

• COLORADO NATURAL  
HERITAGE PROGRAM •



# Panel 2: Natural Climate Solutions: Benefits for Nature and People

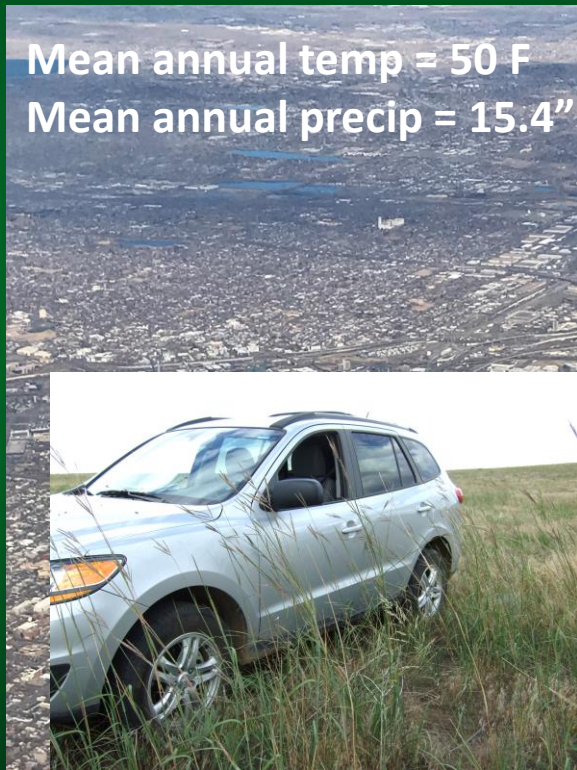
Moderator: **Renée Rondeau**, Conservation  
Planner/Ecologist, Colorado Natural Heritage  
Program

Panelists: **Imtiaz Rangwala**, Research Scientist, NOAA  
ESRL, CIRES/Western Water Assessment  
**Bruce Rittenhouse**, Branch Chief, Cultural and  
Natural Resources, Bureau of Land  
Management  
**George Schisler**, Aquatic Research Chief,  
Colorado Parks and Wildlife  
**Betsy Neely**, Climate Change Programs Manager,  
The Nature Conservancy  
**Robin O'Malley**, Director, North Central Climate Science  
Center



# Denver Analogue: Hot and Dry Scenario RCP 8.5

1981-2000



2075-2100



# Climate Change in Colorado: Past & Future

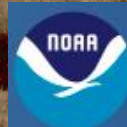
*A quick glance !*

Imtiaz Rangwala

Imtiaz.Rangwala@noaa.gov

March 9, 2018

CNHP Stakeholder Meeting



**Earth System Research Laboratory**  
Physical Sciences Division



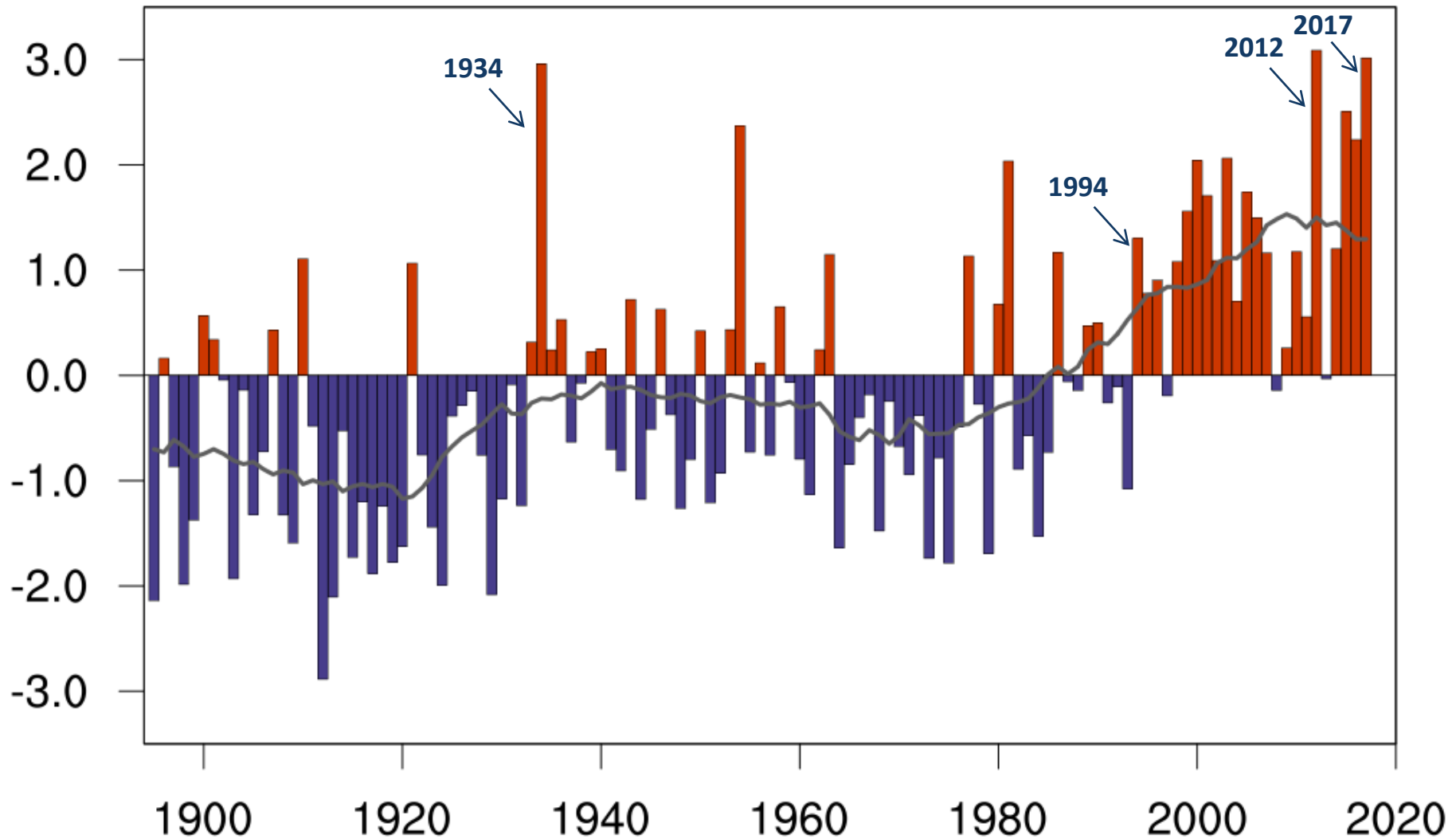
**NORTH CENTRAL  
CLIMATE  
SCIENCE  
CENTER**

