Climate-Related Risks to Colorado's Resilience

RMCO Fact Sheet, August 2014

Hotter Temperatures

So far this century, Colorado has averaged 1.2° Fahrenheit hotter than in 1971-2000. Depending on future emissions of heat-trapping pollution, by mid-century the state could average 1.5° to 6.5° hotter than 1971–2000. By late in the century, Colorado could be 1.5° to 9.5° hotter. The smaller increases would result from rapid global reductions in emissions, and the larger ones from emissions continuing to go up as in recent years.

The figure below shows these historical and projected temperatures.

Historical and Projected Colorado Temperatures

Comparisons to 1971–2000 Averages

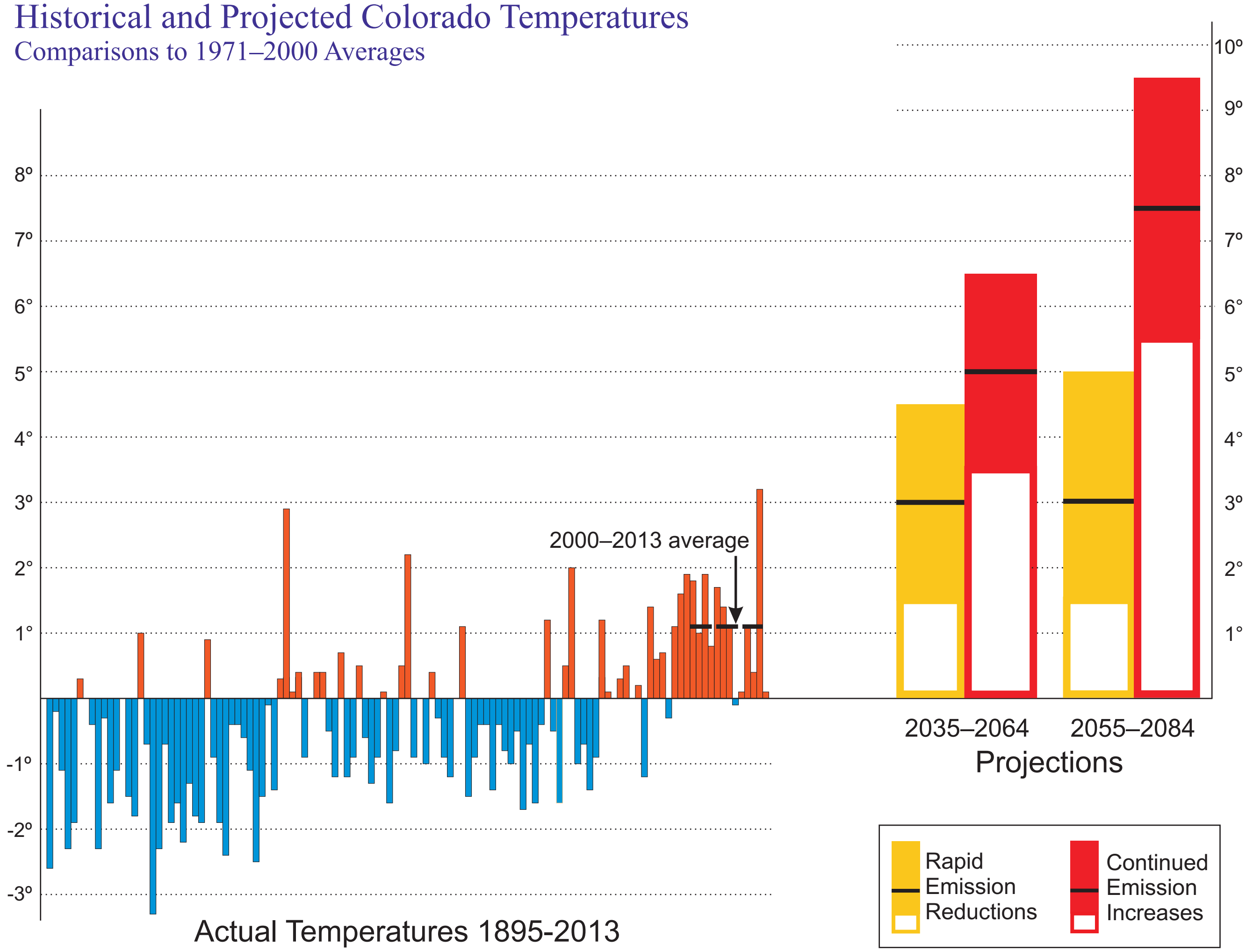

Figure 1. On the left, average statewide Colorado temperatures compared to 1971–2000, in degrees Fahrenheit. Temperatures in 2000–2013 averaged 1.2° higher. On the right, projections of statewide temperatures, again compared to 1971-2000, for two future periods, each with one scenario of rapid reductions in heat-trapping pollution (known as "representative concentration pathway," or RCP, 2.6) and another of continued increases as in recent years (RCP 8.5). The solid colors show the 10th to the 90th percentiles of projections from 23 climate models for RCP 2.6 and 34 for RCP 8.5; the black lines show the averages. Historical data from the National Oceanic and Atmospheric Administration (NOAA), analysis by the Rocky Mountain Climate Organization (RMCO); projections from Western Water Assessment (WWA), University of Colorado at Boulder, using Coupled Model Intercomparison Project (CMIP5).[1] Figure by RMCO.

Full Range of New Temperature and Precipitation Projections

The temperature projections shown on the previous page are from a new analysis by Western Water Assessment (WWA) at the University of Colorado at Boulder, using the latest global climate models and emission scenarios.[2] The WWA analysis covers projected statewide average temperature and precipitation, across all four of the new emission scenarios (now formally known as "representative concentration pathways.") Only the lowest and highest of those emission scenarios are illustrated on the previous page; the table below shows the projections for all four, and for projected changes in precipitation as well as temperature.

