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Watering the Forests for the Trees: Water Yield and Changes in Forest Cover

Science is often about challenging the conventional wisdom, taking an accepted "truth," and putting it to the test. One long-held truism in forest hydrology is that reductions in forest cover through some sort of disturbance (harvesting, beetle kill, stand-replacing wildfire, etc.) increase water yield, or stream flow in a watershed, while increasing forest cover decreases water yield. Decades of research generally support these assumptions, and it makes a certain intuitive sense since water yield is primarily determined by the amount of precipitation minus evapotranspiration. Fewer trees means less interception of precipitation, more snow accumulation, and decreased transpiration following death or removal of trees and other vegetation.

"I would hear from managers again and again, 'Well, if the trees die or if we cut the trees, at least we'll get more water,'" said RMRS researcher Sara Goeking. "But I started thinking: I'm not sure that's what happens everywhere."

Goeking said she started seeing studies about five years ago reporting that stream flow decreased following an increase in tree mortality in some watersheds, especially in semi-arid areas. In some watersheds, increased solar radiation hitting the ground due to the loss of forest cover in these locations means that evaporation increases, resulting in less water yield. In other watersheds, post-disturbance vegetation grew rapidly and took up enough water to overcompensate for the decrease in transpiration from the trees that died.

Goeking and her colleague David Tarboton, a civil engineer and hydrologist at Utah State University, reviewed 78 studies of stream flow response disturbances and reassessed the question: Does water yield or snowpack increase after forest disturbance? They looked at studies examining either stand-replacing (severe wildfire, harvest) or nonstand-replacing (drought, insects, low-severity wildfire) disturbances and described their findings in a recent synthesis paper.

Although some studies observed post-disturbance increases in water yield, as expected, in many cases water yield did not change or even decreased. Decreases were generally observed in areas with the following characteristics: high total radiation and high solar radiation, such as sites at low latitudes and on south-facing aspects; rapid growth of post-disturbance vegetation; and nonstand-replacing disturbances, such as drought and insect-caused mortality.

Scientists measure snow density in order to calculate the snow water equivalent, or the amount of water in the snowpack, at the Fraser Experimental Forest in Colorado (photo by S. Goeking).

The studies showed that places that are already kind of dry—those that tend to lose their snowpack quickly in the spring, for example—are the places that are the least likely to produce more water yield after trees die or are removed.

Although one objective of forest management may be to increase water yield, another might be to encourage post-disturbance forest recovery and resilience by optimizing growing-season soil moisture, which depends on snow accumulation and retention. The ability to meet such goals, and the treatments to accomplish them, depends on residual vegetation, latitude, and aspect.

"If you really want to maintain trees on a site or in a watershed where you're going to do, say, a fuels treatment or salvage operation, consider the value of leaving some of the trees for the benefit of shading slopes in high radiation areas," said Goeking. "If you remove too many trees, it's likely the snowpack is going to melt earlier in the season, the soil is going to dry out sooner, and you're less likely to see rapid recovery, or possibly any recovery, of forests on sites like that."

As the climate warms in the future, the links between disturbances, forest recovery, and water resources will become even more important and tightly linked in forested watersheds.

KEY MANAGEMENT CONSIDERATIONS

- A recently published review and synthesis of 78 scientific studies, published from 2000–2019, of stream flow and snowpack response to disturbances reframes our understanding of how forests affect water supply in the semi-arid West.
- Forest cover loss may decrease water yield, particularly following nonstand-replacing disturbance in semi-arid western forests. This contradicts the long-held expectation that water yield increases when tree cover is reduced.
- Post-disturbance water yield and snowpack are more likely to decrease or not change in areas with rapid post-disturbance growth and in watersheds where net radiation is greater, such as at lower latitudes and on south-facing aspects.
- If snowpack decreases or melts earlier following disturbance, then there will likely be less soil moisture available during the growing season for regeneration and recovery.

Widespread tree mortality in western coniferous forests, such as seen here in the South Fork Flathead River watershed, affects the timing and magnitude of runoff (photo by S. Goeking).

SCIENTISTS

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FURTHER READING

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https://www.fs.usda.gov/rmrs/science-spotlights/disturbance-effects-water-yield-western-coniferous-forests

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