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Slash from the Past: Rehabilitating Pile Burn Scars

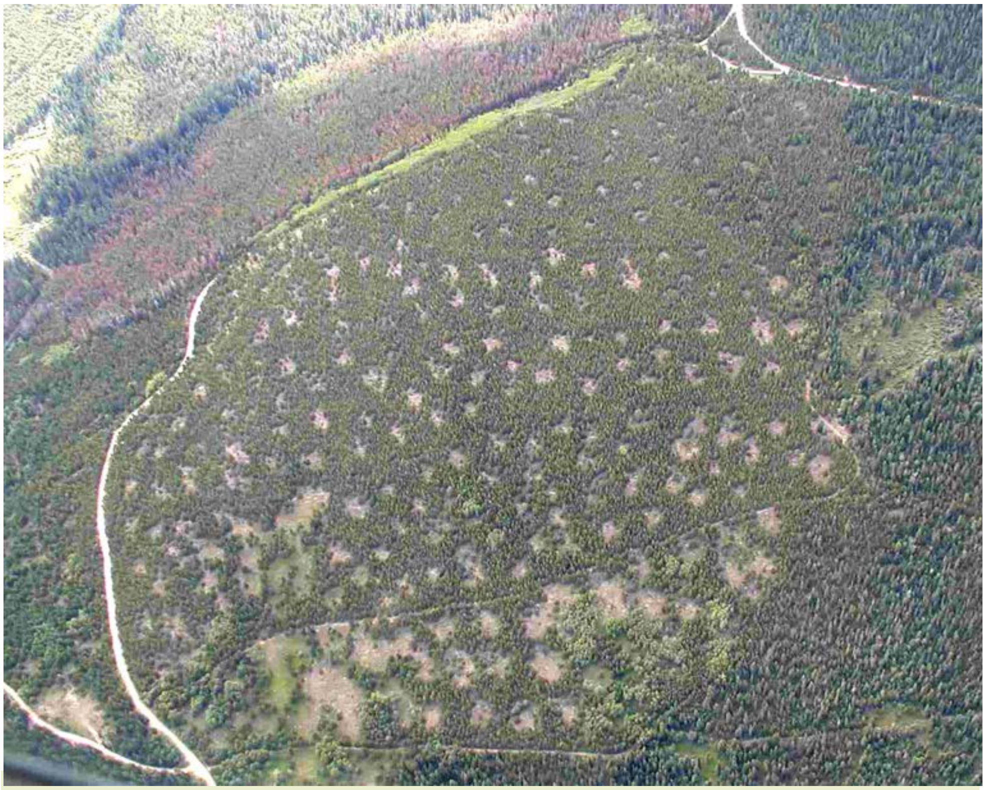
The burning of slash piles is a traditional forestry practice and it remains the most common wood-waste disposal method used in forest management today. (Photo by L. Asherin)

SUMMARY

In the National Forests of northern Colorado, there is a backlog of over 140,000 slash piles slated to be burned, most of them coming from post-mountain pine beetle salvage logging and hazard reduction treatments. Burning slash piles can create openings in the forest that remain treeless for over 50 years, and can also have the short-term impacts of increasing nutrient availability and creating opportunities for weed establishment. Working with managers, RMRS researchers have evaluated the available treatments for short-term rehabilitation of both smaller, hand-built and larger, machine-built burn piles. For the smaller piles, they found that both soil nitrogen and plant cover recovered to a level similar to that of the surrounding forest within two years, indicating that these scars may not need rehabilitation unless in a sensitive area. Seeding with native mountain brome (*Bromus marginatus*) was an effective option for the larger piles, whereas mechanical treatment either alone or with seeding did not increase plant cover. The root causes behind the long-term lack of trees are not yet clear, and the next step is to conduct field and lab studies to evaluate whether soil factors, competition with grasses, and/or herbivory are possible explanations.

In the summer of 2007, US Forest Service colleagues Chuck Rhoades and Liz Schnackenberg were on a field trip in northern Colorado when Chuck pointed out gaps visible in a lodgepole pine forest about a half-mile away—scars created by slash pile burning after a timber sale cut 40 to 50 years prior. “I was amazed and concerned that you could still see these,” recalls Schnackenberg, a hydrologist with the Medicine Bow-Routt National Forest, “because at that time of that field trip we were dealing with a lot of beetle-killed lodgepole pine and creating condominium-sized burn piles of woody slash that were bigger than I’d ever seen.” She began to wonder whether the current burn piles would also leave substantial scars that would persist 50 years into the future.

