ACTIONABLE SCIENCE

The Effects of Wildfire on Snow Water Resources Under Multiple Climate Conditions

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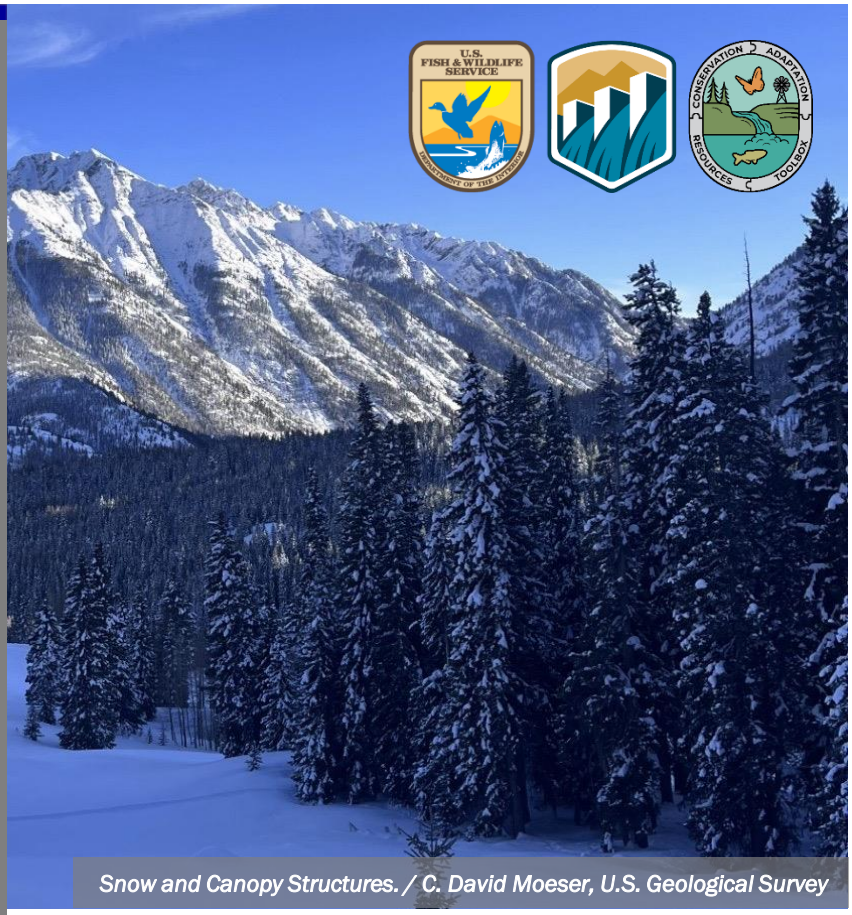
The Rio Grande supplies water to over 13 million people, and approximately 75% of its supply originates from snowmelt. Climate change is increasing the severity of wildfires and bark beetle infestations. These impacts cause forest disturbances that change the timing and quantity of snowfall and snowmelt in the Rio Grande basin. Land managers need accurate snow water resource models to predict how forest disturbances will impact the Rio Grande's water supply. Researchers at the U.S. Geological Survey (USGS) are pairing the Snow Physics and Lidar Mapping model (SnowPALM) with high resolution light detection and ranging (LIDAR) datasets to quantify the impact of wildfire on local snow water resources .



Snow and Canopy Structures. / C. David Moeser, U.S. Geological Survey

KEY ISSUES ADDRESSED

Snow water resource models have been unable to accurately model the impact of forest disturbance on snow water resources due to reliance on forest canopy density alone. However, forest canopy gaps and edges also play crucial roles. Incorporating these additional canopy characteristics can improve the accuracy of snow water models.

Prior modeling platforms have struggled to quantify the effects of forest disturbances on snow-water resources under multiple climate conditions . Land managers need more accurate models that reflect climate change impacts and current and future forest disturbances to better support decision-making in the Rio Grande Basin.

PROJECT GOALS

- Better represent the impact of forest disturbances in snow water resource models by including canopy height, forest gaps, and edges
- Use SnowPALM and LIDAR data to quantify the impacts of forest disturbances on snow water resources under multiple climate conditions
- Utilize model results to support land managers and researchers engaged in decision-making and analysis of forest disturbances on snow water resources

ESTIMATING VARIATION

USGS researchers have shown 40 70% of snow water equivalent variation in forested environments can be estimated using shortwave radiation and canopy structure, metrics that indirectly account for terrain and canopy shading.

Snow Sampling of a Southern Facing Slope/C. David Moeser

PROJECT HIGHLIGHTS

Improved Snow Water Resource Modeling: Using a high-resolution snowmelt model, researchers identified areas in the landscape that may have reduced snow retention and capacity after a forest disturbance. They categorized these areas based on three canopy structure classes and assessed the potential impact of climate change. This is one of the first models to accurately relate forest disturbances to changes in snow.

Post-Forest Disturbance Characteristics: The orientation of forest gaps in relation to terrain slope, and canopy gap size is important for capturing changes in snow water resources after forest disturbances. The most significant decreases in snow water equivalence (SWE) occurred where small gaps transitioned to larger ones toward the south.

Post-Forest Disturbance Changes: Overall, Peak SWE and melt-out date were nearly always higher and later post-fire. However, one-third of the Las Conchas Fire domain showed decreases in SWE and earlier melt-out dates.

Informing Future Decision Making: Understanding the forest-snow relationship can help determine thinning techniques to maximize snow retention, such as minimizing forest gaps to the south and thinning smaller trees.

Collaborators

- U.S. Geological Survey
- Mountain Studies Institute
- University of Arizona
- University of Nevada, Reno
- See online for full list of contributors

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LESSONS LEARNED

Forests in snow water models can be represented in simple components, like forest edges and gaps. Researchers found canopy density is insufficient to capture changes in peak SWE, especially at coarser, larger domains.

High resolution LIDAR data is not widely available throughout the Rio Grande Basin. This can make recreating forest representations and disturbances challenging at coarser resolutions and in areas with less data.

Researchers found that forest disturbances increasing the size of south-facing canopy edges or gaps can reduce the amount of snow water resources and accelerate earlier melt-out dates, which is significant in the Rio Grande Basin, where slight changes in canopy shading can impact snow retention.

This project didn't account for temporary increases in debris, ash, and black carbon falling on snow, which can accelerate snowmelt beyond the burn area. More research is needed to better integrate and quantify temporally changing albedo effects after disturbances.

NEXT STEPS

- Integrate canopy structures into snow models that run over large scales.
- Develop decision support tools to model snow water resource changes given stakeholder defined scenarios and multiple climate conditions.
- Understand how forest disturbances affect base flow, which are the water resources that sustain streamflow through periods without precipitation.

For more information on this project, contact C. David Moeser: cmoeser@usgs.gov

Canopy Coverage in a Field Area/C. David Moeser