



# Climate Change and Water

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**COLORADO**

**Resiliency & Recovery Office**

Governor John W. Hickenlooper

# Colorado Resiliency & Recovery Office



## Colorado Resiliency & Recovery Office

*Who Are We?*

RESILIENCE • PERSISTENCE • SUSTAINABILITY • FORTITUDE  
SUPPORT REBUILD **COMMUNITY** FEEL BACK  
RESOURCES • DISASTER • TOUGHNESS • MAKE • ABILITY  
KEEP GRIT **ABILITY** DETERMINATION • PREPARED  
KEEP • RECOVER • GIVING • RECOVERY • FACE • EVENT • WORK  
ABLE • OVERCOME • COME **BOUNCE** DRIVE  
OBSTACLES • ADAPTABLE FORTITUDE • LIFE • OVER • ALWAYS • DEDICATION • POSITIVE  
COMMITTED • BOUNCE-BACK • BRAVERY • TOGETHER • STATE  
WITHSTAND **BACK** MATTER • ONE • HELP • READY  
FORWARD COMING • LASTING • DURABLE • TENACITY • NEIGHBORS  
OTHERS • HARDSHIP • SITUATIONS • IMPROVED • MOVING  
ENDURANCE • TOUGH **STRONG** STEADFAST  
TOGETHER • PERSISTENT DETERMINED • PERSERVERENCE • WITHSTAND • REBUILDING

# Colorado's Definition of Resiliency

*The ability of communities to rebound, positively adapt to, or thrive amidst changing conditions or challenges - including disasters and changes in climate - and maintain quality of life, healthy growth, durable systems and conservation of resources for present and future generations.*

