Watershed Management Council Networker, Winter 2000

Eighth Street Fire Monitoring Efforts in the Boise Foothills

Excerpted from the ***Report on Monitoring Results for 1998***, March 1999 by Jan Wessman, US BLM, Boise DistrictOffice; Leah Juarros, USDA-FS, Boise NF; Fred Pierson Idaho State Agricultural Research Service, Boise, and Mike Pellant, US BLM, Idaho State Office and personal communication with Forest Soil Scientist Leah Juarros.

Background

On August 26, 2996, the Eighth Street wildfire ignited in the Boise Foothills. By the time it was contained, it had burned over 15,000 acres. The overall fire intensities were 17% high, 64% moderate, and 19% low. The fire reduced effective ground cover from a prefire 30–50% e.g.c. to less than 10% over the high intensity burned areas. With these intensities, all vegetation (predominantly Douglas fir) was killed. At moderate intensities some upland shrubs had remnant leaves and small twigs, while riparian plants remained green or with dead leaves.

The watershed is dominated by fluvial slopes that are moderately dissected with a dendritic pattern. The soils are of two parent materials: Idaho Batholith and a lacustrine deposit of Glens Ferry member of Payette Lake Formation. The soils of granitic origin have dry soil moisture, and have textures ranging from loams to coarse gravelly loams, depending on slope position. Steepness also varies with slope position, ranging from 15–35% in the lower watershed to 40–75% in the upper watershed. Most of the area has moderately deep to very deep soils. After the fire hydrophobic soils developed on 32% of the forest land. Using the USLE (Universal Soil Loss Equation), double-checked by a WEPP run (Water Erosion Prediction Project), erosion was predicted to be around 32 tons per acre per year during the first two seasons after the fire.

The average annual precipitation ranges from 14–30 inches per year; increasing with elevation. Although most of this falls from November through May, rain-on-snow has historically caused only minor flooding, while summer/early fall thunderstorms have a history of flooding.

Like the monitoring team, the BAER team was interagency. In order to satisfy everyone's management goals, a detailed analysis of alternatives with mitigations and effects on various resources was done. A key consideration was protection of life and property in the city of Boise. Once the rehab plan was implemented, a monitoring plan was developed. The 1998 report assessed results after two growing seasons, and outlined monitoring plans for the third season based on what was learned to date. The following is a synopsis of the second season's results.

Three workgroups were formed to implement the plan: hydrology, soil stability, and vegetation. The plan called for assessment of first, fire effects on infiltration capacity, runoff and interrill erosion on the watershed, secondly, effectiveness of erosion control treatments, and third, the success of seeding prescriptions and distribution techniques on the vegetation community.

Fire effects on infiltration capacity and runoff

The hydrology workgroup assessed fire effects rather than treatment effectiveness, so none of the sample sites had burned area emergency (BAER) treatments.The group's objective was to quantify differences in infiltration capacity, runoff, and interrill erosion between burned and unburned areas in order to validate the need for BAER treatment to offset runoff effects predicted during summer thunderstorms. A rainfall simulator was used to apply "raindrops" at a known rate of intensity (0.4 inches/hour).

The fire had its greatest impact on intensely burned southfacing slopes where infiltration was reduced from 2.1 to 1.3 inches per hour. North-facing slopes also showed a significant fire effect, though it was only the reduction in infiltration rate from that of south slopes. One important trend for burned and unburned sites alike was that runoff consistently began between 2 and 4 minutes after rainfall started on these sandy, easily erodible soils. The effect of the fire on soil erosion was even greater than its effect on runoff; nearly 40 times greater on south-facing burned slopes than on same-aspect unburned slopes. One year following the fire, what was thought to be a 100 year thunderstorm event delivered 0.4 inches in the first ten minutes. Upon closer investigation, the team learned that such events, involving intense localized storm cells, are not uncommon, occurring once every five years or so somewhere in the Boise Foothills.

