Assessment Team Considerations For Emergency Stabilization

Primary Treatment Use

Aerial hydromulch provides immediate temporary soil cover to hillslopes inaccessible by ground-based equipment with high-erosion hazard ratings and high- and moderate-burn severity.

Description

Hydromulch refers to fiber mulches and soil stabilizers (tackifiers, polymers, and seeds) that, when mixed with water and applied to the soil surface, form a matrix that helps reduce erosion and fosters plant growth (Robichaud 2003).

Purpose of Treatment

Aerial hydromulch reduces erosion by providing cover that reduces raindrop impact and absorbs overland flow. Hydromulching binds loose soil and ash to protect downstream water quality. The mulch improves moisture retention, which benefits seeded mixtures.

Emergency Stabilization Objective

Aerial hydromulch helps prevent unacceptable degradation to natural resources, including erosion and deterioration of water quality.

Suitable Sites

Treatment is intended for application in one or more of these situations:

- Areas inaccessible by ground.
- Areas with intermingled high- and moderate-burn severity.
- Soils with a high erodibility factor (K) and or educed infiltration capability.
- Sparsely forested areas with slopes between 25 and 50 percent.
- Subwatersheds with high values at risk adjacent to or below the treatment area.
- Subwatersheds that supply domestic water and are vulnerable to ash, accelerated erosion, and sedimentation that could disrupt water quality.
- Areas prone to strong winds where dry mulch would be removed.

Cost

Aerial hydromulch costs range from $2,000 to $3,000 per acre. Application rates vary depending on the fire.
Cost factors include:

- Number of seed mixes
- Helicopter/fixed-wing aircraft turnaround time
- Helicopter/fixed-wing aircraft production rate
- Location of staging areas
- Availability of water close to staging areas
- Road access for large equipment

Treatment Effectiveness

Aerial hydromulching is a new BAER tool. Current effectiveness monitoring conducted on the Cedar and Hayman fires indicated limited effectiveness of aerial hydromulch to reduce post-fire sediment production rates (Hubbert, unpublished paper; McDonald 2004; Robichaud 2003). Hydromulch effectiveness depends on several factors including application rates, slope length, slope steepness, residual canopy, and mulch components.
Application rates (dry product per unit area) can influence treatment effectiveness. For example, on the Hayman Fire, the aerial application rate of 1 ton per acre was intended to provide 70-percent ground cover. Immediately after application, ground cover was 65 percent and declined to 30 percent by the first post-fire year. Measured erosion reduction was only 18 percent in the first post-fire year and 27 percent in the second post-fire year.

Hydromulch applied to slopes of more than 50 percent have varying success rates. On the Cedar fire in California, rilling occurred on slopes of more than 50 percent (Hubbert, unpublished paper). Heavily timbered sites at Cerro Grande lost 40 percent of the application on standing trees (Kuyumjian, personal communication).

Application rates in southern California varied significantly from the prescribed rates. Prescribed application rates were 100-percent broadcast and 50-percent contour strips. Treated strips were 115 feet wide separated by untreated strips 115 feet wide. Actual ground cover was 51 percent for the 100-percent broadcast cover and 30 percent for the 50-percent strip treatment (Hubbert, unpublished paper). There was no first post-fire year erosion reduction in the 50-percent coverage area and a 53-percent reduction in the 100-percent coverage area. In the second post-fire year, there was a 34-percent erosion reduction in the 50-percent coverage area and a 44-percent reduction in the 100-percent coverage area (Robichaud, personal communication).

Cedar fire monitoring found that the intensity of the rain event was an important factor in overland flow, especially when antecedent soil moisture conditions were near or at storage capacity (Hubbert, unpublished paper). Once runoff concentrates, the shear force of the water is greater than the resistive force of the mulch causing it to be displaced. Once exposed, the soil is easily eroded. Hydromulch is more effective on short slope length such as road cuts where concentrated flow is not likely.

Based on the results, hydromulch is not a cost effective erosion control treatment for steep, high-burn severity hillslopes with long slope length.

The effect of hydromulch on native vegetation was monitored on the Cedar fire in southern California. Quantitative findings indicated that vegetation recovery (percent cover) was not hindered by the hydromulch (Hubbert, unpublished paper).

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites to ensure suitability. Key design considerations include nontreatment areas, burn severity, slope length, and overall unit size. Units that are very small can be difficult to treat. Delineate the boundary of the treatment units so that they are clearly viewed from the ground and air.

Establish staging areas close to treatment units that have water and adequate space. Include the aviation specialist assigned to the project in this step. The aviation specialist is responsible for writing the aviation safety plan and approving the staging area. Consult with other specialists to ensure that the final treatment areas and staging sites are approved.

Materials

Evaluate hydromulch components. Hydromulch is a mixture of wood or paper fiber, tackifier, soil binder (polymers), viscosity stabilizer, and water. Manufacturers use various components and ratios of these ingredients. Use a product that will bind to the soil and maintain a strong bonded fiber matrix that is long-lived (greater than 12 months). Hydromulches vary in the length and strength of the fibers as well as effectiveness.

The Hayman fire required seed mixed with woodpulp mulch, water, and a tackifier or polymer to bind the material to the soil, so the seed could sprout. However, different manufacturers used different ratios of the various components that produced different outcomes. Ensure that the material purchased will bind to the soil and maintain a strong bond for greater than 12 months.

Contracting

Aerial hydromulching requires implementation team coordination with the contracting officer to develop a contract that achieves the emergency stabilization objectives within the allowable timeframe.

Review of recent aerial hydromulch contracts recommended the following topics be included within the contract to improve the implementation of the contract.

- Identify the required effective ground cover rather than a fixed application rate.
- Identify how the ground cover will be measured for both depth of material and aerial extent.
- Require that treated-area images are captured and provided to the forest as a contract deliverable.
- Obtain Material Safety Data Sheets from the manufacturer to verify that the pH of the hydromulch is compatible with the pH of the soil.
- Use a coloring agent in the mix to identify treated areas.
- Require that a “satlock” or a GPS platform compatible with USDA Forest Service software is maintained for the spray log (Kuyumjian, personal communication).

Vehicles and Aircraft

Hydromulching has been performed with both rotary-wing and fixed-wing aircraft (crop-dusters or “air tractors”). Fixed-wing aircraft may be less expensive than helicopters depending on production rates. Consider topography and elevation changes when evaluating aircraft.

Sikorsky Sky Crane

Two thousand gallons of mulch slurry per minute were placed into the Sikorsky Sky Crane helicopter in Denver. The seed, water, and site-specific tackifier were stored onsite in large tanks. The slurry of seed, mulch, tackifier, and water was mixed in the hydromulching machines and pumped into 10,000-gallon storage tanks before being pumped into the helicopters. To keep the mixture in suspension, the slurry was constantly recirculated.

Production Rates
Production rates vary based on the number of aircraft flying, proximity to helibase, and weather conditions. The chart below provides information from treated areas.

Fire Name	Acres Treated	Aircraft Type	Production Rate (acres per day)	Total Days	Contact Region and Forest
Trough Fire	6 (experiment)	helicopter	6	1	R-5 Mendocino
Cero Grande	1,450	4 fixed-wing	52	29	R-3 Santa FE
Hayman Fire	1,560	helicopter	50	31	R-2 Pike and San Isabel
Cedar Fire	450	helicopter			R-5 Cleveland

Construction Specifications
- Require an air operations safety plan and safety officer.
- Use the designated airport/operations manager to facilitate activities at a helibase or designated operation areas.
- Use a load counter at each staging area to track number of loads being applied each day and their turnaround time.
- Use two field inspectors to assess production rate and coverage per treatment area. The number of inspectors may change depending on the number of staging areas and helicopters/aircraft flying to different treatment areas.
- Identify treatment polygons with both GPS and ground-based flagging.
- Select the staging areas. All mulching operations including delivery, storage, and aerial operations are conducted from these designated staging areas.
- Avoid applying hydromulch during excessive rain, wind, or snow. Application will be made only when weather conditions meet Federal Aviation Administration visual flight rules. Flight operations shall comply with all applicable Federal aviation regulations.
- Implement project following the aviation project safety plan.
- Maintain daily operation reports tracking the number of flights, areas treated, application rates, and verification of satisfactory application from ground inspectors.
- Inspect areas to validate ground-cover application rates that are consistent with contract specifications. The following indicators may be evaluated:
  - width of swath
  - percent cover
  - depth and uniformity of application
  - avoidance of no-treatment areas (sensitive plant exclusion areas)
  - total net acreage treated within a treatment polygon

Application of hydromulch
There are many different considerations for aerial application of hydromulch. Below is an example of contract specifications from the Cleveland National Forest in southern California. Consult recent hydromulch contracts used in the area to find out what did and did not work when preparing a contract.
- Apply hydromulch with either a fixed-wing or rotary-wing aircraft. Rotary-wing aircraft shall be Type 1 helitankers equipped with a tank capacity for enough hydromulch mixture to cover 1 acre. The helitanker shall be equipped with a manifold with an agitator to keep the hydromulch mixture in suspension during flight. Fixed-wing or rotary-wing aircraft shall be capable of achieving the desired application rate of the hydromulch mixture.
- Use a hydromulch mixture consisting of not less than 2,000 gallons of water per acre, 500 pounds of mulch per acre, and 300 pounds of binder per acre. (Note: this particular contract did not include seed in the hydromulch.)

- Avoid applications within exclusion areas shown on the treatment map, other treatment areas within the polygons that are rockface or rockslope (incapable of vegetation cover), and areas that did not burn.

Inspection

Use the following methodology to validate correct application areas and rates:

- Stake and flag treatment areas, recording GPS coordinates (inspectors).
- Identify any nontreatment areas within a polygon or adjacent to a polygon by flagging and noting the location (inspectors).
- Walk each polygon to inspect the application AFTER HYDROMULCH IS APPLIED (inspectors).
- Mark thin or missed areas with GPS coordinates and flag on the ground for the pilots.
- Fill in the areas with additional drops (contractor).
- Recheck areas for coverage.
- Place transects randomly throughout the polygon (Spiars, unpublished paper).
- Stake the start and end of the randomly selected transect area.
- Record the location (GPS), aspect, slope type (concave, convex) and percent slope for the site.
- Place a 10-meter tape across the slope.
- Photograph the tape and existing coverage prior to collecting the data.
- Take 10 points per meter for a total of 100 points.
- Record both the presence of cover (Y/N) and the depth of cover to the nearest quarter inch.
- Note ground-cover transects lower than the contract-stated application rate and flag for additional drops.
- Record ground-cover transects that meet the application rate and enter into the sample pool for effectiveness monitoring.
- Record treated area accomplishments daily and note any application problems identified.
- Cards are commonly placed on the ground to assure that the correct amount is applied. Field crews inspect application rates for both depth of material and aerial extent. Perform random transects to validate application rates.