Rhoades, a research biogeochemist at Rocky Mountain Research Station (RMRS), had himself become interested in the effects of pile burning a few years earlier. When looking down from the window of a plane during a bark beetle-damage flyover, he had noticed a honeycomb-like pattern of holes in the forest cover near the



Pile burning can create grass and forb-filled openings that often remain treeless for decades, as can be seen in this aerial photo of a 40-year-old regenerating lodgepole pine stand in Grand County, Colorado. (Photo by C. Rhoades)

Fraser Experimental Forest in Grand County, Colorado; these holes appeared to be legacies of past pile burns. Simultaneously, Rhoades' colleague Paula Fornwalt, a research ecologist at RMRS, was noticing how often she was coming across weed-filled pile burn scars in ponderosa pine forests during the course of her research, some of which appeared to be years or even decades old. Persistent effects of pile burning, it seemed, were everywhere.

The burning of slash piles is a traditional forestry practice and it remains the most common wood-waste disposal method used in forest management today. In the National Forests of northern Colorado alone, there are over 140,000 piles of woody debris, or "slash", quietly waiting to be burned—much of it coming from the salvage logging and hazard reduction treatments conducted in response to the widespread lodgepole pine mortality from the mountain pine beetle. Thousands of additional piles are also found in National Parks and other areas of forestland in northern Colorado; this slash comes from both the beetle epidemic and forest restoration and thinning treatments that are a consistent feature of forest management. Pile burning is a relatively inexpensive option for reducing fire risk posed by the post-harvest slash (compared to alternatives such mastication), and less controversial than broadcast burning in densely-populated wildland interface zones. But when a pile is burned, the soil is heated for a long time—much longer than a typical wildfire—and often to a deeper depth and higher temperature. In the short term, this results in a release of nutrients that may pose water quality concerns in nearby streams. And in the long term, burning appears to create grass and forb-filled openings that can—and often do—remain treeless for decades.

Out of concern for the broader implications of the persistence of past pile-burn scars combined with the backlog of piles to be burned, Rhoades, Fornwalt, and Schnackenberg organized the "Miles of Piles" Tour with staff from Medicine Bow-Routt National Forest and the Forest Service Rocky Mountain (Region 2) Regional Office in the fall of 2011. This trip sparked a conversation between researchers and managers to discuss the historic context of pile burning and its relevance to current roadside and landscape fuels treatment. Here, researchers Rhoades and Fornwalt learned of some of the main questions that the forest managers had about pile burning, which included: does the size of the pile matter, and what types of rehabilitation treatments might affect the course of pile burn scar recovery? Through a series of observational and experimental research projects, they have started to uncover some answers that will help managers make decisions about pile size and rehabilitation options.

Feeling the burn: the decades-long legacy of pile burning

The main difference between a wildfire and a pile burn is the fuel load in a given area. "A pile burn concentrates fuels on a given area, and that spot gets really hot," says Fornwalt. The heat damage is usually limited to the top several inches of surface soil, but this can have a significant impact because this is the main zone of biological activity in a

"…We need to figure out what the long-term trajectory of these burn scars is, determine whether they need restoration, and learn how this can best be done," states research biogeochemist Chuck Rhoades.

The clear, long-term legacy of pile burning is the elimination of trees and shrubs from the burn scars. Top – 15 year old pile burn scar, bottom – 50-year old pile burn scar within regenerating lodgepole pine forests in northern Colorado (Photo by C. Rhoades).

forest soil. Fire combusts most or all of the organic matter, kills soil microbes, plant roots, and seeds, and affects soil acidity, nitrogen, and physical properties. Burning slash piles that are built of larger-diameter wood can create kiln-like conditions in the center of the pile, heating soil to an excess of 500 °C and oxidizing the mineral soil into reddish, brick-like chunks. But even though generations of soil scientists have documented these immediate changes, it is not clear why the burn scars remain treeless, and therefore visible, for decades. As Rhoades observes, "We know it gets hot, but what else is going on? We need to figure out what the long-term trajectory of these burn scars is, determine whether they need restoration, and learn how this can best be done."

At the scale of an individual pile within a larger forest, the soil impacts seem minor—after all, the burn scars historically average only 10-15 meters in diameter (they have been growing larger over time). But when you multiply that area by the number of past and future pile burns, it is easy to see why there is growing concern over the practice. To gauge the scale of the problem locally, Rhoades and Fornwalt worked with forest managers and resource specialists in the Medicine Bow-Routt National Forest to identify and estimate the ages of the over 7,500 pile scars created in lodgepole pine stands on this forest since 1960. The pile openings averaged about 3% of treatment areas and exceeded 8% in some individual areas. Other studies have found that the area covered by pile burn scars can reach as high as 15% of a treatment area.