Effectiveness of treatments on soil stability

Treatments included various upslope and channel treatments. Each treatment type had a slightly unique rehab objective and also separate questions, or monitoring objectives. In summary, these were:

Checkdams were designed to maintain channel stability — both strawbale checkdams and gravel bag checkdams were constructed in ephemeral draws, except in the oversteepened headwater reaches. Each design had five sites where photo points and cross-sections were established. Cross-sections both above and below the dams were monitored to see if the dams maintained structural integrity and whether they caused channel erosion. Both dam styles worked as designed, although the gravel bags were mostly disintegrated by the second season. The integrity of the channel at all sites was maintained without downcutting or bank erosion, therefore the dams were judged to be valuable rehabilitation tools.

Various hillslope treatments were done with the objective of reducing overland flow and soil erosion. These included tillage, straw wattles and hand trenches. The tillage, in particular, was intended to increase infiltration by breaking up the hydrophobic layer. The wattles and contour felling were all intended to increase infiltration by retarding surface runoff. This in turn would reduce erosion.

The treatments were monitored to measure soil movement, using 3–F erosion bridges and photo points, at five treatment sites and one control site. Rilling as a result of the August '97 rainstorm caused much of the significant soil loss, and the '98 readings indicated acceleration of rill erosion, with the control and the wattle treatment having the least change in '98. The tilled site showed the greatest and most consistent soil loss, leading to the conclusion that tillage benefits are minimal for BAER. Hand trenches were only effective the first year. Straw wattles were effective.

Mechanical trenches were excavated to stop overland flow in a 100 year event, and in the chance of soil movement, to trap sediment. Every 50 feet, a "baffle" is built into the trench, to minimize drainage area in the event of failure. Trenches were strictly an upslope treatment; that is, the trenches did not extend into swales, as they were not designed for fluvial processes. The monitoring objectives were detection of failure in trapping runoff, to see if the trenches stabilized soil stability and if they maintained adequate storage capacity the first two years. Thirty percent of the trenches were visually inspected for failures. Thirty permanent cross-sections were established in the trenched treatment area to monitor ability to store sediment and loss of trench capacity. Win X SPRO software was used to plot changes and calculate volume stored. The first year decrease in storage volume was 1.3 cubic feet per cross-section, and about half again as much was lost the second year. This amounted to a 14% reduction of total trench storage capacity by year two.

The mechanical trenches have prevented watershed damage from runoff, even given the intense storm after the first growing season. They are "self-healing" since they fill in and revegetate over time. The team felt that they were therefore a valid emergency treatment where downstream values are high,

Sediment basins were installed to collect and store increased water. The six sediment basins were photo-documented to see if any design changes were needed for future applications. The basins were deemed a valid BAER treatment although they were found to be in need of more erosion control fabric to stabilize the spillways.

Vegetation treatment effectiveness

Various seeding and planting prescriptions were done to increase soil cover, encourage recovery of the native plant community, and control the spread of invasive weeds. The monitoring objectives were to identify when ground cover reaches 90% of prefire conditions, and to determine the success of various prescriptions on establishment of seeded species, native plant recovery, and controlling the spread of invasive plants

In a nutshell, the documented results were an increase in basal ground cover due to an increase in the litter from annual grasses. By 1998 all but 1 of 15 sites had exceeded the cover goal. The seeded grasses were most successful on the drilled sites. Native plants at higher elevations showed little variance in stem density between ripped and unripped treatment areas, but the lower elevation ripped sites had higher densities. Cheatgrass increased in many sites at nearly exponential rates, however the amount was the same or only slightly exceeded the densities observed on control sites. The ridge areas were responsive to the drilling treatments in controlling the spread of invasive weeds and reducing fire potential. It appears that natural communities on the north slopes have been able to successfully outcompete weed species.

The noxious weed study objectives included evaluating the effectiveness of herbicide treatments. This involved six plots of 0.32 acres in size—3 drilled and 3 undrilled sites. One herbicide treatment was determined to be more effective than the others. Low level photography was planned to be used to expand the study in 1999.