Projected changes in annual Colorado precipitation range from decreases of 7 percent to increases of 9 percent, again in comparison to 1971–2000 averages. For precipitation, unlike temperature, projections based on lower emission levels are not markedly different from those based on higher levels, nor are projections for later in the century markedly different from those for mid-century.

The WWA projections are from online supplemental information accompanying a report for the Colorado Water Conservation Board, "Climate change in Colorado: A synthesis to support water resources management and adaptation," which also contains much additional useful information.

Projected Changes in Colorado Statewide Temperature and Precipitation

Comparisons to 1971–2000 Averages

	Rapid Emission Reductions	Medium-Low Emissions	Medium-High Emissions	Continued Emission Increases
Temperature (Degrees Fahrenheit)				
Centered on 2050 (2035–2064)	+1.5° to +4.5° (Average: +3°)	+2.5° to +5° (Average: +4°)	+2.5° to +4.5° (Average: +3.5°)	+3.5° to 6.5° (Average: +5°)
Centered on 2070 (2055–2084)	+1.5° to +5° (Average: +3°)	+2.5° to +6.5° (Average: +4.5°)	+3.5° to +7° (Average: +5°)	+5.5° to +9.5° (Average: +7.5°)
Precipitation (Percent Change)				
Centered on 2050 (2035–2064)	-3% to +9% (Average: +3%)	-6% to +6% (Average: +1%)	-3% to +6% (Average: +1%)	-3% to +8% (Average: +2%)
Centered on 2070 (2055–2084)	-3% to +9% (Average: +3%)	-4% to +8% (Average: +3%)	-5% to +8% (Average: +2%)	-7% to +9% (Average: +2%)

Table 1. Projected changes in statewide average temperatures and precipitation amounts in Colorado, compared to 1971–2000 levels, from the latest global climate models and emission scenarios. The emission scenarios are all four "representative concentration pathways:" one assuming rapid global emission reductions (RCP 2.6, as in Figure 1); one assuming a medium-low level of future emissions (RCP 4.5); a medium-high level (RCP 6.0); and a continuation of recent high increases in emissions (RCP 8.5, as in Figure 1). Projections are from 23 climate models for RCP 2.6, 36 for RCP 4.5, 18 for RCP 6.0, and 34 for RCP 8.5; for each scenario, ranges are shown from the 10th to the 90th percentile of of those model runs, plus the averages of all such model runs. Projections are WWA, using the World Climate Research Program's Coupled Model Intercomparison Project phase 5 (CMIP5).[3]

Extreme Heat

Extreme temperatures may increase more than average ones. A report by the Rocky Mountain Climate Organization (RMCO) for the City of Fort Collins documented that in the first 14 years of this century, Fort Collins averaged nearly three times as many 95° days as in 1961–1999.

