Science to Solutions

Sagebrush Rangelands Help Maintain Water Availability

In Brief: Removing encroaching conifer stands from sagebrush ecosystems can increase late season water retention in western rangelands by holding snow longer in the spring. Researchers with the U.S. Department of Agriculture's Agricultural Research Service analyzed snow and streamflow data from a snow-dominated sagebrush steppe ecosystem in southwest Idaho to evaluate the impact that juniper-dominated landscapes might have on water availability in the system. They found that areas with more juniper had earlier snow melt and less streamflow relative to sagebrush-dominated landscapes. The water retention in sagebrush systems comes from the increased water storage within snow drifts and delayed release of the melting snow back into the soils. **Water delivery is delayed by an average of nine days in sagebrush systems compared to juniper-dominated systems.** The implications of this research suggest that conifer removal efforts to support sage grouse restoration also provide the ecosystem service of improved water availability in these semi-arid systems.

Capturing and Holding Snowfall

Imagine standing in a landscape covered with encroaching conifers on a high-elevation ridge in the West during a winter snowstorm. It is cold and quiet, the wind is buffered by the numerous trees capturing and keeping the snow close. The snow is evenly spread throughout the conifer stand and when the spring comes, the snowpack melts quickly. Now picture yourself in a treeless sagebrush landscape during a snowstorm—this time the wind whirls all around you. The blowing snow drifts in wind-sheltered areas, and around the sagebrush and other shrubs. The snow is deeper in these drifts and takes much longer to melt.

For several years, ranchers and land managers who have engaged in conifer removal projects have reported that there is more water flowing in their streams and that there are seeps in areas where they hadn't been previously. These anecdotal stories suggested the broader ecosystem services that conifer removal had for their ranches, but there was little scientific evidence that these stories had merit. While studies have looked at soil water extraction by juniper roots and evapotranspiration from juniper boughs, there was limited understanding of how redistribution of snowfall impacted watershed hydrology.

Evenly distributed snow inside a conifer stand (l) versus drifting in a treeless sagebrush landscape (r). Credit: USDA-ARS.

Studying the Snow

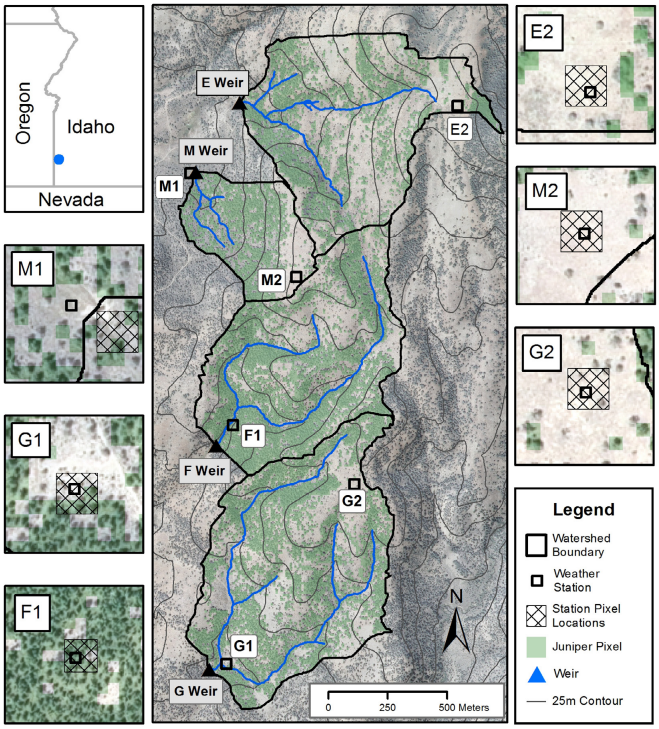
In the high elevations of the arid West, much of the annual precipitation falls in the form of snow. The heightened ability of a system to be able to hold that moisture for extended periods of time can significantly benefit native vegetation and its associated wildlife. Deeper snows improve insulation of soils and prolong water delivery. How and where the snow accumulates establishes variability in vegetation, creating a mosaic of diverse plant species. Understanding the differences of snow distribution between sagebrush landscapes and juniper-dominated landscapes can provide key information in understanding water availability for plants and wildlife.

Coordinated by Patrick Kormos, Frederick Pierson, Jason Williams, and Danny Marks with the U.S. Department of Agriculture's Agricultural Research Service in Boise, Idaho, this new science quantifies whether more water was, in fact, being held in landscapes where there was less juniper invasion. Specifically, scientists assessed the differences in snow distribution and water delivery to the soil surface and the effects of those differences on catchment water and streamflow. Their goal was to better understand the implications of tree-induced changes on water availability and the resulting effects on the sagebrush steppe ecosystem.

> *"Snow is the important dynamic affecting water availability in western rangelands. We demonstrate here how snow works within the system and the resulting benefits of conifer removal to ecosystem dynamics."* ~Frederick Pierson

Snow Accumulation Models

Kormos and his colleagues built their analysis using existing streamflow data from four catchments on the South Mountain Experimental Catchments in the Owyhee Mountains of southwest Idaho. Precipitation at the study area is predominantly from snowfall and the area has abundant juniper cover. The study team had data for six water years, from 2008 to 2013, providing a range of precipitation and temperature conditions typical for the region. Working with the physical data from weather stations in the study area, the scientists used *iSnobal* to model and estimate snow accumulation and melt for both the existing juniper cover and for a healthy sagebrush landscape with no juniper.