For details of the monitoring methods or results by the vegetative or other workgroups, contact the authors. Each year a report is produced which includes updated plans for the next monitoring season as well as results to date.

Conclusion

While the Eighth Street monitoring team has gained much knowledge on what works for BAER in the Boise Foothills, caution should be applied when transferring techniques to other places. The natural processes acting on a particular landscape, as well as the values at risk, need to be recognized. Negative side effects from a given treatment, such as the potential for trenches to adversely affect slope hydrology in landslide-prone ground, should be carefully considered.

Watershed Management Council Networker

Advancing the art and science of watershed management

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Evolving Attitudes Toward Fire in the Watershed: A Farewell to the 1900s

Roberta Van de Water, guest editor

Back in the pre-Ecosystem Management times of the '70s and '80s, we watershed managers were largely occupied with trying to protect water quality in the face of clear-cut-and-burn and other intensive forms of management. The task then was to quantify effects of man-caused fire, applying research results from experimental watersheds which had often been converted to nuclear-blast zone equivalents. The effects we looked at were those on soil (nutrient cycling and erosion), on water (much the same plus temperature), and on beneficial uses. Our knowledge was used to help land managers avoid going too far with site conversion and site preparation projects. Meanwhile, when our fire management counterparts weren't broadcast burning, they were preoccupied with preventing fire and suppressing it when it started. The watershed expert's role had been to pick up the pieces after a wildfire, euphemistically called rehabilitation.

Little by little, it became painfully evident that the watershed which underwent large, stand-replacing fire could be as rapidly restored as could Humpty Dumpty. The old paradigm of preventing soil and water effects by suppressing all fire at any cost has faded during the emergence of ecosystem management and its attendant watershed analyses in the '90s.

But old habits die hard, and the century-long debate over fire suppression for control, versus protection through fuel management, rages on. This will certainly remain so in "fire years" like this, especially where people and property are at risk. Still, trade-offs are being discussed in town halls, and new solutions are materializing through a critical mass of fire science.

To discern what types of disturbance stimulate or inhibit specific ecosystem functions, researchers have turned to increasingly sophisticated inquiries into fire effects. They help decision-makers and the public better understand the spatial and temporal variability of effects. Such knowledge can guide

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Forest Fire Effects on Hillslope Erosion: What We Know

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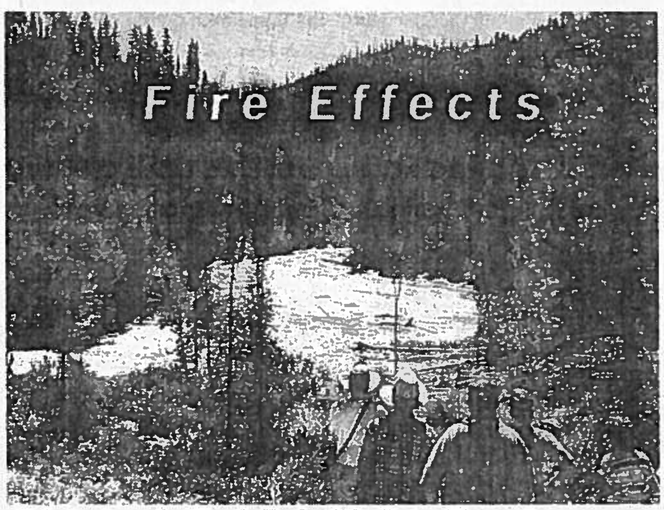
Introduction

Increased awareness of the role of fire in healthy ecosystems has focused attention on some of the effects of fires, wild and prescribed, on watershed condition and health. Precipitation events after forest fires may cause high sediment inputs, destruction of aquatic habitat and downstream flooding, all which may be part of the natural ecosystem response. However, if the fires are more severe due to past fire suppression activities, then the fire effects may be greater than natural. Fire and erosion are both natural processes that have been impacted by forest management activities such as fire suppression, logging, and road building during the last century. Management activities may contribute to increased streamflows and increased sediment supplies to streams and rivers. Additional sediment places streams and rivers at a higher risk for degradation. Sediment adversely affects spawning and rearing sites for anadromous and resident fish species, mobilizes in-stream sediment, and destroys aquatic habitat. Therefore, various management and mitigation strategies are often devised to reduce the threat of increased sediment. This paper reviews the effects of fire on hillslope erosion and the associated risks on watershed health.