Safety

- Conduct project and aviation operations in a safe and effective manner and in full compliance with the aviation project safety plan.
- Mitigate dangers and hazards to the general public from project activities.
- Use dust abatement on staging areas and access roads.
- Provide traffic control on roads with high public use.
- Prevent spread of noxious weeds.
- Ensure that all equipment is free of soil, seeds, vegetative matter, or other debris that could contain or hold noxious weed seed.
- Rehabilitate and revegetate staging areas using a noxious-weed free native-species mix appropriate for the site.
- Mitigate damage or potential damage to private property.
- Perform a job hazard analysis (JHA) for each phase of the work including using airplanes and helicopters, driving, and field monitoring in rugged terrain.
- Ensure that safety concerns can be mitigated prior to project implementation.

Figure 1—Aerial application after the Cedar Fire, Cleveland N.F., December 2003.

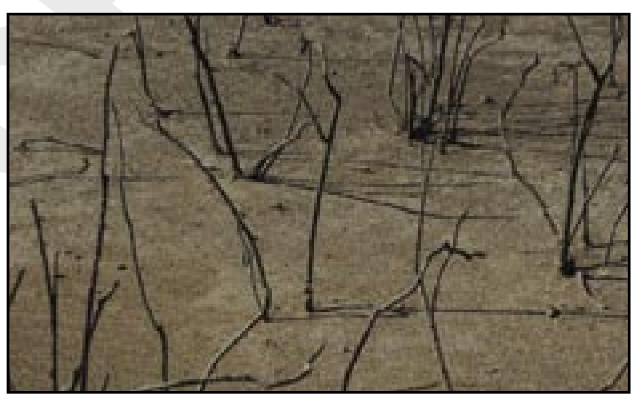

Figure 2—Treated areas on Cedar Fire, December 2003.

Figure 3—Aerial hydromulching requires close access to water, large staging areas, and close proximity to treatment units.

Figure 4—Hydromulch fibers form a smooth dense mat.

Figure 5—The relative thickness of the aerial hydromulch application.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were staging areas or helispots rehabilitated after use?
- Were noxious and invasive weed-detection measures taken?
- Was the correct application rate applied uniformly?

Effectiveness

- Are there signs of erosion onsite?
- Did the hydromulch stay onsite?
- What is the percent cover provided by the hydromulch?
- Is natural vegetation recovering?

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Hydromulch is used in high-burn severity areas where increased erosion and sediment from the road backslope and adjacent hillslope may endanger life and property. Hydromulching is used in areas where the BAER assessment team has identified an increased risk of invasive and noxious plants along roads.

Description
Ground-based hydromulching is applied from the road using truck-mounted applicators that can reach 200 to 300 feet, depending on the equipment. Hydromulch is a slurry applied to hillslopes with or without seed. Hydromulch is an all-inclusive term that includes fiber mulches, soil stabilizers, tackifiers, and polymers that when mixed with water and applied to the soil surface form a matrix that helps reduce erosion and foster plant growth (Robichaud 2000).

Purpose of Treatment
Hydromulch protects the soil surface from erosion, reduces adverse impacts to values at risk (water quality, fish habitat), and may reduce noxious and invasive plant establishment.

Emergency Stabilization Objective
Hydromulching reduces hillslope erosion and protects identified values-at-risk.

Suitable Sites
Hydromulching is intended for use in one or more of these locations:
- Soils with high-burn severity and high-erosion potential
- Slopes between 25 and 50 percent without effective soil cover
- Areas without needle-cast or regrowth potential within the first year
- Areas with high values at risk immediately adjacent to the site or downstream
- Slopes with less than 25-percent surface rock and soil deeper than 8 inches

Costs
Ground hydromulching applied between fiscal year (FY) 2000 and 2003 in the Southwestern Region (R3) cost $1,675 to $3,000 per acre (Kuyumjian, personal communication).

Cost factors include:
- Availability of hydromulch services
- Availability and location of water for mix
- Number of seed mixes
- Accessibility and road condition
- Applied rates

Treatment Effectiveness
Quantitative data on the effectiveness of ground-based hydromulch is limited. Effectiveness monitoring from the Hayman fire found ground hydromulching ineffective in reducing erosion because the treatment did not significantly reduce the amount of bare soil (MacDonald 2004).

Laboratory tests of hydromulch plots identified the application rate as the critical element in effectiveness. Field observations indicate slope length is critical to treatment effectiveness. Longer slopes begin to rill as runoff concentrates on the smooth surface. Further monitoring of hydromulch will help determine where and when this costly treatment is most effective.

Project Design and Implementation Team Information

Design
After the BAER assessment team designates potential treatment areas, review the field sites to ensure suitability. Key design considerations include slope steepness, slope length, hazard trees, nontreatment areas (rocky areas), and invasive and noxious plant sites.

Review the entire treatment polygon and flag areas of low-burn severity, steep slopes, and rocky areas. Identify on the ground the extent of the treatment unit for the contractor and for implementation monitoring.

Materials, Tools, and Equipment
The contractor is responsible for supplying all material and equipment including transportation to and from the designated locations. Four-wheel-drive equipment may be necessary depending on road conditions. Road-improvement work may be needed to clear tree limbs and hazard trees to allow a semitruck-size hydromulcher access.

Design and Construction Specifications
The following is a sample hydromulch specification. Specifications may vary by hydromulch selection. Coordinate hydromulching with an experienced crewmember.

1. Lay out hydromulch area with stakes, flags, and GPS coordinates to delineate treatment polygons.
2. Identify no-treatment areas that may have rocky or shallow soils and clearly delineate for the crew and contractor.
3. Determine treatment mix with an interdisciplinary team to identify whether the application will include seed and fertilizer.
4. Recommend a two-step application for best results. First, apply the seed mix. Second, apply a mulch and tackifier separately. Validate that the two-step practice is used in your area.
5. Meet all Federal and State requirements and guidelines for seed if a seed mixture is included.
6. Apply 1.25 tons of mulch per acre. Validate application rates for site-specific conditions.
7. Apply a Guar-based tackifier at a rate of 75 pounds per acre, or 3 percent of the mulch rate. (Example only, validate for site specific conditions)
8. Have a maximum discharge distance for the hydroseeder/hydromulcher on level ground of not less than 200 feet from the nozzle. Clearly delineating the upslope boundary of the treatment area helps ensure appropriate application rates.
9. Have a constant hydraulic or gear agitation of the slurry tank in the hydroseeder/ hydromulch equipment that provides an even mix of seeds, mulch, and fertilizer.

Safety

Ground hydromulching uses existing roads that may have other traffic. Develop a road safety and traffic management plan to mitigate hazards. Identify hazards and develop mitigation measures for ground hydromulching. Include the following in the JHA:

- Hazard trees within treatment areas
- Conditions that make driving unsafe
- Presence of large equipment on roads with other traffic

Treatment Monitoring Recommendations

Implementation

- Were contract requirements met for pure live seeds per square foot? (If applied in a two step process)
- Were contract specifications for depth and extent of mulch and tackifier achieved?

Effectiveness

- Are there indications of rilling?
- Did sediment reach the road and affect access?
- Did the pure live seed germinate? How much?
- Are noxious and invasive plants present in the treated area? Amount and extent?
- Did sediment reach streams or impact values at risk (fish)?
- Was the hydromulching designed for a specific storm event?
- Had the storm event occurred at the time of effectiveness evaluation?
- What was the slope of the treated area?

Figure 6—Ground application of hydromulch.

Figure 7—Treated cutslopes above the highway with vegetation resprouting.

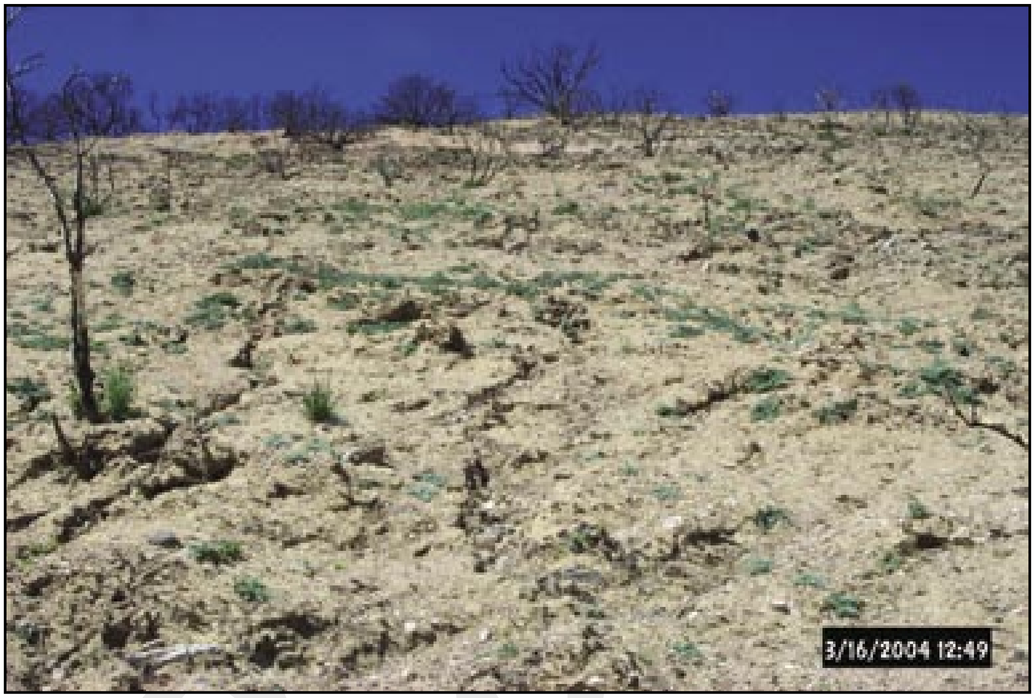

Figure 8—Treated cutslope with rilling. Longer slope lengths tend to have rilling as the runoff concentrates on the surface.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Straw mulch provides immediate ground cover and protection to soils from erosion. BAER assessment teams recommend this treatment in areas of moderate- and high-burn severity where erosion potential is high.