Rhoades and Fornwalt chose a subset of these pile burn scars of different ages, dating from the 1960s to the present, to compare numbers of trees in the burn scars to the adjacent forest that had regenerated after harvesting. Their findings confirmed what can be clearly seen in the field—the burn scars only had 10% of the tree density of the surrounding stand, with the oldest scars remaining just as treeless as the more recent ones. Seedling numbers were also low in scars of all ages, indicating that forest regeneration in these areas isn't simply delayed—it's just not happening. Shrubs commonly occurring in the neighboring, regenerating forest, such as Vaccinium, are similarly absent from the burn scars. The clear, long-term legacy of pile burning is the elimination of trees and shrubs from the burn scars for decades.

Burning piles built of larger-diameter wood can create kiln-like conditions that can heat soil above 500 °C and transform mineral soil into reddish, brick-like chunks. (Photo by C. Rhoades)

Knowing that every pile burn creates a long-term scar is useful to managers, according to Eric Schroder, a soil scientist with the Arapaho and Roosevelt National Forests. He says, "We are adaptive and we always try to use the best available practices. This research helps us describe and predict the potential effects of pile burning in our environmental impact reports." Additional information can help managers determine what, if anything, to do differently.

Options for reducing short-term impacts of pile burning

Slash pile burning has short-term as well as long-term ecosystem impacts. Pile burning increases availability of nutrients, which can pose water quality problems near streams, particularly from nitrate runoff. Knowing this, managers have historically sited slash piles away from streams, but the mountain pine beetle epidemic changed that. “After the beetles came through, we had to do roadside hazard treatments so we wouldn’t have dead trees falling on vehicles. We were clearing swaths 100-200 feet wide and creating a lot of burn piles near streams where we normally avoid cutting. But we can’t avoid it here because roads are often built near streams,” explains Schnackenberg. The bare soil, high nutrients, and low native plant cover on burn scars also invite colonization by non-native weeds. Forest managers in the Medicine Bow-Routt and Arapaho and Roosevelt National Forests want to know how to better design the slash piles and also what post-burning rehabilitation treatments they can implement to improve recovery of burn piles, with the short-term goals of reducing these nutrient runoff and weed colonization issues. “I think there’s a willingness to do something, but it costs money, so we want to be sure that what we’re doing is effective,” observes Schnackenberg.

In the short term, the main objective of rehabilitation treatments is to cover bare soil inside the burn scars to hold the soil and nutrients in place, and to keep the area from being colonized by weeds. A common operating procedure for such treatments is to scarify (roughing up of the soil surface) and then seed, according to Fornwalt. But, she adds, “Managers have told me that if scarification isn’t effective, they would be really happy to not have to do it because it takes a lot of time and working in ash is very messy.” Mulching burn scars with wood chips is also an option in some cases, and can help to prevent weeds from colonizing while retaining soil nitrogen released by the burning. According to Schnackenberg, managers also wonder whether it is better to build more small piles or fewer large piles. The assumption is that small piles burn a larger surface area but don’t burn as hot and therefore recover faster, and that large piles burn hotter, but with a smaller overall footprint. Whether this assumption is correct is “something that managers need to know, because to some extent we can limit pile size or encourage building bigger piles, depending upon what is best for recovery,” she notes.

“...[T]o some extent we can limit pile size or encourage building bigger piles, depending upon what is best for recovery,” notes research ecologist Paula Fornwalt.

To help managers answer some of these questions, Rhoades and Fornwalt conducted an experimental comparison of surface manipulations and amendments aimed at developing rapid and cost-effective rehabilitation options for both small and mid-sized pile burn areas. Although their research is ongoing, the findings described below can assist managers now in planning burn scar rehabilitation.

Rehabilitation of smaller, hand-built pile burn scars

To test the options for rehabilitation of small piles (< 5 meters in diameter), Rhoades and Fornwalt carried out studies that looked at how the soils and plants were affected by mulching, seeding, and scarification treatments in hand-built pile burn scars in ponderosa pine and lodgepole pine forests of the Colorado Front Range. They found that burning small piles exposed bare ground and increased soil nitrogen similar to burning larger piles, and that the impacts were most intense in the center of the pile. A more surprising finding was that within two years, piles left to recover without any rehabilitation treatments had the same amount of grass and forb cover as piles where seeds were added. This is valuable information for managers wondering how to treat these areas. According to Rhoades, “Our take-home message is that many of these small piles don’t need follow-up treatments.”