Debris clogs the North Fork of the Boise River after a summer thunderstorm the first year after a wildfire. (Fig. 1: What we know)

Fire is a natural and important part of the disturbance regime for forested terrestrial and aquatic systems, especially in the western USA (Agee 1993). However, much uncertainty exists in quantifying fire effects on ecosystem components such as watershed condition and health.

Wildfires

Wildfires, which burn both small and large land areas, are often associated with lightning strikes from thunderstorms

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The Shingletown Fire-Safe Project

Seven Years of Successful Self-Help Community Action

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Fire season 1999 in northern California was a season of destruction. On the Fourth of July weekend, an escaped prescribed fire destroyed homes and incinerated the landscape in Lewiston. Then, at the end of August lightning storms ignited wildfires that burned more homes, killed one wildland-urban intermix resident, and blackened thousands of acres. Some lightning fires in the Trinity County Big Bar Complex are still burning and might still burn homes. It isn't over yet. In the last week of September, strong, sustained north winds drove an intense wildfire through the community of Happy Valley south of Redding burning more than 50 homes and more outbuildings. Both the landscape devastation and the destruction of homes could be reduced, perhaps eliminated, if the landscape was restored to conditions similar to the fire-adapted native forest. The residents of Shingletown Ridge show how people can work together to create a community forest that can burn safely and be a pleasure to live in.

From the beginning, the Shingletown Project engaged as many neighbors as possible. It has always been a local project supported by government—not a government project supported by locals and that has made all the difference. The result has been seven years of sustained community involvement, removal of almost 2000 green tons (3,852,000 pounds) of fuels around homes, completion of 3 shaded fuel break miles, and coordinated fuel management on neighboring commercial forests. In 1993 California Department of Forestry and Fire Protection (CDF) Shasta-Trinity Unit Chief Ray Stewart contracted Dr. Ron Hodgson of California State University, Chico to develop a community based

Turning wildfire hazard into power. Shasta Forest Village residents chip vegetation cleared from around their homes. Wheelabrator-Shasta Energy Company will burn the chips to generate electricity.

hazard mitigation project and appointed Battalion Chief Ralph Minnich to head the effort. When Chief Stewart retired, Chief Duane Fry continued CDF's commitment.

Hodgson based the action plan on social marketing and innovation diffusion theory and the results of his research, supported by CDF and the Forest Service, on the adoption of defensible space. They selected Shasta Forest Village because John Welch, a noted wildlife artist, recognized the fire threat and had already begun to organize his neighbors. They first identified neighborhood organizations, opinion leaders and other key people. Next residents learned fire behavior and fire ecology basics. Then, an acceptable plan for hazard mitigation was developed with the neighborhood. Finally, neighborhood groups with CDF assistance implemented the project.

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during the dry seasons and human-caused ignition (Agee 1990). Fire severity is a qualitative term used to measure the effect of fire on ecosystem components (Walstad et al. 1990) and is often used to describe fire effects on soil (Simard 1991). Ryan and Noste (1983) used ground char (burnt organic matter) classes to quantify fire severity. Fire effects on erosion are related to the effects of ground cover destroyed by fire. Ground cover usually consists of duff, grasses and debris on the ground surface. During fire, the consumption of ground cover (i.e. duff) exposes mineral soil which can be subject to overland flow and raindrop impact. The amount of vegetation, residue, and forest floor consumed and the soil heating caused by burning determines the extent to which soil properties are altered. The effects of fire on the forest floor can range from removing just the litter to total consumption of the forest floor and alteration of the mineral soil structure (Wells et al. 1979). The depth of the forest floor (litter layer and humus layer above mineral soil), the moisture content, and the amount of woody residue determine forest floor consumption during fire. When the forest floor is shallow or moisture content is low, fires consume more of the forest floor and have the potential to alter mineral soil (Reinhardt et al. 1991).

