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Angle of Repose: Testing Erosion and Prescribed Fire in Eastern Oregon and Washington's Blue Mountains

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RESEARCH SUPPORTING SOUND DECISIONS

Every landscape is unique, and studying the effects of treatments such as prescribed fire on erosion rates in a particular place, with particular soils, plants, topography and weather is critical. The beautiful Blue Mountains rise from the Columbia River basin, a land shaped by volcanic flows and ice age landscape-ripping floods.

Angle of Repose: Testing Erosion and Prescribed Fire in Eastern Oregon and Washington's Blue Mountains

Summary

Some forest lands in the United States are overgrown with small trees and thick with fuels. Prescribed fire has been used in many forests and woodlands to reduce fuel loads and the risk of wildfire. But forests are unique, with different soils, plants, weather, and topography. While erosion from prescribed fire would seem to be less severe than from a wildfire, prior to this study, little data existed on erosion rates and the influence of prescribed fire on erosion in the Blue Mountains of eastern Oregon and Washington. This study showed that hillslope erosion in the volcanic rock and ash derived soils of the study area were related to slope aspect and the amount of bare ground. Prescribed fire had little effect, but intense storms that drive erosion did not occur during the study.

Key Findings

- In the absence of major storms, erosion rates were low, regardless of fuel treatment.
- Hillslope erosion rates were related to slope aspect and amount of bare ground—south-facing slopes and areas with more bare ground displayed more erosion.
- Elk trampling and ground squirrel burrowing caused much of the erosion measured in the study plots.
- Prescribed fire had little effect on measured hillslope erosion rates over the course of this three-year study, but none of the study areas experienced intense rainstorms that can cause severe erosion.
- Comparison of data from the hillslope erosion plots with whole watershed sediment yields suggested that rare episodic processes, such as intense storms following severe fire, likely play the biggest role in producing and transporting sediment. These events control watershed-scale sediment budgets.

Introduction

Prescribed fires have been used successfully in many different forest and woodland types across the United States. But just as the medical field continues to discover that human health is best treated with therapies geared toward the individual as much as possible, scientists recognize that the answer to restoring forest health doesn't rest on a few broad prescriptions and treatment options. As much as possible, scientists want to answer what is good at this time, for this forest, with these soils, plants, weather, and topography. And that means having as many answers as possible to the myriad variables. While it would seem that the severity of fire effects, such as erosion, would be less in a prescribed fire treatment than in a wildfire, for example, what do we really know about those rates? This was the question, Steve Wondzell, Research Riparian Ecologist with the Pacific Northwest Research Station, wanted to answer, for a particular forest, with particular soils, and with its plants, topography, and weather.

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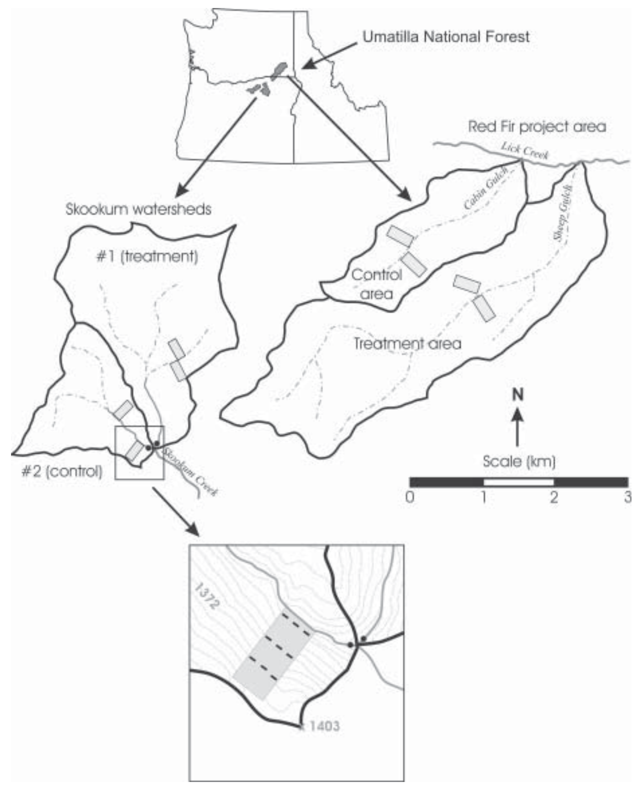
Raising the question…

Improving forest health by reducing the risk of severe wildfire, improving habitat to protect endangered species, keeping the water clean and clear for fish are goals managers strive for in implementing management plans and projects. But with few published studies on sediment movement in the volcanic rock-and-ash derived soils of eastern Oregon and Washington, managers must rely on studies performed in other areas. Wondzell, with Catherine Clifton, Forest Hydrologist on the Umatilla National Forest, designed a study to provide some answers to these questions: First, some background data on erosion rates, and then, the effects that prescribed fire would have on erosion rates. And finally, how much sediment would be delivered to streams.