*-Colorado Resiliency Working Group*

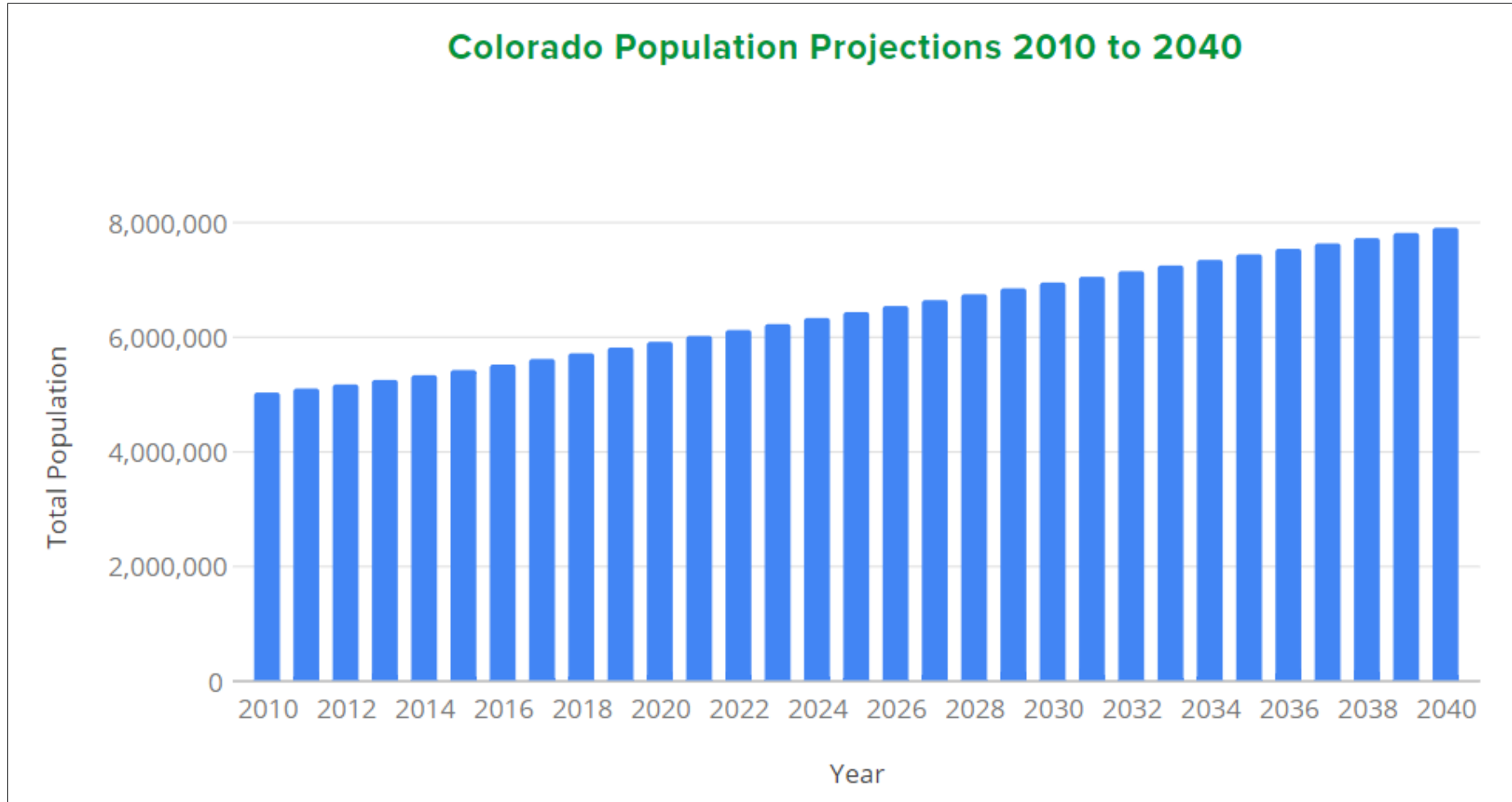


# Why Resiliency?

Disaster	Communities Impacted	Disaster Impacts
1965 Floods	Colorado Front Range (South Platte and Arkansas basins)	21 lives lost; \$540M damages (1965 dollars); resulted in construction of Chatfield and Bear Creek reservoirs
Big Thompson Flood (1976)	Primarily Larimer County between Estes Park and Loveland	8 inches of rain in a one hour period; 145 lives lost; 418 houses destroyed.
2002 Drought and Wildfires	Statewide. Major fires included Hayman, Coal Seam, Missionary Ridge and others	Hayman fire burned 137k acres; Missionary Ridge 70k acres
2012-2013 Wildfires	Statewide; large fires in Larimer, El Paso, Fremont counties and the San Luis Valley	More than 1100 homes destroyed, \$1.2B in insurance claims
2013 floods	24 counties impacted	10 lives lost; 1800 homes destroyed, \$3.9B in damages

# Why Resiliency?

Population is growing



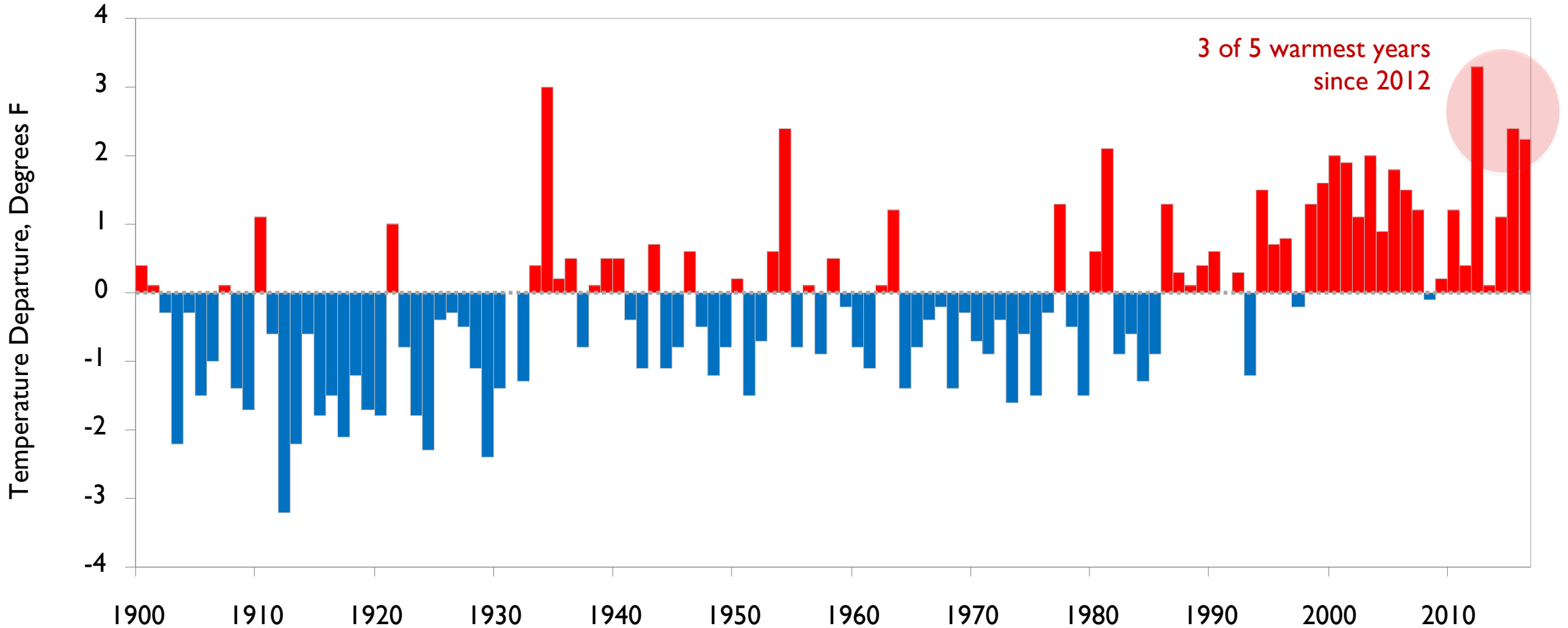
# Why Resiliency?