High severity burn areas experience higher rates of soil loss from erosion (McNabb and Swanson 1990), increased peak flows of runoff, greater duff reduction, loss in soil nutrients (Harvey at al. 1989), and soil heating (Hungerford et al. 1991). Water and sediment yields may increase as more of the forest floor is consumed (Robichaud and Waldrop 1994, Soto et al. 1994, Wells et al. 1979). If the organic layers are consumed and mineral soil is exposed, soil infiltration and water storage capacities are reduced (Robichaud 1996). Such impacts may last weeks or decades, depending on the fire's severity and intensity, any remedial measures, and the rate of vegetative recovery (Baker 1990). Burning also reduces the amount of rainfall interception by the forest canopy and reduces evapotranspiration by the forest vegetation.

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Prescribed Fires

The use of prescribed fire has increased tenfold over the last decade, as land managers are trying to restore fire suppressed landscapes. For example, logging residue is often burned after timber harvesting. Burning is used alone and in combination with other treatments to dispose of slash, reduce the risk of insects and fire hazard, prepare seedbeds, and suppress plant competition for both natural and artificial regeneration. The effect of prescribed burning on the forest floor varies greatly, depending on fire severity and duration, forest floor consumption, and soil heating.

Hillslope Erosion

Surface erosion is the movement of individual soil particles by a force, either by uniform removal of material from the soil surface (sheet erosion) or by concentrated removal of material in the downslope direction (rill erosion) or gravity inducted (dry ravel) or by mass movement as landslides and debris flows (Foster 1982) (Figure 1). Inherent erosion hazards are defined as the site properties that influence erosion. They include the ease with which the individual soil particles are detached (soil erodibility), slope gradient and length. Forces required to initiate and sustain the movement of soil particles can be from many sources, such as raindrop impact (Farmer and Van Haveren 1971), overland flow (Meeuwig 1971), gravity, wind, and animal activity. Protection is provided by all material on or above the soil surface, such as vegetation, surface litter, duff, and rocks that reduce the impact of the applied forces (Megahan et al. 1986; McNabb and Swanson 1990).

Figure 2: Water repellent soils below wettable soils after a high severity wildfire shortly after a summer thunderstorm

Soils are critical to the functioning of hydrological processes. Within a watershed, sediment and water responses to wildfire are often a function of fire severity and the occurrence of hydrologic events. For a wide range of fire severities, the impacts on hydrology and sediment loss can be minimal in the absence of precipitation. However, when a precipitation event follows a large, high-severity fire, impacts can be substantial. Increased runoff, peak flows, and sediment delivery to streams can affect fish populations and their habitat (Rinne 1997).

Fire can destroy the forest floor and vegetation, altering infiltration by exposing soils to raindrop impact or creating water repellent conditions (DeBano et al. 1998). Loss of soil from hillslopes produce several significant ecosystem impacts. Soil movement into streams, lakes, and riparian zones may degrade water quality and change the geomorphic and hydrologic characteristics of these systems and soil loss from hillslopes may alter future site productivity.

Water Repellency

Two types of water repellency are common in forest environments: the first occurs when the soils and organic material are very dry, and the second occurs when the soils are heated due to fires (Figure 2). Combustion of surface fuels and the forest floor vaporizes hydrophobic organic substances which may move downward and condense at cooler underlying soil layers (DeBano 1981; DeBano et al. 1998). Water repellency in the mineral soil can contribute to reduced infiltration of water into the soil and increased erosion (Robichaud 1996).

