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BAER Truth: Fertilization and Yarrow Show Promise for Restoring Vegetation Cover after Fire on the Okanogan-Wenatchee National Forest

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Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Washington State's 2006 Tripod Fire served as one of the study sites evaluating the effectiveness of seeding and fertilization for increasing plant cover during the first two years after a severe wildfire. Credit: Inaki Baralbar.

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Summary

For this study, researchers tested the effectiveness of seeding and fertilization treatments for increasing total live plant cover and reducing bare soil during the first 2 years following wildfire in dry mixed-conifer forests of north-central Washington state. Results suggest that fertilization treatments can increase the effectiveness of seeding treatments and stimulate regrowth of surviving native vegetation after fire, particularly in forest types with understory vegetation dominated by species that resprout. Yarrow seed was a surprising performer, especially in combination with fertilization. Effectiveness of treatments varied greatly depending on site characteristics that included elevation, precipitation and postfire plant survival.

Key Findings

- Fertilization accelerated the development of live plant cover following severe wildfire, thereby reducing bare soil cover and, presumably, water runoff and soil erosion.
- In deciding when and where to apply fertilization treatments, fire severity and surviving plant density are important considerations.
- Of the plant species tested in this study, yarrow produced the most organic soil cover, both alone and in combination with fertilization.

Reality check

Controlling erosion and water runoff are important objectives for land managers following severe wildfires. High-severity fire can kill the vast majority of trees and plants in its path, consuming ground cover and exposing soils. Severe fire can also temporarily reduce soils' capacity to absorb rain and snowmelt. Precipitation that would normally percolate into the ground ends up running downhill on the soil surface, increasing erosion and sending sediment into streams, particularly during heavy rains. These fire-induced effects typically subside over time as vegetation recovers and replaces lost plant and litter cover.

A severely burned area of the 2006 Tripod Fire. Credit: SilverCreekGarden@Flickr.com.

Although erosion and runoff are natural ecosystem responses to severe wildfire, they can present some unacceptable hazards to human health and property in lower areas of affected watersheds. Increased sediment delivery to streams and/or loss of forest productivity can also be undesirable, even where human interests aren't threatened. To reduce erosion, flood hazard and protect natural resources, land surface treatments are often applied on public lands following wildfires as part of burned area emergency response (BAER) or emergency stabilization and rehabilitation efforts. These treatments of the soil surface can include seeding, fertilizing, and mulching. Seeding is used to increase plant cover by promoting establishment of new plants, typically from fast-growing species and readily available seed stocks. Fertilizers enhance availability of soil nutrients, supporting growth of surviving and newly established plants. Mulch is applied to cover bare soil immediately after fire until plants have the time to begin their return. Annual costs for these treatments have been increasing in recent years for several reasons. More area is burning severely which has increased postfire threats to human health and property as communities and infrastructure continue to expand into natural areas susceptible to fire's natural processes. In addition, the price of mulching treatments has continued to rise. Despite escalating expenditures and widespread use, rigorous testing and effectiveness monitoring of land surface treatments has been spotty at best, making it more challenging for agencies to justify continued expenditures.

David W. Peterson, a research forester with the Forest Service's Pacific Northwest Research Station in Wenatchee, Washington, was approached by BAER team leaders from the Okanogan-Wenatchee National Forest looking for scientific studies that would help them better assess the likely effectiveness of BAER land surface treatments, anticipate potential secondary effects of treatments on long-term ecosystem recovery, and generally improve their post-fire management practices. They noted that without new research, there was a tendency to simply continue using traditional practices following high-severity wildfires, even if past results had been variable. Working with Okanogan-Wenatchee BAER Team Leaders Terry Lillybridge (forest botanist) and Carl Davis (soil scientist), Peterson and Richy Harrod (deputy fire management officer for the Okanogan-Wenatchee National Forest) designed a study to address treatment effectiveness in the dry forests of north central Washington through a replicated field experiment. They examined the effects of seeding and fertilization treatments on plant cover and bare soil—two measurements most closely related to erosion and sediment production—for

2 years following the fires. They also evaluated treatment effects on native vegetation recovery and exotic plants.

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"Local managers were asking for this type of study," says Peterson. "They don't want to spend time and resources on something that isn't going to do what they intend. For studies like this, a finding of no effect can be just as important as a significant effect."

Fertilization previously unproven

Fertilization has received little study as an erosion control treatment. It's considered a possible, but unproven, postfire erosion control treatment, generally applied only in combination with seeding. "Fertilizer use has been around for a while, but it's probably the least accepted," Peterson says. "There was some local research on the Okanogan-Wenatchee National Forest from the 1970s suggesting that fertilization could be effective as a post-fire rehabilitation treatment, but it hadn't been tested in a rigorous way. After large wildfires in this region, local managers would often propose using fertilization as a BAER land surface treatment, but the request would often be rejected because fertilization was not considered to be 'proven effective.'" A key component of this study was to prove or disprove fertilization effectiveness by applying it with and without its usual seeding partner and see what happened.