UNIVERSITY CONSORTIUM



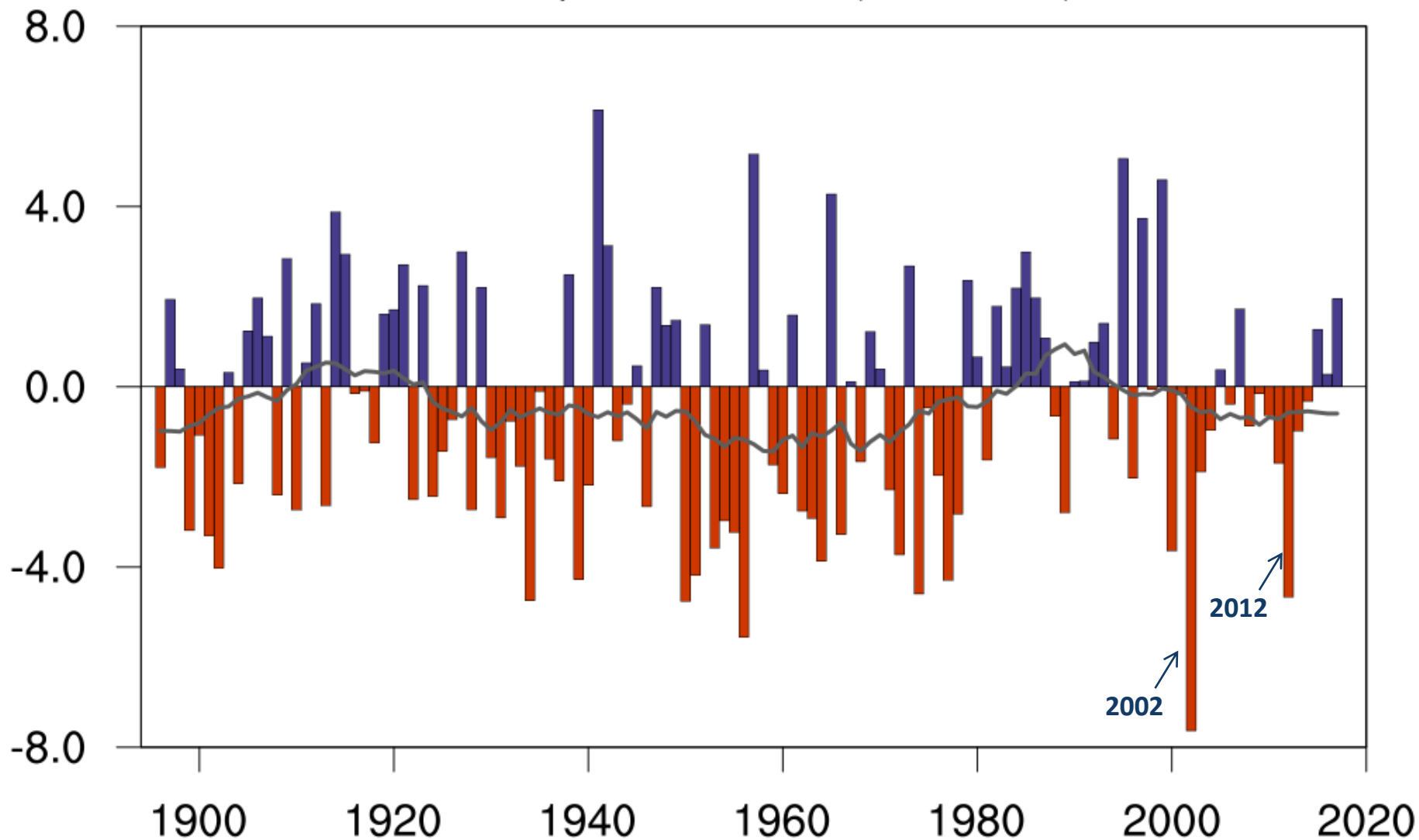
# Colorado has warmed by at least 2°F

Annual Temperature, °F (1895-2017): Colorado



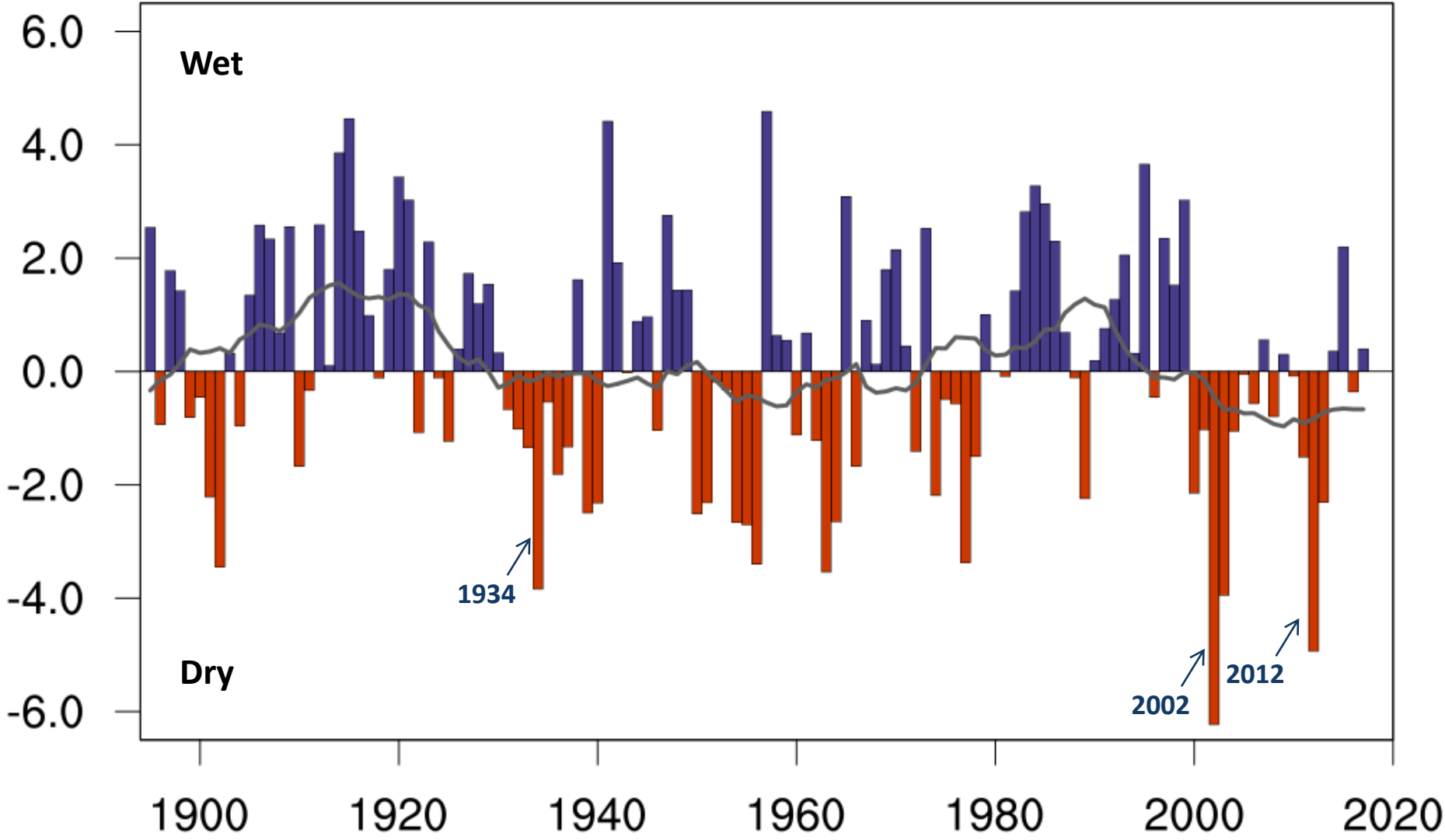
# No apparent trend in Precipitation

Water-Year Precipitation, Inches (1896-2017): Colorado



# CO experienced unprecedented droughts in recent years

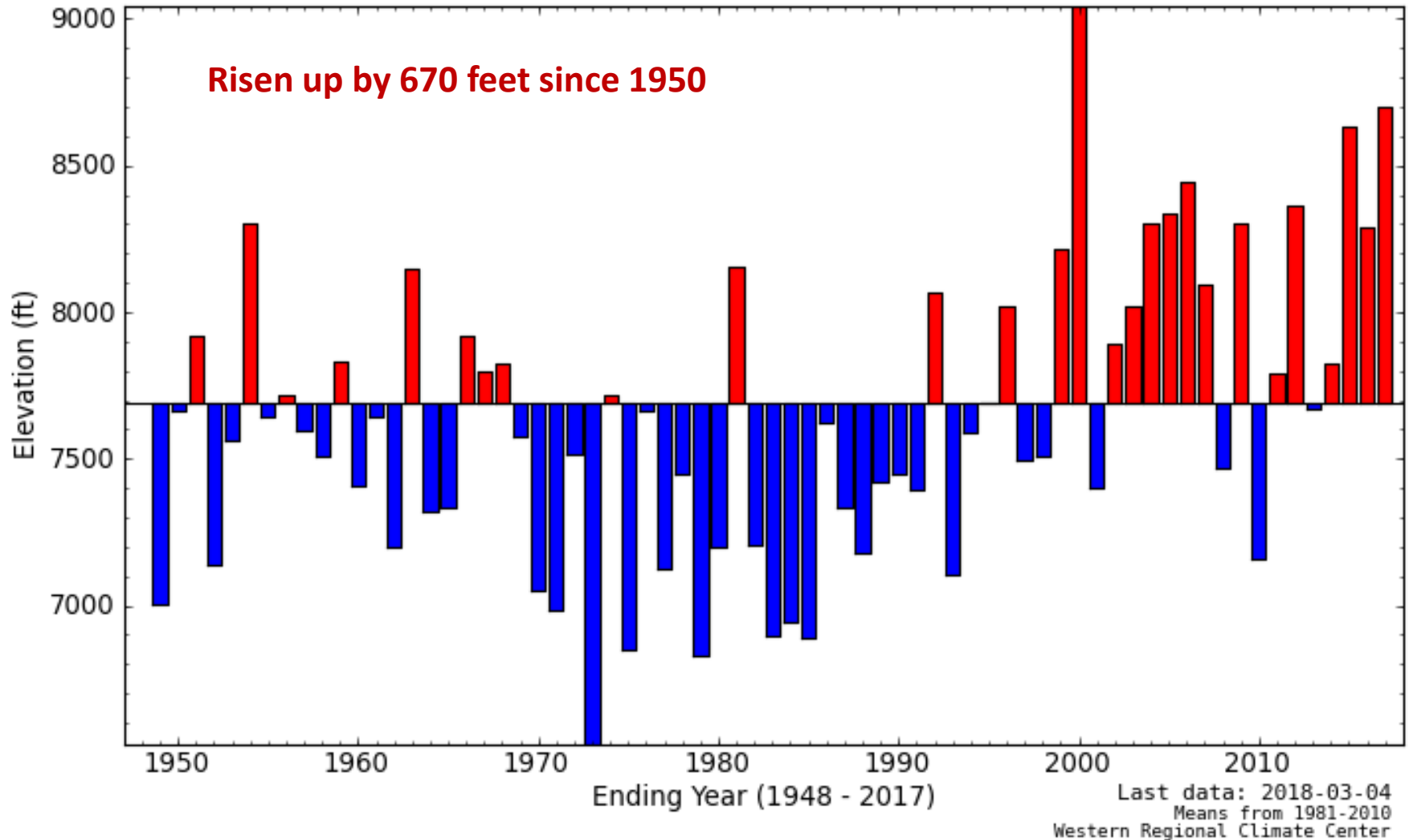
## May-October PDSI (1895-2017): Colorado



Data: U.S. Climate Divisional Database

# Cold Season (Oct-May) Freezing Level (~Snowline) Trend *Rocky Mountain National Park*

0°C Level at 40.34°N, 105.69°W - 8 Months Ending in May

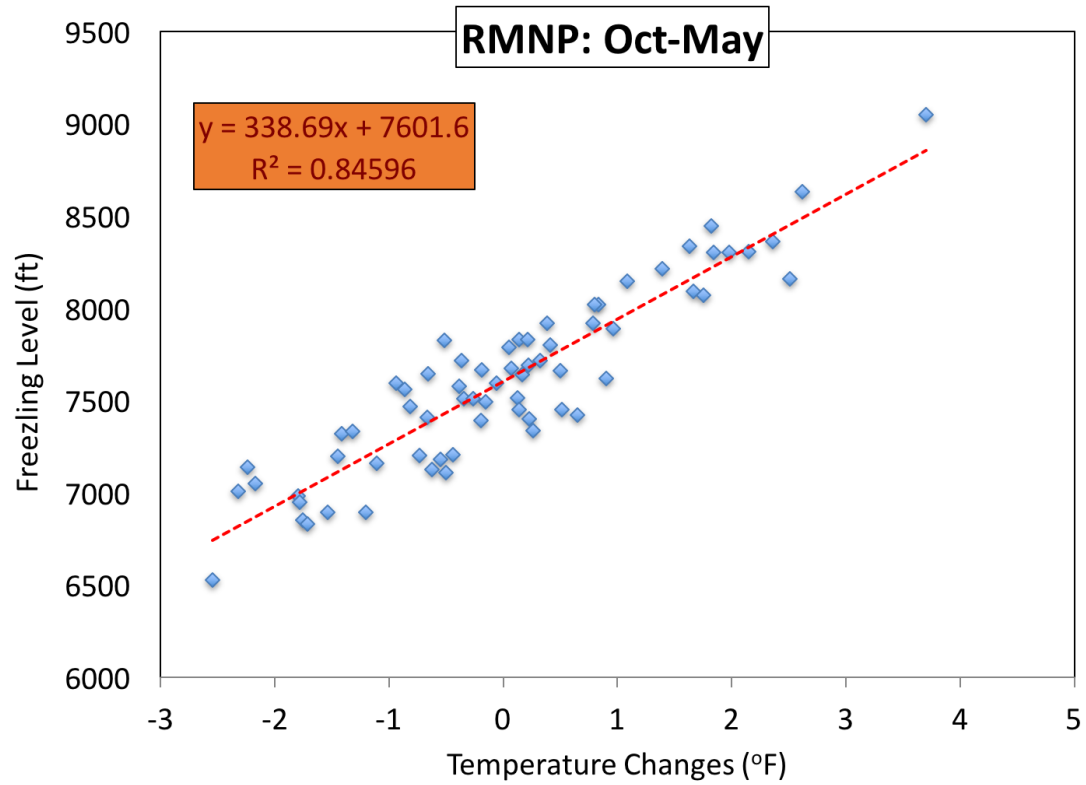


Implication: More rain than snow



# Freezing Level vs. Temperature

## *Rocky Mountain National Park*

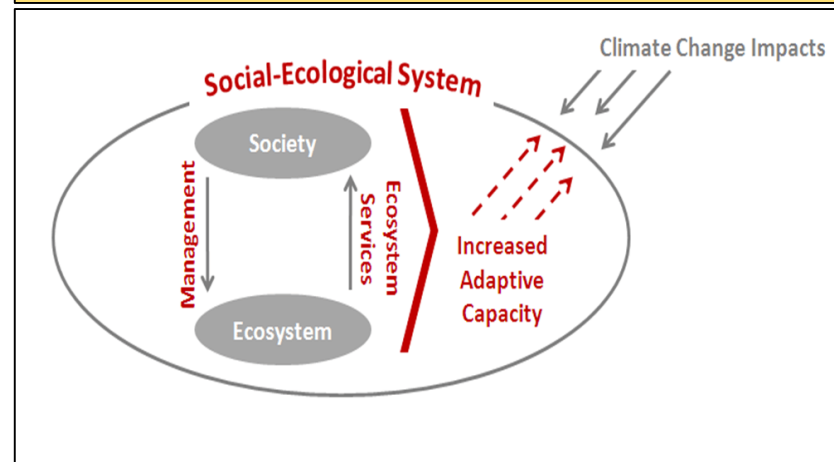
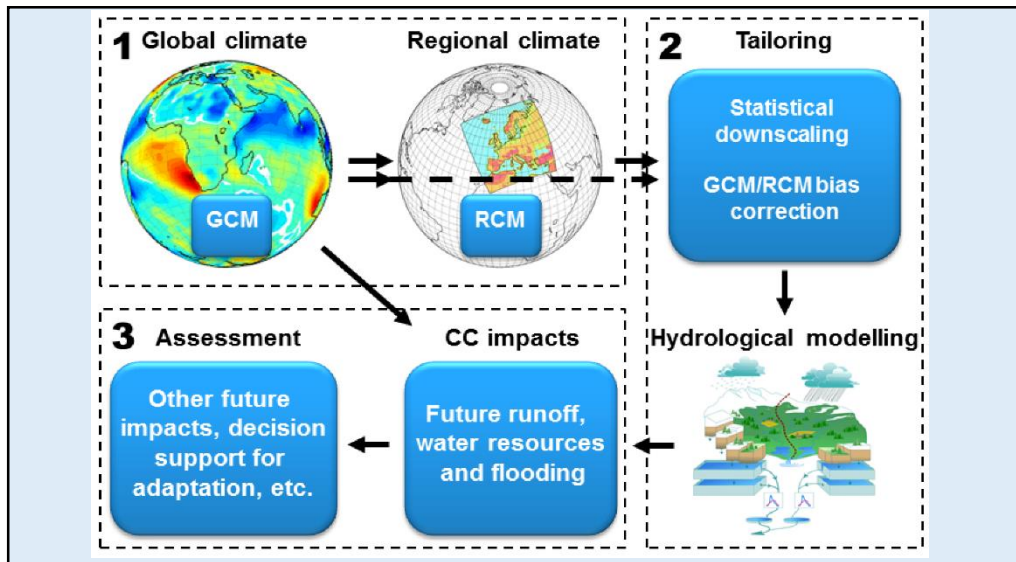
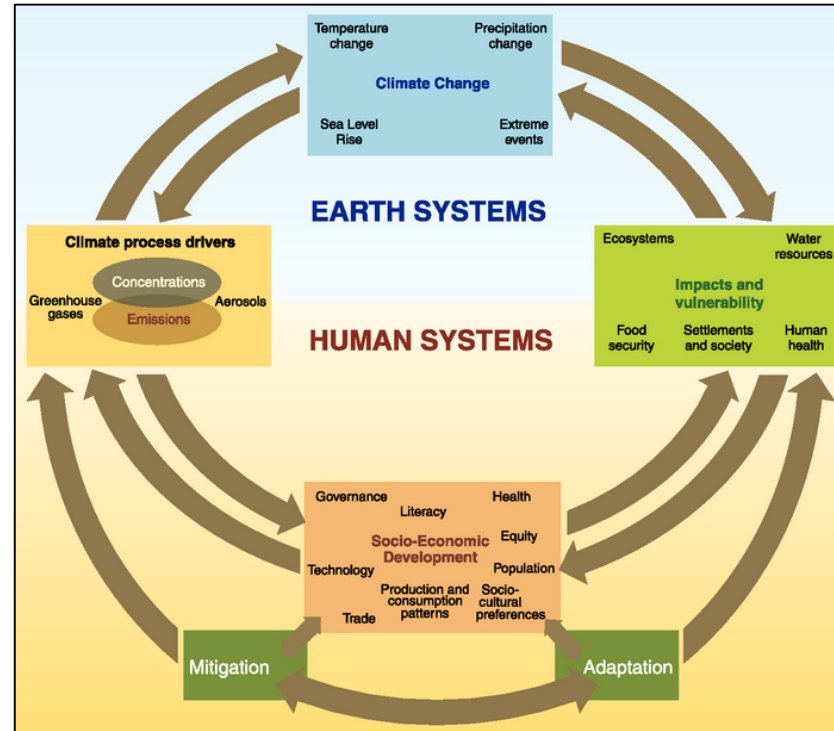
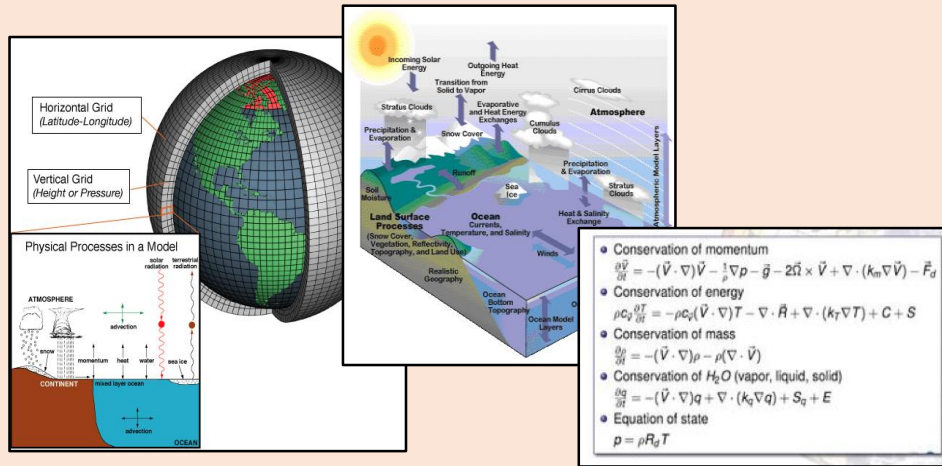


**Rule of thumb:** 330 ft upward shift in snowline for every °F increase in temperature

# Future Climate Projections

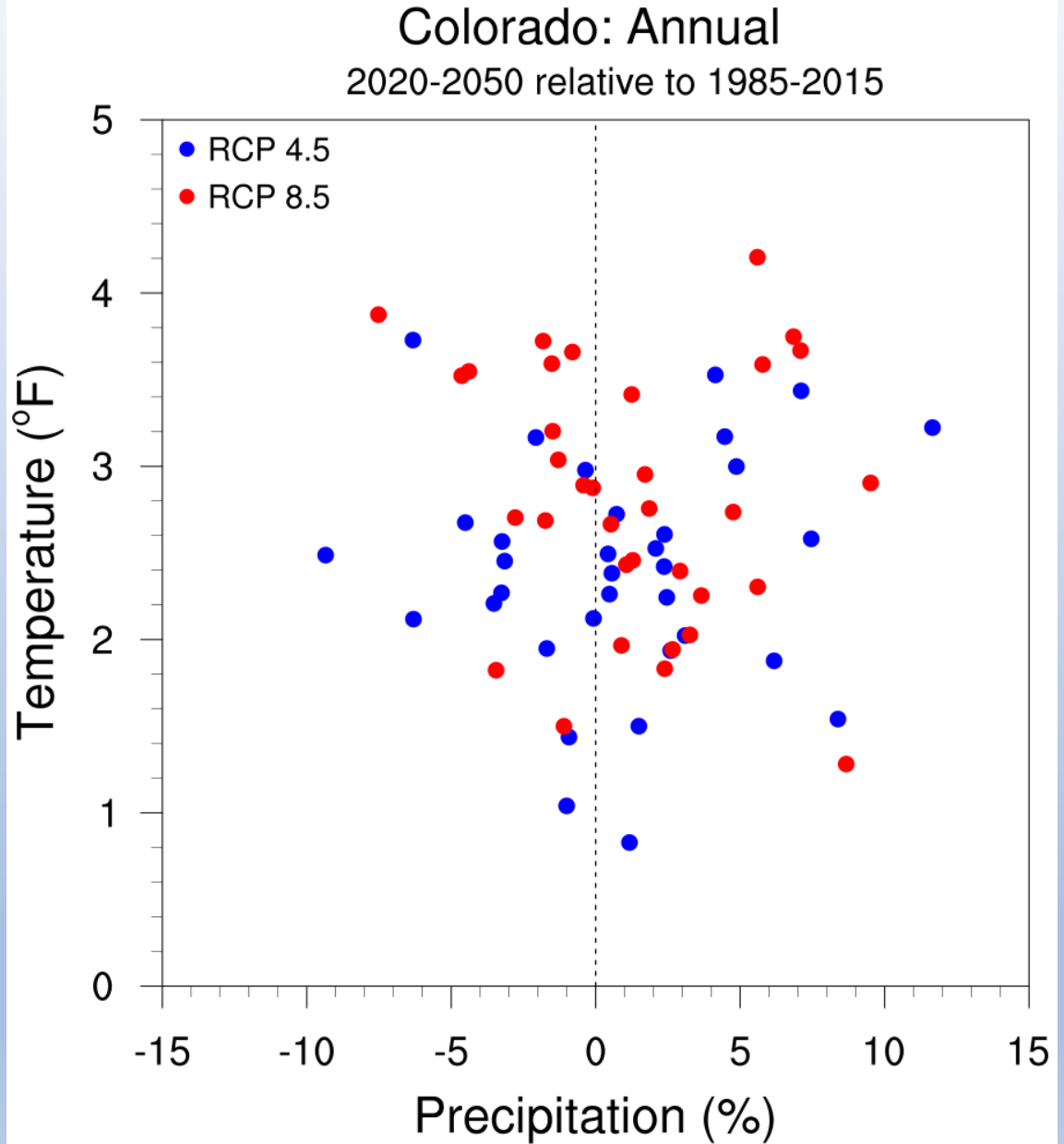
# We rely on all kinds of models to get perspective on future changes in climate and its impacts

