

Burned Area Emergency Watershed Rehabilitation: Program Goals, Techniques, Effectiveness, and Future Directions in the 21st Century

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Abstract.—Following wildfires, burned areas are assessed by special teams to determine if emergency watershed rehabilitation measures are required to restore watershed function and minimize damage to soil resources. The objective of burned area emergency rehabilitation (BAER) treatments is to restore watershed condition and reduce erosional losses on hillslopes, in channels, and on road surfaces and peripheral areas such as ditches. In the Western United States, a project is currently in progress to determine the costs and effectiveness of BAER projects in restoring watershed function. Results of this project will help establish the future directions of the BAER program into the 21st century.

Introduction

All disturbances produce impacts on forest ecosystems. The level and type of impact, whether negative or positive, depends on ecosystem resistance and resilience as well as the severity of the disturbance. Fire severity is important since it covers a spectrum that may or may not entirely occur on the same site (DeBano et al. 1998). The term “intensity” has often been confused with severity in documentation of wildfire damage to natural resources. Severity is qualitative measure of the effects of fire on soil and site resources although some aspects can be quantified (Hartford and Fransen 1992). The variability in soil and watershed damage, and resource response is highly dependent on fire severity (DeBano et al. 1998).

Soils are critical to the functioning of hydrological processes (DeBano et al. 1998). On a watershed basis, sediment increases and water-yield responses to fire are a function of fire severity and the occurrence of hydrologic events. The impacts of wildfires on hydrology and sediment loss can be minimal in the absence of an im-

mediate precipitation event. However, when major precipitation events occur after large, moderate- to high-severity fires, impacts can be significant. For example, increased runoff, peakflows, and sediment delivery to streams can impact fish populations and habitat environment (Rinne 1997).

The hydrologic cycle quantifies the interactions between the atmosphere, geosphere, and hydrosphere (Brooks et al. 1997). Water, the primary driving force in ecosystem processes and fluxes, integrates the processes occurring on watersheds. The quantity and quality of water emanating from watersheds are indices of ecosystem condition. Watershed condition describes the ability of a watershed system and soils to receive and process precipitation without ecosystem degradation. Wildfires can have significant impacts on watershed condition (DeBano et al. 1998).

Fire destroys all or part of the organic forest floor and vegetation thereby altering infiltration and percolation capacity of the soil by exposing it to raindrop impacts. Under the right conditions, fire creates water repellent layers in the surface horizons of soil that prevent deep percolation of rainfall (DeBano et al. 1998). This action alters watershed condition, with erosion increasing as watershed condition deteriorates from good to poor. Loss of soil from hillslopes produces several significant ecosystem impacts. Soil movement into streams, lakes, and riparian zones deteriorates water quality, and changes the geomorphic and hydrologic characteristics of these systems. More importantly, soil loss from hillslopes results in reduced future ecosystem productivity.

The effects of disturbances on water yield from forest and shrub watershed studies throughout the world have been well documented and reviewed (Anderson et al. 1976, Bosch and Hewlett 1982, and Neary and Hornbeck 1994). Water yields increase when mature forests are harvested, burned, blown down, or attacked by insects. The magnitude of measured water-yield increases the first year after fire disturbance varies greatly depending on fire severity, climate, precipitation, geology, soils, watershed aspect, latitude, tree species, and proportion of the forest vegetation burned. Streamflow increases produced by forest disturbance decline as woody and herbaceous vegetation regrow. This recovery period can range from a

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few years to decades. Peakflow increases of 500% to 9600 % are common in the Southwestern United States while those measured in the Cascade region are much lower (<45 %) (Anderson et al. 1976). Another concern is the timing of stormflows or response time. Burned watersheds generally respond to rainfall faster, producing more flash floods (Anderson et al. 1976, DeBano et al. 1998).

Erosion is a natural process occurring on landscapes at different rates and scales depending on geology, topography, vegetation, and climate. Fires and fire suppression activities affect erosion processes. Erosion is the most visible and dramatic impact of fire apart from burned vegetation (DeBano et al. 1998).