Depending on future emissions of heat-trapping pollution, the city by mid-century could average up to 10 times as many 95° days as in 1961–1999, and by late in the century up to 20 times as many.[4]

The increases in average and extreme temperatures could cause many impacts in Colorado, some of which are summarized on the next page.

Historical and Projected Extreme Heat
Number of 95° Days per Yea in Fort Collins

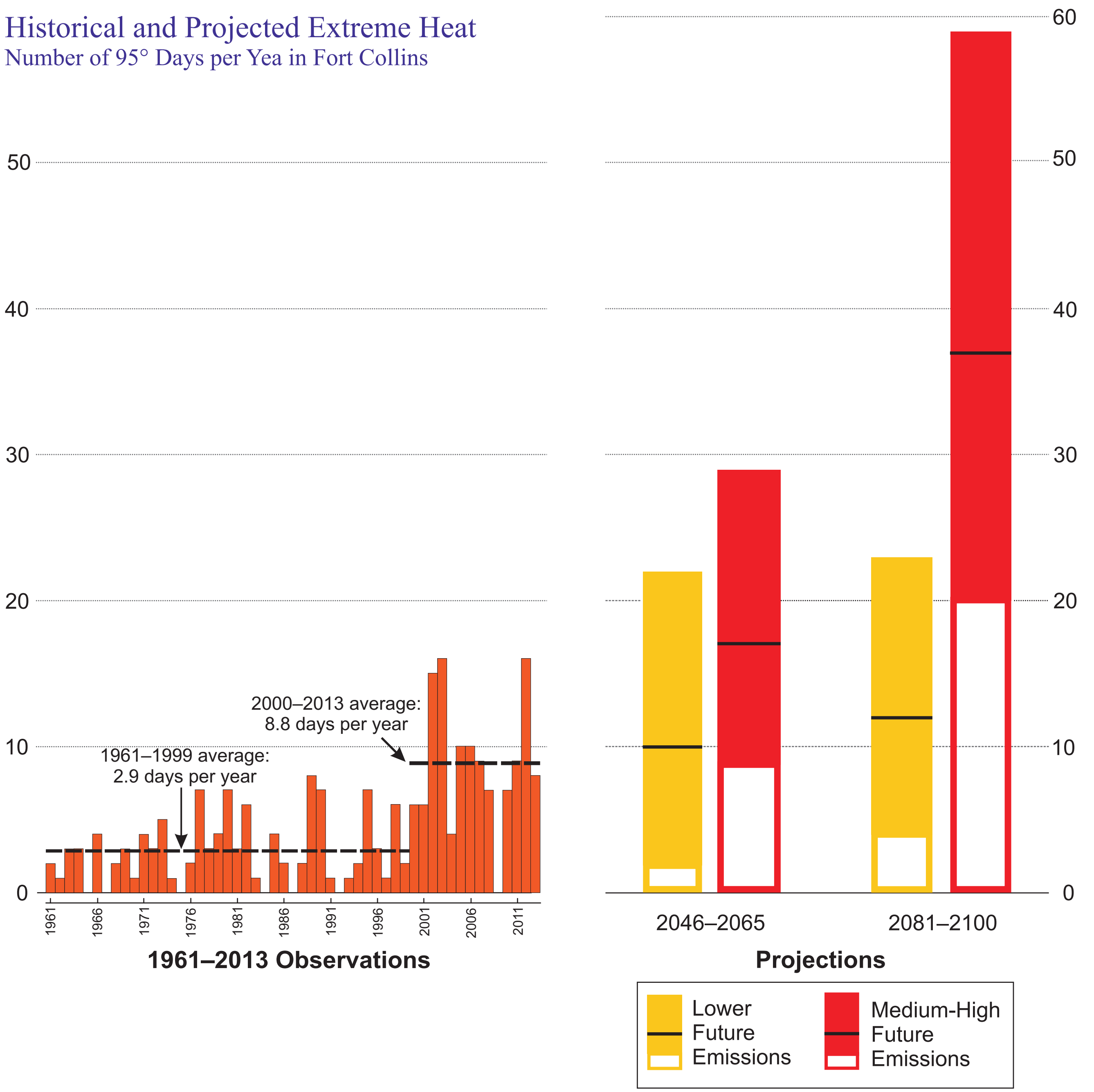

Figure 2. On the left, the number of days per year 95° or hotter in Fort Collins. The average number in 1961–1999 was 2.9 per year, and in 2000–2013 8.8 per year. On the right, projections for two future periods, each with one scenario of lower and another of medium-high future emissions. The solid colors show the 10th to the 90th percentiles of 30 projections of annual 95° days for each period/scenario combination, and the black lines the averages. Data from NOAA and the Coupled Model Intercomparison Project (CMIP3); analysis by the Rocky Mountain Climate Organization.[5]

Heat Waves

Scientists have high confidence that multi-day heat waves in this part of the country will increase in frequency, intensity, and duration.[6] Heat waves already kill more Americans than hurricanes, tornadoes, floods, and earthquakes combined.[7]

Local plans can reduce mortality in heat waves. In Chicago, a heat wave in 1995 killed more than 700 people, leading to local planning to prevent deaths in future heat waves—and as a result a similar heat wave in 2012 led to few fatalities.[8] But most local governments in the country still have inadequate or no response plans.[9]

Wildfires

Large wildfires have recently become more frequent in the West, driven largely by higher temperatures and earlier snowmelt.[10] In Colorado, the number of structures burned and the loss of insured property have set state records in three of the past four seasons.[11] The record-setting fires of 2012 and 2013 started on days with record-tying and record-setting high temperatures of 100° and 97°, respectively.[12]

The National Research Council has projected that a (very modest) temperature increase of 1.8° could lead to a 656 percent increase in the area burned by wildfire in the Southern Rockies (primarily comprised of Colorado's mountains), compared to 1950–2003 levels.[13]