Description

Straw mulch with weed-free straw helps provide temporary cover to erosion-vulnerable areas as a result of the fire. Straw is applied with helicopters (helimulching) to treat large areas, or by hand for smaller treatment sites. A straw blower pulled behind a light-duty truck is used for roadside application. Straw is applied in contour strips or broadcast to achieve a certain percent of ground cover. Straw mulching is popular due to improved application methods (helicopter) that quickly and efficiently treat large areas prior to precipitation.

Purpose of Treatments

Straw mulch provides immediate ground cover and protects the soil from erosion and loss of nutrients. Mulch can reduce downstream peak flows by absorbing rainfall and allows prewetting of water repellent soil. Straw helps to secure seeds that are stored in the soil, or applied as an emergency treatment. Straw mulch on burned areas helps maintain a favorable moisture and temperature regime for seed germination and growth.

Emergency Stabilization Objectives

Mulch helps reduce surface erosion. Mulch may also reduce water quality degradation offsite.

Suitable Sites

This treatment is intended for use in one or more of the following locations:

- Areas of high- and moderate-burn severity.
- Slopes up to 65 percent (Mankins, unpublished paper).
- Areas that do not receive high winds.
- Areas that have been identified for seeding.
- Areas with sensitive or rare plants should be avoided.
- Areas in the upper portions of watersheds with high- and moderate-burn severity.
- Areas with some surface roughness to hold mulch, or if surface roughness can be created with felled or limbed trees to avoid redistribution of the straw.

Cost

Straw helimulching ranged in price from $250 to $930 per acre from treatment cost tracking conducted by the Southwestern Region (R3) from FY 2000 to 2003.

Hand application of straw mulch ranged from $500 to $1,200 per acre. Application of straw with the strawblower was completed at a cost of $425 per acre.

Application rates are approximately 1 to 2 tons per acre. This rate provides an average mulch depth of 1 to 2 inches.

Cost factors include the following variables:

- Type of application (aerial, hand, or machine).
- Proximity from helispot to treatment areas (turnaround time).
- Access for large-vehicles to the helispot or staging area.
- Number of days suitable for flying as determined in the aviation plan.
- Size of access areas may require additional staging areas or helispots to be built.
- Availability of experienced crews for both helimulching (helitack crew) and hand application.
- Availability of certified weed-free straw.

Treatment Effectiveness

Qualitative and quantitative monitoring indicate that mulch is an effective treatment when applied to suitable sites. Effectiveness of straw mulch whether aerially applied or hand spread, is related to the amount of ground cover it provides. Generally, mulch is applied at a rate of 1 ton per acre, which corresponds to about 70-percent ground cover.

After the Hayman Fire, in an aerially applied straw mulch site, ground cover was 79 percent after application, 52 percent in the first post-fire year, and 62 percent in the second year. Over time, decreases in mulch cover due to decomposition are offset by the increases in natural vegetation. First post-fire year erosion reduction was 64 percent and second post-fire year reduction was 65 percent (Robichaud, personal communication).

Straw mulch provides greater reduction in erosion than hydromulch. Because straw has longer fiber lengths than hydromulch materials, this treatment requires greater shear force to displace it. Straw can be moved by runoff; however the straw forms mini-debris dams with interlocking straw that allow it to store sediment and slow velocities. Additionally, straw mulch encourages high soil moisture retention, which can increase natural and introduced seeding survival and recovery.

The most common reason for treatment failure is the wind blowing the mulch offsite or piling the straw so deeply that vegetation is suppressed. Keys to effectiveness include even application and consistent thickness, regardless of treatment method. Steep slopes are avoided because straw will move, especially if the slope is uniform. In occasionally windy areas, assessment teams may consider crimping, using tackifier, or creating surface roughness by felling trees normal to the prevailing winds (Kuyumjian, personal communication).

Other variables include the size, age, and type of straw. Dry straw comes apart easily and does not clump whereas straw that has been sitting baled in the field can develop a crust and will not spread as well. Some contractors rebale the straw for better dispersal. Fluffing the straw with equipment breaks the crust and allows the straw to fall independently. Fluffing also prevents any jarring to the helicopter and pilot as the straw is released (Mankins, unpublished paper).

Problems can arise with straw containing noxious or invasive weeds. Require weed-free straw and include followup monitoring of staging areas and treatment areas to detect any weeds.

Straw mulching combined with seeding improves seed germination by providing an improved growing site. The seed in turn helps stabilize and hold the straw onsite as it grows (Kanaan, personal communication).

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites to ensure suitability. Key design considerations include slope steepness, wind, clear identification of nontreatment areas (rocky areas, green, or partially burned trees), staging areas, and helicopter safety in and out of the treatment area (powerlines, homes, highways, or other hazards).

Review the entire treatment polygon and flag and stake on the ground for field monitors. Use GPS points on the treatment area, in the contract, and for subsequent implementation and effectiveness monitoring.

Construction Specifications

Follow these steps to implement a successful straw-mulch treatment:

Helimulch

1. Identify the treatment areas with flagging, staking, and/or GPS coordinates.
2. Work with the helicopter manager to review treatment units, identify potential staging areas, and helispots.
3. Work with the helicopter manager and the forest aviation safety officer to develop the aviation safety plan and JHA. In some regions the aviation safety plan is reviewed at the regional office.
4. Obtain heritage resource clearances for any proposed enlargements to staging areas or temporary helispots.
5. Work with contracting officers to obtain bids on certified weed-free straw and a helicopter or fixed-wing aircraft for application (Dean, Web site; Mankins, unpublished paper).
6. Start your mulch project with an experienced project leader.

Hand Application

1. Identify the treatment areas with flagging, staking, and/or GPS coordinates.
2. Identify available work crews since this is a labor-intensive treatment.
3. Validate that work can be completed prior to first damaging storm event.
4. Order straw and identify suitable staging areas to reduce the amount of straw that needs to be packed by crewmembers.
5. Use tools such as gloves, pitch forks, and baling hooks to expedite the moving and spreading of straw. Use caution with hooks and pitch forks.
6. Use hand-application treatments for contour-strip mulching or 100-percent broadcast. Ensure that field crews understand the correct application rate.

Straw blower application

Areas above or below roads can be treated with a truck-pulled strawblower. Some forests have a strawblower or the work is contracted. Important considerations for this treatment include identifying the staging areas and straw length for stability on the soil. In some cases a tackifier may be needed.

Safety

Straw mulching is a hazardous treatment to implement. Consider all the hazards and review and update the JHA daily to avoid injuries. Include the following in the JHA:

- Eye irritations and skin rashes from handling and inhaling straw.
- Back strain from lifting heavy bales.
- Helicopter use must follow the aviation safety plan.
- Strawblower use requires additional safety considerations.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- What is the percent cover provided by the straw?
- Were staging areas or helispots rehabbed after use?
- Were noxious and invasive weed-detection measures taken?
- Was the correct application rate applied uniformly?

Effectiveness

- Are signs of erosion evident onsite?
- Did the mulch stay onsite?
- What is the percent cover provided by the straw?
- Is natural vegetation recovering?

Figure 9—Helimuch applications on the Bear Fire in northern California.

Figure 10—Straw broadcast from the sky to provide fast soil cover.

Figure 11—Helitack crew and equipment help load the cargo nets at the staging area.

Figure 12—Crew applying straw by hand.

Figure 13—Use gloves and other protective equipment when applying straw.

Figure 14—In windy areas straw will move offsite, leaving the soil prone to erosion.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Slash spreading provides soil cover to moderate- and high-burn severity areas. The treatment is designed to reduce hillslope erosion by increasing ground cover with available onsite materials. Recent studies by Missoula Technology and Development Center (MTDC) and Rocky Mountain Research Center used onsite small diameter trees to provide effective ground cover. (Groenier, 2004)

Description

Slash spreading involves felling, lopping, and scattering submerchantable trees and brush to provide soil cover.

Purpose of Treatments

Slash spreading reduces erosion by providing soil cover.

Emergency Stabilization Objectives

Slash spreading reduces erosion to prevent the unacceptable degradation of critical natural resources.

Suitable Sites

This treatment is intended for use in one or more of the following locations:

- Areas of high- and moderate-burn severity.
- Areas burned but with available slash material onsite.
- Soils with high erosion-hazard ratings.

Cost

Cost data for slash treatments in the Southwestern Region (R3) for FY 2000 to 2003 ranged from $220 to $1,000 per acre.

Cost factors include the following variables:

- Availability of submerchantable trees or brush for slashing.
- Topography of treatment area.
- Ease of obtaining good soil contact with slash material (amount of chain saw work required).

Treatment Effectiveness

Chain saw-created slash spreading is ineffective in many areas due to the large amount of material needed for adequate soil cover. Burned areas lack enough slash for erosion control. Production rates are slow because extensive chain saw work is needed for good soil contact.

Slash spreading is used in small areas where unique resources and adequate slash are found. Slash spreading protects cultural resources from erosion and can camouflage the sites.

New studies reveal additional opportunities to provide erosion control by engineered wood products or through mastication and onsite shredding of small diameter trees.

Engineered wood mulch was tested for use on burned areas. This type of product consists of a blend of sliced wood strands that provide erosion control over two or more seasons. Rainfall simulation studies completed by Rocky Mountain Research Station indicate the effectiveness of engineered wood mulch. BAER teams have had difficulty procuring the material which sells for about $60.00 per 600-pound bale or $8.75 per 50-pound bale (elwdsystems, Web site).

Use of track-mounted shredders on the Borrego Fire and the Clearwater National Forest demonstrate opportunities for shredding to reduce erosion. Track-mounted machines can shred trees 6 to 8 inches in diameter and provide “weed free” erosion control (Groenier, 2004). Equipment varies but generally enables an operator to treat an area within a 20-foot radius from a single position. Tested track-mounted machines in New Mexico exerted less than 4 pounds per square inch of ground pressure (Armstrong, unpublished paper).

The mulching head is capable of grinding the tree into chips or severing the tree into coarse pieces. Other equipment combinations include an excavator with shredder and a centrifuge blower to distribute the wood. MTDC is conducting studies to review alternative collection and distribution systems including aerial applications to place the material within the treatment unit.

Project Design and Implementation Team Information

Design

Review the treatment areas in the field to ensure that sites are suitable. Identify any hazards that may have to be removed or avoided prior to implementing treatment. Obtain heritage-resource clearance if heavy equipment is used to implement the treatment.

Tools/Equipment
Slash spreading commonly is implemented with a hotshot crew or a 20-person handcrew with chain saws. Mechanized equipment (hydro-ax) masticates trees into smaller pieces and provides more uniform cover (Kuyumjian, personal communication).