Population is growing

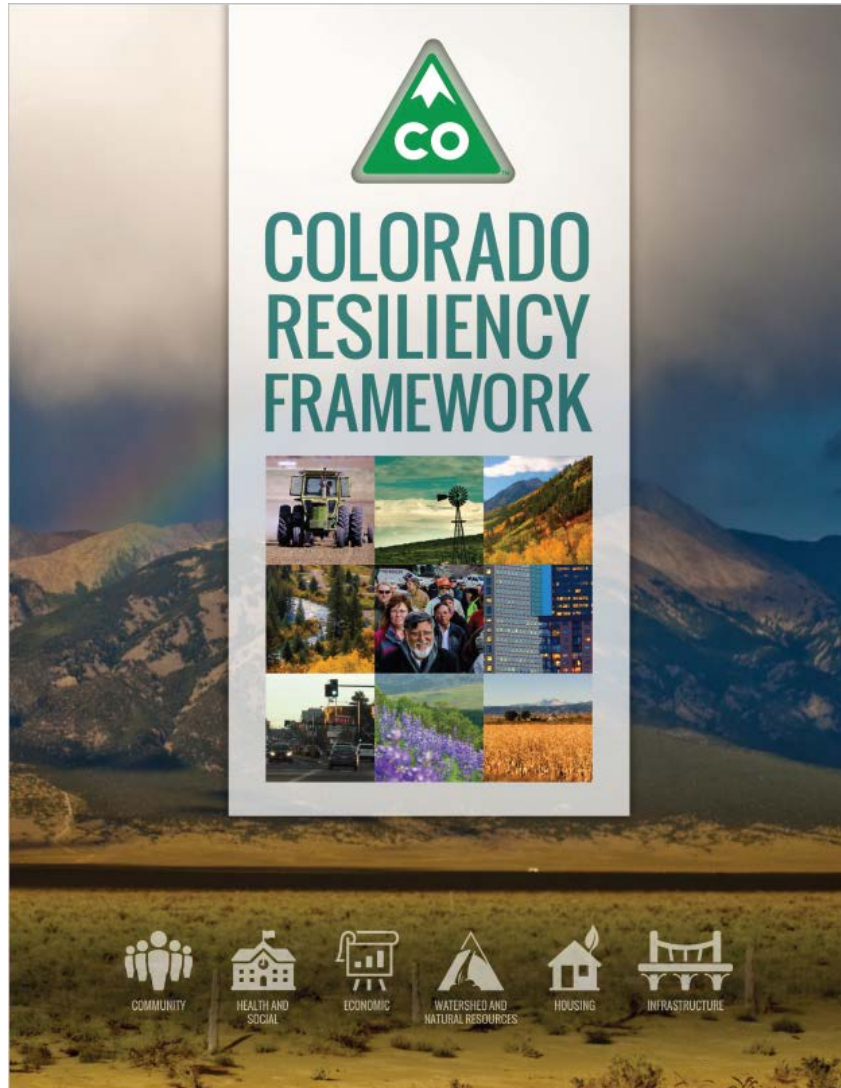
Population Current and Projected -- Statewide and Select Counties				
Jurisdiction	2010 Census	Estimated 2013	Estimated 2020	Estimated 2040
State of Colorado	5,029,196	5,264,890	5,924,692	7,752,887
City and County of Denver	604,879	648,978	734,079	867,545
Morgan County	28,196	28,317	30,232	39,017
Larimer County	299,630	315,728	356,900	471,612
Mesa County	147,112	148,293	162,034	215,237
La Plata County	51,441	53,407	61,785	85,770

# Why Resiliency?

Colorado statewide annual temperatures have warmed by 2°F in past 30 years



# The Colorado Resiliency Framework



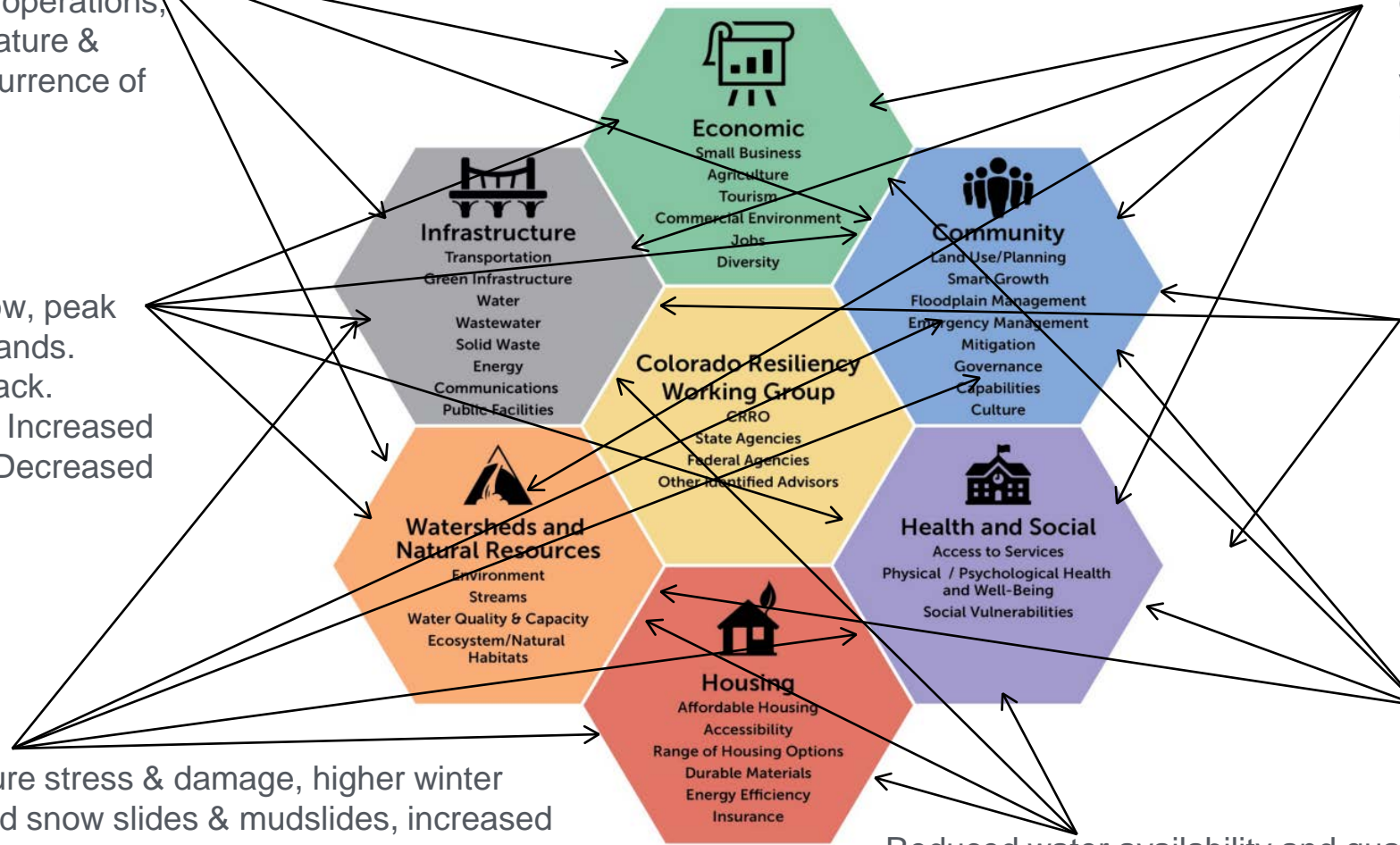
***While the recent disasters catalyzed the development of the Colorado Resiliency Framework, implementation is about protecting and enhancing our future.***