In the short term, the main objective of burn scar rehabilitation is to cover bare soil, reduce nutrient losses and keep the area from being colonized by weeds (Photo by C. Rhoades).

According to Rhoades, "Our take-home message is that many of these small piles don't need follow-up treatments."

When large bole wood makes up a significant portion of a pile, as in areas of high tree mortality, high soil temperatures under the piles are more likely to create lasting soil changes. (Photo by C. Rhoades)

However, rehabilitation of small piles may be needed in sensitive areas, such as those with water quality or weed concerns. For example, wood chip mulching treatments retain the excess nitrogen created by pile burning and, if thick enough, can prevent weed establishment. Rhoades says, "We recommend mulching soon after burning in a site that is weedy or where there are water quality concerns. If you want to mulch to keep nitrogen from going into the creek, you need to get on it right away." They also found several noxious weeds present at their study sites, which could invade untreated scars. "If you're interested in enhancing native species composition and concerned about non-natives, seeding small piles with a native seed mix would be a good idea," says Fornwalt. Although this study was conducted primarily in northern Colorado, the researchers speculate that their findings may be applicable in other coniferous forests of the Rocky Mountain region.

Rehabilitation of big pile burn scars from roadside hazard treatments

The main determinant of the size of a slash pile is operational. If the cutting operation is manual, the piles tend to be hand-built and therefore smaller; if equipment is involved in creating the slash, then the slash piles are also usually machine-built and therefore larger. "Once you have a machine involved, the smallest pile you might make is still pretty big—and the scar may be too big to recover on its own," says Fornwalt. Changes in overstory and slash prescriptions and wood utilization standards have increased pile size in the past decade. Scar size from machine-built piles averages nine meters in diameter—three times the size of the average hand-built pile.

Previous research by the USFS has found that pile size alone does not dictate where the highest soil temperatures or the greatest damage will be found, as most of the heat in a fire rises regardless of size. The size of the material within the pile really does matter, though. When large bole wood makes up a significant portion of a pile, as it does in areas of high tree mortality, the soil temperatures under the piles are more likely to exceed the soil-oxidizing temperature of 500 °C. Huge piles of dead lodgepole pine boles, like those accumulating in beetle-killed lodgepole forests, represent a worst-case scenario for creating long-lasting pile burn scars.

Fornwalt and Rhoades evaluated the effect of rehabilitation treatments on the recovery of these larger, machine-built piles created by post-beetle roadside hazard treatments, comparing the effects of seeding with native mountain brome, mechanical scarification, doing both, and doing nothing. The native mountain brome grass (*Bromus marginatus*) collected from local populations was seeded because it provides quick cover, and is known to do well along roadsides. Tracked excavators were used to rake and scarify the burn scars.

They found that seeding with mountain brome effectively revegetated burn scars. Fornwalt says, "Brome is a good option for covering bare ground in these scars, but it would be useful to develop some native plant seed mixes that also perform well." On the other hand, mechanized scarification was not effective - scarified burn scars had similar plant cover to those that were left untreated. In some cases, seeding

*Seeding with native mountain brome (*Bromus marginatus*) effectively revegetated most burn scars (above) compared to unseeded scars (below) (Photo by C. Rhoades).*

of scarified areas failed to provide any grass cover after three growing seasons; these areas where seeding failed also had soil ruts and ponding. Rhoades indicates, “Machine traffic disturbed and compacted the exposed pile burn soil.” The negative effects of machine scarification are likely dependent on soil texture and moisture of the site.

The value of this experiment is that it evaluated a common procedure for scar rehabilitation, consisting of machine scarification followed by seeding. Results indicating that the seeding is valuable, but that the scarification can do more harm than good, can inform future practices and save limited funds. Rhoades and Fornwalt’s recommendation to managers is that seeding is all you may need to do in the bigger piles to cover up bare ground. “The idea that scarification may not be always be effective is something that

“We will definitely use these findings. If seeding is cheaper and more beneficial than scarification, we’ll be implementing this information on future burn piles,” says forest hydrologist Liz Schnackenberg.

we will try to incorporate that into our future approach. There is a ground disturbance aspect to scarification, and if it is not needed, then we can use that time and money for something more cost-effective,” says Schroder. Schnackenberg adds, “We will definitely use these findings. If seeding is cheaper and more beneficial than scarification, we’ll be implementing this information on future burn piles.”

In some cases, seeding mechanically-scarified burn scars with a native grass seed failed to provide any grass cover; these areas where seeding failed also had soil ruts and ponding (Photo by C. Rhoades).

