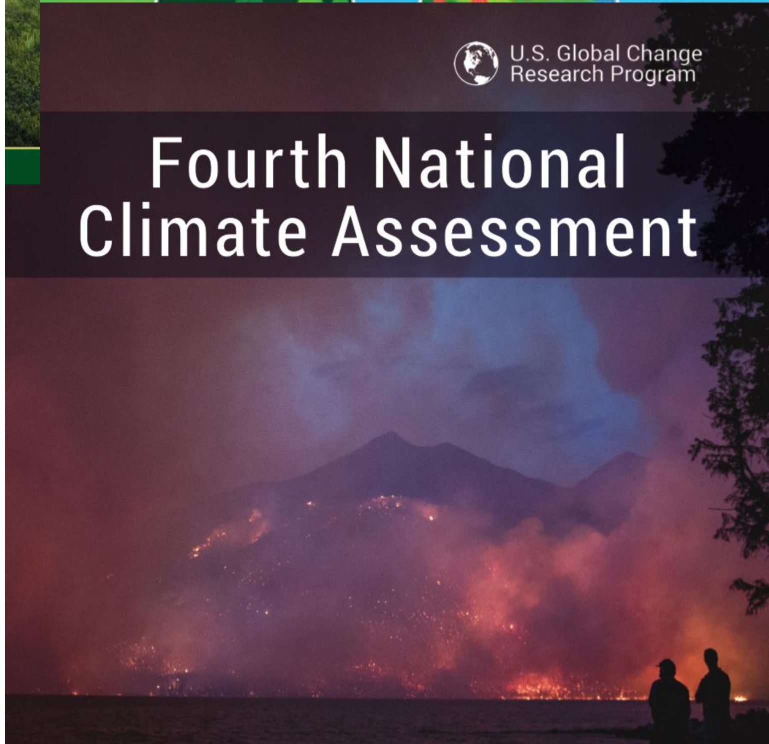

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What are the USDA Climate Hubs?

USDA's Climate Hubs are a unique collaboration across the department's agencies. They are led by Agricultural Research Service and Forest Service senior Directors located at ten regional locations, with contributions from many other programs including the Natural Resources Conservation Service, Farm Service Agency, Animal and Plant Health Inspection Service, and the Risk Management Agency. The Climate Hubs link USDA research and program agencies in their regional delivery of timely and authoritative tools and information to agricultural producers and professionals.

Mission

The mission of the Climate Hubs is to develop and deliver science-based, region-specific information and technologies, with USDA agencies and partners, to agricultural and natural resource managers that enable climate-informed decision-making, and to provide access to assistance to implement those decisions. This is in alignment with the USDA mission to provide leadership on food, agriculture, natural resources, rural development, nutrition, and related issues based on sound public policy, the best available science, and efficient management.

Modules - Climate Change and the Water Cycle

1. Course Intro (and Introduction to Climate Smart Agriculture)
2. Introduction to the Water Cycle
3. Changes in Historical Air Temperature
4. Changes in Historical Precipitation
5. Projected Temperature and Precipitation Trends
6. Changes in Water Demands
7. Changes in Snowpack Amounts and Runoff Timing
8. River Basin Flow Projections
9. Changes in Water Quality
10. Changes in Floods and Droughts
11. Changes in Water Management
12. Wrap Up