# Integrated and Interdisciplinary



## Colorado Resiliency Framework Sectors



Warming in the shoulder seasons & decreased cold snaps may effect snow-making operations, earlier melt, temperature & seasonal shifts, occurrence of avalanches.

Decreased water availability, increased drought, increased crop demands, increased heat stress, decreased crop yield, increased weeds & pests

Changes in streamflow, peak runoff, and crop demands. Decreases in Snowpack. Increases in drought. Increased water temperatures. Decreased water quality.

Decreased air quality, water quality, increased vector-borne disease, and frequency/intensity of extreme weather events

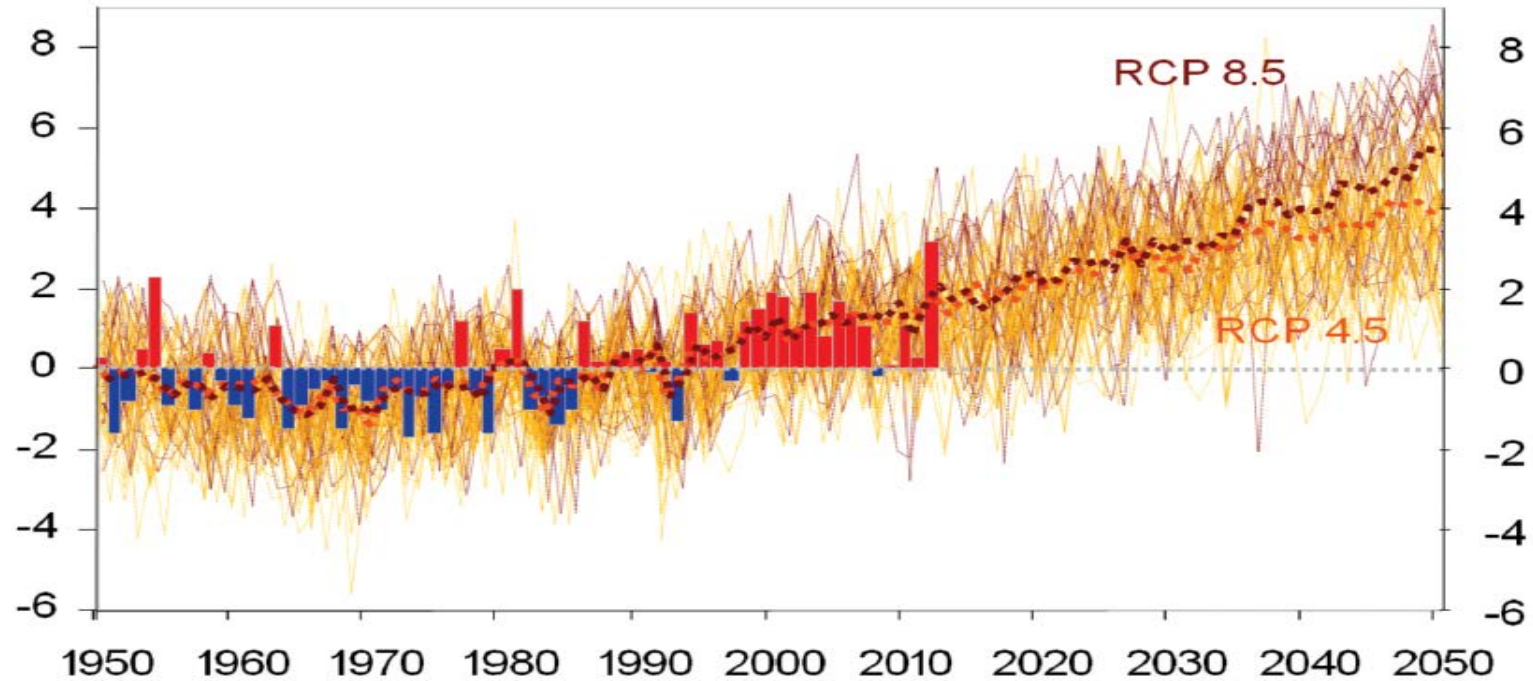
Increased susceptibility to insect and pathogen invasions, phenology shifts, wildfire, decline in habitat suitability, drought stress

