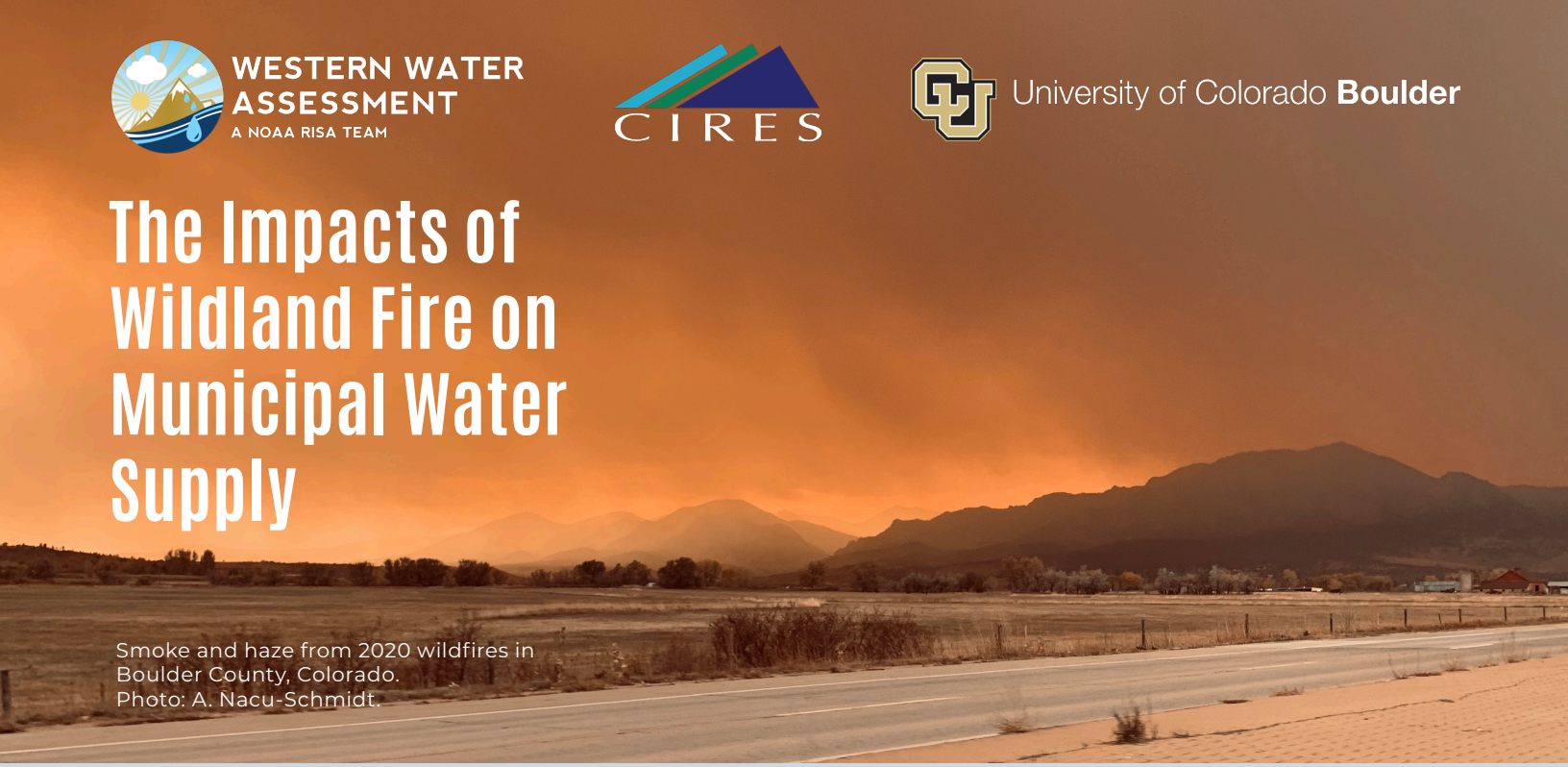
WESTERN WATER ASSESSMENT
A NOAA RISA TEAM