Fire-related sediment yields vary from ecoregion to ecoregion depending on factors such as fire frequency, climate, vegetation, and geomorphic factors (e.g., topography, geology, and soils). In some ecoregions, over 60% 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 (DeBano et al. 1998).

Post-wildfire sediment yields can range from very low on flat terrain without major rainfall events to extreme in steep terrain affected by high intensity thunderstorms. Erosion on burned areas usually declines in subsequent years as the site stabilizes, but the rate varies depending on fire severity (DeBano et al. 1998). Nearly all fires increase sediment yield, but wildfires in steep terrain produce the greatest increases.

Burned area emergency rehabilitation (BAER) treatments are designed to mitigate the impacts of severe wildfires on watershed condition. Consequently, BAER treatments can be very important in minimizing site damage. Few wildfire effects studies reported in the literature have examined the effects of post-fire BAER treatments on sediment yield.

BAER Program

History

Emergency watershed rehabilitation after wildfires first occurred in the late 1960s and early 1970s. At this time, no formal rehabilitation program existed, so funds were obtained from fire suppression accounts. In the early 1970s, a congressional inquiry, conducted to determine the need for and use of emergency watershed rehabilitation funds, led to formation of the BAER program in 1974. Initially, the BAER program was established to restore or repair burned-over areas to achieve soil stability, runoff control, and unimpaired stream channel carrying capacities. Later,

restoring wildlife habitat, range forage, and recreation facilities also became program goals.

In the late 1980s, a coordinated interagency effort was initiated to train BAER team leaders and to coordinate evaluation of fire severity, funding request procedures, and treatment options. Annual BAER training programs at regional and national levels were also initiated. During this time, National Forest System specialists were encouraged to accomplish implementation monitoring as well as some form of effectiveness monitoring.

In the mid 1990s, there was a major effort to revise and update the BAER handbook. A steering group consisting of regional BAER coordinators and other specialists organized and developed the handbooks that used today. Since individual agencies had interpreted the congressional appropriations for BAER differently, a national effort was started in the late 1990s to establish consistent blend BAER policies across federal agency boundaries.

Treatments

BAER treatments have been traditionally grouped into hillslope, channel, and road treatments. Functionally, hillslope treatments are divided into revegetation, erosion barrier, physical soil manipulation, and other ground cover treatments. Channel BAER treatments consist of check dams, grade stabilizers, and other miscellaneous treatments. The functional groups for road treatments are culvert-bridge-ditch improvements, shaping, protection, and surface manipulations. Another group of BAER treatments can be classified as treatment protection (fencing, road/trail closures, signing, etc.).

Hillslope treatments are designed to either reduce erosion or hold soil and sediments on-site (Miles et al. 1989). Revegetation treatments to aid plant reestablishment on burned slopes consist of aerial and ground seeding, fertilization, and mulching. Erosion barriers, such as logs, straw wattles, straw bales, soil and sand bags, and silt fences, are placed to trap eroded soil material on the slope. Physical soil manipulations, such as contour trenching and ripping/tilling, are used to either trap and store eroding soil or to reduce erosion potential by improving surface roughness, depression storage, and infiltration capacity. Other ground cover techniques used to reduce erosion include slash spreading, felling snags along the contour, and laying erosion control fabric.

Channel treatments are designed to store sediment in channels or reduce the erosive power of water flow. Check dams are often used to detain sediment in channels. These can be straw wattles, straw bales, logs, rocks, or rock gabions. Grade stabilizers that lower the velocity of streamflow by reducing channel gradient via a series of steps can be constructed of logs or rocks. Other types of channel BAER treatments include debris basin construc-

tion, woody debris removal, small dams, and channel-bank armoring.

Road treatments are mainly used to help roads and road structures survive the additional streamflows and surface runoff that often occur after wildfires. Culvert, bridge, and ditch improvements, such as culvert upgrades, culvert removals, culvert riser installation, ditchline debris removal, and ditch check dam construction, help control additional water flow or prevent ditch downcutting and culvert blowouts. Shaping road surfaces by outslipping, water bar installation, and rolling dip construction limits erosion by reducing water velocity. Road protection can be accomplished by installing trash racks to trap woody debris that might block culverts, patrolling roads and culverts during storm events, and constructing overflows that provide relief to culverts during excessively high stormflows. Surface manipulations, such as outslipped resurfacing, ripping/tilling, and the armoring of crossings and drains, provide additional reductions of road surface and side-slope erosion during storm runoff events.