Heat-related infrastructure stress & damage, higher winter snow removal, increased snow slides & mudslides, increased delays, degraded operations, increased washouts, increased wildfires/ closures, changes in air density, increased costs.

Reduced water availability and quality, shift in timing of water availability, increased energy demands, disruptions to operations, decreased reliability

# Climate Trends

## Observed & Projected Annual Temperatures



Source: Adapted from Lukas et.al, Climate Change in Colorado, 2014

# 2050 Temperature Projections in Context

**2°F: Denver's** seasonal temperature cycle will become more like **Pueblo** today



**4°F: Denver's** seasonal temperature cycle will become more like **Lamar** today



**6°F: Denver's** seasonal temperature cycle will become more like **Albuquerque** today



# Observed Statewide Climate Trends since 1980s

Annual temperature

warmer

Heat waves

more frequent

Cold waves

less frequent

Frost-free season

longer

Annual precipitation

no significant trends

Palmer Drought Index

more drought

# Projected Climate and Hydrology Changes

**Annual streamflow**

**decreases in majority of projections**

**Peak runoff timing**

**earlier in all projections**

**Crop water use**

**increases**

**April 1 snowpack**

**decreases in most projections**

**Palmer Drought Index**

**more drought**

**Heat waves**

**more frequent**

**Cold waves**

**less frequent**

**Frost-free season**

**longer**

**Wildfires**

**more frequent**

# *Impacts: Water*

**Vulnerabilities:** Changes in streamflow, peak runoff, and crop demands. Decreases in snowpack. Increases in drought. Increased water temperatures. Decreased water quality.



# *Sector Impacts: Public Health*

Vulnerabilities: decreased air quality, water quality, increased vector-borne disease, and frequency/intensity of extreme weather events





# *Sector Impacts: Agriculture*

Vulnerabilities: decreased water availability, increased drought, increased crop demands, increased heat stress, decreased crop yield, increased weeds & pests



# *Sector Impacts: Tourism and Recreation*

Vulnerabilities: Warming in the shoulder seasons & decreased cold snaps may effect snow-making operations, earlier melt, temperature & seasonal shifts, occurrence of avalanches.



# *Sector Impacts: Natural Habitats*

Vulnerabilities: increased susceptibility to insect and pathogen invasions, phenology shifts, wildfire, decline in habitat suitability, drought stress.



# Summary of Projected Climate Effects on Water Resources

ELEMENT	PROJECTED CHANGES AND POTENTIAL EFFECTS	STUDIES THAT HAVE ASSESSED THIS VULNERABILITY FOR COLORADO
Overall Surface-Water Supply	Most projections of future hydrology for Colorado's river basins show decreasing annual runoff and less overall water supply, but some projections show increasing runoff. Warming temperatures could continue the recent trend toward earlier peak runoff and lower late-summer flows.	Colorado Water Conservation Board (CWCB) (2012); Bureau of Reclamation (BOR) (2012); Woodbury et al. (2012)
Water Infrastructure Operations	Changes in the snowpack and in streamflow timing could affect reservoir operations, including flood control and storage. Changes in the timing and magnitude of runoff could affect the functioning of diversion, storage, and conveyance structures.	CWCB (2012); BOR (2012)
Crop Water Demand, Outdoor Urban Watering	Warming temperatures could increase the loss of water from plants and soil, lengthen growing seasons, and increase overall water demand.	CWCB (2012); BOR (2012)
Legal Water Systems	Earlier and/or lower runoff could complicate administration of water rights and interstate water compacts, and could affect which rights-holders receive water.	CWCB (2012)
Water Quality	Warmer water temperatures could cause many indicators of water quality to decline. Lower streamflows could lead to increasing concentrations of pollutants.	Environmental Protection Agency (EPA) (2013)
Groundwater Resources	Groundwater demand for agricultural use could increase with warmer temperatures. Changes in precipitation could affect groundwater recharge rates.	
Energy Demand and Operations Costs	Warmer temperatures could place higher demands on hydropower facilities for peaking power in summer. Warmer lake and stream temperatures, and earlier runoff, could affect water use for cooling-power plants and in other industries.	Mackenick et al. (2012)
Forest Disturbances in Headwaters Region	Warmer temperatures could increase the frequency and severity of wildfire, and make trees more vulnerable to insect infestation. Both have implications for water quality and watershed health.	
Riparian Habitats and Fisheries	Warmer stream temperatures could have direct and indirect effects on aquatic ecosystems, including the spread of non-native species and diseases to higher elevations. Changes in streamflow timing could also affect riparian ecosystems.	Rieman and Isaak (2010)
Water- and Snow-based Recreation	Earlier streamflow timing could affect rafting and fishing. Changes in reservoir storage could affect recreation on-site and downstream. Declining snowpacks could affect winter mountain recreation and tourism.	BOR (2012); Battaglin et al. (2011); Lazar and Williams (2008)