DeBano and Krammes (1966) and Robichaud and Hungerford (In press) found that water repellency was dependent on the heating temperatures. At typical wildfire soil profile temperatures (less than 500 F, 260 C) and when the soil was dry, water repellency occurs at shallow depths (less than 1 inch, 25 mm). With wet soils, i.e. conditions that commonly occur during prescribed fire in the spring and fall, water repellency was less pronounced and only occurred after long heating times which, under field conditions, would typically only occur during smoldering fires. Therefore, water repellency after prescribed fire would probably be minimal (Robichaud and Hungerford In press).

Infiltration and erodibility

We have used rainfall simulations and concentrated flow for the past decade to measure infiltration, interrill and rill erodibility and effects of various surface conditions. There are four hydrological surface conditions which are important to characterize hillslope erosion potential in forest environments. These are unburned/undisturbed areas, low severity burn areas, high severity burn areas and skid trails or other highly disturbed areas (Robichaud et al. 1993).

To obtain infiltration and interrill erodibility estimates, simulated rainfall is applied to 11 ft^2 (1 m^2) plots (Figure 3). Rainfall intensities usually were 4 in hr^{-1} (100 mm hr^{-1}) for three 30-minute events. Timed bottled samples are collected at the base of the plots. The samples are weighed and dried for flow volumes and sediment yields. Infiltration and erodibility are then calculated. Values depend on surface conditions and inherent soil variability. For example, unburned infiltration rates vary from 1.4 to 3.1 inches hr^{-1} (35 to 80 mm hr^{-1}), while high severity rates vary from 0.8 to 2.4 inches hr^{-1} (20 to 60 mm hr^{-1}). Infiltration rates following high severity burns often increase with time, due to water repellent conditions breaking down (Robichaud In press).

Rill erodibility has been measured using concentrated flow down hillslopes (Robichaud and Brown 1999a) (Figure 4). Rill erosion is one of the dominant mechanisms of hillslope erosion. Various flow rates were used from 1.8 to 12 gal $minutes^{-1}$ (7 to 45 l min^{-1}) for 12 min with timed bottled samples used to collect runoff. These results were used to calculate sediment concentrations and rill erodibility. Sediment concentrations vary from 0.008 to 0.8 lb gal^{-1} (0.1 to 100 g l^{-1}) which also vary according to surface condition and slope.

Figure 3: Rainfall simulator used to obtain infiltration and interrill erodibility values on the Idaho Panhandle National Forest.

Spatial Variability

Fire severity is often variable, making erosion potential from burnt hillslopes also variable (Robichaud 1996). Spatial variability is an important characteristic of burned hillslopes. Geostatistical methods may be used to describe the spatial variability and topographic effects (Robichaud and Miller In press). The importance of variability observed in the field has been verified with erosion prediction models examining various arrangements of high- and low-severity fires on a hillslope (Robichaud and Monroe 1997). For example, for a 100 m hillslope with "low- above high-severity" burn and "high- above low-severity" burn condition arrangement, the high-severity burn condition above the low-severity burn condition produced about 50 percent more sediment since the rilling initiated in the upper portions of the hillslope continued down throughout the lower portion. When two thirds of the upper portion of the hillslope is in high-severity burn conditions, it produced twice as much sediment as compared to when the upper two-thirds were in low-severity burn conditions. The arrangement of high-severity burn conditions above the low-severity burn condition on a hillslope is common. As a fire burns, the heat generated can dry-out the upper portions of a hillslope and cause it to burn more severely.