Treatment protections include temporary fencing, road and trail closures, and signing that are used to aid post-wildfire watershed restoration. They can be used on hillslopes, in channels, or on roads. The purpose of these treatments is keep vehicle, foot, and domestic animal traffic off of sensitive, fire-disturbed soils, road, and trail surfaces. Site vegetation and soil recovery occurs faster if additional post-fire disturbances are reduced or eliminated.

Program Assessment

The effectiveness of many emergency rehabilitation methods has not been systematically tested or validated. Although BAER expenditures accounted for <1% of total Forest Service fire expenditures in 1994 (Schuster et al. 1997), concerns about its effectiveness have been raised at a national level due to rapidly rising costs of this program in the 1990s. Over the past 3 decades, \$83 million has been spent to treat 5.4 million acres of National Forest System lands. BAER team leaders and decision-makers often do not have information needed to thoroughly evaluate the short- and long-term benefits and costs of various treatment options. In 1998, a joint study was initialized between the Rocky Mountain Research Station and the Pacific Southwest Station to evaluate past BAER emergency rehabilitation methods. This assessment was undertaken to collect information on past usage of BAER treatments, attributes that made the treatments succeed or fail, and effectiveness of the treatment to achieve desired goals. Since much of the information was not published and was qualitative in nature, a survey was designed to ask resource specialists specific questions regarding their BAER programs. Additional information was obtained from BAER report files, monitoring reports, and related docu-

ments. Publication of the results is expected in the fall of 1999 (Robichaud et al. in press).

Future Directions

Three BAER program areas, increased training, policy consistency, and funding review, were targeted for improvement in the late 1990s. Three areas of training were enhanced including BAER Team Leader training, implementation training, and on-the-ground treatment installation training. Additional training is needed in the areas of effectiveness monitoring methods and resource impact assessment procedures (Robichaud et al. in press).

In 1999, the Forest Service, the Bureau of Land Management, the National Park Service, the Fish and Wildlife Service, and the Bureau of Indian Affairs approved a policy for a consistent approach to BAER. The new policy broadens the scope and application of BAER analysis and treatment by: 1) monitoring to determine if additional treatment is needed, 2) evaluating treatments to improve effectiveness, 3) repairing facilities for safety reasons, 4) stabilizing biotic communities, and 5) preventing unacceptable degradation of critical cultural sites and natural resources. Funding requests need careful scrutiny at the regional and national levels to ensure that they are reasonable, practicable and cost-effective and provide significant improvement over natural recovery.

Results of the current BAER program review suggest that in the future there should be increased use of native or sterile seed sources, consideration of longer-term benefits in the initial post-fire assessment, increased effectiveness monitoring, and improved prescriptions for local conditions. Current Forest Service policy requires an immediate assessment of site conditions following wildfire and, where necessary, implementation of BAER treatments to: 1) minimize the threat to life and property onsite and offsite, 2) reduce the loss of soil and onsite productivity, 3) reduce adverse changes in streamflow regimes, and 4) reduce deterioration of water quality. Increased Forest Service emphasis on ecosystem management and sustainability, as elucidated recently in the Chief's natural resources agenda, will also improve support for the BAER program.

Summary

The BAER program has been operational since the 1970s to immediately assess site conditions following wildfire. When necessary, emergency rehabilitation measures have been implemented to reduce the loss of soil and

onsite productivity, and reduce deterioration of watershed condition, streamflow characteristics, and water quality. Future directions in the 21st century will include: 1) additional funded monitoring and research studies to better understand the effectiveness of BAER treatments on watershed restoration, 2) increased use of native or sterile seed sources, 3) consideration of long-term benefits, and 4) improved prescriptions for local conditions.

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