## Global Climate Models (GCMs)



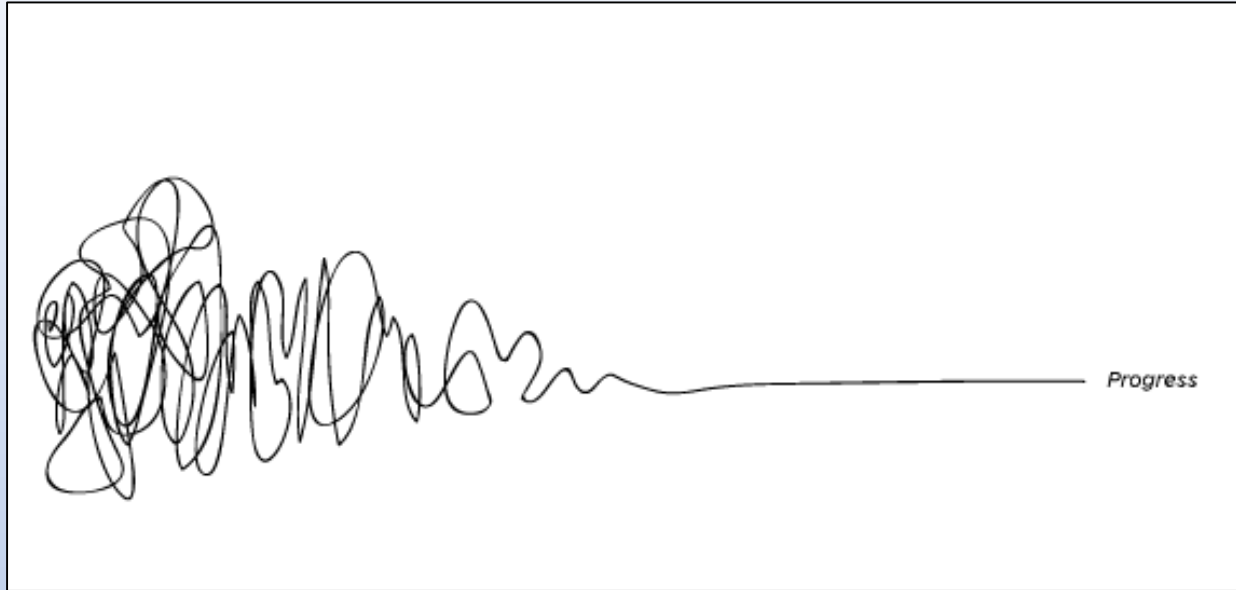
### Future Projections (2020-2050)

- ❖ 34 GCMs from CMIP5
- ❖ 2 Emissions Scenarios
- ❖ Warming by 1-4 °F
- ❖ Precip changes by -5% to 10% (4 scenarios of <-5%; 12 scenarios of >+5%)





# Reducing Uncertainty



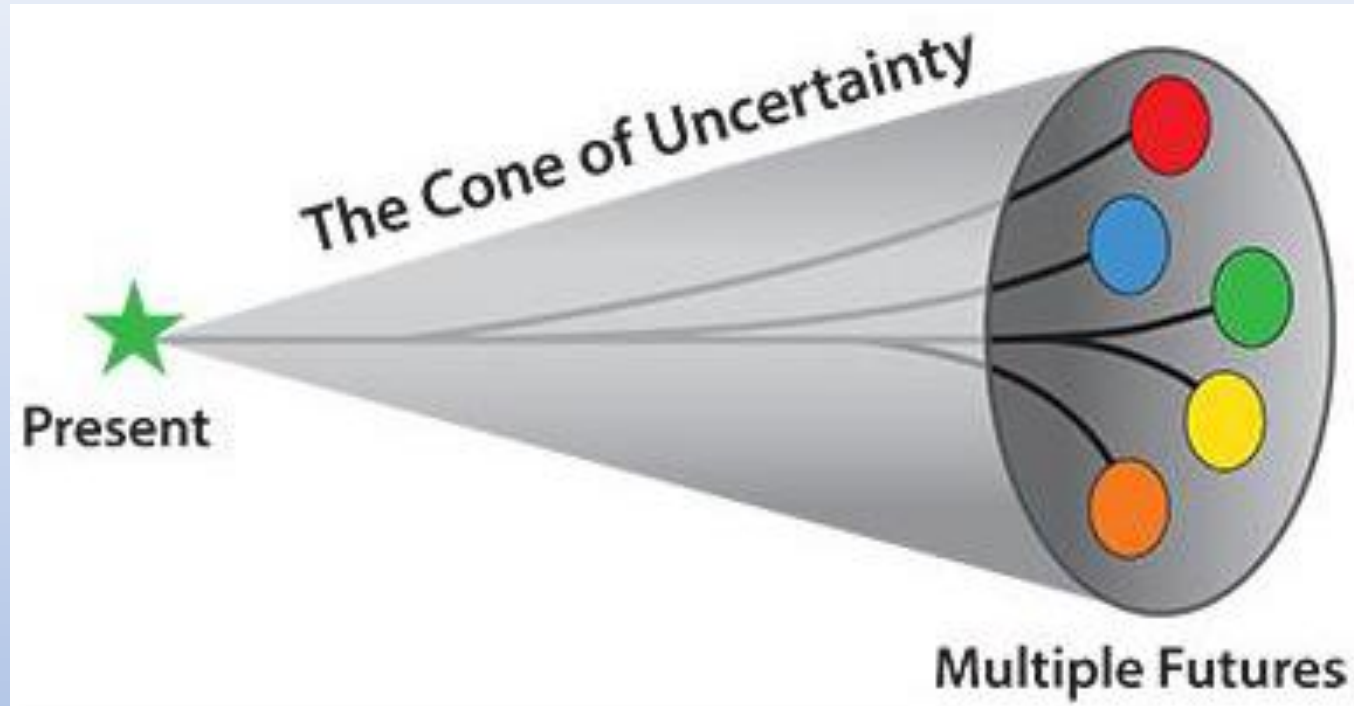
**Deliberate efforts towards reducing uncertainty could be going down a slippery slope**



# On Robustness...

- ❖ Approaches that work across a range of multiple futures, and
- ❖ Cover divergent and differential risks from known and presumably unknown uncertainties

# Scenarios Based Approach

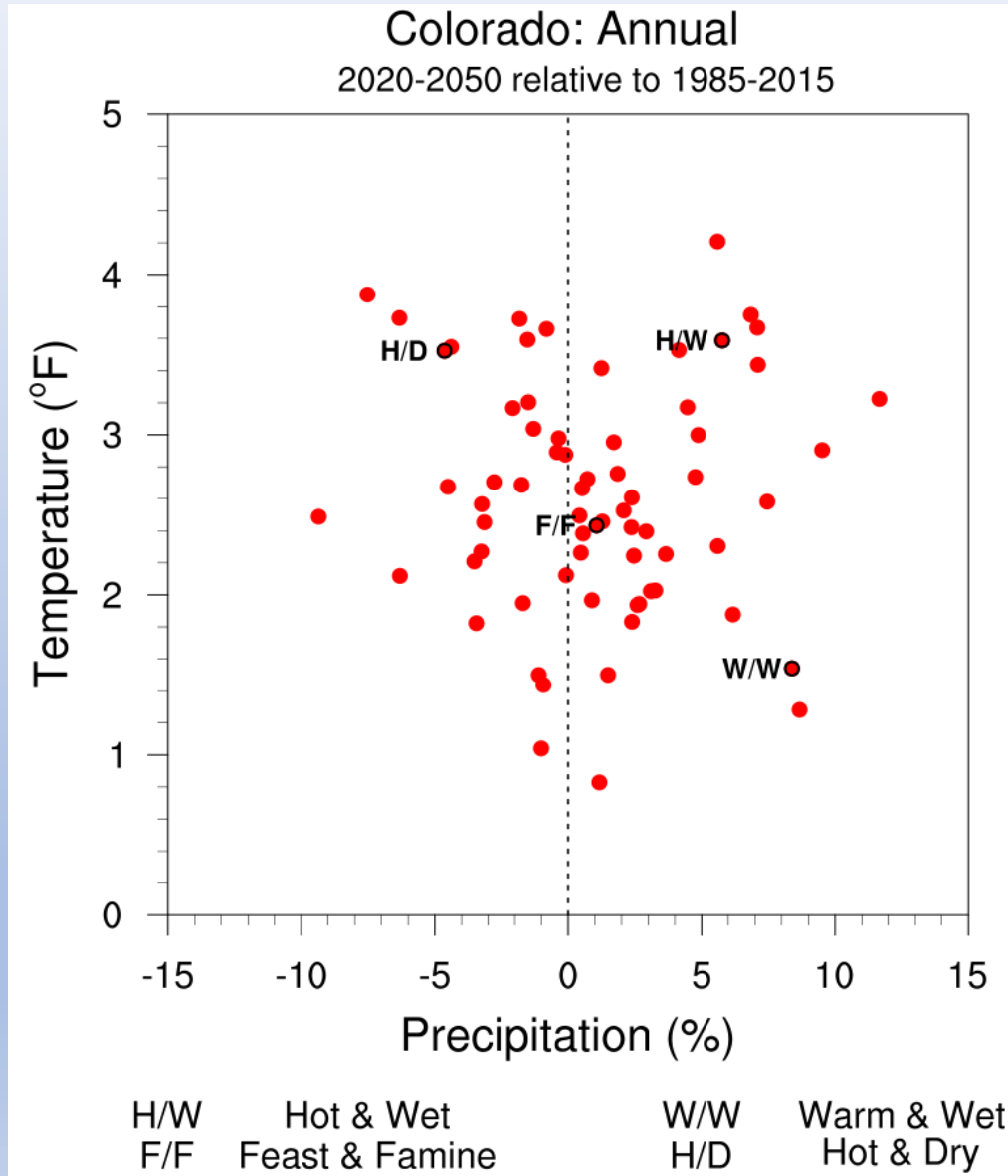


*“particularly applicable in situations of high uncertainty and complexity...” (Rowland, Cross & Hartmann 2014)*

- ❑ Has been historically used by the military and corporations
- ❑ National Park Service – Adopted it in a big way

# Selecting and working with divergent Climate Scenarios

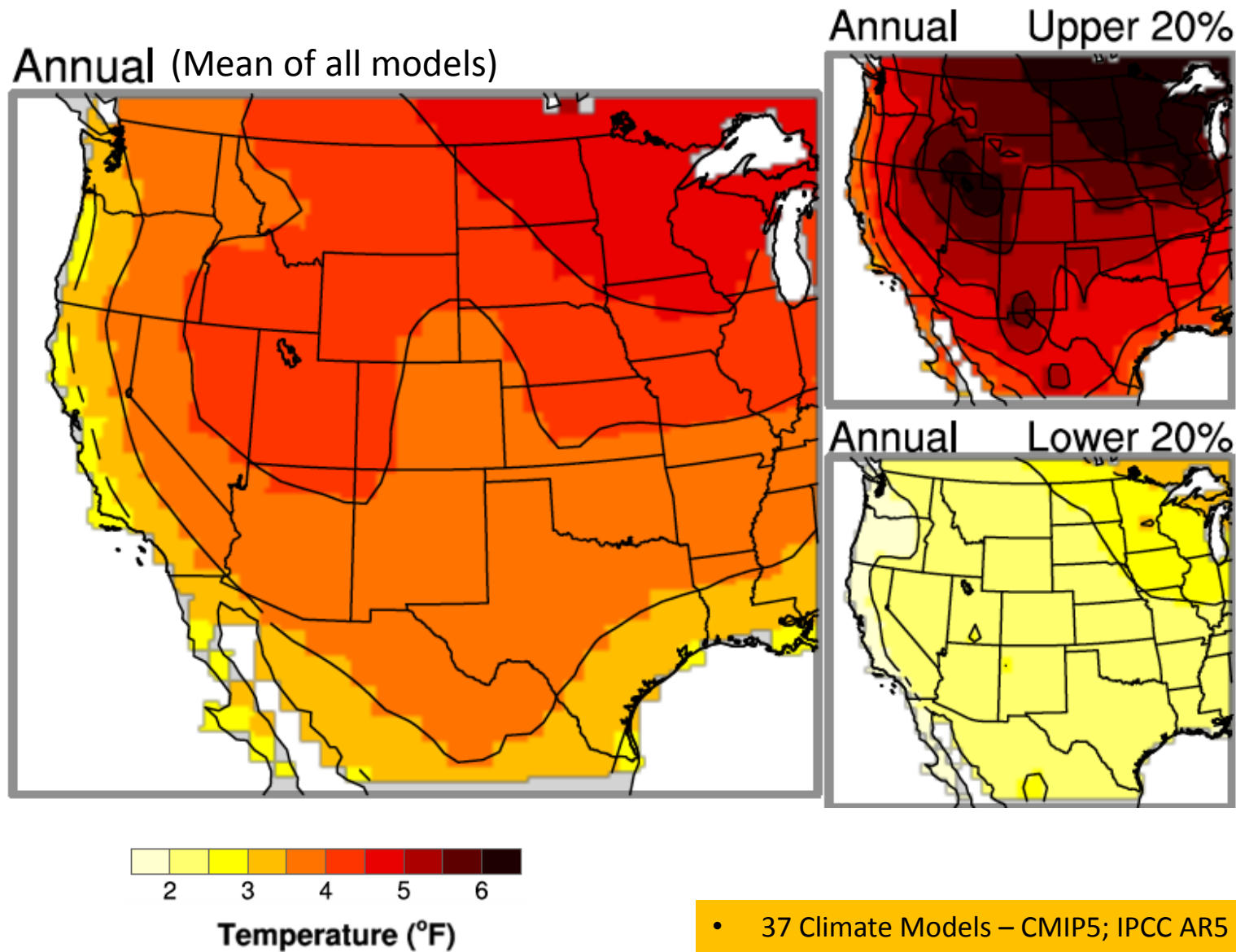
(e.g., TNC-CO Climate Impacts & Opportunities project)