Safety
Slash spreading can be hazardous. Consider all hazards and update the JHA daily to avoid injuries. Include the following in the JHA.

- Hazard associated with tree felling and chain saw operation.
- Hazards associated with heavy equipment using sharp, high-speed moving parts.
- Stump-holes and unstable footing.

Treatment Monitoring Recommendations
Implementation

- Was the treatment implemented as designed?
- Were guidelines followed regarding effective soil coverage?

Effectiveness

- Did the slash spreading trap sediment?
- Did the slash spreading reduce erosion in the treatment area?
- Did the slash stay onsite?
- Was the percentage of soil cover known? If so, how much?
- Was the treatment tested by the design storm at the time of monitoring?

Figure 15—Mechanized equipment can quickly produce slash for effective soil cover.

Figure 16—Completed unit with slash spread uniformly.

Figure 17—Closeup of the slash material generated with heavy equipment.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Erosion control mats are a temporary erosion control measure for sites at risk from erosion and increased runoff. Erosion control mats treat site-specific resource concerns including heritage sites, water intake facilities, and other critical locations.

Description

Erosion control mats or rolled erosion control products (RECP) provide soil stability to sites until vegetation can establish. RECPs are either synthetic or organic and temporary or permanent. Organic RECPs are biodegradable and made from a variety of materials including coconut, wood excelsior (aspen), or straw. Material is contained in lightweight netting that lasts from several months to several years. Netless products are currently available. RECPs are tested to meet erosion control standards. Consult with the Erosion Control Technology Council (ECTC) for information on products. Although the products are expensive they are effective when installed correctly.

Purpose of Treatment

Erosion control mats reduce erosion caused by raindrop impact and absorb overland flow. The erosion control mats reduce soil temperature and provide moisture conservation, which fosters site revegetation.

Emergency Stabilization Objective

Erosion control mats prevent unacceptable degradation of a facility, National Register of Historic Places (NRHP) site, or site officially eligible for listing in the NRHP (BAER Guidance Paper-Heritage Resources).

Suitable Sites

This treatment is intended for application in one or more of the following situations:

- Areas of high-burn severity with loss of effective soil cover.
- Areas small in size with high values at risk.
- Areas with a persistent hydrophobic layer at or affecting the site.
- Soils with a high erosion hazard rating.
- Areas with increased overland runoff threatening the site or site feature.

Cost

Costs vary depending on the type of material selected for the site. Contact erosion control product distributors for price estimates. Consult the ECTC (ECTC, Web site) and International Erosion Control Association (IECA, Web site) for a list of distributors.

- Questions for identifying the best product for your specific area include:
    - o Treatment area slope gradient
    - o Products' functional longevity

Most RECPs are priced by the square yard and sold in rolls. Prices range from 35 to 50 cents per square yard to more than $1 per square yard. Installation is extra.

Cost factors include the following variables:

- Time frames for vegetative recovery.
- Native seed viability.
- Type of erosion control products.
- Site location and ease of access.

Treatment Effectiveness

Erosion control products work well on graded or homogenous sites which are uncommon in forested environments. Site preparation is required to provide good contact between the soil and the appropriate erosion control product.

Erosion control products rarely are used for BAER treatments so effectiveness data is limited. Tests conducted at Shasta College in California indicated an 81-percent reduction in soil loss compared to bare soil when RECPs were used (McCullah, 2000). Additional testing information is available from ECTC. Installation requires an experienced crew. Good ground contact also is necessary for an effective treatment.

Some erosion control products can trap animals or affect native plant establishment. Consult the distributors to ensure that the product is appropriate for your site conditions. New RECPs include netless blankets with biodegradable stakes. Each manufacturer and distributor has a variety of products to select from and when correctly installed there is little difference between products.

Project Design and Implementation

Design

After the BAER assessment team has designated potential treatment areas, review the sites in the field to ensure site suitability for erosion control mats. Key design considerations include slope uniformity, onsite rocks and debris, runon control from other sources, and treatment area size.

Erosion Control Mat Implementation

Make the soil surface stable, firm, and free of rocks and other obstructions. Install RECPs according to the manufacturer's published installation recommendations or use these minimum guidelines.

1. Install RECPs after applying seed, fertilizer, and other necessary soil amendments, unless soil in-filling of the RECP is required.
2. Use stakes or staples at least 6 inches long to secure RECPs to the soil. Longer anchors may be necessary in sandy, loose, and/or wet soils.
3. Unroll the RECP parallel to the primary direction of flow and place it in direct contact with the soil surface. Do not stretch or allow material to bridge over surface inconsistencies. Overlap edges of adjacent RECPs by 2 to 4 inches.
4. Use a sufficient number of stakes or staples to prevent seam separation. Overlap roll ends of joining RECPs 2 to 6 inches in the direction of flow.

Slope Installations

At the top of slope, anchor the RECP using one of these methods:

Staples. Install the RECP 3 feet over the shoulder of the slope onto flat final grade. Secure with a single row of stakes or staples on 1-foot centers.

Anchor trench. Construct a 6 inch by 6 inch anchor trench. Extend the upslope terminal end of the RECP 3 feet past the anchor trench. Use stakes or staples to fasten the product into the anchor trench on 1-foot centers. Backfill the trench and compact the soil. Apply seed and any soil amendments to the compacted soil and cover with the remaining 1 foot terminal end of the RECP. Secure the terminal end with a single row of stakes or staples on 1-foot centers.

Check slot. Construct a stake- or staple-check slot along the top edge of the RECP by installing two rows of stakes or staples 4 inches apart on 4-inch centers. Drive all stake and staple heads flush with soil surface.

After the RECP is fastened at the top of the slope continue with the installation as follows:

1. Fasten all RECPs securely to the soil by installing stakes or staples every 5 to 10 feet depending upon the site's wind conditions.
2. Overlap rolls by 2 to 4 inches in shingle style. Each roll should overlap in the slope's downstream direction.
3. Secure the bottom of each roll with one staple per linear foot.
4. Minimize foot traffic during installation to avoid tears and holes.

Safety

Erosion control mats require an experienced crew to implement safely. Mitigate hazards and update daily to avoid injuries. Include the following in the JHA:

◊ Back strains from lifting mats.
◊ Stump-holes and unstable footing.
◊ Splinters from stakes to fasten RECPs.

Treatment Monitoring Recommendations

Implementation

- Was the project implemented as designed by heritage resource and watershed specialists?
- Were manufacturer guidelines for installation and application followed according to specifications?
- Was the erosion control product anchored correctly?
- Is there close adhesion to the soil?
- Were staple and stake guidelines followed?

Effectiveness

- Did the treatment protect the site from erosion?
- Did the treatment avoid diminishing the integrity of the site?
- Has the area stabilized with vegetation?
- Did the treatment meet other resource objectives for revegetation and wildlife?

Figure 18—Erosion mats come in various types depending on site specific needs.

Figure 19—Erosion mats may be used for heritage sites to provide cover to unique features at risk of erosion.

Figure 20—Proper implementation of erosion control mats ensures treatment success.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Log erosion barriers (LEBs) are used in timbered areas with moderate- and high-burn severity where hillslope erosion rates are increased significantly from the fire.

Description
LEBs (contour felled logs, log terraces, or terracettes) are logs placed in a shallow trench on the contour. LEBs trap sediment if laid in a bricklayer pattern on the hillslope. The potential volume of sediment stored is dependent on slope, size, and length of the felled trees, and proper implementation. LEBs with soil end berms trap more sediment.

Purpose of Treatment
LEBs reduce erosion by shortening slope length, providing surface roughness, improving infiltration, and trapping sediment (Clifford, unpublished paper).

Emergency Stabilization Objective
LEBs reduce hillslope erosion and adverse effects to identified values at risk (ecological integrity and water quality).

Suitable Sites
Use this treatment in one or more of these locations:
- Hillslopes with high- and moderate-burn severity.
- Slopes between 25 and 60 percent.
- Water repellant soils are present.
- Soils with high erosion-hazard ratings.
- Watersheds with high values at risk.

Cost
LEBs vary in price based on cost factors. LEB-treatment implementation costs summarized by the Southwestern Region (R3) from FY 2000 to 2003 ranged from $420 to $1,200 per acre.
Cost factor variables include:
- Treatment-area terrain
- Site access (vehicle or helicopter)
- Number of logs placed per acre
- Crew knowledge and experience

Treatment Effectiveness
LEBs were the northwest's second most used treatment from the 1970s to the 1990s (Robichaud 2000). However, with cheaper and more effective hillslope treatments, such as helimulching, the use of LEBs has decreased.

Quantitative studies on the sediment-trapping efficiency of LEBs ranged from 6.7 cubic yards per acre to 72 cubic yards per acre with a high density of logs. Research in southern California found soil depths and soil water-holding capacity dictated LEB effectiveness (Wohlegemuth 2001).

Six paired watershed sites from throughout the western United States are being monitored for determining effectiveness of contour-felled logs. The storage capacity of each log was determined by calculating storage volume from onsite measurements. Volumes were calculated using the average depths and lengths then discounted for poor ground contact and slope placement. There were an average of 90 logs ha^{-1}. Average initial individual log storage was 0.38 m^3. An ocular estimate for log soil contact was also made.

Findings show the effectiveness of contour felled logs is dependent on rainfall intensity. Observations from numerous rainfall events at these six paired watershed sites indicate that the logs are more effective at trapping sediment if the 10-minute rainfall intensity is low (less than 30 millimeters per hour). With high intensity rainfall (10-minute rainfall intensity greater than 50 millimeters per hour), trap efficiency declines to less than 60 percent, which also decreases by 10 to 15 percent with each successive rain events. Soil end berms increase the storage capacity by about 12 to 15 percent, thus end berms improve their performance. (Robichaud, personal communication)

Measurement of over 3,000 logs suggests several causes for the observed compromises in effectiveness. Some of these factors can be controlled by improved installation strategies and other factors are inherent from settling and downslope runoff. Some observations include:
- 20 percent of the logs were not placed within 5 percent of the hillslope contour.
- 5 percent of the logs rolled due to stake failure.
- 15 percent of the soil end berms failed due to inadequate height and washout caused by runoff.
- 30 percent of the logs were not backfilled with soil to prevent runoff from undermining the log.