CIRES

University of Colorado Boulder

The Impacts of Wildland Fire on Municipal Water Supply

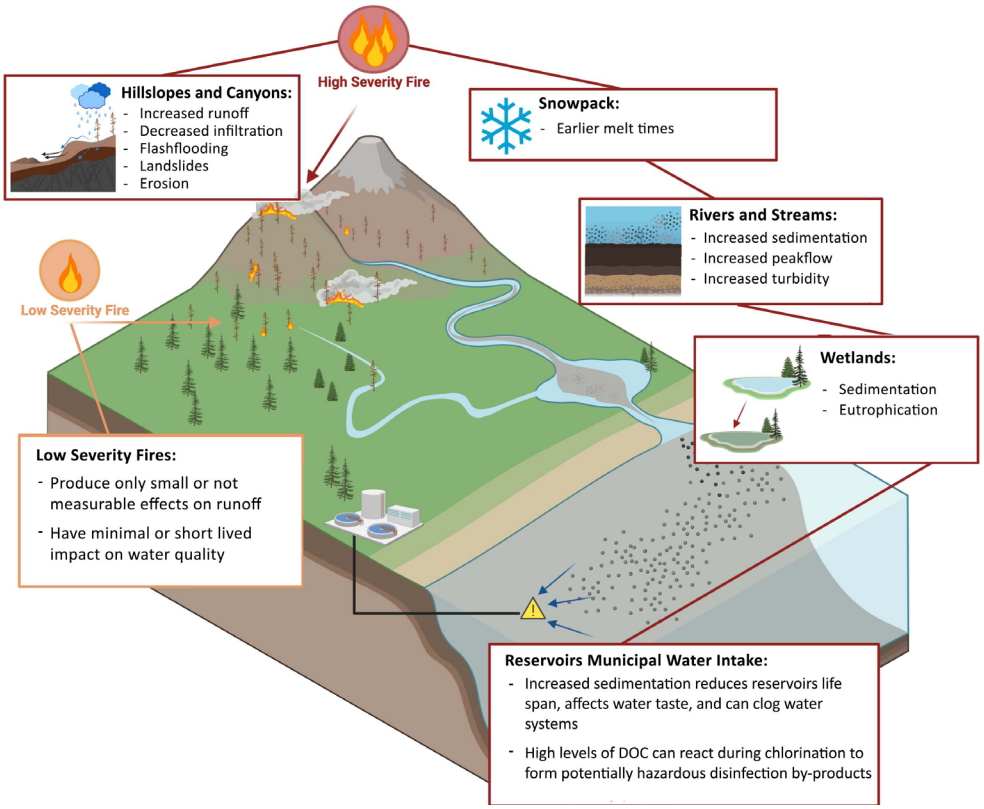


Smoke and haze from 2020 wildfires in Boulder County, Colorado.
Photo: A. Nacu-Schmidt.

For much of the last century, forested upland watersheds have provided reliable water for millions of people across the Intermountain West. This forest filtered water is generally of higher quality and cheaper to treat than other sources. Ironically, the same forests that provide high quality water make watersheds and the municipalities that rely on them vulnerable to a changing climate. Climate change and other factors such as overly dense stands, can lead to larger and higher severity fires. When burning through critical watersheds, these fires have the potential to degrade once reliable water resources. Using foundational research papers about wildland fire and water supply, this factsheet summarizes the leading impacts wildland fire has on the quality and quantity of water in municipal watersheds in the Intermountain West and highlights leading mitigation and response measures.[1,2]

An Era of Megafires Threatens High Quality Water

Spurred on by a combination of climate change, widespread drought, and high fuel loads, the extreme fire behavior seen across the mountain west in recent years is expected to continue.[3] Projections of future wildfire activity in the US suggest that the Intermountain West and California will see the greatest increases in megafires as anthropogenic warming intensifies.[4] While fire is a natural and necessary ecological phenomenon, these increasingly large and intense fires have the potential for devastating compound impacts when burning through municipal watersheds.