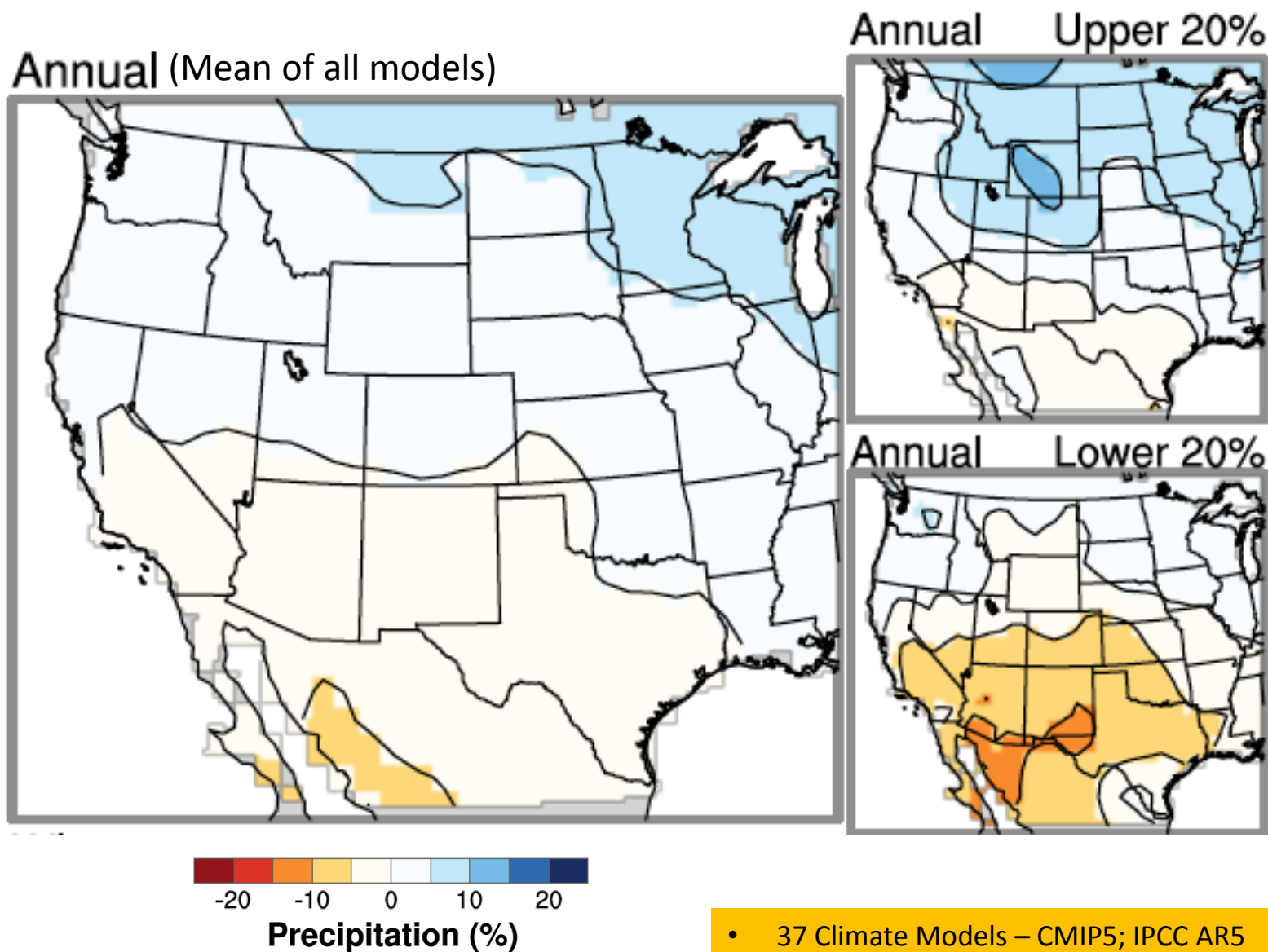
Extra Slides

# Temperature Change by 2050 relative to late 20<sup>th</sup> century



- 37 Climate Models – CMIP5; IPCC AR5
- RCP 4.5 (**Moderate Emissions**)
- Change by 2050 (2035-2064) relative to 1971-200

# Precipitation Change by 2050 relative to late 20<sup>th</sup> century

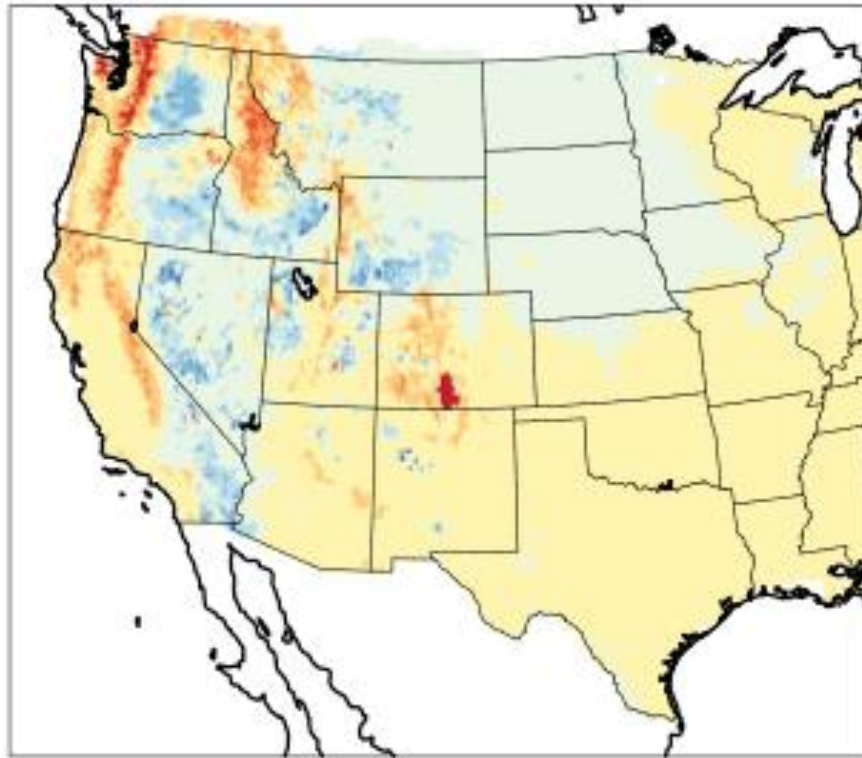


Source: Lukas et al., 2014 (*Climate Change in Colorado Report to CWCB*)

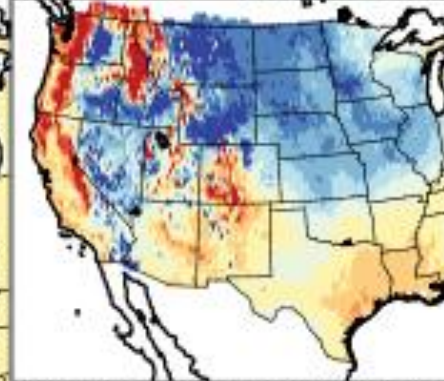
- 37 Climate Models – CMIP5; IPCC AR5
- RCP 4.5 (**Moderate Emissions**)
- Change by 2050 (2035-2064) relative to 1971-200

# Soil Moisture Change by 2050 (standardized)

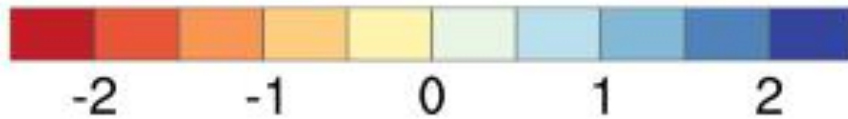
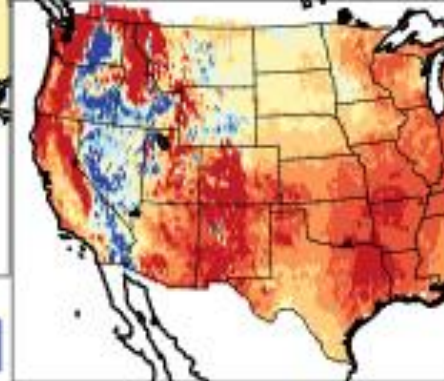
Summer



Summer Wetter 20%



Summer Drier 20%







U.S. Department of the Interior  
Bureau of Land Management

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# BLM Colorado Climate Adaptation Plan

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# Partner Recognition

**Corrie Knapp**, Western State Colorado University, Gunnison  
Colorado, [cknapp@western.edu](mailto:cknapp@western.edu)

**Lee Grunau**, Colorado Natural Heritage Program, Fort Collins  
Colorado, [Lee.Grunau@colostate.edu](mailto:Lee.Grunau@colostate.edu)

**Shannon McNeeley**, Colorado State University, North Central  
Climate Science Center, Fort Collins, CO,  
[Shannon.McNeeley@colostate.edu](mailto:Shannon.McNeeley@colostate.edu)

**Renee Rondeau**, Colorado Natural Heritage Program, Fort Collins,  
Colorado, [Renee.Rondeau@colostate.edu](mailto:Renee.Rondeau@colostate.edu)

**Karin Decker**, Colorado Natural Heritage Program, Fort Collins,  
Colorado, [Karin.Decker@colostate.edu](mailto:Karin.Decker@colostate.edu)

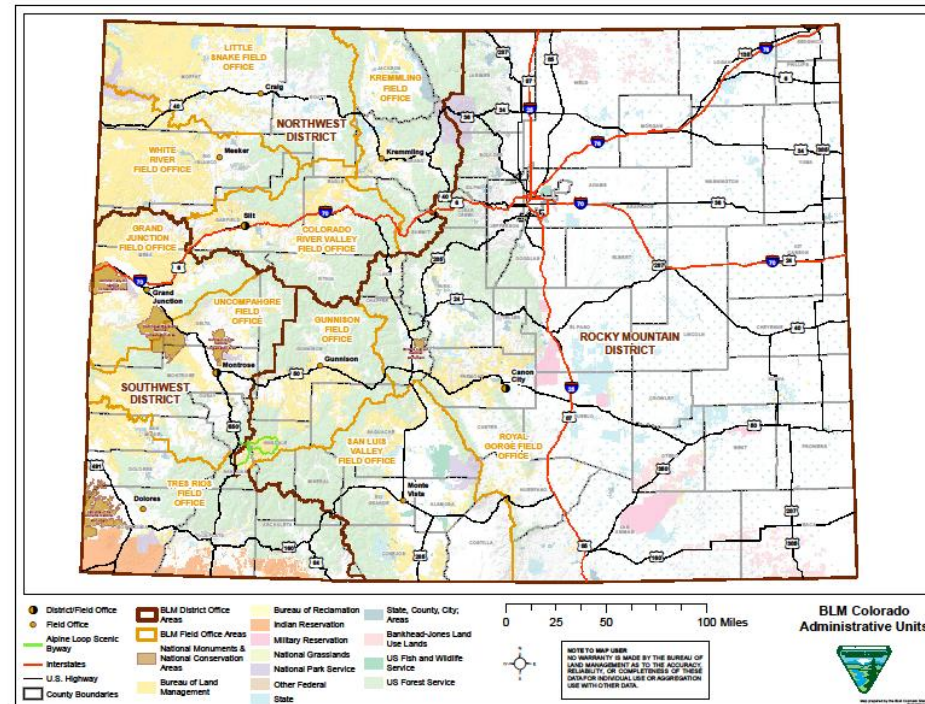






# BLM Colorado

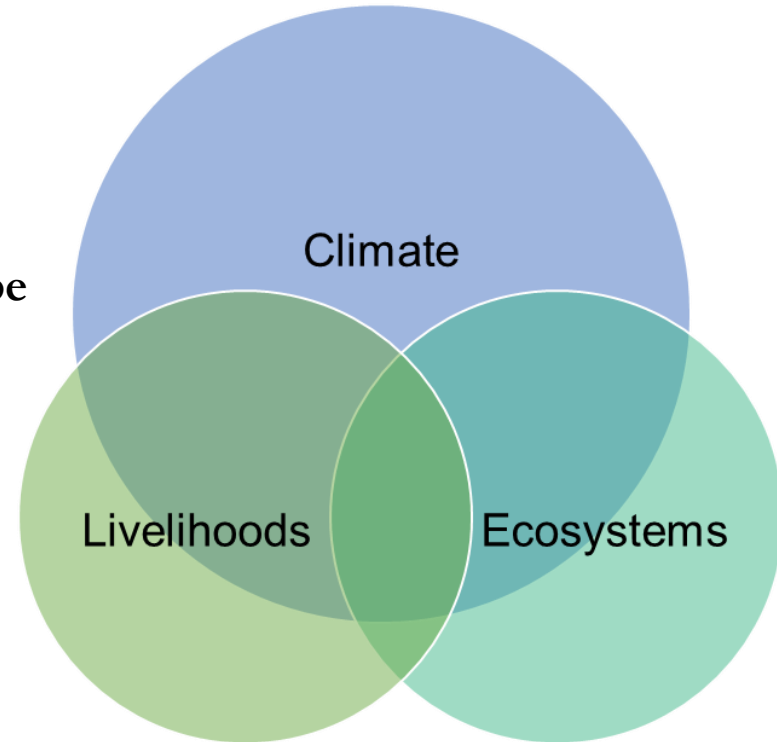
- Multiple Use Land Management Agency
- Manage 8.3 million surface acres
- Manage 27 million subsurface mineral rights
- 3 Districts/10 Field Offices
- 5 National Conservation Land Units (2 National Monuments and 3 National Conservation Areas)





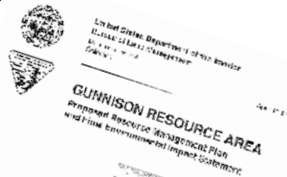
# Objectives

1. **What Natural Resources are vulnerable to projected climate trends that may exacerbate ecosystem changes?**
2. **How selected livelihoods (livestock grazing and recreation) that are dependent on public lands be affected by projected changes?**
3. **How BLM planning and decisions may affect these livelihoods?**
4. **How has BLM analyzed projected changes in climate in planning documents?**
5. **How can we integrate climate and adaptation principles (Social and Ecological) into BLM's planning, programs and daily operations.**





# Climate and BLM Planning



BLM Field Office	Year RMP Published	Mentions of "Climate Change" in final RMP
San Miguel/San Juan (Uncompahgre)	1985	0
Uncompahgre	1989	0
San Luis Valley	1991	0
Gunnison	1993	0
Royal Gorge	1996	0
White River	1997	0
Little Snake	2011	0
<b>Tres Rios</b>	<b>2013</b>	<b>4</b>
Colorado River Valley	2015	0
Grand Junction	2015	0
Kremmling	2015	0



# Natural Resource Vulnerability

Ecosystem Target	Exposure - Sensitivity final ranking	Resilience - Adaptive Capacity final ranking	Combined ranks	Overall vulnerability rank
<b>Forest and Woodland</b>				
Aspen forest	Low	High	L/H	Low
Lodgepole pine forest	Low	Low	L/L	Moderate
Mixed conifer forest	Moderate	Moderate	M/M	Moderate
Pinyon-Juniper woodland	Moderate	Low	M/L	High
Ponderosa pine forest	Moderate	Moderate	M/M	Moderate
Spruce-Fir forest	Low	Low	L/L	Moderate
<b>Shrubland</b>				
Desert shrubland	Moderate	Moderate	M/M	Moderate
Oak & mixed mountain shrub	Low	High	L/H	Low
Sagebrush shrubland	Low	Moderate	L/M	Low
Sandsage shrubland	High	High	H/H	Moderate
<b>Grassland or Herbaceous</b>				
Alpine	Low	Moderate	L/M	Low
Montane grassland	Moderate	High	M/H	Moderate
Semi-desert grassland	Low	High	L/H	Low
Shortgrass prairie	High	Moderate	H/M	High
<b>Riparian &amp; Wetland</b>				
Riparian woodland & shrubland - east	High	Moderate	H/M	High
Riparian woodland & shrubland - mountain	Low	Moderate	L/M	Low
Riparian woodland & shrubland - west	High	Low	H/L	Very High
Wetlands - east	High	Moderate	H/M	High
Wetlands - mountain	Moderate	Moderate	M/M	Moderate
Wetlands - west	Moderate	Moderate	M/M	Moderate