BAER implementation teams have reported the following problems with LEBs, which can be avoided with training and implementation monitoring. Common reasons for treatment ineffectiveness include:

- Trees improperly bedded caused runoff and erosion under the log.
- Trees not placed on the contour concentrated runoff and erosion at the ends of the log.
- LEB density (logs per acre) was insufficient for the slope and burn severity.
- LEBs placed on slopes greater than 60 percent.
- Areas with rocks prevented proper installation and accelerated erosion.
- Limbs left untrimmed prevented ground contact and resulted in erosion.
- Crew training was inadequate and resulted in poor implementation.
- Inspection or implementation monitoring was infrequent.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites to ensure suitability. Key design considerations include standing dead-tree-diameter (8 to 12 inches), site accessibility, and safety. Larger tree diameters can trap and store more sediment but can be unwieldy.

LEBs are used in high-burn severity areas. Review the entire treatment polygon and flag rocky areas, low-burn severity areas, and slopes of more than 60 percent. For slopes less than 20 percent, evaluate the need for LEBs with a BAER team member or the forest soil scientist. Have the archeologist review the area and flag areas to avoid (Ruby, unpublished paper).

Tools/Equipment

To ensure safe felling, limbing, trenching, and backfilling each log, select trees that measure 8 to 12 inches diameter breast height. Tree species include conifer, alder, birch, and aspen. Straight trees make firm contact with the soil. Logs should be 10- to 20-feet long. Longer logs are difficult to handle and place correctly.

Tools

- Chain saw with complete sharpening and repair equipment (extra chain, file).
- Hazel hoe or mattock for bedding logs.
- Single-bit axe to cut and pound stakes.
- Carpenter level to ensure that logs are on the contour.
- Stakes 12 to 16 inches long to hold logs in position.
- Tape measure.

LEB Implementation

Demonstrate the correct installation method prior to implementing LEBs. Alert the crew and inspectors on spacing for different slope classes, placing the log on the contour, bedding the log, and establishing the bricklayer pattern. Use soil end berms to improve trapping efficiency (Robichaud, personal communication). Once the demonstration is complete, assign crews and inspectors to treatment areas. (Tracy, unpublished paper)

Crews should work in teams of three with one sawyer, followed at a safe distance by two people trenching and bedding the logs. Total crew size varies depending on the treatment area. Crews should start at the top of the unit and work downslope offsetting the LEBs in a bricklayer pattern.

Installing LEBs is challenging and hazardous work. Hotshot crews are commonly used to install LEBs because of their skills and experience. Contract crews also can be used.

Designate inspectors for unit layout and implementation monitoring. The inspector ensures that LEBs meet construction specifications for spacing, alignment, density, and bedding. Inspectors can use a global positioning system (GPS) to mark treatment areas for subsequent effectiveness monitoring.

Vehicles/Aircraft

- Crew carriers can be used to access designated sites.
- Helicopter access is required occasionally for more remote locations. Ensure that appropriate flight plans and JHA are included.

Production Rates

Production rates vary with the number of LEBs placed per acre. Reducing the number of LEBs to expedite the treatment jeopardizes effectiveness.

Specifications require that logs from burned trees 15 to 20 feet in length be placed 10-feet apart on slopes more than 50 percent. For slopes less than 50 percent, trees are placed 15-feet apart. Distance on the contour between the LEBs is 10 feet. Approximately 95 trees per acre are required to meet this specification based on a 20-foot log length that would provide 1,900 linear feet per acre. An estimated 100 to 200 logs per acre at 20-foot length would be required to obtain 2,000 to 4,000 linear feet per acre (See Appendix G).

The LEB installation rate for a well-trained crew is approximately 1 acre per person-day depending on spacing and linear feet per acre. Experienced crews can treat 3 or more acres per person-day. Validate production rate from recent LEB installation contracts. Be sure to compare slope, spacing, and actual linear feet installed per acre.

Method of Installation

1. Identify treatment polygons on a map and clearly mark in the field.
2. Use inspector(s) review each polygon and determine whether the area complies with the specifications. Nonwork areas such as large openings (areas where burn severity will be lower), rocky areas, and slopes more than 60 percent will be identified as bypass areas (Ruby 1995).
3. Flag the perimeter of each area with a discrete color code, marked on the ground with a wooden stake, and indexed on the stake and on a project map. Record the size of the polygon.
4. Consult with the cultural resource staff prior to starting the project. Placement of LEBs is a ground-disturbing activity and requires clearance to ensure that resources are avoided and/or protected.
5. Start installation of LEBs at the top of the treatment area (Schmidt 2003).
6. Work in teams with one sawyer safely ahead of two individuals to bed the log. Some implementation teams use larger crews with a sawyer and swamper followed by four individuals to bed the log. Team size is determined by safety and efficiency.
7. Use sawyers to delimb the log to allow for 100-percent contact with the ground.
8. Check that the log is on the contour with a hand level.
9. Dig a trench on the contour 3 to 5 inches deep depending on the size of the log to break up water repellant soils.
10. Place the log in the trench on the contour and backfill the log ensuring that there are no gaps.
11. Anchor the log with wooden stakes if needed.
12. Place limbs or branches on the slope and ends of the LEBs for surface roughness and to break up concentrated flows.
13. Use inspectors to review and approve all work when treatment within a block is complete.
14. Report daily acreages treated, with acres per person-day and costs.
15. Track acres treated per block and continue layout on planned work (Tracy, unpublished paper).

Safety

LEBs are a hazardous treatment. Consider all hazards and review and update the JHA daily to avoid injuries. Include the following in the JHA:

- Chain saw operation and felling trees.
- Hazard trees within treatment areas.
- Stump-holes and unstable footing.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were specifications for spacing, logs per acre, and bypass areas implemented?
- How many linear feet per acre were implemented?

Effectiveness

- Did the LEBs trap sediment?
- Did the LEBs fill with sediment?
- Are there signs of rilling?
- Did water move under the LEB?
- Was there overtopping of the LEB?
- Was the storm event the LEBs were designed for in the burned area report (FS 2500-8)?
- Had storm events occurred at the time of effectiveness evaluation?

Figure 21—High-burn severity areas on the Santa Fe N.F. with available trees that are candidate sites for contour felled LEBs.

Figure 22—Contour felled LEB held in place with existing tree and stump.

Figure 23—Contour felled LEBs 2 years after treatment.

Figure 24—Contour felled LEB 2 years later that has not trapped any sediment.

Figure 25—Area initially treated with LEBs, but secondary treatment of straw mulch is added to reduce erosion.

Figure 27—Once the LEB fills, sediment will move over or around the log. Soil berms on the sides of LEBs help hold more material behind the log.

Figure 26—Contour felled LEB which has filled with sediment and then failed. Sediment trapping ability of LEBs on steep slopes is limited.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Fiber rolls are used in high-burn severity areas where soil erosion and water quality deterioration are at risk. Fiber rolls are used where LEBs are not practical. They are for intensive treatment of high values at risk including heritage sites.

Description

Fiber rolls, commonly called wattles, are prefabricated rolls manufactured from rice straw and wrapped in ultraviolet degradable plastic or jute netting. Fiber rolls are approximately 9 inches in diameter and up to 25 feet long. A 25-foot-long fiber roll weighs 35 pounds. Fiber rolls are designed for low-surface flows not to exceed 1 cubic foot per second. They are not for stream channels or gullies (Morris 2004).

Purpose of Treatment

Fiber rolls reduce erosion by shortening the slope length to slow overland flow velocity. Fiber rolls trap sediment and provide a seedbed for vegetative recovery. If water repellant soils are present, the installation of the fiber rolls may break through the water repellant layer and can improve infiltration.

Emergency Stabilization Objective

Fiber rolls reduce erosion and may reduce adverse effects to identified values at risk (ecological integrity and water quality).

Suitable Sites

Use fiber rolls in one or more of these locations:

- Areas of high- and moderate-burn severity.
- Slopes with less than 40 percent of the original ground cover remaining.
- Slopes between 20 and 40 percent.
- Soils not less than 8 inches deep.
- Slopes with less than 25-percent surface rock.

Cost

Fiber rolls are expensive to implement. Costs vary by project. Fiber-roll treatment implementation costs summarized by the Southwestern Region (R3) from FY 2000 to 2003 ranged from $1,100 to $4,000 per acre.

Cost factors include:

- Distance from site to staging area.
- Access to staging area for large-vehicles.
- Experience and availability of crews to install fiber rolls.
- Placement method for fiber-rolls (helicopter or handcrews).
- Vegetation remaining.
- Requirements for fiber-roll spacing.

Treatment Effectiveness

Limited effectiveness monitoring data is available on fiber rolls. Monitoring of the 2003 Cedar fire used field observations and select photopoints to document the effectiveness.

Findings indicate the need for implementation monitoring to ensure proper location, spacing, and placement of the fiber roll. Do not place fiber rolls in drainages or turn the ends down. Fiber rolls in drainages failed and fiber rolls with the end turned down contributed to rill formation (Hubbert, unpublished paper).

Vertical spacing of fiber rolls remains highly variable. Consult manufacturer guidelines, soil-burn severity maps, and erosion-hazard ratings for slopes.

Fiber rolls can attract small rodents, which in turn attract snakes that can become trapped in the netting. The wildlife biologist can assist in determining wildlife concerns (Kuyumjian, personal communication). Specify that fiber rolls are certified weed free for the installation State.

Other informal observations of fiber rolls (wattles) and their effectiveness are:

- Fiber rolls provide good germination of seed as compared to the rest of the slope. Breaking up slope length provided germination sites (Morris 2004).
- Fiber rolls had undercutting below the wattle where there was overtopping.
- Fiber rolls function for up to 2 years but remain for several years after filling.
- Fiber rolls are awkward to transport and are difficult to install on steep slopes.
- Fiber rolls work best when placed in a trench with complete ground contact and firm anchoring.
- Fiber rolls are expensive and labor intensive. Ensure that enough experienced crews are available to complete the work in the timeframe required (Robichaud 2000).
- Fiber rolls work well in coarse-grain soils. Tests at San Diego State University Soil Erosion Research Laboratory demonstrated that fiber rolls reduce offsite sediment delivery from bare soil by as

much as 58 percent with proper installation (Earth Savers, Web site).

Inspect fiber rolls after each storm event. Fiber rolls are unsuitable in areas with high-intensity, short-duration storm events where they fill quickly with material. Check the past performance of fiber rolls in the area prior to prescribing their use. Further monitoring efforts are needed to fully identify the failure mechanisms.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites for suitability. Key design considerations include site accessibility, vegetation remaining, and correct spacing. Fiber rolls are delivered in large trucks and the closer the trucks can get to the site the lower the cost. In some cases, helicopters can transport the wattles to the treatment area.