In spring 2005, Peterson and his team established experimental field plots at eight sites within severely burned areas of the 2004 Pot Peak Fire near Chelan, Washington. They monitored postfire vegetation recovery by observing and recording plant species cover during the summers of 2005 and 2006, surveying plant cover during midsummer when live plant cover was near its annual peak. They also established similar studies after the nearby Deer Point (2002), Dirty Face (2005), and Tripod (2006) wildfires, testing the effects of different seeding and fertilization treatments in different combinations at each site.

In addition to the experimental treatments, they studied the effects of mulching treatments on vegetation cover at four sites within the Pot Peak study area, where wheat straw mulch was applied by helicopter as part of operational soil erosion control efforts. Mulch was applied during fall and spring immediately following the fire. Although mulching was not applied as part of a planned experiment, Peterson and his colleagues surveyed straw cover on all plots within the treated areas to assess the amount of soil cover produced and the effects of varying levels of mulch cover on vegetation responses to seeding and fertilization treatments.

Fertilization's potential benefits confirmed

The researchers were surprised to find that the best overall treatment was the truly unproven one—fertilization—and that seeding with the standard seeding treatment alone accomplished little or nothing. Using increased soil cover as an effectiveness indicator, fertilization alone proved to be more effective than seeding for increasing total plant and litter cover and reducing bare soil area. It appeared to stimulate growth and litter production in understory vegetation. "We didn't expect the operational seeding treatment to be so unsuccessful, or for fertilization to not only increase the effectiveness of seeding but help the native vegetation recover with very few detrimental effects," Peterson says. "Even better, the benefit wasn't offset by any significant increase in the spread of weeds." By the second year after fire, the most effective treatment combinations reduced bare soil area to below 40 percent. Mean bare soil area approached 40 percent for all of the treatments that included fertilization. Peterson says that if 40 percent bare soil is indeed the level at which soil erosion rates begin to approach background levels, fertilization would have reduced postfire soil erosion by a meaningful amount by the end of the second year.

Tiny yarrow seeds perform

Fertilization did indeed improve the effectiveness of some seeding treatments; particularly a seed mixture developed for warm, dry sites that contained yarrow—a native, perennial forb with tiny seeds. Yarrow clearly produced the most organic soil cover both alone and in combination with fertilization. Yarrow's small seeds establish and grow quickly, taking advantage of water and nutrients early in the season, putting on good growth and cover before hot summer temperatures arrive. Wheat has been used extensively for postfire seeding in the Pacific Northwest for the last 15 years or more largely because it is readily available, has produced good cover in some cases and rarely persists beyond the second or third year.

Aerial seeding during the early autumn following the Tripod Fire. Credit: Steve Bauman.

However, wheat seeding also tends to be unreliable. Where wheat seeding produced high levels of plant cover, it reduced cover and species richness of native plants, demonstrating tradeoffs between effectiveness for erosion control and impacts on native vegetation recovery and biodiversity. While yarrow seed isn't as readily available as wheat, it's becoming more available due to its use in restoration projects. As with wheat there was some tradeoff between cover attained and impacts on other native vegetation cover and biodiversity, but these were not severe.

"That was the really interesting thing about this," Peterson says. "The balance between positives and negatives was really pretty good. For the most part the operational treatment of seeding winter wheat did virtually nothing. In some places you could hardly find any evidence that you'd seeded. The seed mixture treatment contained perennial grasses that provided some meaningful cover by the third or fourth year but, for purposes of reducing soil erosion hazards we really care the most about the first two years, while native vegetation is still recovering. The grasses were just too slow. Yarrow was the one that worked."

Mulching

Mulching was effective at reducing bare soil cover during the first year after fire, as has been documented previously. This study indicated that mulching reduced bare soil cover at a rate that slightly exceeded the rate of mulch application, perhaps due to germination and growth of residual wheat seed in the straw. A potential drawback of mulch use is that it may affect long-term vegetation recovery by introducing exotic species or interfering with plant establishment. Peterson's team found no evidence that mulching reduced live plant cover in either year at Pot Peak. A follow-up study on the Tripod Fire also found that mulching had no detrimental effects on vegetation recovery as long as mulch was applied as a thin layer without clumping.

Site conditions key to success

Peterson emphasizes that the success of fertilizer was strongly impacted by the conditions at each site. He points out that when you are looking at any treatment designed to increase plant cover and reduce erosion you're limited by the most limiting factor. Elevation, precipitation, and postfire plant survival all contribute to the likelihood of success. "It's like a triangle," he says. "If you have enough plants and enough water, then the nutrients in the fertilizer can really be helpful. If you're missing either the water or plants then it won't be helpful." For example, the timing and conditions on the Pot Peak fire were a good fit for fertilization because the fire burned at lower elevations relative to some of the other study areas. There was enough understory vegetation coming back to take up the fertilizer and actually use it. The first spring after the fire was fairly moist, so the plants had the water they needed. But when they tested fertilizer's effects on higher elevation sites on the Dirtyface and Tripod Fires (4,000 to 6,000 feet), it didn't do much. There weren't enough resprouting plants on these sites, so fertilization alone wasn't effective.

