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Rocky Mountain Research Station

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Streamwater nitrogen and forest dynamics following a mountain pine beetle epidemic: Insights from three decades of research at the Fraser Experimental Forest, CO

A recently published study by a team of Rocky Mountain Research Station (RMRS) scientists describes a 10-year investigation of streamwater nitrogen (N) and forest dynamics following a mountain pine beetle epidemic. Unlike the abrupt nutrient changes typical after a wildfire or timber harvesting, the outcomes of insect outbreaks are poorly understood. RMRS Scientists Chuck Rhoades, Rob Hubbard, and Kelly Elder capitalized on long-term, pre-outbreak monitoring at the Fraser Experimental Forest near Winter Park Colorado where the U.S. Forest Service has studied the forest and hydrologic processes responsible for regulating streamflow from high elevation watersheds since 1937. Contrary to expectations, watersheds with extensive MPB-caused forest mortality 'leak' very little stream N.

For example, the stream N response to the beetle infestation at Fraser differed between watersheds

MANAGEMENT IMPLICATIONS

- Wildfires, harvesting, and beetle outbreaks all have different effects on forest dynamics and biogeochemical responses.
- Responses to beetle outbreaks vary with forest species composition, understory conditions, tree size and age, and other factors.
- Larger trees are more susceptible to mountain pine beetle attack. Mixed-age stands at the Fraser Experimental Forest had lower overall tree mortality and greater recovery potential.
- These findings provide support for maintaining age, species, and structural diversity within headwater forests.
- Ongoing watershed research at Fraser and elsewhere will help land managers better predict the impacts of beetle outbreaks on delivery of clean, low nutrient water and assess management responses to beetle outbreaks or other forest disturbances.

Dramatic overstory mortality was caused by epidemic mountain pine beetle levels at Fraser Experimental Forest. Unlike logging or wildfire, forest mortality from bark beetles does not disturb the soil surface and the many remaining young trees take up nitrogen (photo by C. Rhoades).

comprised primarily of large trees that are more susceptible to the bugs and watersheds with a mixture of large and small trees. Old-growth watersheds lost 85 percent of large lodgepole pine, representing nearly half of the entire forest basal area. In contrast, mixed-age watersheds lost only a quarter of total stand basal area. Stream N increased significantly in two old-growth watersheds during the decade after beetles arrived but remained unchanged in two mixed-age stands.

So where did the nitrogen go?

In addition to lower beetle-related mortality, mixed age watersheds support twice as many small trees as old-growth watersheds. Smaller conifers use more soil resources—including nitrogen—per unit leaf area than larger trees. Death of large trees reduces competition for sunlight, water, and nitrogen; young trees respond rapidly with increased growth and demand for soil resources. Nitrogen liberated by the beetle-killed trees is taken up to support growth of live trees and understory plants as well as soil microbes

Despite the dramatic overstory mortality that occurred a decade ago, the forests at the Fraser Experimental Forest are thriving today. This research that utilized historic watershed studies, helps underscore how multiple-age stands may increase forest resilience to insect outbreaks. It also validates the sustainable forestry practice of retaining live understory trees that have potential to respond rapidly to death of mature overstory trees and mitigate potential water quality responses.

Questions about this study can be directed to Chuck Rhoades: crhoades@fs.fed.us.

MORE ABOUT STREAMWATER NITROGEN

Why do stream nitrogen levels matter? Nitrogen is essential for plants and increased soil N fertility is associated with higher plant growth in ecosystems around the world. However, excess nitrogen can leach from soils and degrade water quality. High concentrations of N or phosphorus promote algal blooms that can severely deplete oxygen in the water and harm fish and other stream organisms. At high levels, stream nitrate-nitrogen is a human health hazard and a regulated water quality constituent. Excess stream nutrients affects about 1/3 of streams in the continental United States.

Stream nitrogen monitoring helps scientists study forest and watershed change. Headwater forests typically produce low nutrient water that maintains healthy stream ecosystems and delivers clean water to downstream users. When a large number of trees are harvested or die, that lack of plant uptake and site disturbance often increases N in soils and streams. Unlike logging or wildfire, forest mortality from bark beetles does not disturb the soil surface and dying trees add pine needles that can conserve N within impacted forests. Increased N deposited with rain or snow has been shown to aggravate N losses from forest dieback in some areas. Researchers working throughout the U.S. Forest Service Experimental Forest Network measure N entering and exiting watersheds effected by forest change.

FURTHER READING

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