…And why so few trees in these openings?

Given the well-known effects of pile burning on the soil, it is logical to assume a cause-and-effect relationship between soil damage and lack of trees. However, these openings are not without plants—in fact, usually they are filled with grasses and forbs. “The soils are certainly affected by burning, but when I walk out there and see lush plant growth, I think, the soils are still productive—something else must be keeping the trees out,” says Rhoades. But what could it be?

One hypothesis is that the grasses and forbs that establish quickly after pile burning may be the main culprits in keeping the scars treeless for so long. Fornwalt observes, "Tree seeds are burned with the logging slash. By the time the pine trees regrowing in the harvested area are producing seeds, the burn scars have become densely filled with forbs and grasses." Just as it is difficult for tree seedlings to colonize a suburban lawn, any tree seedlings that are trying to get established in these openings have to deal with competition from grasses for light and water. "The fire may have started the problem by killing all the seeds, but the grasses and forbs are probably keeping the trees out for the longer term," adds Rhoades. The forb and grass dominated openings attract wildlife and it also seems possible that herbivory may keep pines from colonizing these areas. The researchers are currently planning lab and field studies to answer the question of whether the altered soil, thick grass cover, and/or herbivory is keeping pine trees from growing in the scars.

So, is the lack of trees in these openings necessarily a bad thing? This depends on your perspective. After all, in forestry school, most future managers learn about the importance of forest openings for increasing the diversity of understory plants and the wildlife they support. But with so many piles throughout the forest, the cumulative effects of pile burning on the landscape will be significant. As Fornwalt puts it, "You can paint a rosy picture with regards to understory plants and wildlife, but it's also worth noting that pile burning causes changes that appear to be permanent."

Alternatives to pile burning

As long as forests are being managed by people, there will likely be piles of woody residue from management operations.

KEY FINDINGS

- In northern Colorado, pile burn scars from the 1960s to the present had very low numbers of trees, seedlings, and woody shrubs compared to the surrounding regenerating forest, indicating that pile burning creates a long-term land use legacy.
- For smaller burn scars (< 5 m diameter) at coniferous forest sites across the Colorado Front Range, plant-available soil nitrogen and native herbaceous plant cover return to pre-burn condition within two years of pile burning.
- Larger burn scars (> 5 m diameter) were effectively revegetated with seeding (a native brome grass), whereas mechanical treatment (scarification) both alone and in conjunction with seeding did not affect the total plant cover.

Knowing about the longevity of pile burn scars, it makes sense to ask—is there anything else we can do with this material? One option, obviously, would be to just leave the piles in place, unburned. But, according to Fornwalt, "We really don't have a good understanding of what would happen if the material was just left on the ground." There is the perception that piles increase fire risk, and there have been reports of unburned piles producing firebrands when burned by wildfires. "Piles are burned because 'we've always done it that way', and fuel reduction and removal is the underlying reason. Also, it's commonly considered the only logical thing to do with small material if you don't have an economically viable option for it," explains Rhoades. Finally, Schnackenberg points out that people don't like to look at large piles of slash that sit around for decades. "It's a visual problem. These piles can be around for 80 years, and for that whole time there is nothing growing underneath."

Other options for utilizing slash are slowly gaining traction in the Rockies. Driven largely by the push to develop more renewable energy sources, slash and wood waste is being used to generate heat and electricity, biofuels, and products such as biochar and activated carbon. One USDA-funded regional project, the Bioenergy Alliance Network of the Rockies (BANR), is exploring the use of beetle-killed forest biomass as a bioenergy feedstock. Colorado's first biomass plant, located in Gypsum, has been generating electricity from beetle-killed trees since 2013. Still, there will always be slash piles that are too inaccessible to be transported, and so continued work for mitigating pile burn effects will remain relevant, especially for sensitive and inaccessible areas.

MANAGEMENT APPLICATIONS

- Managers should be aware that burning large piles can create non-forested gaps that remain visible on the forest landscape for more than 50 years. Pile burn scars may comprise 3-8% or more of the treatment area.
- Not all pile burn scars require rehabilitation. For small piles, rehabilitation may be unnecessary except in areas with water quality, invasive plant, or visual impact concerns.
- Where needed, burn scar rehabilitation can be simple. Inexpensive treatments using local woody residue (wood chips) and grass mixtures may be sufficient to curtail exotic plant invasion and limit soil degradation and water quality concerns. Costly mechanical treatments are not necessarily more effective.

FURTHER READING

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