Water Yield

Total water yields across the western U.S. vary considerably depending on precipitation, evapotranspiration, soils, and vegetation. The magnitude of measured water yield increases the first year after fire. This magnitude can vary greatly within a location or between locations depending on fire severity, precipitation, geology, topography, vegetation, and proportion of the vegetation burned (DeBano et al. 1998). Increases in water yield are primarily due to elimination of plant cover, with subsequent reductions in the transpiration component of evapotranspiration (Anderson et al. 1976). Water repellent soils and cover loss will cause flood peaks to arrive faster, rise to higher levels, and entrain significantly greater amounts of bedload and suspended sediments. Elevated streamflows decline as both woody and herbaceous vegetation revegetate during a recovery period ranging from a few years to decades.

Increases in water yield from wildfires and prescribed fires are highly variable. The first-year increase in water yield after a prescribed burn in a Texas grassland was 1,150 percent of the unburned control watershed (Wright et al. 1982). In Arizona chaparral burned by wildfire, the first year water yield increase exceeded 1,400 percent mainly due to water repellent soils.

The effects of disturbance on storm peakflows are highly variable and complex. Wildfires generally increase peakflows. For example, the Tillamook burn in 1933 in Oregon increased the total annual flow of two watersheds by 9 percent and increased the annual peakflow by 45 percent (Anderson et al. 1976). A 310 ac (127 ha) wildfire in Arizona increased summer peakflows by 500 to 1,500 percent, but had no effect on winter peakflows (Anderson et al. 1976).

Sediment Yield

Fire-related sediment yields vary, depending on fire frequency, climate, vegetation, and geomorphic factors such as topography, geology, and soils (Swanson 1981). In some regions over 60 percent of the total landscape sediment production over the long-term is fire-related. Much of that sediment loss can occur the first year after a wildfire (Agee 1993, DeBano et al. 1998, DeBano et al. 1996, Robichaud and Brown 1999b). Suspended sediment concentrations in streamflow can increase due to the addition of ash and silt-to-clay sized soil particles in streamflow which can adversely affect fish and other aquatic organisms.

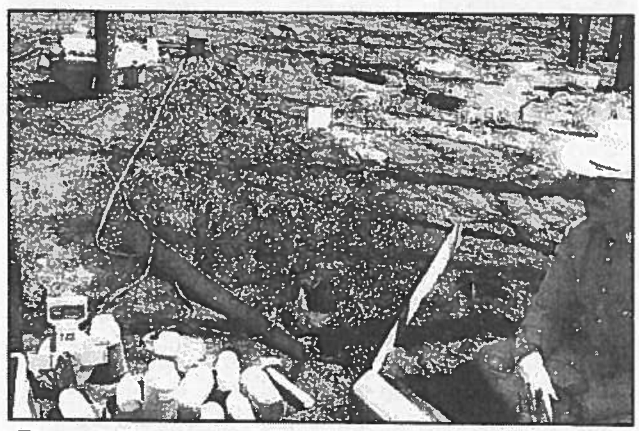

Figure 4: Concentrated flow being used to determine rill erodibility values on the Wenatchee National Forest.

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Sediment yields one year after prescribed burns and wildfires range from very low in flat terrain and in the absence of major rainfall events to extreme in steep terrain affected by high intensity thunderstorms (Figure 5). Erosion

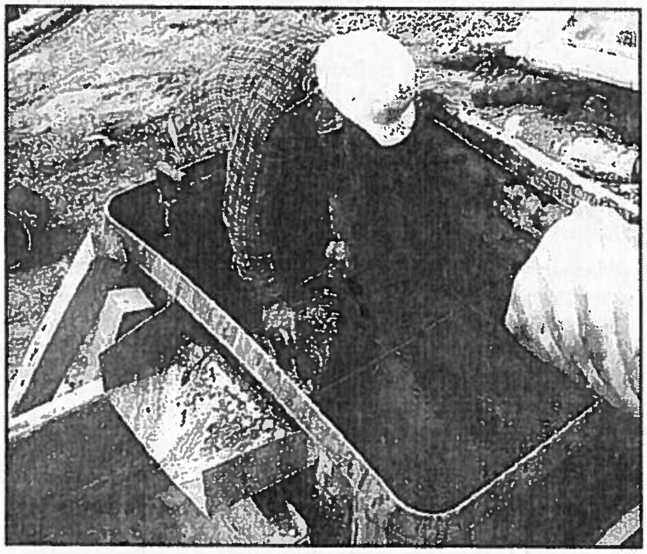

Figure 5: Cleaning debris from a sediment trap at the base of hillslope on the Wenatchee National Forest