The Blue Mountains rise from the interior Columbia River basin—a place shaped by constructing forces of volcanic flows and topography-ripping ice-age floods. On a more recent time scale, it is also a place where geography made human history. American Indian tribes traded with one another, and when they arrived, Euroamerican trappers joined in the native trade language known as Chinook jargon, a mix of Indian and European languages that helped multinationals communicate. The Skookum watersheds in northeast Oregon that the team studied bears an artifact of this history—skookum means "strong" or "able." The team's prescribed burn study area, Red Fir, is located in the lower Snake River basin in southeast Washington. Both places feature similar forests—open stands of ponderosa



Study areas within the Umatilla National Forest of eastern Washington and Oregon included data gathering at the watershed and hillslope scales. Silt fences collected erodable materials at the upper, mid, and toe-slope positions.

pine and Douglas-fir on the dry south and west-facing slopes, with western larch and lodgepole pine growing in the deeper soil of hillslope hollows and draws. High on top, and on the cooler north and east slopes, thicker stands of larch, lodgepole pine and grand fir grow.

The scientists describe the historic fire regime as characterized by mixed types of burns, with areas of low, moderate, and high severity fires. While fuel loads on the dry slopes facing south seemed to correspond to historical amounts, the scientists saw a vastly different situation on cooler and wetter sites. In these places, shade tolerant conifers grew thickly. In the dense stands on the cool slopes of the Skookum study area, spruce budworms had made trees into wood debris. Large numbers of dead trees had fallen, adding tons of fuel to the landscape. Wondzell's study took advantage of eleven years of pre-treatment data, including discharge, suspended sediment, bedload sediment and water temperature, carried out by the USDA Forest Service on the unlogged and roadless Skookum watersheds. Wondzell's team added to existing measurements by installing silt-fence erosion plots to measure the rates of erosion on hillslopes within the watersheds.

Silt fence installed lengthwise across the slope allowed scientists to collect and measure the amount of eroded materials.

Because the Forest Service did not treat the Skookum areas with prescribed fire as planned (too big of an area, too much fuel, too close to a large roadless area, and consequences too big if a fire escaped), Wondzell's team used the Red Fir area to test the relation of prescribed fire and erosion. Using plots in areas not burned (control) and burned (treatment), the team placed sediment fences at the upper, mid and toe-slope positions along the length of the hillslope to catch eroded soils, gravels, dirt and debris. The team collected sediment caught in the fences in the late spring, after snow melt, and again in the fall. They also intended to collect again after each heavy summer rain that poured on the slopes, but none occurred. In addition to catching the moving pieces that make up eroded materials, the team looked at the condition of the slopes—how much ash, charcoal, bare ground? How much ground was covered with gravel, rock, duff, wood? This would reveal the amount of surface that rain could hit. How much canopy was there? Grass, forbs, shrubs, trees? How much was there to break the rain's fall? The summer before, and every summer after treatment, the team collected this data from the control and burn plots. So what kind of erosion had occurred, at the plot level, and up to the watershed level? And where had those sediments come to rest?

Hillslope erosion rates were greatly related to slope aspect and amount of bare ground—south facing slopes and areas with more bare ground displayed more erosion.

Showing some grit

Though the Skookum area had not been treated, it provided scientists with useful background information on erosion rates, and how those rates were affected by slope aspect and position. In these study areas, data showed a highly variable rainfall pattern over the years, and equally variable sediment yields. Slope aspect played a big part in the amount of sediment collected by the fences—higher rates on south-facing slopes where soils are more exposed and have less organic litter to cover them. The scientists also found that animal burrowing on the south slopes dislodged sediment that was caught by the fences. The death of vast numbers of trees also probably contributed to variable annual erosion amounts. With the canopy gone, bare ground exposed, root wads upended, there was greater potential for erosion. Fallen trees and understory plants, now growing thick in these areas, are protecting the soil from erosive forces. With so many differences in the amount of sediment released over the years, and between watersheds, separating out the effects of prescribed fire, if it had been applied, on erosion at the watershed level would have been difficult unless the area of burn treatment was considerable and the burning severe.

Fallen trees and understory plants, now growing thick in these areas, are protecting the soil from erosive forces.

Elk trampling and animal digging caused much of the erosion measured in the study plots.