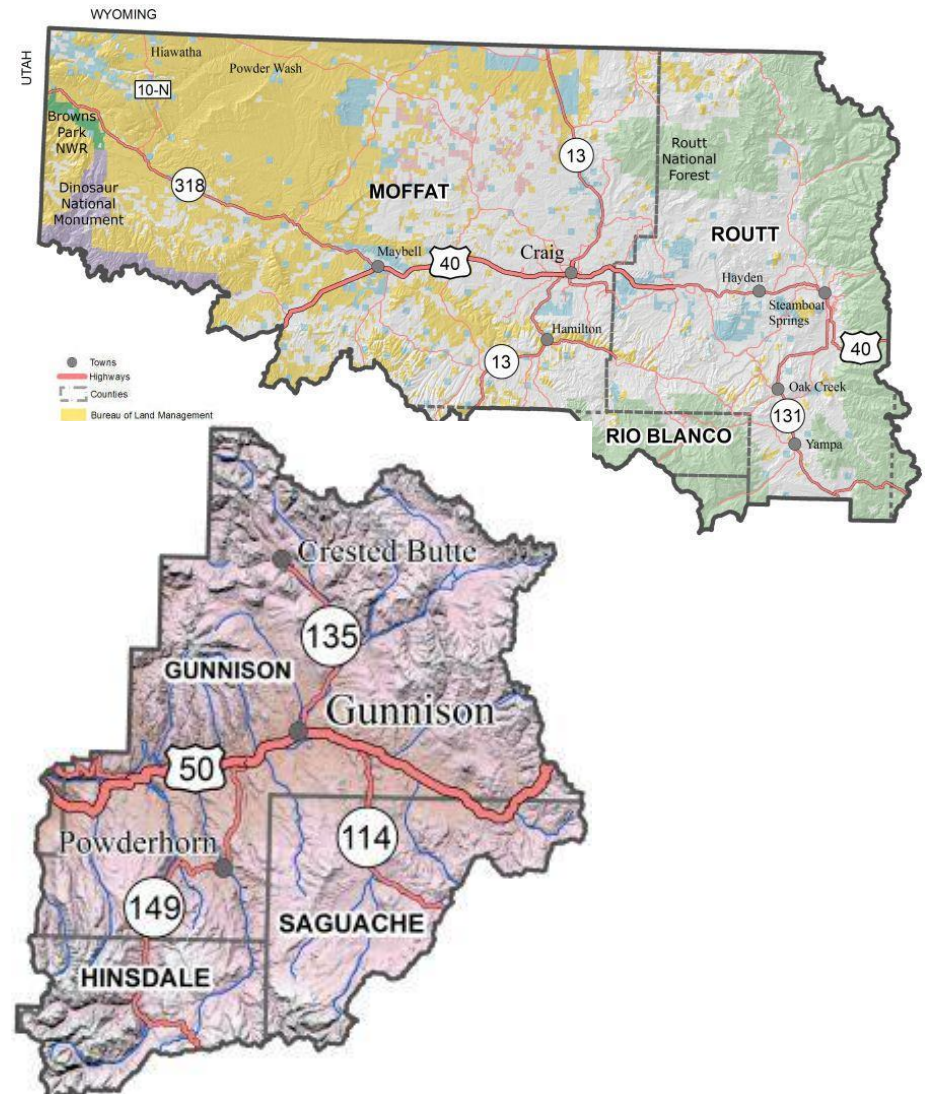




# Social Vulnerability

## Supporting Text

- **Two field offices**
  - Little Snake Field Office (Craig CO)
  - 1.3 million acres in NW CO
  - Gunnison, CO Field Office
  - 600,000 acres in Central CO
- **60 Interviews**
  - 15 BLM employees
  - 24 ranchers
  - 21 recreation-based businesses





# Social Vulnerability Results

- **BLM Managers and Staff**
  - Lack of agency training/information to address climate adaptation
- **Flexible management (access & timing)**
  - Development of trust with permittees is critical
  - RMP's must incorporate adaptive management
- **Timely range improvements**
  - Streamline NEPA for time-sensitive projects
- **Commitment to partnerships**
  - Can improve use values while stewarding natural systems
- **Need for landscape scale management**
  - Can better coordinate to allow for flexibility and avoid degradation







# Social Vulnerability Conclusions

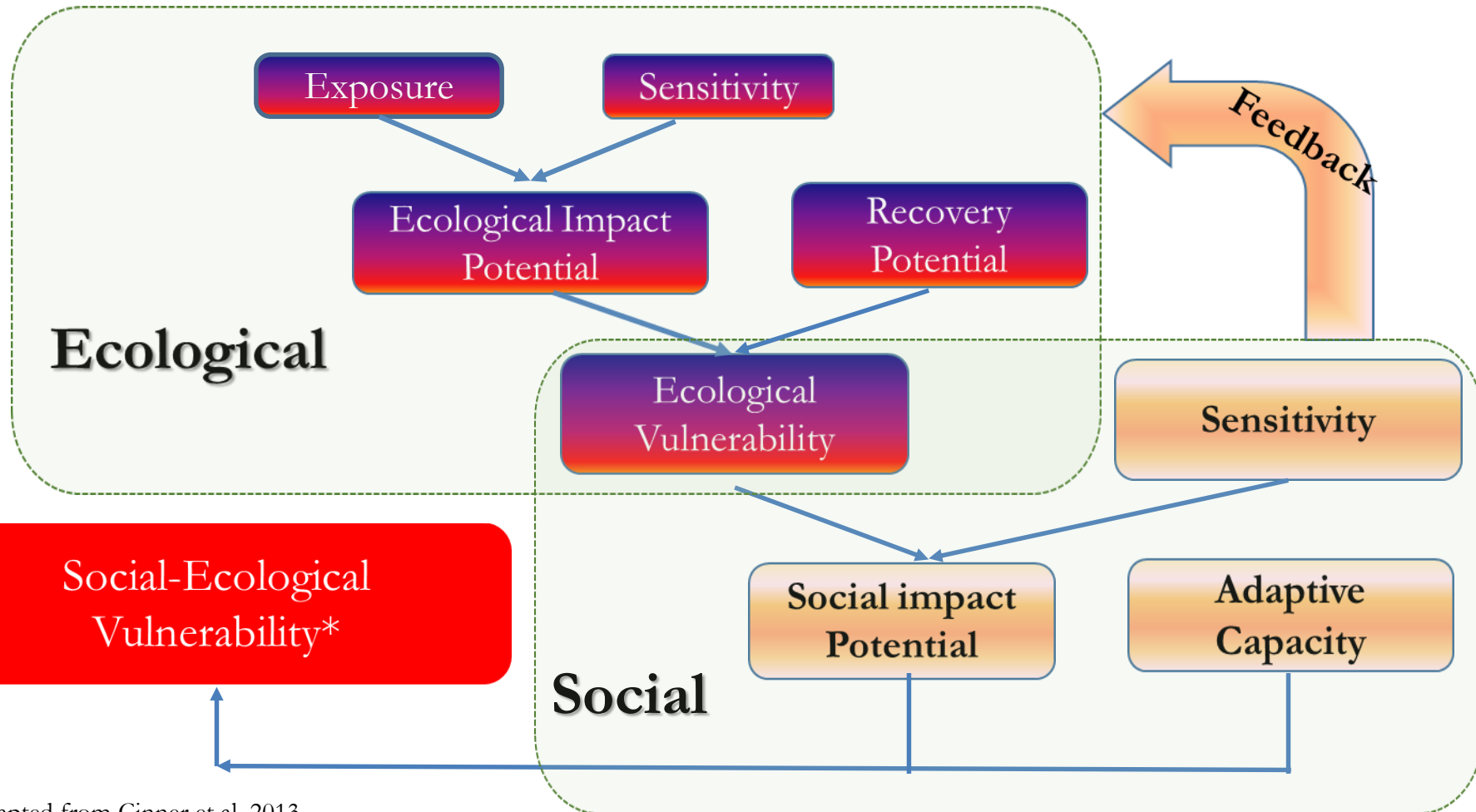
- **Additional climate adaptation training and awareness;**
- **Planning needs to incorporate climate adaptation to better prepare for changing futures**
- **Uncertainty in BLM decision-making**
- **Public land users rely upon ecosystem services from BLM lands, as well as providing feedbacks which may be altered by future climate change and other stressors which will lead to changing ecosystems**
- **Interaction of climate with other management issues (e.g. endangered species)**







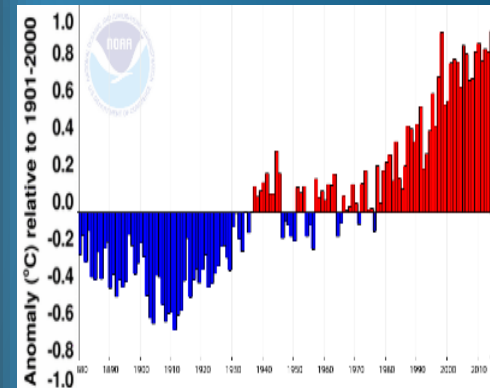
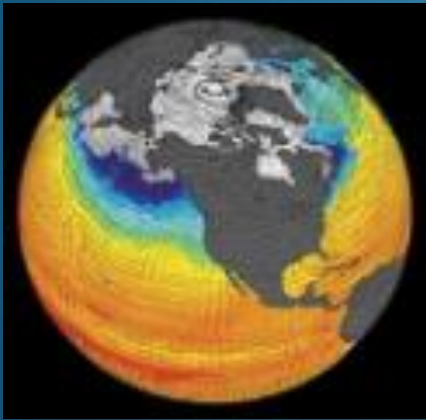
# Socio-Ecological Vulnerability



\*Adapted from Cinner et al. 2013

# Fisheries Management in Colorado

## Implications of Climate Change



George J. Schisler, Ph.D.  
Colorado Parks and Wildlife Aquatic Research Chief

Dan Isaak, Ph.D.  
U. S. Forest Service Fish Research Scientist



# Climate Concerns for Aquatic Systems

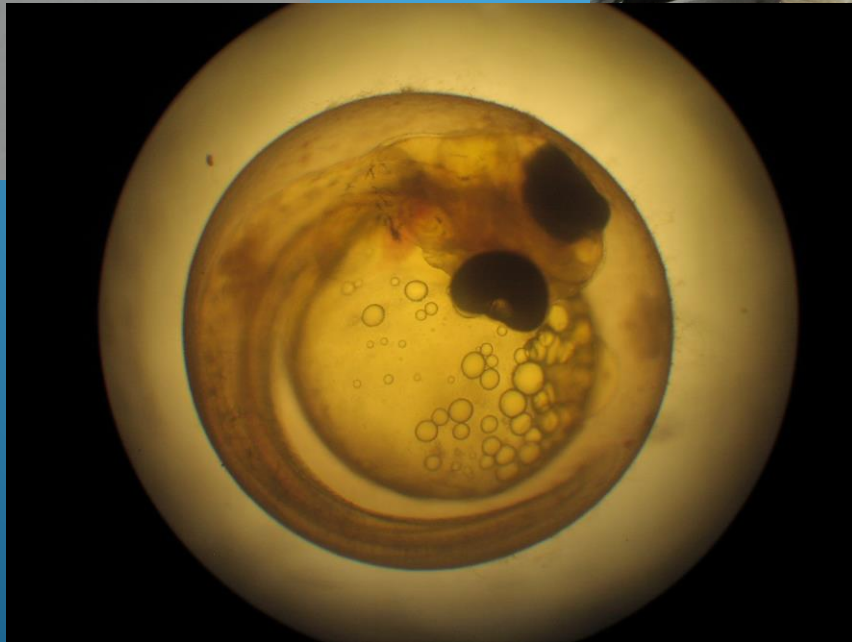
- Changes or loss of Suitable Habitat
- Changes in Spawn Timing and Reproductive Success
- Proliferation of Disease
- Aquatic Nuisance Species
- Loss of Native Species



# Loss of Suitable Habitat

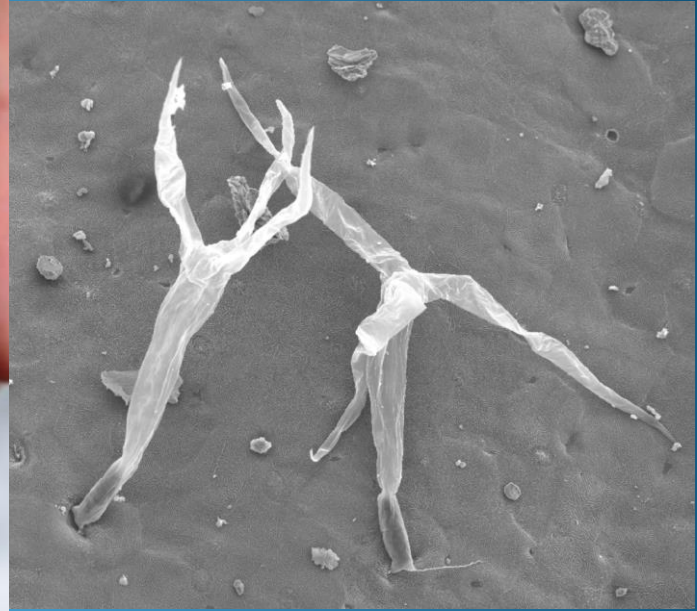


# Changes in Spawn Timing and Reproductive Success





# Disease and Stressors



# Aquatic Nuisance Species of Concern

Invasive Species!