on burned areas typically declines in subsequent years as the site stabilizes, but the recovery rate varies depending on fire severity. Soil erosion after fires can vary from under 0.4 to 2.6 t ac^{-1} yr^{-1} (0.1 to 6 Mg ha^{-1} yr^{-1}) in prescribed burns and 9 to over 49 t ac^{-1} yr^{-1} (21 to over 110 Mg ha^{-1} yr^{-1}) in wildfires (Megahan and Molitor 1975; Noble and Lundeen 1971; Robichaud and Waldrop 1994; Robichaud and Brown 1999b). For example, Radek (1996) observed erosion of 0.1 to 0.8 t ac^{-1} (0.3 to 1.7 Mg ha^{-1}) from several large wildfires that covered areas ranging from 375 to 4,370 ac (200 to 1,770 ha) in the northern Cascades mountains. Three years after these fire, large erosional events occurred from spring rainstorms, not from snowmelt. Robichaud and Brown (1999b) reported first year erosion rates after a wildfire from 9 to 22 t ac^{-1} (21 to 49 Mg ha^{-1}) decreasing by one to two orders of magnitude by the second year and to no sediment by the fourth in an unmanaged forest stand in eastern Oregon. Erosion rate reduction was due to recovery of natural vegetation. First year growing season shrubs, forbs and grasses accounted for 28 percent of the total ground cover whereas after the second growing season, total ground cover was 82 percent.

DeBano et al. (1996) demonstrated that following a wildfire in ponderosa pine, sediment yields from a low severity fire recovered to normal levels after three years, but moderate and severely burned watersheds took 7 and 14 years, respectively. Nearly all fires increase sediment yield, but wildfires in steep terrain produce the greatest amounts. Noble and Lundeen (1971) reported an average annual sediment production rate of 2.5 t ac^{-1} (5.7 Mg ha^{-1}) from a 900 ac (365 ha) burn on steep river breaklands in the South Fork of the Salmon River, Idaho. This rate was approximately seven times greater than hillslope sediment yields from similar, unburned lands in the vicinity.

Potts et al. (1985) indicated that wildfires increased water yield and sedimentation. Post-burn sediment increases were severe only on sites with both steep slopes and large fires. They found maximum annual sediment production of 1.9 t ac^{-1} (4.3 Mg ha^{-1}), an increase of 284 percent over natural yields. These estimates were based on large-scale regional estimates on metamorphic parent material.

Hillslope Erosion Modeling

The Water Erosion Prediction Project (WEPP) model can be used to predict hillslope erosion from disturbed forest environments (Elliot et al. 1999). The approach is to predict the probability of erosion occurring after a disturbance by running WEPP model for 50 to 100 years of stochastic climates. Thus, the results will emphasize the risk of various erosion events occurring immediately after a fire and in the following years, when revegetation has caused the area to be hydrologically recovered. Field data collected over the last ten years is being used to populate and validate our modeling efforts.

Summary

Hillslope erosion processes can dominate landscape shape, especially after wildfires. Rill erosion is often the dominant mechanism for delivering sediment to the base of the hillslopes. The often denuded landscapes allow for direct impact of precipitation events and overland flow. Sediment may adversely affect aquatic habitat and water quality. Since most of our land management activities have increased sediment loads to rivers and stream, any additional sediment due to the fires could likely be detrimental.

When analyzing hillslope erosion, especially after fire, we should remember that erosion potential is not equal everywhere, erosion will only occur if a precipitation or snowmelt event occurs, and annual sediment yields generally decrease rapidly as natural vegetation reestablishes itself.

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