A Colorado task force recently identified some actions that could prepare for more and larger wildfires, but its recommendations mostly have not yet been implemented.

Ecosystems

From 2000 to 2012, bark beetle outbreaks in the West killed trees across an area almost the size of Colorado.[14] Hotter and drier conditions have been identified as the trigger for the outbreaks.[15] Bark beetles are projected to become more widespread as a result of further climate change.[16]

Hotter and drier conditions early in this century also killed many aspens in Colorado.[17] Areas with mortality were concentrated in areas projected to lose their climatic suitability for the species.[18] Sixty percent of the current range for aspens in Colorado is projected to no longer be suitable for them by 2060. Other areas could become newly suitable for aspens, but the projected net change is a 45 percent decline in their statewide range.[19]

Disruption of Colorado's forests could harm the outdoor recreation and tourism sectors that help drive our state's economy.

Less Water

Projections are mixed on whether and how average statewide precipitation may change in Colorado (see Table 1.) But river flows can be reduced even if precipitation increases, because higher temperatures can reduce snowpacks and increase water loss (evapotranspiration) from soils, reservoirs, and plants.[20] And changing climatic conditions are "slowly tipping the balance in favor of more frequent, longer, and more intense drought," according to a recent regional climate assessment.[21]

In the first decade of this century, the streamflow of the Colorado River, the state's largest water source, was 16 percent lower than its 20th century average.[22] The flow of the upper Rio Grande was 23 percent lower than its 1941–2000 average.[23] Further climate change is projected to worsen a Colorado River imbalance between water supplies (which are decreasing) and demand for water (which is increasing).[24] For the upper Rio Grande, the average projection (across all emissions scenarios) is that climate change will reduce water flows by one-third in this century.[25]

The first-ever Colorado Water Plan now being developed is an important opportunity to address these impacts to the state's most important natural resource.