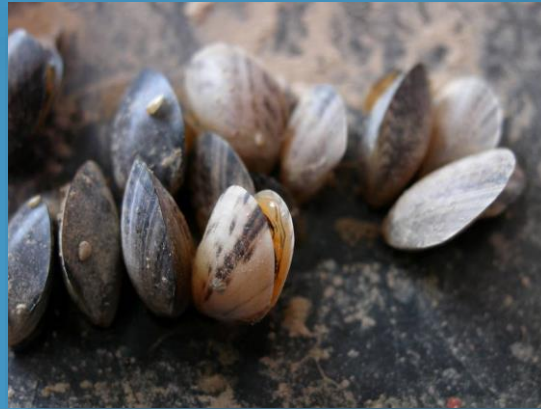


# Aquatic Nuisance Species of Concern

New Zealand Mudsnail



Quagga Mussel



Zebra Mussel



Rusty Crayfish

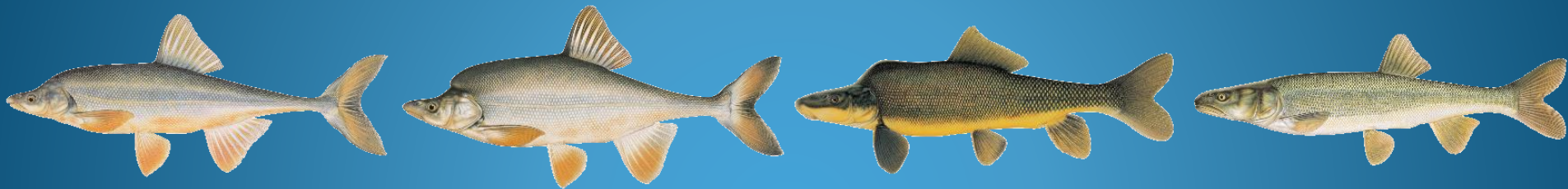


Eurasian Watermilfoil



# Federally Listed Species

## Federally Endangered



## Federally Threatened



## Federal Not Warranted





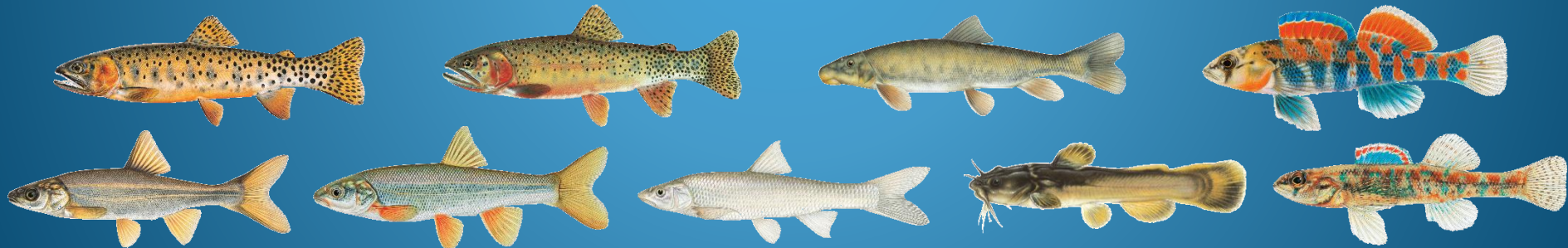
# State Endangered



# State Threatened



# State Special Concern



# Other



# Management Actions to Improve Resilience

## ➤ Fish Passage

- Allow fish to complete life cycles
- Movement to thermally favorable locations

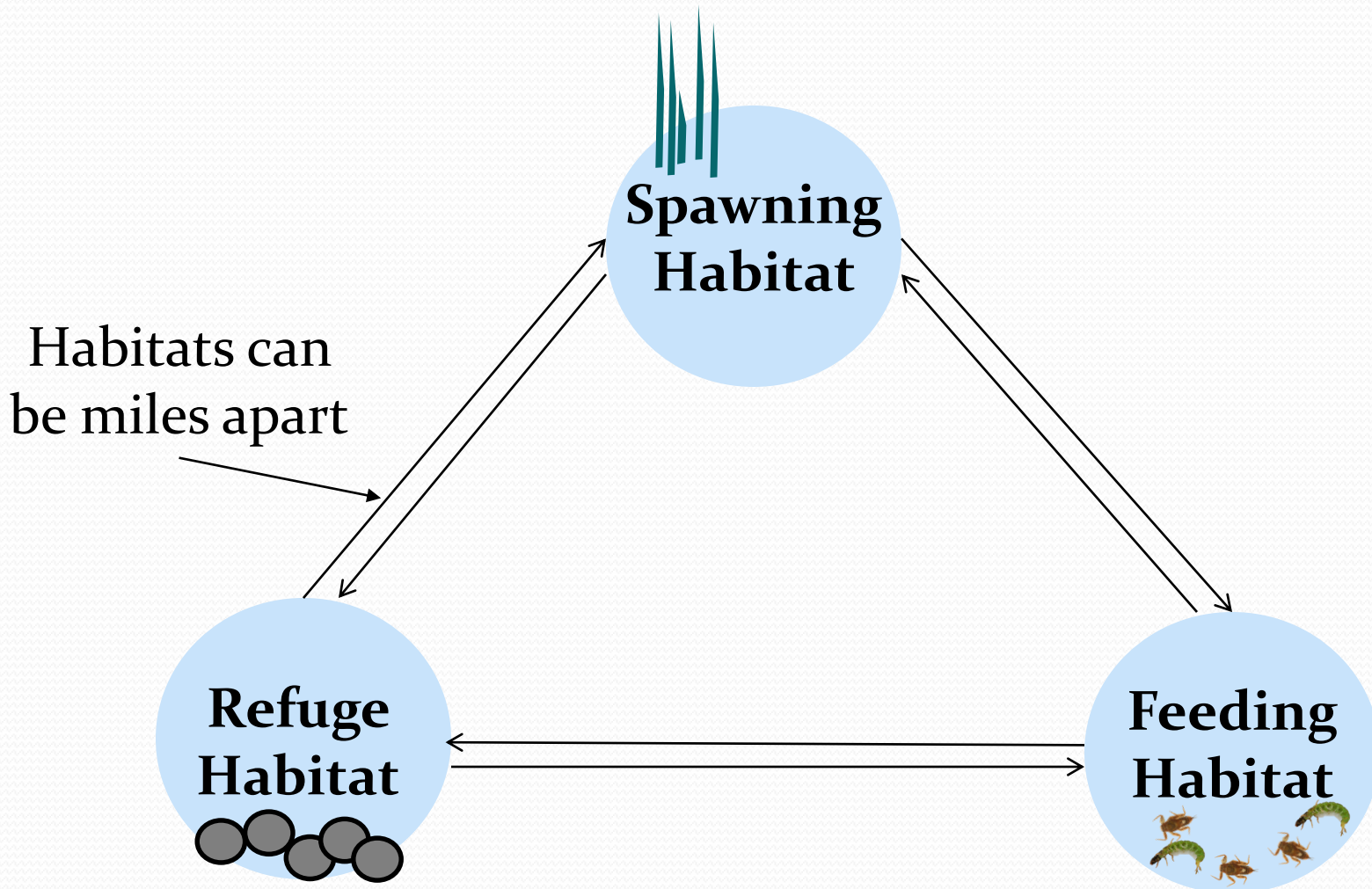
## ➤ Increase summer flows and protect cold water sources

- Prevent stranding
- Directly cool temperatures

## ➤ Habitat Improvement

- Increasing channel complexity to increase hyporheic exchange
- Provide refugia during low flows
- Increasing riparian vegetation to provide shading

# Basics of Stream Habitat





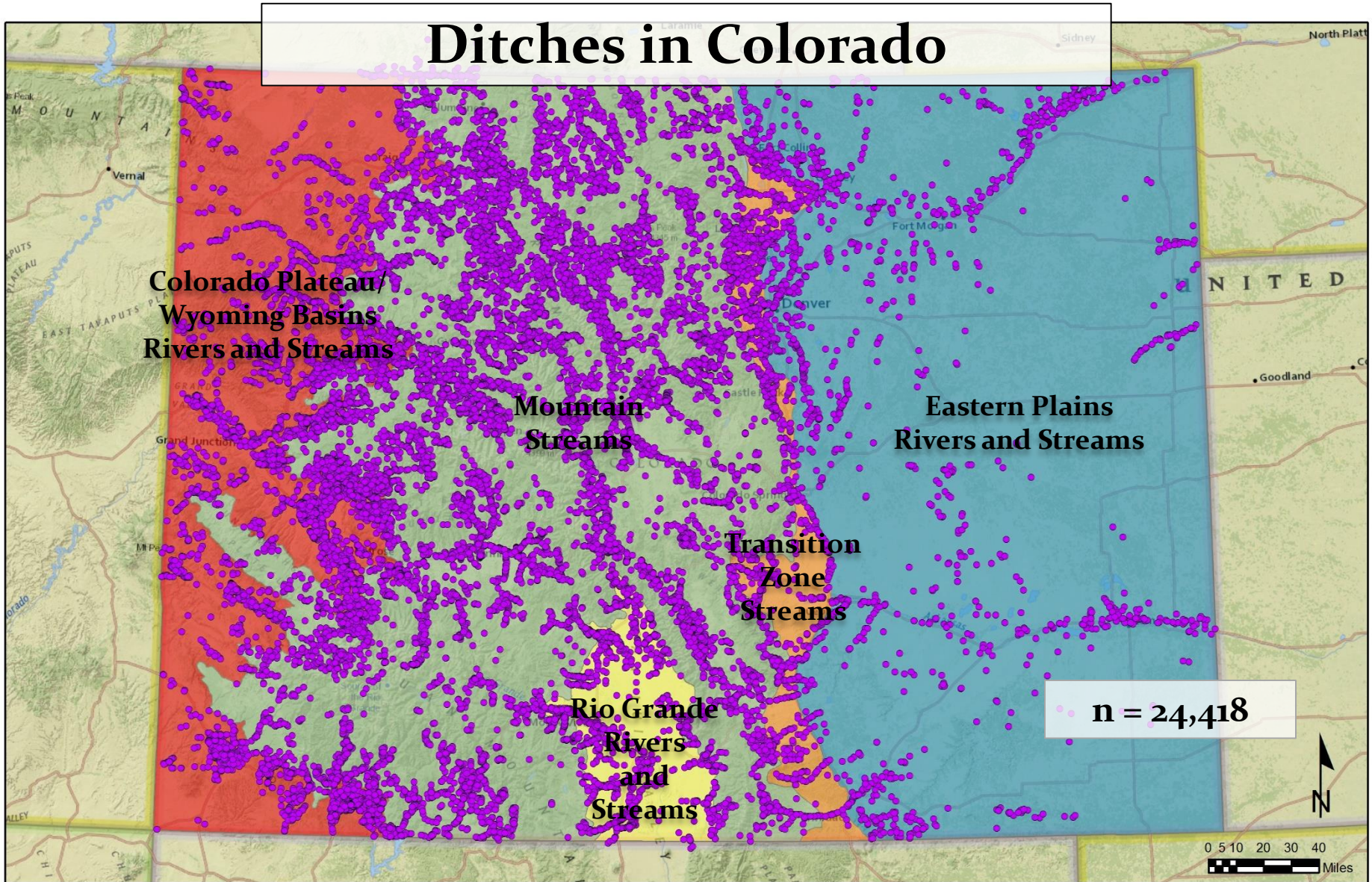
# Fish Passage

**Fossil Creek Reservoir  
Inlet Diversion,  
Cache la Poudre River**





# Ditches in Colorado



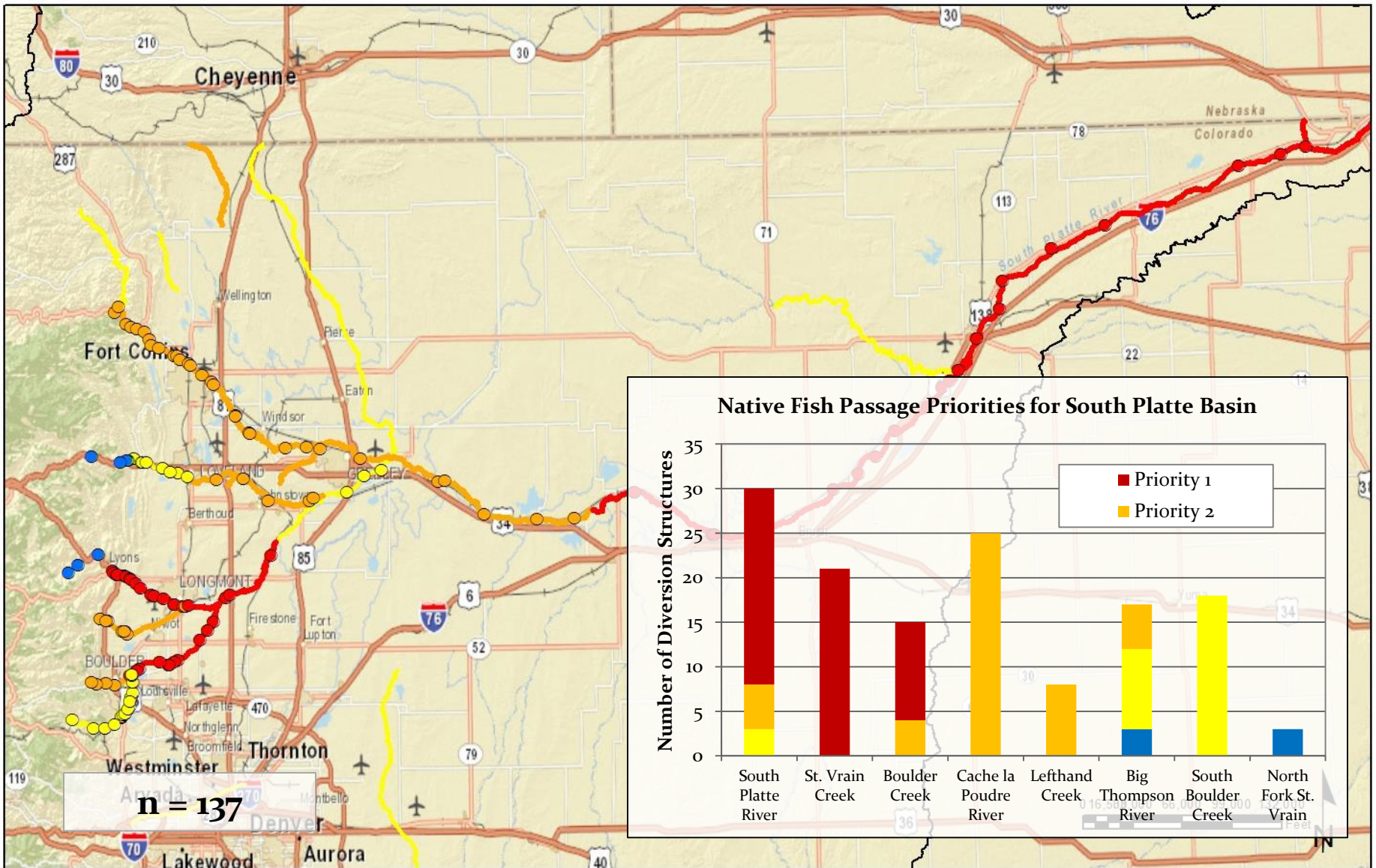
- Eastern Plains
- Mountain Streams
- Rio Grande
- Transition Zone
- Wyoming Basin/Colorado Plateau
- Ditch

POINTS OF DIVERSION	
DRAWN: ERICHER	6/23/2017
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

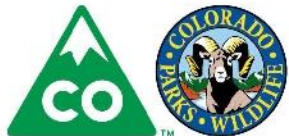
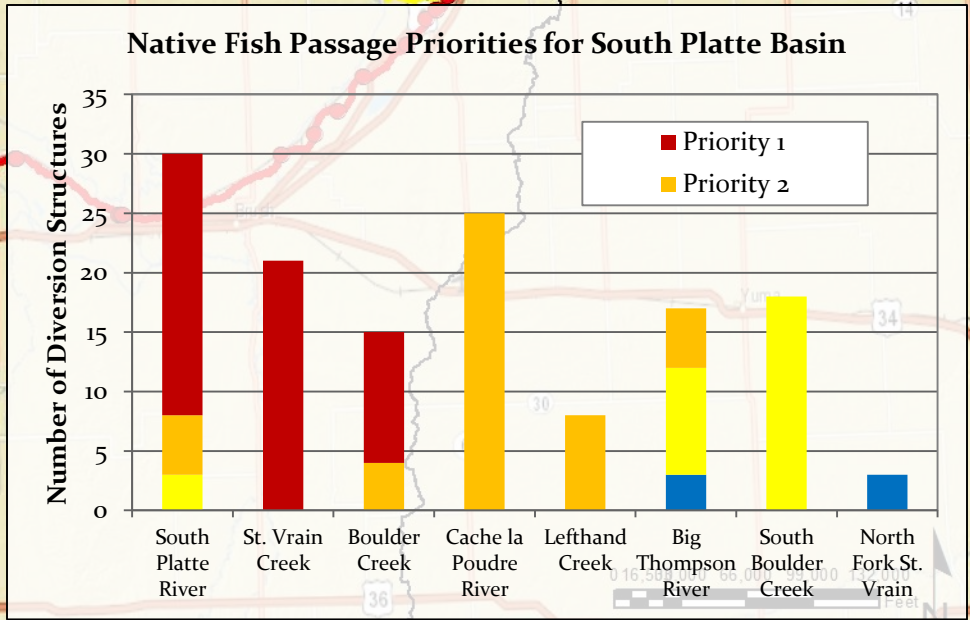
STATE OF COLORADO  
DEPARTMENT OF NATURAL RESOURCES  
COLORADO PARKS AND WILDLIFE  
FORT COLLINS, COLORADO

**WATER DIVERSION  
STRUCTURES IN COLORADO**





n = 137



**Streams      Diversion Structures / Potential Barriers**

- Priority 1      ● Priority 1
- Priority 2      ● Priority 2
- Priority 3      ● Priority 3
- Priority 4      ● Priority 4

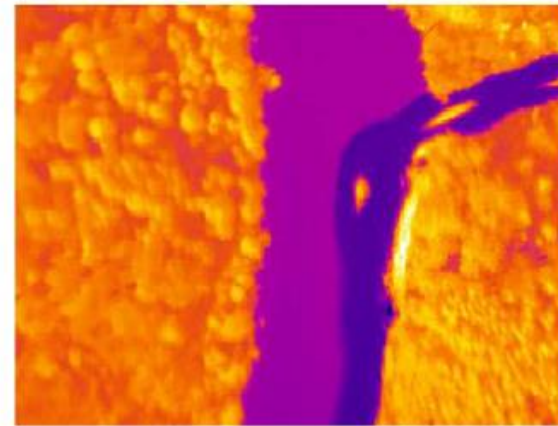
NATIVE FISH PASSAGE PRIORITIES		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO  <b>SOUTH PLATTE BASIN          FISH PASSAGE PRIORITIES          PLAN VIEW</b>
DRAWN: ERICHER	8/20/2014	
CHECKED:		
APPROVED:		
SHEET: 1 OF 1		