# HB 13-1293

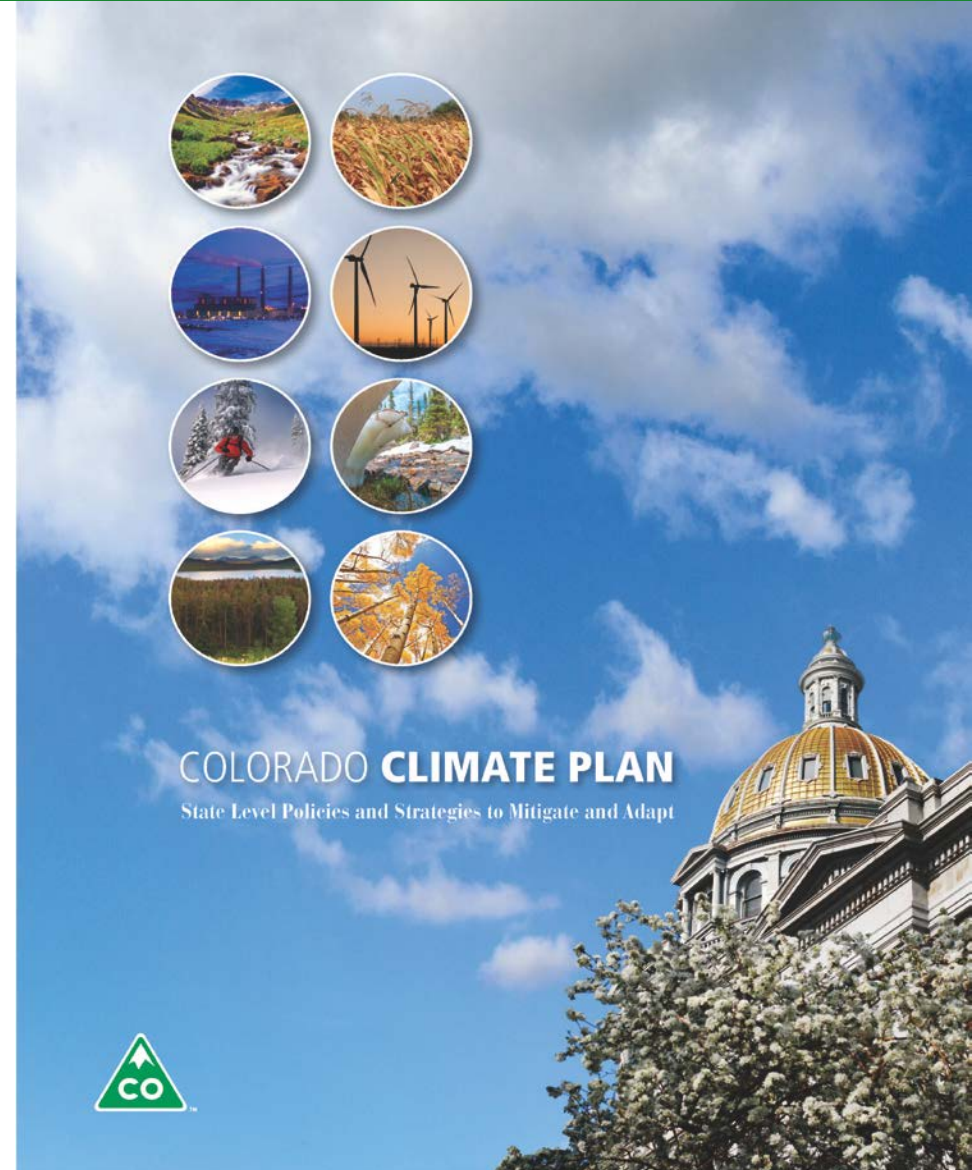
*“The general assembly hereby declares that climate change presents serious, diverse, and ongoing issues for the state's people, economy, and environment...ensure that the state is apprised of the threats that climate change poses to Colorado and the progress made to mitigate and address those threats...”*



- Development of a Plan
- Collaboration with other entities regarding climate change preparedness studies.
- Annual Report to legislature
- Efforts to reduce emissions of gasses and to reform practices known to exacerbate climate change
- Efforts (proposals) to prepare the state for the effects of climate change