Primary Impacts of High and Moderate Severity Fires

Smaller and low severity fires rarely have significant and lasting impacts on municipal water supplies. However, when wildfires burn at moderate to high intensity over geographically extensive areas, these fires can have immediate and long lasting effects.

More Water, Faster!

High and moderate severity fires impact the timing and intensity of runoff from mountainous watersheds, generally resulting in more flood-prone streams. The high-intensity rainfall commonly produced by the Intermountain West's summer thunderstorms can produce large overland flows, flash flooding, and mudslides. Though the increased flows are most pronounced in the first few years after fires, studies in the Colorado Front Range have recorded increased peak flow up to 5-times higher than normal as many as 7 years after an event.[5]

Fires impact spring snowmelt as well. The removal of vegetation cover reduces tree interception, or the volume of snow caught and evaporated straight off tree branches, resulting in complex changes and potential increases to on-ground snow accumulation.[6] Come spring, these areas then experience rapid melt. Coupled with little vegetation to absorb water, overland flow increases, leading to increased early spring flows and possible flooding.

East Troublesome Fire, October 2020. Photo: Adobe Stock.

Adversity and Resilience

In July 2021, runoff from the Cameron Peak and East Troublesome burn scars in northern Colorado contributed to flash flooding as well as high ash and sediment loading on the Cache la Poudre River. Water quality was severely affected, forcing the city of Fort Collins to close its river intake and source all of its water from the Horsetooth Reservoir. As part of the Colorado-Big Thompson Project, Horsetooth receives water from watersheds both east and west of the Continental Divide. Such diversity of water sources provides short term resilience, allowing the city to draw on stored clean water during sediment laden, high flow events on the Poudre River.

Erosion and Sedimentation

As overland and instream flows increase post-fire, so does erosion. The redistribution of material can lead to the mobilization of heavy metals, increased stream turbidity, and extensive sedimentation in lakes, wetlands, and reservoirs. From a water resource perspective, post-fire turbidity degrades water taste, impacts treatment equipment, and reduces the lifespan of reservoirs as they fill with sediment.

Photo: John A. Moody, USGS.

Cameron Peak Fire, September 2020. Photo: Cameron Peak Fire media.

Dissolved Organic Carbon, Nutrient Loading, and Heavy Metals

Burn scar runoff can carry with it high levels of dissolved organic carbon (DOC), excess nutrients, and in some cases heavy metals. Each constituent presents its own challenges to water managers. Excessive nitrogen and phosphorus loads can lead to toxic algal blooms in waterways and reservoirs, increasing treatment costs. High levels of DOC can create taste and odor issues while also decreasing the effectiveness of the water treatment process and leading to the possible formation of carcinogenic chemical disinfection byproducts. The same storm events that bring high flows and erosion can also help mobilize heavy metals. Though few long term data exist, studies along the Colorado Front Range have shown burned areas and streams to have elevated concentrations of arsenic, aluminum, cadmium, iron, lead, and mercury several years after a fire.[7]

Woolsey Fire Burn Scar Seen from Space. Photo: NASA, Joshua Stevens.

Short and Long Term Impacts and Investments

High severity fires west of Denver have had short and long term impacts on water quality and downstream reservoirs. Collectively, Denver Water estimates more than $27 million was spent on initial response to water quality degradation and infrastructure repair after the 2002 Hayman and 1996 Buffalo Creek Fires. Increased erosion was a leading impact as sediment from burned hillslopes contributed to filling nearly 13% of the Strontia Springs Reservoir with sediment. An attempt to remove sediment in 2010 was only partially successful, removing 228,000 cubic yards of sediment at a cost of $18.5 million. These multi-year impacts led Denver Water and the US Forest Service to begin active collaborative forest management with the goal of restoring burn scars and reducing the potential for high severity fires in critical watersheds. Between 2010 and 2021, the From Forests to Faucets program grew to include the Colorado State Forest Service and the Natural Resources Conservation Service. Together, these organizations spent tens of millions on fuel reduction, tree planting, and erosion mitigation. These investments paid off! In 2018 a wildfire ignited in Silverthorne, Colorado, threatening homes and millions in damages. However, due to existing fire breaks established by the From Forests to Faucets program firefighters were able to quickly extinguish the blaze. For more information about the From Forests to Faucets program visit Denver Water's management and protection webpage.[8]