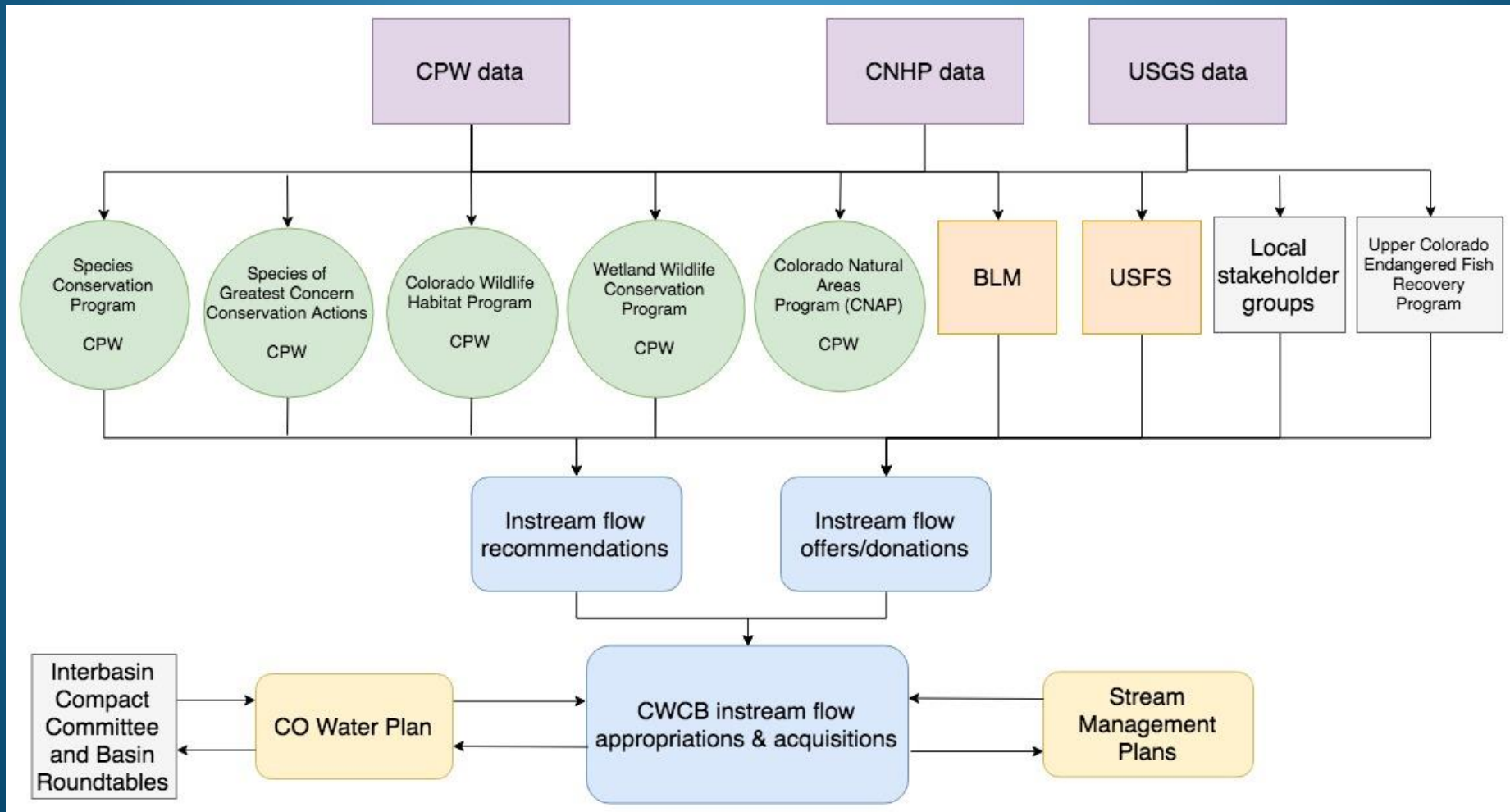
# Increase Summer Flows and Protect cold water Sources



© Reuters



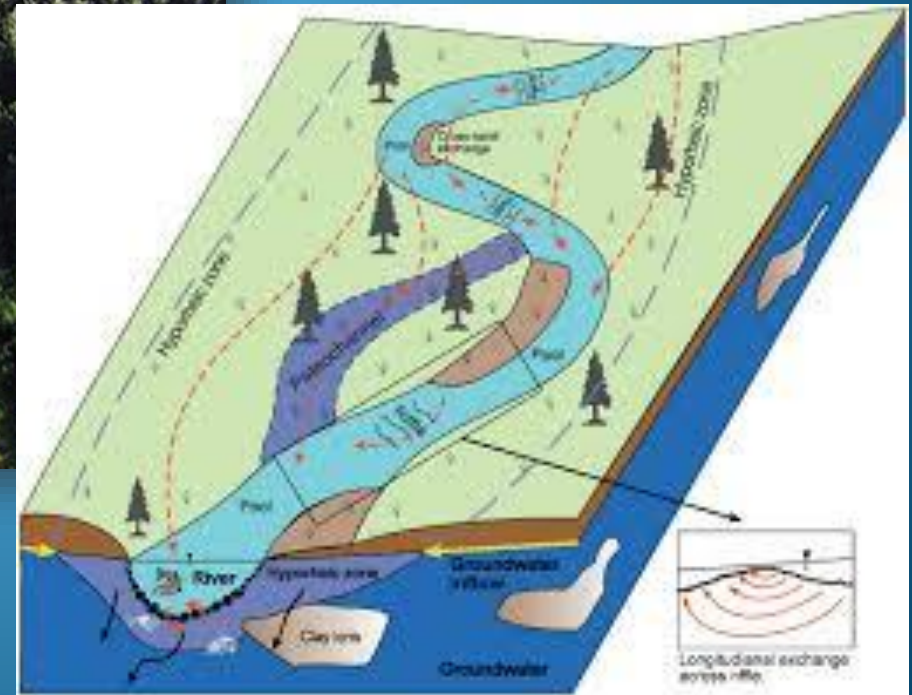
# Increase Summer Flows and Protect cold water Sources





# Increasing Probability of Persistence Through Habitat Restoration

- Groundwater
- Hyporheic exchange





# Increasing Probability of Persistence Through Habitat Restoration





# Increasing Probability of Persistence Through Habitat Restoration





# Increasing Probability of Persistence Through Habitat Restoration



# Conclusions

Climate change is a concern for a variety of reasons, directly and indirectly related to temperature change.

Temperature influences multiple different aspects of survival and reproduction of fish.

In order for fish to adapt and for fish populations to be resilient in the face of climate change, conditions need to be provided for success.

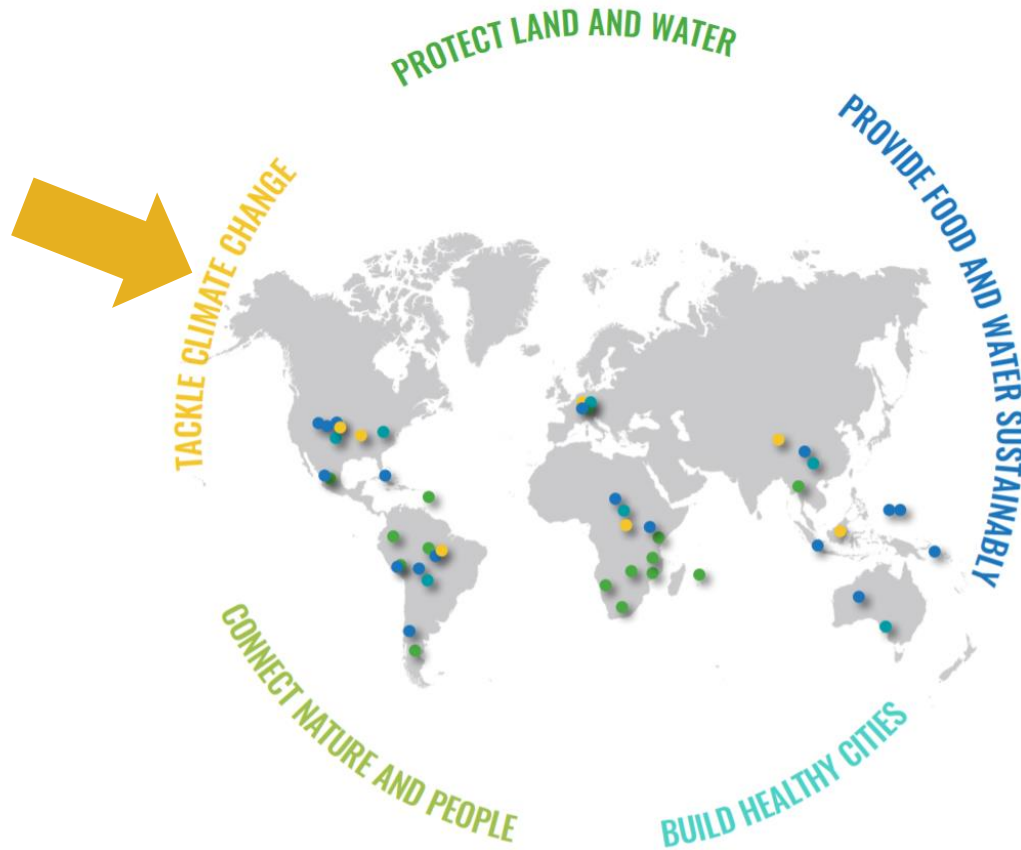




# Natural Climate Solutions

CNHP Partners Meeting  
March 9, 2018  
Betsy Neely, The Nature Conservancy

# Global Priorities







# Natural Climate Solutions

Restoring, conserving & better managing forests,  
grasslands, farmlands & wetlands

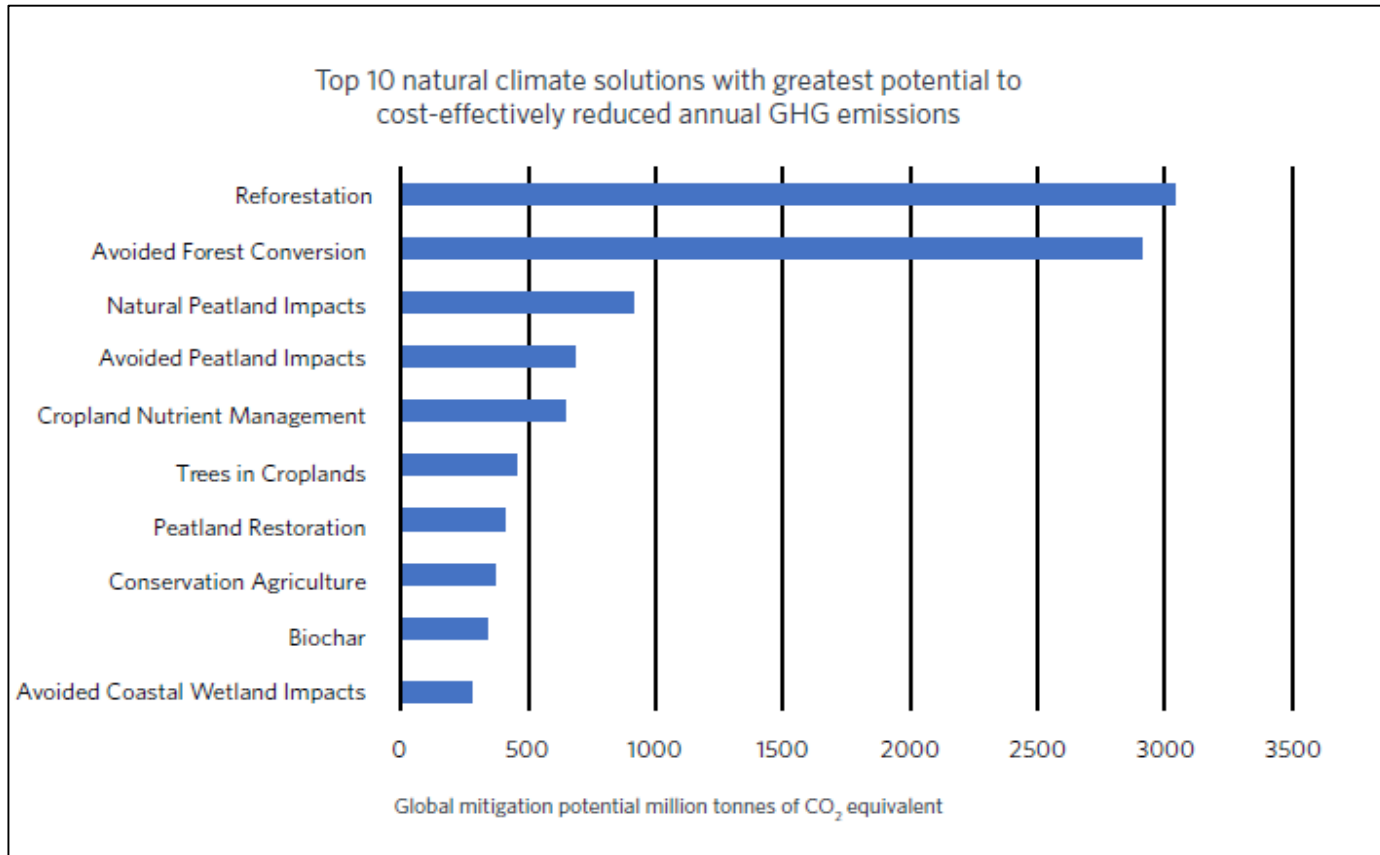
Could deliver 37% of carbon reductions needed by  
2030 to keep warming below 2°C &

Help nature & people adapt

Griscom et al. 2017 PNAS

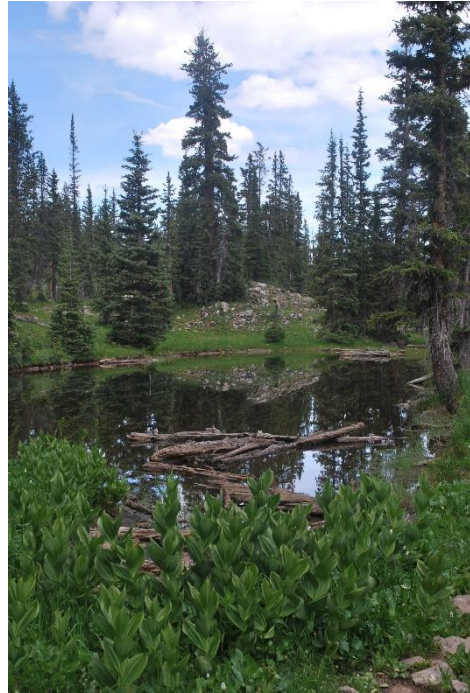


# Natural Climate Solutions: Global Analysis



Griscom et al. 2017

# Natural Climate Solutions: Colorado





- Colorado's lands play an crucial role in mitigating climate change
- Managing lands to improve carbon sequestration can contribute to climate goals
- Seek policies & practices to improve management of lands for carbon