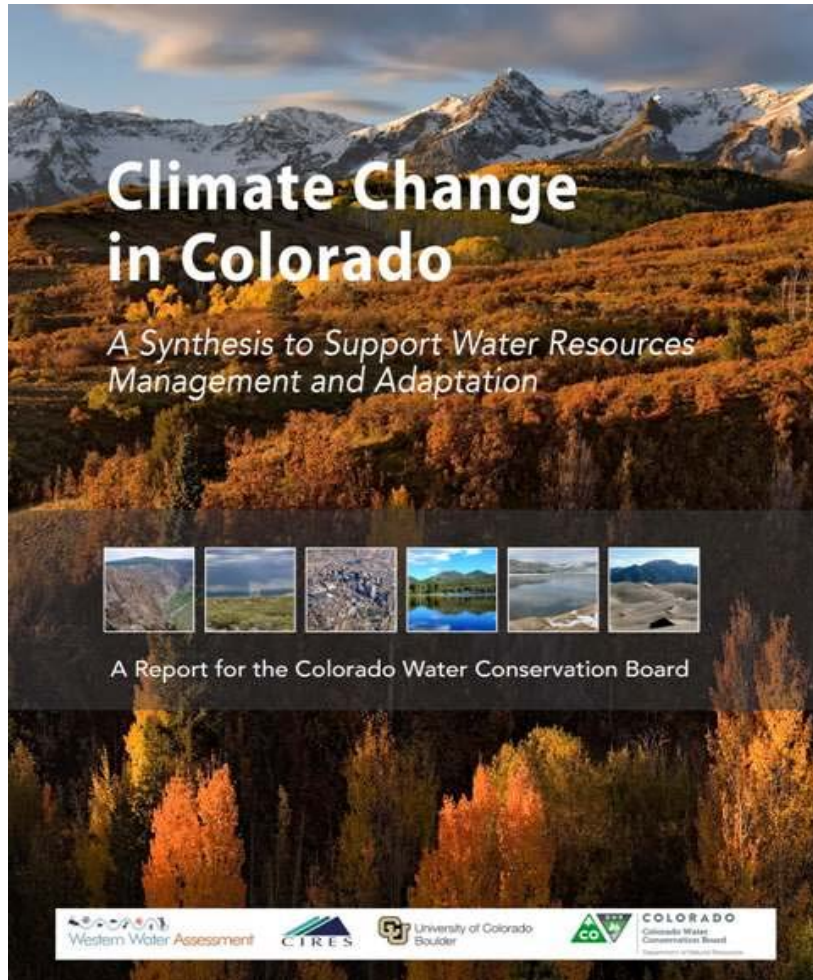
# Colorado Climate Plan

- Multi-sectoral state level policies and recommendations
- Includes mitigation and adaptation
- Collaborative effort by state agencies



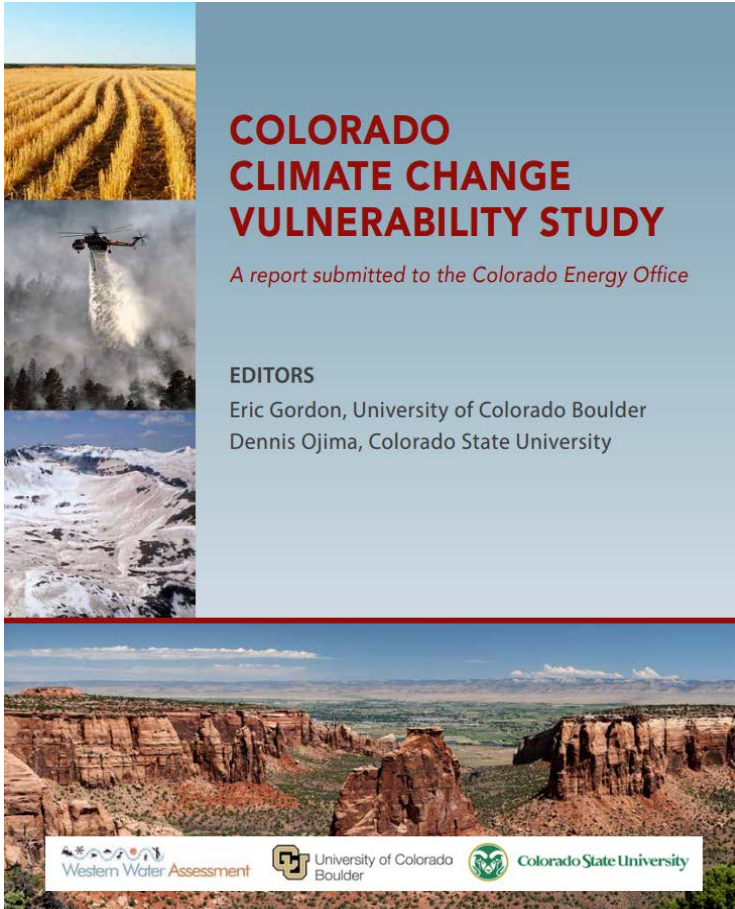
# Climate Change in Colorado Report

## A Synthesis to Support Water Resources Management and Adaptation



- A synthesis of climate change science important for Colorado's water supply.
- Observed trends, modeling, and projections of temperature, precipitation, snowmelt, and runoff.
- Colorado-specific findings from peer-reviewed regional studies.
- Presents new graphics derived from existing datasets.
- Released August 2014