Review the entire treatment polygon and flag rocky areas, low-burn severity areas, and slopes over 45 to 50 percent. For slopes less than 10 to 15 percent, evaluate the need for fiber rolls with a BAER team member or the forest soil scientist. Have the archeologist and wildlife biologist review the area and flag areas to avoid.

Construction Specifications

1. Lay out a contour line on the slope with a hand level and wire flags.
2. Dig a shallow depression 3 to 5 inches deep with a pulaski or pick and place the fiber roll in it.
3. Place excavated soil downslope of the trench.
4. Place the fiber roll and backfill the upslope length of the fiber roll with the excavated soil. Compact to prevent water from flowing under the fiber roll.
5. Turn the ends of the fiber roll upslope slightly (like a smile) to trap sediment and prevent channeling of flows.
6. Drive a 1- by 2-inch or 2- by 2-inch wooden stake through the center of the fiber roll and at least 6 inches into the ground. Stop 2 inches above the fiber roll. (Stake lengths should be 18 to 24 inches. For rocky soils, rebar has been used, but should be removed after the site is stabilized.)
7. Put four stakes in a 12-foot fiber roll, five stakes in each 20-foot fiber roll, and six stakes for 25-foot fiber roll.
8. Space (horizontal) for fiber rolls depends on normal rainfall intensity, slope steepness, soil characteristics, and the extent of surface cover remaining on the slope.
9. Place wattles 50 feet apart (872 per acre) on moderate-burn severity on slopes of 20 to 50 percent. Place wattles 20 feet apart (2,178 per acre) on high-burn severity slopes. (Natural Resource Conservation Service Web site).
10. Stagger the layout on the slope in a bricklayer pattern starting at the top of the slope with a 12- to 18-inch overlap.

Materials and Tools

Material

- Contour straw wattles 9 to 12 inches in diameter and 10 to 30 feet in length.
- Wooden stakes, 5- (1 by 2 inch or 2 by 2 inch) 18 to 24 inches long per wattle.

Tools

- Shovel
- Pulaski
- Hammer
- Hand level
- Flagging

Safety

Fiber rolls are implemented safely when the following items are included and mitigated in the JHA.

- Aircraft-safety plan if using any aircraft to move wattles.
- Injuries from stakes, splinters, and traversing rugged ground.
- Allergies to straw.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were specifications for spacing, location, and installation of fiber rolls implemented?
- How many linear feet per acre were installed?

Effectiveness

- Did fiber rolls trap sediment?
- Are there indications of rilling?
- Were the fiber rolls undercut?
- Was there overtopping of the fiber roll?

- What type of storm event were fiber rolls designed for in the FS-2500-8?
- What storm events had occurred at time of effectiveness evaluation?
- Did the fiber roll trap seeds for revegetation establishment?

Figure 28—Fiber roll placed across the hillslope. Not all the fiber rolls are on the contour which can accelerate erosion.

Figure 29—Avoid placing the fiber rolls in drainages.

Figure 30—Fiber rolls do not reduce erosion but trap sediment on the slope. Where high values are at risk identify the emergency objective and select the treatment which best meets that objective.

Figure 31—To ensure proper installation, work with experienced crews and inspect as the fiber rolls are installed. Improper installation negates the effectiveness of this expensive treatment.

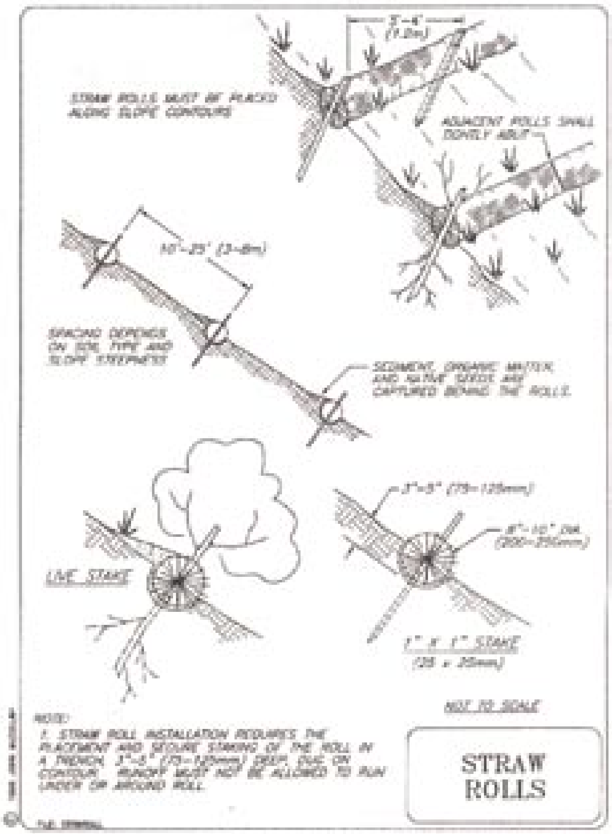

Figure 32—Fiber roll installation guide.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Silt fences trap soil and sediment but are used infrequently as a BAER treatment.

Description
Silt fences are a geotextile fabric that traps sediment. They are installed with wooden posts or metal T-posts, and are firmly sealed and anchored below groundlevel. Geotextile fabric attached to hogwire adds strength to the fence.

Purpose of Treatments
Silt fences are used to trap sediment. Place silt fences in areas with high values at risk where other treatments, such as log erosion barriers or fiber rolls may be ineffective. Use silt fences to monitor sediment movement during effectiveness monitoring (Robichaud 2002).

Emergency Stabilization Objectives
Silt fences trap sediment and protect areas with high values at risk including heritage resources, water quality, and aquatic resources.

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Areas with high values at risk.
- Areas accessible for inspection and maintenance.
- Areas with site-specific resource concerns (heritage sites).

Cost
Silt-fence materials are available widely. Material costs are low, $50 per roll, but labor costs and installation effort and maintenance can increase costs. Installed silt fences range from $150 to $250 for each fence. Once the site is stabilized, remove the fences. Removal cost can be paid for with BAER funds.
Cost factors include the following:

- Proximity to vehicle access
- Size and number of fences
- Soil characteristics
- Maintenance frequency
- Removal of silt fences

Treatment Effectiveness
Silt fence effectiveness on reducing erosion is high if the silt fences are installed properly (anchored properly with the bottom of the silt fence keyed into the soil allows water to pass through slowly while trapping sediment) and maintained. Robichaud and Brown (2002) have measured trap efficiency of over 90 percent for silt fences used as a hillslope erosion measurement devise. These silt fences were carefully installed with the bottom of the silt fence properly anchored and the end of the silt fence turned upslope to prevent sediment from going around the end. Silt fences, although very effective, require significant installation effort and constant maintenance if they are to remain effective. Contributing areas should not exceed 10,000 square feet, and once they are partially filled they need to be emptied to maintain their effectiveness.

Project Design and Implementation Team Information
The following method describes how to implement silt fences as a treatment. Additional information is available for silt fence construction in (Robichaud 2002). Major differences in the design specifications are using wooden stakes and the anchoring method. Both designs work well if implemented correctly.

Design and Construction Specifications
1. Visit each site to determine exact needs including number of silt fences, spacing, and layout.
2. Stake the locations to ensure that the contributing watershed is not too large to overwhelm the silt fence.
3. Coordinate with other resource specialists (heritage resources) prior to installing the silt fences.
4. Dig an 8-inch trench along the contour.
5. Drive the posts to approximately 16 inches below the soil surface.
6. Unroll the geotextile and wire (if used). Attach the geotextile to the wire with tiewire.
7. Place the fence in the trench and attach to the fence posts.
8. Backfill the trench and tamp to ensure adequate compaction.
9. Inspect the silt fence after every runoff event if possible.
10. Repair any damage immediately.
11. Remove sediment and debris from the fence when visible bulges appear or the silt fence is one-third full.
12. Remove the silt fence after vegetation or other permanent erosion control measures are installed and functional.

Equipment and Materials

Material

- Hardwood posts at least 36 inches long with a minimum cross section area of 3 inches, use standard T- or U-section steel posts that weigh at least 1 pound per linear foot.
- Wire-fence material, at least 14-gauge, with openings no larger than 6 by 6 inches.
- Geotextile material (for the fence).
- Tiewire (to attach the fence to the wire).

Equipment

- Fencepost pounder (for installation).
- Wire cutter.

Safety

Include the following items and mitigation on the JHA. Consider all hazards and update daily to avoid injuries.

- Injuring back from the fencepost pounder.
- Ensuring adequate eye protection.
- Cutting wire can cause injury.

Treatment Monitoring Recommendations

Implementation

- Was the silt fence installed as designed?

Effectiveness

- Did the fence trap sediment?
- Was there a failure of the structure? If so, how? Overtop, endrun, or blowout?
- What was the size of the contributing watershed?
- Was the structure tested by the design storm during monitoring?

Figure 33—Silt fence are generally used for monitoring treatment effectiveness.

Figure 34—Silt fences are effective at trapping sediment but require inspection and maintenance. Silt fences should be removed once the area has stabilized.

Figure 35—A recently installed silt fence.

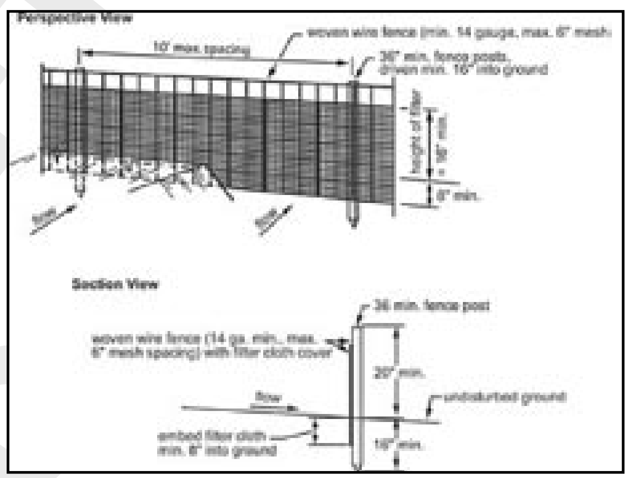

Figure 36—Properly installed and maintained silt fences have a 90 percent trap efficiency.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Soil scarification prepares the seedbed for seeding and improves infiltration. Soil scarification is for areas of high-erosion hazard rating and high-burn severity where values at risk are high.

Description
Scarifying soils to reduce water repellency became popular after the Cerro Grande and Hayman fires. Volunteer groups--anxious to assist in the recovery process--used rakes to break up the shallow hydrophobic conditions and provide a good seedbed. This provided temporary erosion control. Raking was done on the contour both with and without untreated strips. More recent application had an all-terrain vehicle (ATV) with a 4-foot-by-4-foot chain-link harrow with 4-inch-long teeth scarify the ground and create a seedbed. Seed is applied at the same time with the ATV (Kanaan, personal communication).