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"Under these conditions you have to either combine it with seeding or have enough sprouting shrubs or naturally reseeding species to take it up. When we tried fertilization at the Deer Point fire in 2003, it was one of the driest summers on record and the fertilizer did virtually nothing," Peterson explains. He adds that it will be important to gain a better understanding of the causes for the variability in seeding success if seeding is to continue as a land surface treatment. Some variability is likely due to uncontrollable variables such as year-to-year changes in precipitation and soil moisture. He suggests that restricting seeding of varying species to environments where they are generally successful might bring more consistent results.

Need for more meaningful monitoring

Assessing treatment impacts across different site and climate conditions will require an adaptive management approach in which promising treatments are applied operationally and their effectiveness monitored by managers on the ground. Managers are already being asked to monitor results, but they don't have much guidance on how to monitor in a way that can give them the complete picture. "The point the study makes is that if you're relying on something like seeding you might just be replacing one plant with a different one," Peterson explains. "You can't just use seeded species cover as a measure of success. Some kind of control area is needed to tell the story of what would have happened if they hadn't seeded."

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He realizes that managers have enough on their plates already, but points out that monitoring doesn't have to be complicated or expensive to be useful. "Monitoring is one area where research-management partnerships can be really useful," he says. "Scientists can help design or adapt monitoring plans to make sure the results are valid, but managers need to be actively engaged in the process to make sure the work is appropriate and can get done."

Peterson suggests two approaches that could help solve the critical need for meaningful effectiveness monitoring of operational treatments. "We can either have the research branch do some of this for managers, given that it's more along our line of work, or at the very least we could come up with some straightforward, standardized protocols for how managers can do it themselves."

The next questions

Peterson points out that although studies like this are useful for comparing the effects of competing treatments on common sites and identifying promising treatments, the ability to extrapolate results to sites with environmental conditions different from those of the study areas is limited. Causes for variability in site responses to fertilization are not yet fully understood but progress has been made. The researchers are hopeful that clearer patterns of variation in effectiveness will emerge as results from similar studies on other wildfire areas become available. Questions remain surrounding the success of yarrow as well. It provided greater benefits than the normally prescribed winter wheat in this study but it's still unclear why. Is it because yarrow is

better adapted to the biophysical settings, established better on burned soils, produced faster initial growth, was less susceptible to seed predation, or all of the above?

Further study appears warranted to identify species for seeding that perform consistently well, or to better match seeded species to the environments in which they can be expected to perform well. Peterson says it's also important to address questions about tradeoffs between the practical advantages of seeding highly available nonnative species and possible biodiversity benefits of seeding native species from either local or distant seed sources. Further studies relating soil cover (or bare soil) to soil erosion rates will also be helpful for testing and improving soil erosion models, defining soil cover levels that can be counted on to make a difference. This will help managers better determine when the potential benefits of land surface treatments are likely to be sufficient to justify application costs and provide the desired protections for human health and property.

Peterson and his colleagues continue to dig for more answers. They're currently looking at an observational study about mulching alternatives to seeding and fertilization where questions remain about introducing agricultural weeds and whether the straw going to suppress regrowth of native vegetation. They're also looking more closely at all of the important site variability questions. They've replicated their treatments on the Deer Point, Dirty Face and Tripod Fires seeking more specifics regarding what makes a site suitable or unsuitable for treatment. "Is it the site or is it the luck of the draw in terms of the weather?" he says. "We'd like to see if we can finally say which treatments are effective at specific elevations, and how much understory cover and site moisture play a part." Peterson is also looking into ways of making meaningful effectiveness monitoring easier for managers. "I'd like us to be able to say to managers—here's exactly what you need to do—and find ways to help them do it."

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Management Implications

- Fertilization is a potentially effective treatment for increasing plant cover and reducing bare soil during the first 2 years following wildfire, but more work is needed to determine optimal application rates, formulations, and variability in effectiveness across a range of climates, fire severities, and soil and vegetation types.
- Seeding was not very effective in this study, suggesting that it may not be the best choice for erosion control in this area. The performance of yarrow, however, suggests that seeding effectiveness may be improved by choosing different species or species mixtures for seeding.
- Mulching significantly reduced bare soil cover, but it is not clear whether the reductions in erosion risk were large enough to justify the high application costs and elevated risks of exotic species introduction.

Further Information: Publications and Web Resources

Peterson, D.W., E.K. Dodson, and R.J. Harrod. 2007. Assessing the effectiveness of seeding and fertilization treatments for reducing erosion potential following severe wildfires. In: B.W. Butler; W. Cook, (comps.) 2007. The fire environment – innovations, management, and policy; conference proceedings. 26–30 March, 2007; Destin, FL. Proceedings RMRS-P-46CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 662 p. CD-ROM. Available at: www.fs.fed.us/rm/pubs/rmrs_p046/rmrs_p046_465_474.pdf

Peterson, D.W., and R.J. Harrod. 2008. Evaluating the efficacy and ecological impacts of BAER slope stabilization treatments on the Pot Peak/Deep Harbor Wildfire Complex. JFSP Final Report.

Project website: http://www.fs.fed.us/r6/wenatchee/fire/baer/baer-study.shtml

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