Flooding

As Coloradans well know, September 2013 brought historic rainfall and flooding along the Front Range. For most areas of the world and the United States, a hotter climate is projected to lead to more extreme precipitation and more flash flooding, as warmer air holds more moisture and so storms should become larger.[26] Whether this will hold true for Colorado is still unclear.[27] But areas previously burned by wildfires are much more prone to flooding, and so more wildfires increase flooding risks. It also is clear from Colorado's 2013 floods that timely flood control measures prevent more extensive damage than what would occur without that work.[28]

Notes

1. Figure 1 is prepared by the Rocky Mountain Climate Organization (RMCO). The historical temperature data are from the climate division dataset of the National Climatic Data Center, National Oceanic and Atmospheric Administration, as obtained from the Western Regional Climate Center. The projections are from Western Water Assessment (WWA), University of Colorado at Boulder, from supplemental information accompanying Jeff Lukas and others, "Climate change in Colorado: A synthesis to support water resources management and adaptation," an August 2014 report for the Colorado Water Conservation Board; both the supplemental information and full report are available here.

2. WWA, supplemental information (see previous note).

3. Ibid.

4. Rocky Mountain Climate Organization, "Extreme heat in Fort Collins: A report for the City of Fort Collins, revised February 2014," S. Saunders, T. Easley, and M. Mezger, authors, 2014.

5. The older-generation emission scenarios used in the analysis illustrated in Table 2 are not the same as the newer ones used in the WWA analysis reflected in Figure 1 and Table 2 (see note 1). The lower emissions scenario in Figure 2 (known as scenario B1) assumes emissions that are not as low as RCP 2.6, and the medium-high scenario in Figure 2 (scenario A2) assumes emissions that are not as high as RCP 8.5. Figure 2 is adapted from "Extreme heat in Fort Collins" (see previous note).

6. A. Gershunov and others, "Future climate: Projected extremes," in *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*, G. Garfin and others, editors, a report by the Southwest Climate Alliance, 2013.

7. Centers for Disease Control and Prevention, "Heat waves."

8. E. Klineberg, *Heat Wave: A Social Autopsy of Disaster in Chicago* (Chicago: University of Chicago Press, 2002); C. C. Burt, "Why was the Chicago heat wave of 2012 so much less deadly than that of 1995?," Weather Underground, 2012.

9. J. L. White-Newsome and others, "Survey of county-level heat preparedness and response to the 2011 summer heat in 30 U.S. states," *Environmental Health Perspectives*, 2014.

10. A. Westerling and others, "Warming and earlier spring increase western U.S. forest wildfire activity," *Science*, 2006.

11. Rocky Mountain Insurance Information Association, "Wildfire."

12. RMCO, "Extreme heat in Fort Collins" (see note 4), p. 8.

13. National Research Council, *Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia* (Washington: National Academies Press, 2011).

14. U.S. Forest Service, "Areas with tree mortality from bark beetles: Summary for 2000–2013, Western US," 2013.

15. B. J. Bentz, *Bark Beetle outbreaks in Western North America: Causes and Consequences* (Salt Lake City: University of Utah Press, 2009).

16. E. Fleishman and others, "Chapter 8: Natural ecosystems," in *Southwest Assessment* (see note 6).

17. J. J. Worrall and others, "Recent declines of Populus tremuloides in North America linked to climate," *Forest Ecology and Management*, 2013.

18. J. J. Worrall and others, "Sudden aspen decline. Grand Mesa, Uncompahgre, and Gunnison National Forests, CO," 2014.

19. J. J. Worrall and S.B. Marchetti, personal communications, 2014, providing Colorado data from "Recent declines" (see note 17).

20. Gershunov and others, "Projected extremes" (see note 6).

21. Ibid.

22. M. Hoerling and others, "Chapter 5: Present weather and climate: Evolving conditions," in *Southwest Assessment* (see note 6).

23. Ibid.

24. U.S. Bureau of Reclamation, *Colorado River Basin Water Supply and Demand Study*, 2012 and 2013.

25. U.S. Bureau of Reclamation, Upper Colorado Region, *West-Wide Climate Risk Assessment: Upper Rio Grande Impact Assessment*, 2013.

26. A. Georgakakos and others, "Ch. 3: Water resources," in *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T. C. Richmond, and G. W. Yohe, editors (Washington: U.S. Global Change Research Program, 2014).

27. Georgakakos and others, "Water resources" (see previous note); Gershunov and others, "Projected extremes" (see note 6).

28. C. Coleman, "The big one," *Headwaters*, Colorado Foundation for Water Education, summer 2014.