Purpose of Treatments
Soil scarification reduces overland flow and erosion by increasing infiltration and creating surface roughness. Hydrophobic layers are broken down with scarification. Additionally, seedbed preparation fosters seed germination and growth.

Emergency Stabilization Objective
Soil scarification can reduce erosion by increasing infiltration. Seeding further helps to reduce erosion and stabilize the soil in year two.

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Areas of high- and moderate-burn severity.
- Slopes with high erosion potential.
- Slopes less than 20 percent (with ATVs or small dozer).
- Slopes between 20 and 40 percent (with handcrews).

Cost
Implementation costs vary depending on application method. Volunteer crews often are willing to prepare the seedbed with rakes. Crew costs are $245 to $300 per acre. This cost assumes treating an 8-foot-wide swath on the contour and leaving an untreated area of 20 to 30 feet between raked and seeded areas. Roughly 20 acres per day can be treated by a 20-person crew (Kuyumjian, personal communication).

ATV use has considerably lower costs, $50 per acre with a production rate of 40 acres per day per ATV, for both seeding and scarifying (Kanaan, personal communication).

Cost factors include the following:

- Ground-disturbing BAER activity that requires cultural clearance work. The extent of the project and acres to be treated will affect treatment costs.
- Terrain of treatment site dictates the application method. ATVs are not recommended for slopes of more than 20 percent or in dense stands of timber.
- Safety issues can increase costs if the site area is very hazardous.

Treatment Effectiveness
Treating hydrophobic soils with soil scarification equipment is not uncommon. However, only limited data supports the efficacy of this treatment. In some situations the scarification has worked well and in others it has failed. More recent efforts combined soil scarification with seeding. Ongoing studies of scarification and seeding on the Bobcat fire in Colorado did not significantly reduce sediment yields (MacDonald 2000).

Effectiveness of soil scarification on reducing erosion by increasing infiltration and breaking up the water repellent soil conditions was monitored on Hayman Fire sites. To determine effectiveness of this treatment, research plots were scarified with McLeods by raking on the contour to a depth of 1.5 inches adjacent to control (untreated) plots on 20-percent and 40-percent slopes. There was no difference in ground cover amount among the treated and untreated sites the first 2 years after the fire. Erosion rates from the scarified plots were not statistically different than the control for either the first or second postfire years.

During rainfall events, it was observed that runoff was delayed several minutes as water entered the scarified soil. However, after several more minutes of rainfall, overland flow occurred and carried the soil, which has been loosened by the treatment downslope (Robichaud, personal communication).

BAER specialists that implemented scarification feel the risks in high-burn severity areas outweigh the benefits derived. Other lower risk treatments, including seeding with dry mulch application, should be applied first (Kannan and Kuyumjian, personal communications). Little data is available on the benefit of scarification on seedling establishment (Robichaud, personal communication).

Soil scarification is a tool for assessment teams but it is recommended that other treatment options be pursued prior to recommending this treatment for emergency stabilization.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites to ensure suitability. Key design considerations include worker safety, high- and moderate-burned areas, nontreatment areas, and slope class. ATVs and dozers have slope limitations. Lay out treatment areas by comparing slope breaks with burn severity maps. Specific equipment is matched to a treatment area. Identify treatment type in the field. Use GPS coordinates for boundaries for both the contract and subsequent implementation and effectiveness monitoring.

Construction Specifications

- Identify and lay out proposed treatment polygons with flagging and GPS units to obtain coordinates.
- Obtain cultural resource clearance for treatment areas.
- Identify and remove hazardous snags with a saw team prior to implementing the project.
- Identify staging area for crews, equipment, and material (seed).
- Treat alternating areas on the contour. Treated areas with a handcrew may be approximately 8 feet wide, and areas with an ATV will be as wide as the chain link harrow (approximately 4 feet wide).
- Distance between treated strips depends on the slope.
- Use of ATVs is faster but limited to approximately 20-percent sideslopes.
- Use dozers with ripper shanks on a hydraulic toolbar. Problems can arise with trapping woody material in the shanks which slows production rates considerably.

Tools

This work can be done with handcrews, ATVs, dozers, or volunteer crews. Hazards associated with snags, stump holes, and rugged conditions need full consideration. The JHA should be developed carefully for this treatment.

- Flagging and staking of treatment areas.
- Using rakes or McLeods.
- Using a chain saw.
- Using a hand seeder (belly grinder).

Equipment

- Utility ATV
- Dozer equipped with tool bar and ripper shanks
- Chain link harrow with 4-inch-long teeth mounted behind the ATV
- Seeder mounted on back of ATV
- Personal protective equipment for ATV riders and hand crews

Safety

Soil scarification is a hazardous treatment to implement as crews are exposed to unsafe working conditions. Consider all hazards and update the JHA daily to avoid injuries. Include the following in the JHA.

- Establish communications plan (radios and spare batteries).
- Establish safety officer position, especially with large crews and volunteer groups.
- Know the weather forecast and be alert for hazards, especially windy conditions.
- Work with volunteer groups is fun and challenging. Ensure that the groups have the proper protective equipment, especially boots, for their safety.
- Access by road to remote sites may have snags, heavy equipment, and other hazards. Flag and sign the access to identify the route clearly.

Treatment Monitoring Recommendations

Implementation

- Were treatment specifications met in regard to depth and width of seedbed preparation?

Effectiveness

- Are signs of rilling and erosion apparent?
- Did treatment reduce the hydrophobic conditions?
- What were the precipitation events prior to monitoring?

- What design storm was used for the treatment?
- Did treated strips trap sediment from the untreated strips and reduce erosion?

Figure 37—Crews using hand rakes scarify soils and follow with hand seeders. Studies indicate this treatment is not effective.

Figure 38—Larger equipment is used for deeper ripping to increase infiltration and break through water repellent soils.

Figure 39—Use of an ATV and a chain harrow to scarify and seed soils.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Seeding reduces hillslope erosion. Seeding also is prescribed for areas at risk from the spread of invasive and noxious plants.

Description
Seed is applied with fixed-wing aircraft or helicopters for large treatment units and with belly grinders for smaller treatment areas. Since seeding is ineffective the first year, it is included with other treatments, such as straw mulching, hydromulching, or soil scarifying.

Previous effectiveness results of seeding alone showed poor results the first year and variable results in subsequent years (Beyers 2003; Janicki 2003; Robichaud 2000). Seed mixes vary from region to region and depend on BAER treatment objectives. Revegetation information available from the fire-effects information system helps assessment teams evaluate natural vegetation recovery rates for a particular species and area.

Purpose of Treatments
Seeding minimizes soil and wind erosion by providing vegetative cover. Seeding may prevent the introduction and increase of noxious and invasive plants. Seeding may help protect threatened and endangered habitat, and reduce sediment delivery and transport to drainages.

Emergency Stabilization Objectives
Objectives are to reduce erosion and prevent the introduction or spread of noxious and invasive plants (Smith, unpublished paper).

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Areas of high-burn severity
- Areas within or adjacent to high values at risk
- Soils without soil cover that are highly erodible
- Slopes up to 60 percent
- Areas with potential for spread of known noxious and invasive plants

Cost
Seeding costs vary depending on the cost factors below. Seeding costs summarized by the Southwestern Region from FY 2000 to 2003 ranged from $20 to $170 per acre.
Cost factors include the following variables:

- Availability of seed mix
- Implementation timeframe
- Number of landowners involved
- Elevation and climate
- Size of fire or complex of fires
- Aircraft type, fixed-wing or helicopter
- Topography and terrain
- Number of species in seed mix
- Proximity of treatment blocks to staging areas
- Timing and weather conditions during seeding

Treatment Effectiveness
Seeding alone has become less popular as a treatment due to its limited effectiveness. In a review of existing studies on seeding, few studies demonstrate statistically significant decreases in sediment movement (Beyer 2003). In addition, seeding rarely provides any effective cover the first year after the fire. Assessment teams hope that second-year effects warrant the treatment and that soil losses the first year are not too dramatic.

Due to seeding's limited effectiveness, some assessment teams prescribe combining mulching with seeding to provide immediate soil cover. The mulch protects the seeds from drying out and once the seed germinates it holds the straw in place. The combination extends the life of the mulch treatment (Kuyumjian and Kanaan, personal communications).

Robichaud et al (2000) examined nine seeding studies in conifer forest that provided quantitative ground cover data. In the first growing season after the fire, about half of the studies reported less than 30-percent ground cover and only 22-percent reported at least 60-percent ground cover. At least 60- to 70-percent ground cover is needed for erosion reduction (Robichaud et al 2000). Better cover, and thereby better erosion mitigation, can be expected in the second and subsequent years. Several other studies from the western United States show that the second and, in some cases, third and fourth year erosion rates were not affected by seeding (Roby 1989, Van de Water 1998, Wohlegemuth et al 1998, Wagenbrenner 2003).

Project Design and Implementation Team Information

Design

Review the BAER assessment team findings on the ground to validate the treatment areas. Use stakes, flags, or GPS coordinates to identify the treatment units.

Identify the applications method: hand seeding, drill seeding, or aerial seeding for large areas. Have the archeologist review the area if ground-disturbing methods are recommended to create a seedbed.

Coordinate with the botanist to identify any no-seed areas and delineate accordingly. Work with the botanist to ensure that the seed selected is appropriate. Soil types, climatic factors, timing, natural regeneration, and slope all factor into revegetation objectives. The criteria for selecting seed species includes (Smith, unpublished paper):

- Effectiveness for erosion control.
- Compatibility with other resource objectives.
- Species adaptability.
- Native versus nonnative species.
- Number of species in mix.
- Certified seed.
- Seed laws.

Once the seed method is selected, consult the BAER Web site for information on applying seed with helicopters and fixed-wing aircraft. The lesson plan, Aerial seeding – Planning and Implementation, outlines the steps to implement a seeding treatment. Drill seeding also is common in flatter topography. In many cases revegetation is improved by selecting the appropriate time of application and cultivation method, such as drill seeding, aerial, or harrowing.

Safety

Seeding is implemented safely when all hazards are mitigated and reviewed daily to avoid injuries. Include the following in the JHA.

- Hazard trees within treatment units
- Application using helicopters or fixed-wing aircraft
- Access to treatment units

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Was the correct amount of pure live seed applied?
- Were sensitive or no-seed areas avoided?