Dredging Operations in Strontia Springs Reservoir for sediment removal. Photo: Denver Water.

Smoke fills the sky as the East Troublesome Fire burns outside Granby, Colorado in October 2020. Photo: Adobe Stock.

Response and Mitigation Strategies

Many frontline communities have limited resources, hindering their ability to increase the resilience of their water system to wildfire. Additional financial and information resources are critically needed to support these communities as they prepare for and respond to wildfires.

Coordination between land managers, public water providers, and nonprofits is crucial for upland forested watersheds to continue to provide clean, reliable water across the Intermountain West. Fire is a natural phenomenon on the landscape and is crucial for many ecosystem processes. Therefore, best practices for fire mitigation and response do not aim to eliminate fire from key watersheds, but strive to bring fire return intervals close to historic normals while reducing fire severity and impact to human infrastructure. Collaborative forest management programs will be key to meet these challenging goals.

Fuel reductions through mechanical thinning and controlled burns can help realign fire return intervals to historic norms while reducing fire severity and size. Increased public awareness of fire bans can help reduce the number of human ignitions.

Though costly, infrastructure improvements including diversified water sources, sediment settling basins, parallel water systems that use untreated water for irrigation to reduce treatment needs, and the use of smart water infrastructure, all improve the resilience of municipal systems.

Post-fire, timely, collaborative work can have important impacts on short term water quality. Erosion mitigation projects that help stabilize stream banks, mulching, and water bar construction, can all help to reduce sediment and other water contaminants from entering water supplies downstream.

References

1. Bladon, K. D., M. B. Emelko, U. Silins, and M. Stone, 2014. Wildfire and the Future of Water Supply. *Environmental Science & Technology* 48, 8936–8943.
2. Emelko, M. B., U. Silins, K. D. Bladon, and M. Stone, 2011. Implications of land disturbance on drinking water treatability in a changing climate: Demonstrating the need for "source water supply and protection" strategies. *Water Research* 45, 461–472.
3. Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam, 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science* 313, 940–943.353.
4. Barbero, R., J. T. Abatzoglou, S. Larkin, C. A. Kolden, and B. Stocks, 2015. Climate change presents increased potential for very large fires in the contiguous United States. *International Journal of Wildland Fire* 24, 892–899.
5. Moody, J. A. and D. A. Martin, 2001. Initial hydrologic and geomorphic response following a wildfire in the Colorado front range. *Earth Surface Processes and Landforms* 26, 22.
6. Burles, K. and S. Boon, 2011. Snowmelt energy balance in a burned forest plot, Crowsnest Pass, Alberta, Canada. *Hydrological Processes* 25, 3012–3029.
7. Writer, J. H. and S. F. Murphy, 2012. *Wildfire effects on source-water quality--Lessons from Fourmile Canyon fire, Colorado, and implications for drinking-water treatment*. U.S. Geological Survey, doi: 10.3133/fs20123095.
8. Watershed Protection & Management. *Denver Water* https://www.denverwater.org/your-water/water-supply-and-planning/watershed-protection-and-management.

Fact sheet written by Ethan Burns. Figures created in BioRender.

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The Western Water Assessment is a university-based applied research program that addresses societal vulnerabilities to climate variability and climate change, particularly those related to water resources. Our mission is to conduct innovative research in partnership with decision makers in the Rocky Mountain West, helping them make the best use of science to manage for climate impacts.