## Carbon Sequestration in Colorado's Lands: An Integrated Spatial & Policy Analysis





# Colorado Climate Impacts & Opportunities Project

Collaborative Effort with TNC, CNHP & Western Water Assessment/NOAA

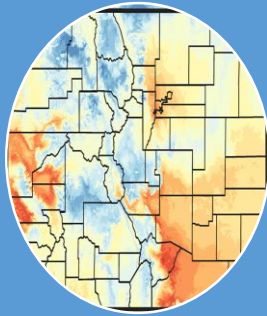


## Goals



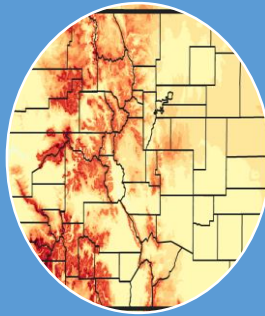
Targets &  
Goals

## Climate Scenarios



Hot & Dry  
Feast & Famine  
Warm & Wet  
Hot & Wet

## Ecological Response Models



Drought  
Fire  
Insects  
Stream Flows  
Temperature

## Situation Analysis



Social &  
Ecological  
Connections  
Climate Impacts  
Interventions

## Results Chains



Strategies



Actions





# Pilot, Evaluate & Share on-the Ground NCS Projects

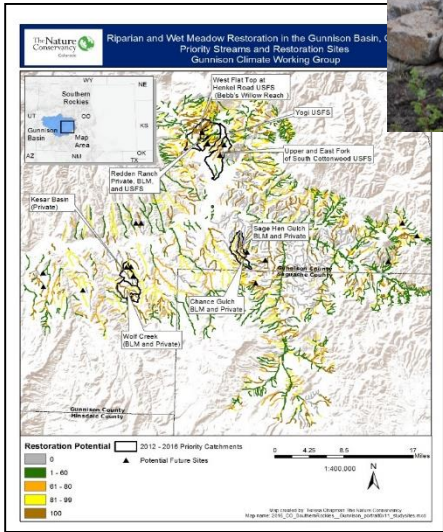


Restore & Build Resilience of Wet Meadows in Sagebrush Landscape

Rondeau, CNHP



# Scaling Up for Greater Impact



**TECHNICAL NOTES**

U.S. DEPARTMENT OF AGRICULTURE STATE OF COLORADO NATURAL RESOURCES CONSERVATION SERVICE

Range Technical Note No. xx XXXX 2018

**Hand-Built Structures for Restoring Incised Meadows in Sagebrush Rangelands**

*Examples and lessons learned from the Upper Gunnison River Basin, Colorado*



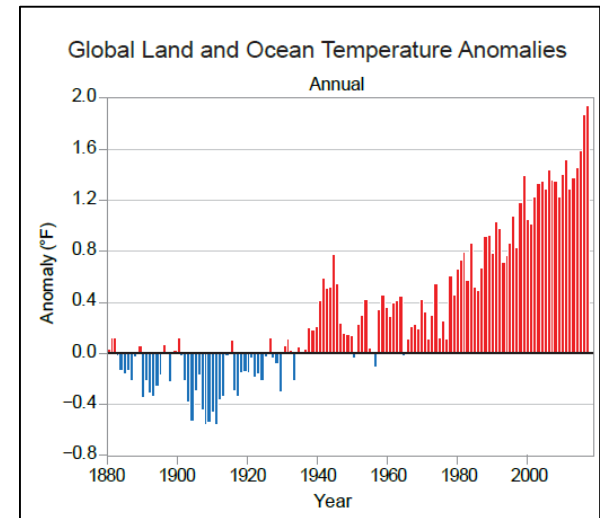
Zachyk rock structures installed to restore incised channel. Photo by: Gunnison Climate Working Group

Grant, UGRD

Rondeau, CNHP

# Moving the Needle

1. Statewide collaborative cross-boundary climate initiative
2. Climate Summit
  - Natural climate solutions
  - Adaptation
  - Mitigation



4<sup>th</sup> National Climate Assessment 2017

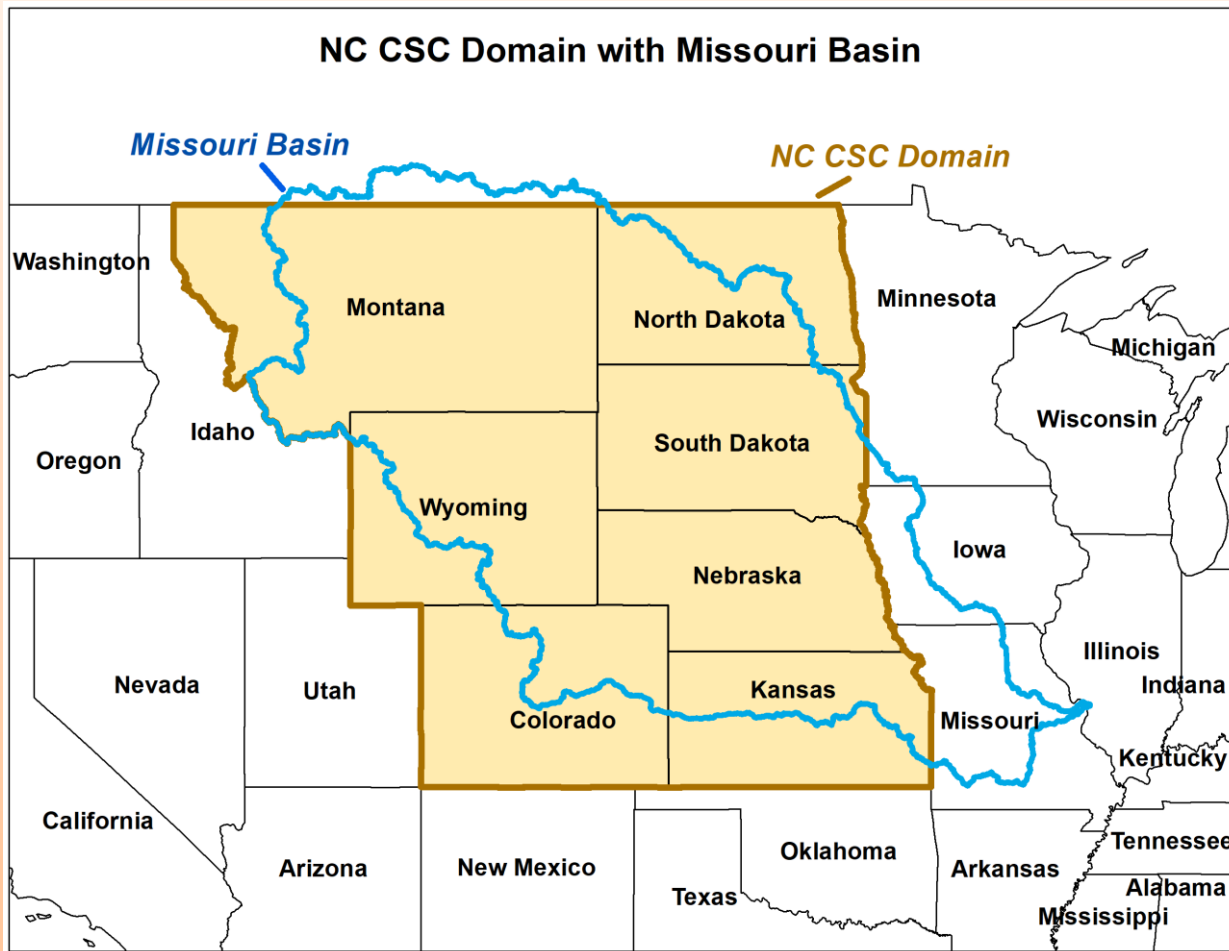
**Managing fish and wildlife habitat in the age  
of climate change: providing *actionable*  
*science* to resource managers**

***Robin O'Malley***

Director, USGS North Central Climate Science Center.



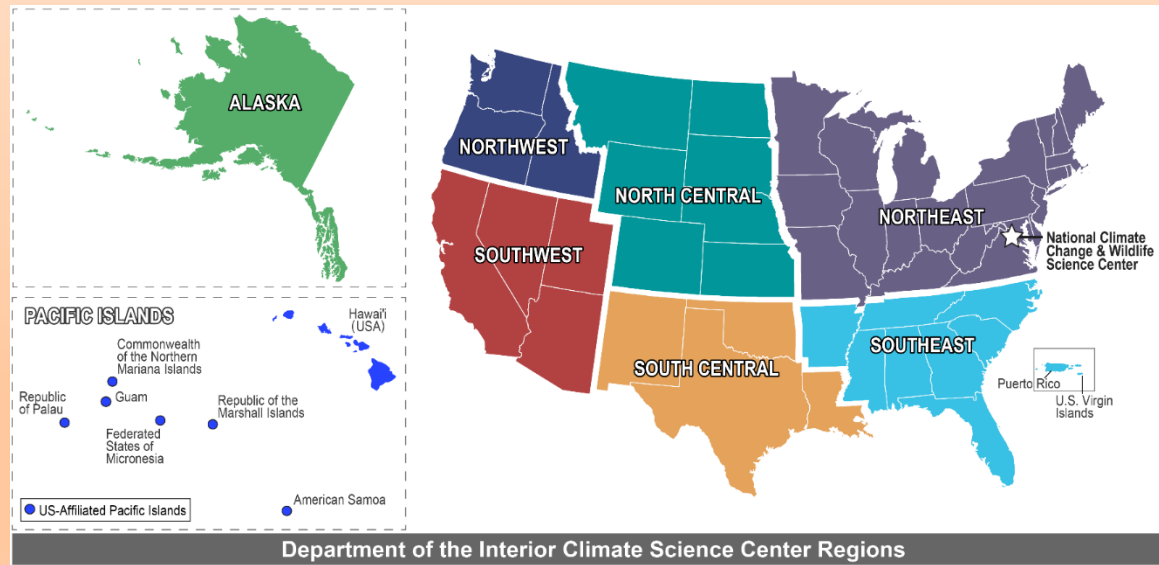


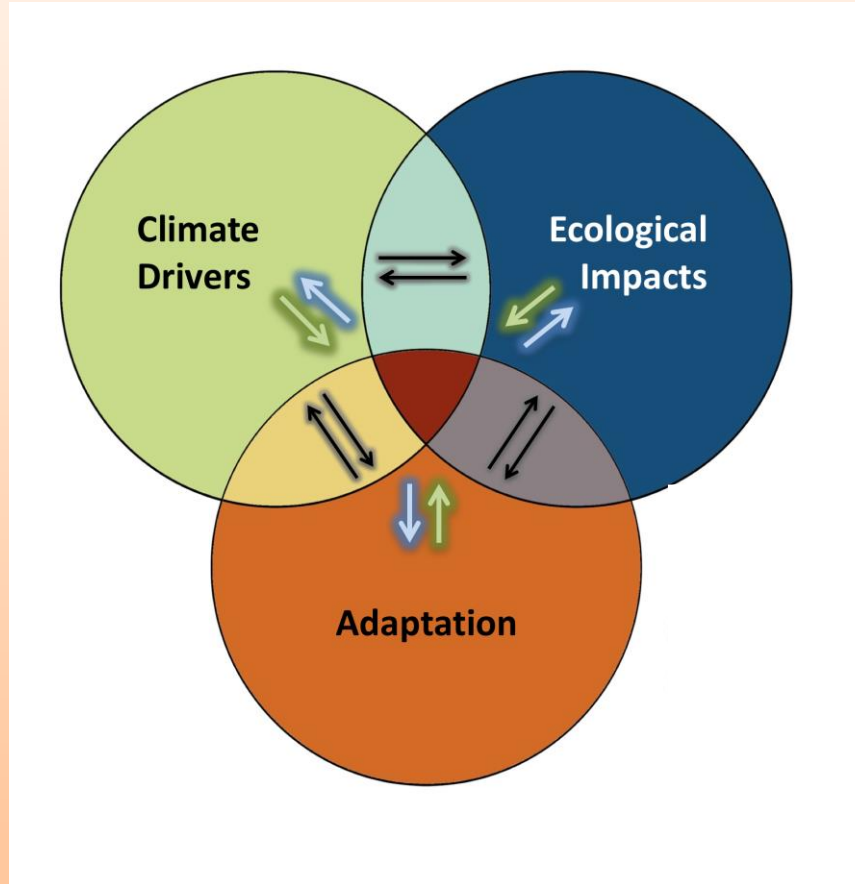


## The North Central CSC

- Federal + university consortium
- Established 2011 as part of 8-center network
- Small staff >> deep bench
- ~\$2.0 million per year (smaller than most CSCs)
- Natural / cultural / DOI resources
- “Actionable science”

Colorado State University (CSU)  
University of Colorado (CU)  
Colorado School of Mines (CMC)  
University of Nebraska-Lincoln (UNL)  
Iowa State University (ISU)  
University of Wyoming (UW)  
Montana State University (MSU)  
University of Montana (UM)  
Kansas State University (KSU)



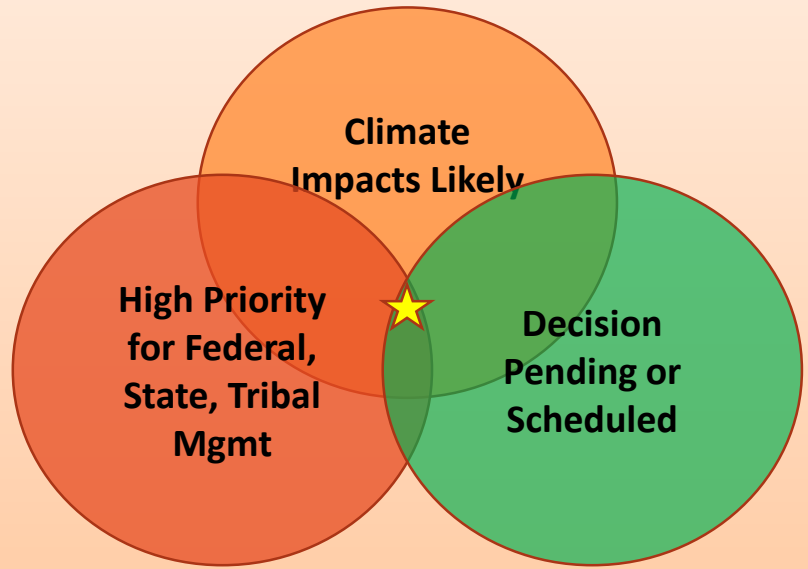




**Actionable science** provides data, analyses, projections, or tools that **can support decisions** regarding the management of the risks and impacts of climate change. It is **ideally co-produced** by scientists and decision makers and creates **rigorous and accessible** products to meet the needs of stakeholders.

Advisory Committee on Climate Change and Natural Resource Science, 2015





## Core Products and Services from NC CSC

- **Climate data**
  - Maps, time series graphics, gridded data
  - Consultancy on model, emissions, and downscaling choices
- **Remote sensing products and analysis**
  - Including expertise on drought, fire, and phenology data sets
- **Ecological response modeling**
  - Habitat suitability and species distribution modeling
  - Simulation modeling (state-and-transition and agent-based)
- **Integrated approach to socio-ecological systems**
  - Interdisciplinary social science-driven co-production of climate-responsive adaptation science
- **Scenario planning for management decisions**
- **GIS services to combine data and models**
- **Training**
  - Regional offerings of National Conservation Training Center courses
  - NASA remote sensing, simulation modeling
  - “Hands-on” as part of research projects

**Co-developed solutions  
leading to actionable  
science**





1. Assisting ranchers and BLM adapt to climate change in SW CO
2. Supporting the CO State Wildlife Action Plan
3. Assessing adaptation options statewide for the BLM
4. Supporting National Park Service Planning (Badlands, Devils Tower)
5. Identifying state-level priorities for species of conservation concern
6. Assisting tribal water managers understand and respond to drought early warnings
7. Evaluating forest migration in response to climate – and impacts to forest dependent species (wolverine, WBP)
8. Modeling sage brush persistence under climate change
9. Synthesizing “state of the science” for Pinyon-Juniper management
10. Learning how financial incentive programs interact with other factors to affect private land owner decisions



Thank you

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571-294-0922



# Break (2:30-2:45)

**Next: Panel 3: Private Land Conservation Services**

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