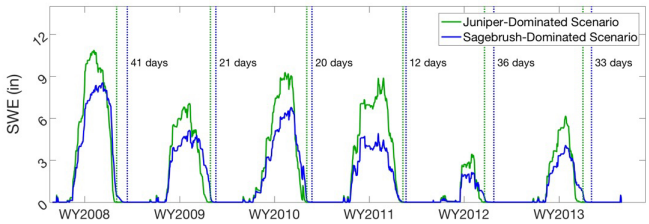
Map of the South Mountain Experimental Watershed study area that shows general location, topography, and juniper cover.

iSnobal has been used extensively to evaluate snow physics, processes, and the distributed melt patterns using catchment topography and metereological data such as solar radiation, wind speed, and other information. The model produces estimates of snow water equivalent (SWE), snow melt, and surface water input (the combination of liquid water draining from the bottom of the snowpack and from the rain on the ground's surface). Juniper cover is accounted for in *iSnobal* by classifying areas as juniper-dominated, juniper-sheltered, forest opening, or open. The juniper cover affects several variables in the model including snow accumulation, surface wind speeds, net solar radiation, and incoming thermal radiation. The scientists then used field measurements and modeled results describing water delivery at the four study catchments to identify when 75% of the modeled surface water input enters the catchments.

Conifer removal projects can help retain water and restore the sagebrush sea. Credit: Charles Sandford.

Drifting in the Sagebrush

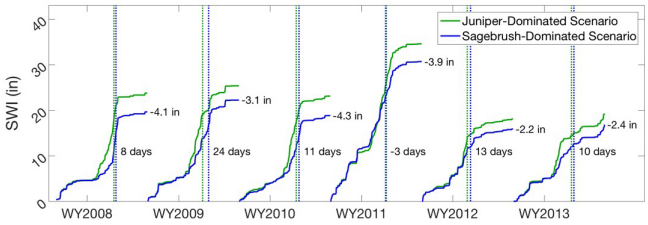
Through the modeling process, the researchers found that drifting in sagebrush-dominated systems delayed snowmelt into the watershed by an average of nine days. The juniper-covered landscape caused more uniform snow distribution across the landscape with less drifting. As a result, the snow melted more quickly and entered the watershed earlier. The researchers compared the modeled results for the juniper-dominated system with actual measurements from the study area and found that the models were highly consistent with the actual behavior of the snowfall on the ground.



Modeled total basin snow water equivalent (SWE) for juniper runs and sagebrush model scenarios showing higher peak accumulation and earlier melt out for juniper model runs.

The absence of trees in sagebrush-dominated landscapes creates more varied snow distribution. When the wind is able to blow across the landscape, the topography causes snow to consistently drift in the same places, creating deeper drifts in very specific parts of the landscape. Because those areas hold more water for longer periods most years, the vegetation is more diverse, leading to a mosaic of plant communities and higher quality habitat for wildlife species.

Wet areas are important for sage grouse in late summer, and removing encroaching conifers helps retain water on the land. Credit: Jeremy Roberts/Conservation Media.



Modeled total basin cumulative surface water input (SWI) from each of the catchments showing the time of delay of water inputs (days) in sagebrush model scenarios, and the higher magnitude of total surface water inputs (in) in juniper simulations.

Benefiting More than the Birds

While many juniper-removal studies have demonstrated value to wildlife species, this research adds an entirely different dimension to the practice – the improvement of ecosystem services provided by sagebrush habitats. Rangelands in the West face harsh, dry conditions with plenty of wind, and in higher elevations the vast majority of precipitation comes in the form of snowfall. **Holding water later into the summer season helps the sagebrush system become more diverse, benefiting vegetation, wildlife, and ranchers. This is one of the greatest services that an ecosystem can provide in the West.**

Both cows and birds gravitate toward mesic areas in the summer. Credit: Tim Griffiths.

Wet summer habitats, 80% of which are on private lands, have been found to be green magnets for sage grouse raising their young: 85% of leks are located within six miles of these water sources. By removing encroaching junipers on snow-dominated rangelands, ranchers and land managers can actually delay the release of water and maintain higher

> *"Our research suggests that it makes sense to maintain sagebrush-dominated landscapes in these higher-elevation, snow-dominated systems that get the majority of their annual precipitation through snowfall."* ~Jason Williams

streamflows later in the season. Increased water availability also supports the diversity of grasses and forbes, improving rangeland health and providing the "green groceries" wildlife and livestock depend on. With declining snowfall at lower elevations due to a warming climate, this ability for a system to increase water availability will become even more important.

Previous Sage Grouse Initiative Science to Solutions reports have spotlighted the value of conifer removal for other migratory songbirds and for sage grouse, as well as the value for fire resistance and resilience on western rangelands. This latest research now also proves the importance for maintaining or even improving streamflows. The accumulation of data proving the many ecosystem benefits of conifer removal adds scientific validation to the practice. As investment in conifer removal increases across the West, the return on the investment through improved wildlife populations and enhanced ecosystem services for ranchers and other water users will also increase.

Use SGI's New Web Tool for Restoration Planning

Interested in planning a sagebrush habitat restoration project across your landscape? SGI has a new web tool that maps tree canopy cover in high-resolution across sage grouse range. The map allows managers and planners to zoom in on a local site or scale up to a county or state to see where conifers are encroaching on sagebrush landscapes. The raster data is free to download to your GIS for planning and conservation projects. Use SGI's new web tool at **http://map.sagegrouseinitiative.com/**

Contacts

Patrick Kormos

- Frederick Pierson, USDA Agricultural Research Service, Boise, ID
  fred.pierson@ars.usda.gov
- Patrick Kormos, USDA Agricultural Research Service, Boise, ID
  patrick.kormos@ars.usda.gov

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Sources

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Additional Resources

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To find your local NRCS Service Center, visit the NRCS website at **http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/local/.**

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Writer: Jodi Stemler, Jodi Stemler Consulting LLC, www.stemlerconsulting.com
Designer: Maja Smith, MajaDesign, Inc. majadesignvt@00
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