Interestingly, at the Red Fir study area, the scientists found no great difference in hillslope erosion rates between the burned and unburned plots. The prescribed fire applied to the north-facing treatment hillslope didn't even burn down to the middle and lower slope plots. On the south-facing slope, the effect was very similar—prescribed fire burned only the upper and middle portion of the hillslope, leaving the lower plots unburned. Many of the south-facing erosion plot silt fences were damaged by vandals—of the ungulate kind. The team observed hooved tramplings, which they attributed to curious elk. "The relation between the area of bare ground and erosion also appears to vary with aspect, with an equivalent bare ground area supporting higher erosion rates on south-facing aspects than on north-facing aspects," the team offers. They observed that on south-facing slopes, burned plots often had the greatest area of bare ground and also some of the highest erosion rates.

A slant to consider

The high temperatures of a severe wildfire, and the ash left behind, change the surface soil layer, making it more difficult for water to infiltrate the soil. As a result, rains that would have previously soaked the soil, promoting lush plant growth, pool on the soil surface and then begin to run downhill. The more severe the fire, the greater the potential for erosion. But most prescribed fires are applied with careful consideration of weather and fuel moisture, making a large, severe prescribed fire unlikely, the team explains. Slopes burned prescriptively should not erode much. But it is the work of water to erode the soil. What happens if there is a major rainstorm just after a prescribed fire? Especially a fire burning tons of fuels, densely accumulated over the last century? Because the areas never experienced a major rainstorm during the course of the study, the scientists did not get a chance to answer their question—they never got to shovel a heap of soil, gravel, and rocks from a bulging sediment fence. Instead, they were on their hands and knees, with whisk brooms and dust pans. The tiny amounts of sediment they swept up came from the hillslope just above the fences, from distances of inches up to a few feet. They never observed substantial hillslope erosion.

The more severe the fire, the greater the potential for erosion.

Plots in the Red Fir study area, before (top) and after (bottom) prescribed burn. The study revealed the relation of bare ground and erosion appears to vary with slope aspect. With equal amounts of bare ground on south-facing and north-facing slopes, erosion will be greater on the south-facing side.

The scientists also looked at how much sediment was deposited in the stream channels, and how much total sediment was produced from the watershed. By looking at samples they took from outlet streams, the scientists estimated that hundreds of times more sediment is leaving the watershed than is eroding from the hillslopes. That sediment must be coming from the eroding streambanks and streambed. They stress that erosion patterns are highly episodic—after big fires, intense rainstorms could fill valley floors with eroded sediment. Over the next century or so, the stream would gradually carry that sediment away while forests regrow and vegetation once again stabilizes hillslope soils. It is easy to see the big erosion events after a wildfire, but the work the stream does over the intervening centuries is nearly impossible to see without a careful, scientific study.

To implement the Endangered Species Act, the Forest Service follows a guideline that calls for no measurable effect from prescribed fire on streams and riparian areas of streams that support populations of threatened or endangered fish. But this creates a management paradox and an important question for scientists to answer. Keeping burn treatments out of the riparian areas may keep large amounts of sediments out of streams—over the short term. But over the long term, the lack of fire would increase fuel loadings, creating conditions that could enable more severe burns in streamside areas, and potentially lead to severe habitat degradation from sedimentation. At the same time, however, treating upland areas should reduce the overall risk of fires. Over the long term, would it be better to treat riparian areas, risking short-term sedimentation of streams in order to potentially reduce the long-term risk of severe fires? Could prescribed fire be used in riparian area to improve habitat? Or are riparian areas better left to fend for themselves? Looking at landscape conditions from different angles, and looking at the different forests and landscapes of western North America, it is easy to see that the search for effective management plans will require better answers to many difficult questions.

Further Information: Publications and Web Resources

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Management Implications

- With prescribed fire having little effect on measured hillslope erosion rates, in the absence of major storms, current best management practices appear to effectively limit surface erosion and prevent sediment delivery to streams.
- The relatively low severity of prescribed fire allows rapid regrowth of understory plants and the development of the organic litter layer—factors that limit erosion.
- Prescribed fires in this study did not reach the riparian zone, effectively leaving a wide buffer. These buffers will effectively limit the amount of eroded sediment that will reach streams.
- Because fuel loadings were extremely high, the USFS did not conduct the planned prescribed burns in the Skookum watersheds. Treating forests with extreme fuel loads has high costs and poses great risks. Managers are cautioned that the effect of prescribed burns under these conditions remains unknown.

Scientist Profiles

Steven M. Wondzell is a Research Riparian Ecologist with the Pacific Northwest Research Station in Olympia WA. Wondzell has a BS in Range Management, an MS in Plant Community Ecology, and a Ph.D. in Forest Ecology. With a background in both plant ecology and hydrology his research interests focus on riparian zones, and how they are affected by natural and human caused disturbances.

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Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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