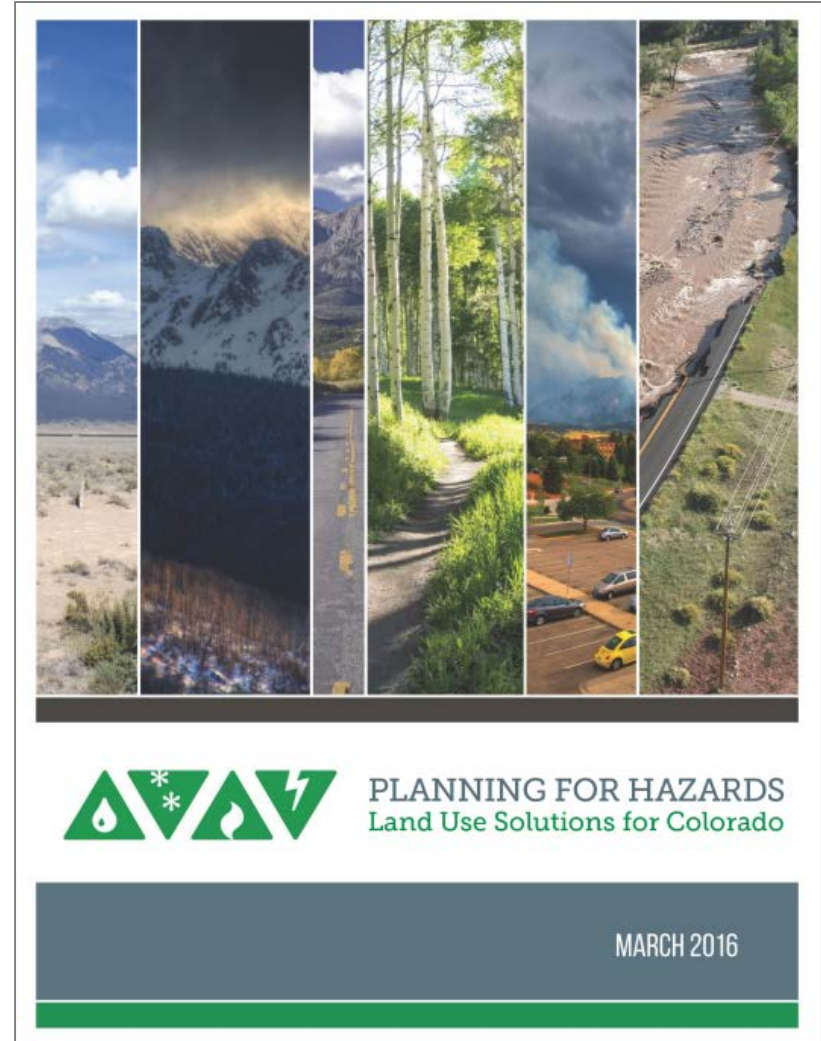
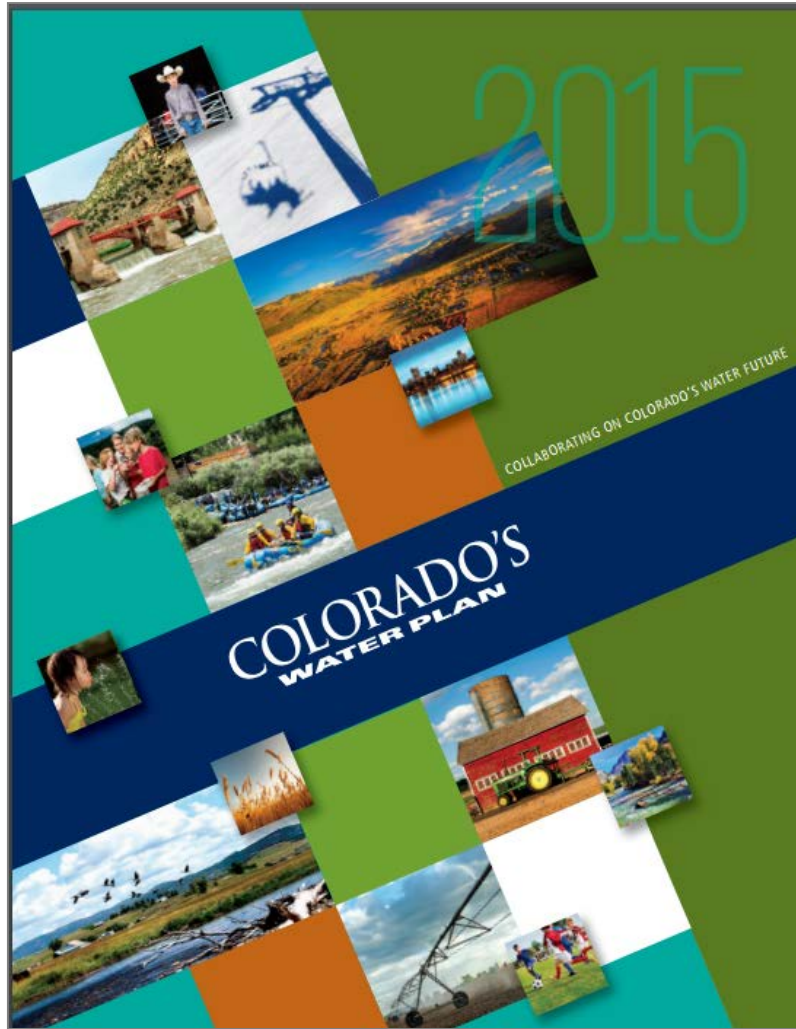
# Climate Change Vulnerability Study



- Lead Agency: CEO
- Project Goal: To provide an assessment of the key climate change vulnerabilities facing Colorado's economy and resources.
- Qualitatively assesses vulnerabilities in the following sectors:
  - Water
  - Energy
  - Public Health
  - Transportation
  - Ecosystems
  - Agriculture
  - Tourism
- Conducted by researchers at CU & CSU
- Released February 2015



# Other Resources





*Questions?*

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