Effectiveness

- Are there signs of rilling or sheet erosion?
- Did the seed germinate and provide effective cover to stabilize the soil?

Figure 40—Loading seed into the aircraft.

Figure 41—Helicopter with bucket for applying seed.

Figure 42—Validating the proper seeding rate with monitoring cards.

Figure 43—Seed germination the first winter.

Figure 44—Seeded area is prone to accelerated erosion during the first year.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Treating noxious and invasive weeds prevents the serious threat these plants have on ecosystems. Depending on the plant type, and its response to fire, the BAER team may recommend chemical, biological, hand, mechanical, or prevention-seeding to treat invasive plants.

Description
Noxious weeds are listed on the Federal and/or State noxious weed lists. Invasive weeds are plants that have been introduced into an environment outside their native range.

Noxious-weed specialists on BAER teams evaluate the potential for spread from existing populations and from proposed BAER activities. Once the weed characteristics are known, the BAER team recommends a method for the threat consistent with forest direction. For example, chemical or biological treatments are allowed only if the affected area has a completed environmental document.

Surveying an area where the threat of noxious or invasive plants is identified is the first step. If noxious or invasive plants occur, remove isolated populations by hand. Where a robust population exists and the BAER team feels the fire's effect has exacerbated the threat to the ecosystem, mechanical or prevention seeding is recommended (BAER Guidance Paper-Noxious and Invasive Weed Treatment).

Purpose of Treatments
Invasive plants are a serious threat to the stability and function of ecosystems. Often these plants rapidly colonize a burned area, reducing other plant abundance and diversity.

Emergency Stabilization Objectives
Noxious or invasive weeds are treated with BAER funds to stabilize and prevent unacceptable degradation to natural and cultural resources.

Suitable Sites
This treatment is intended for use in one or more of the following locations:

- Sites with preexisting weed species in the area or nearby.
- Areas where fire suppression activities may have introduced noxious or invasive weeds.

Cost
Costs vary depending on how the population is treated. Common treatment methods are chemical, biological, and hand- and prevention-seeding. Consult with the forest BAER coordinator or the regional BAER coordinator for cost information. Cost factors include the following variables:

- Treatment methodology selected
- Site location and access
- Frequency of detection survey required
- Size of area for detection survey

Treatment Effectiveness
No data on treatment effectiveness is available. If a BAER team is considering treatments, check with the regional BAER coordinator to get informal feedback on effective methods. Effectiveness monitoring of the different methods is needed.

Project Design and Implementation Team Information

Design
Review the BAER assessment team findings on the ground to validate potential locations. If the BAER team recommended seeding or chemical treatments, establish the treatment areas with flagging, staking, and identifying treatment area coordinates.

If the BAER team recommended a mechanical treatment, ensure that proper archeological clearance is received prior to implementation. Establish treatment area perimeters so that archeologists, botanists, contractors, and contract inspectors know the extent of the treatment areas.

If the plant's response to fire is uncertain, then much of the work is detection. Survey to see whether the plants move into an area or how they reestablish themselves after a fire. Map areas of potential infestation and establish a detection survey schedule. Identify whether other USDA Forest Service personnel are working in the area and whether with training, they can help with the detection survey. Document the detection survey schedule throughout the year and, if the plants are found in the areas, determine the method of treatment. Submit a funding request to the regional BAER coordinator to implement the treatment method identified (FSM 2500-2523).

Tools/Equipment
Tools and equipment will vary depending on the treatment method used.

Safety

Ensure that a JHA is developed for the treatment method identified. If seeding with an aircraft, follow all direction for airplanes and helicopters ensuring the safety of the pilots, groundcrew, and field monitors.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Was detection survey set up to establish the post-fire presence of invasive species?

Effectiveness

- Was the treatment effective in preventing or eradicating the invasive species?
- If seeding was used, did it out-compete the noxious or invasive plants?

Figure 45—Invasive plant populations may exist in or adjacent to the area prior to the fire.

Figure 46—Ensure that all straw is certified weed free. Know the origin of the material especially if crossing State lines.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use
Hazardous material stabilizing methods are used when the USDA Forest Service has sole responsibility for the hazardous materials which pose post- fire, health, and safety concerns.

Description
Hazardous material treatments include stabilizing or removing toxic materials created (lead battery burns up in the fire and lead is now leaching out) or destabilized by the fire. Use BAER funds when the Forest Service is solely responsible for the hazardous material. The USDA Forest Service is solely responsible for items that it owns, including batteries, vehicles, and buildings. The Forest Service does not own hazardous materials in a recreation residence or at an abandoned mine. If the Forest Service moves or manipulates any hazardous material that it does not own, the Forest Service could become legally responsible for cleanup of the entire site (BAER Guidance Paper-Hazardous Materials).

Treatment preference for emergency stabilization of hazardous materials is:
- Prevent contamination through site stabilization (e.g., erosion control, ground cover, and so on)
- Control contamination by inplace isolation (e.g., barriers, containment measures, and so on)
- Remove hazardous materials.

Purpose of Treatments
Treatments are prescribed to prevent or control contamination of the area from the hazardous material.

Emergency Stabilization Objectives
Objectives include reducing the threat to human health and/or preventing the unacceptable degradation to natural resources including water, soil, or wildlife.

Suitable Sites
This treatment is intended for use in one or more of the following locations:
- Sites where the Forest Service has sole responsibility for these hazardous materials.
- Hazard is directly related to the fire (did not exist, was unknown, or was not hazardous prior to the fire).
- Hazard poses significant threat to health, safety, or natural resource degradation.

Cost
Treatment cost varies on the method required to prevent, control, or remove the hazardous material. BAER guidance directs treatment prescribed to be the minimum necessary to stabilize the site or relieve significant threats.

Treatment Effectiveness Information
Effectiveness of hazardous material treatments has not been documented. Further monitoring of the types of methods used to reduce the hazard is needed.

Project Design and Implementation Team

Design
Coordinate any stabilization or removal activities with qualified Forest Service hazmat personnel. For hazardous materials not under Forest Service jurisdiction, such as special-use cabins, refer permittees to State or county hazmat authorities for assistance.

If hazardous material is removed from the forest, follow applicable Federal, State, and local regulations. Hazardous material must be removed and disposed of with personnel qualified in hazardous material response.

Safety
Hazardous material stabilization is inherently dangerous. Mitigate all hazards in the JHA to avoid injuries. Include the following in the JHA.
- Unmarked containers containing hazardous materials.
- Unstable ground near mines on forest service lands.
- Unexploded ordinances in burned areas.

Treatment Monitoring Recommendations
Implementation
- Was the treatment implemented as designed?
- Was the treatment implemented in a timely manner?

Effectiveness

- Was the treatment effective in preventing or eliminating the identified threat?
- Was the treatment the minimum necessary to stabilize the site

Figure 47—Hazardous materials may range from large facilities to propane tanks or car batteries.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Heritage site stabilization protects the qualifying site characteristics from exposure by erosion, overland runoff, sun baking, and mechanical disturbance without displacing or damaging the remains.

Description

Stabilizing treatments protect sites, human remains, and artifacts to maintain site integrity and allow vegetative regrowth. Stabilizing methods vary from erosion control and camouflage to strategic manipulation of potential hazards (felling trees to avoid site impacts). Specific treatments used to stabilize heritage sites include the following:

- Covering sites with rolled erosion control mats.
- Removing hazard trees to avoid site impacts.
- Padding human remains to protect remains.
- Using log deflectors to channel runoff away from site.
- Using log-grade stabilizers to reduce downcutting at site.

Purpose of Treatments

Heritage site stabilization reduces erosion and maintains site integrity with vegetative or physical stabilization methods.

Emergency Stabilization Objective

Stabilizing heritage sites prevents unacceptable alteration of any National Register of Historic Places (NRHP) qualifying characteristics. These characteristics include its location, design, setting, materials, workmanship, or association from increased erosion, storm runoff, debris flow, or looting (BAER Guidance Paper-Heritage Resources).

Suitable Sites

This treatment is intended for application in one or more of the following locations:

- Areas of high-burn severity
- Areas within close proximity to trails and access routes
- Areas with little or no remaining vegetative cover
- Areas with highly erodible soils
- Areas of high cultural significance
- Areas where wind-throw would uproot site features
- Areas listed or proposed for listing on NRHP

Cost

Costs vary depending on the size of the area stabilized and the materials available. Hand crews rather than heavy equipment stabilize and disguise sites due to site sensitivity. Mapping the extent of the area at risk defines the extent and the amount of material needed to cover or protect the area. Cost factors include the following variables:

- Crew availability (experienced) to implement the treatment
- Site location and ease of access
- Material availability
- Consultation requirements

Treatment Effectiveness

A literature search of monitoring records for heritage-site stabilization did not show any results. However, in reviewing the fire's effects on heritage resources, the major factor is heat intensity. Heat intensity depends on fuel loading and fire duration. In areas where fires burn brush and move quickly through a site, the damage to the soil profile is less and stabilization efforts are effective. Sites burned with high-soil-burn severity are harder to stabilize. Through analysis of the area's soil condition and information on plant community reestablishment, the BAER assessment team can determine the best stabilization technique.

Project Design and Implementation Team

Design

After the BAER assessment team has designated potential treatment areas, review these field sites with the archeologist to ensure suitability. One key design consideration is defining the threat to the site. Will overland flow, flood, erosion, or tree uprooting be the major threat to the site? Once this is established, select the stabilizing treatment with the archeologist.

Hazard Tree Removal

Hazard tree removal in heritage sites is determined with the archeologist and qualified sawyer. Key design considerations include preventing site damage from falling trees and excessive fuel loading that may threaten the integrity of the site. Review the field sites to determine which trees could adversely impact the site, where the trees could be felled safely, and how the material is removed from the site. In some cases limbs and logs are used for soil cover or log diverters to prevent run-on to the site. Designate a disposal area for material that will not impact the site.

Construction Specifications

1. Map the site and flag the boundary to define the limits.
2. Identify and mark trees to be removed with flags or paint.
3. Flag the disposal area.
4. Designate an area to store all fuel, oil, and tools downhill and outside of the site boundary.
5. Conduct all chain saw fueling, repairing, and sharpening within the designated area.
6. Fell designated trees and use smaller limbs and vegetation for soil cover and camouflaging within the site.
7. Photograph the site after completing the treatment.
8. Monitor the site to evaluate the treatment in regard to reducing adverse impacts from hazard trees.

Erosion Control Mats

Erosion control mats or blankets are commonly referred to as rolled erosion control products (RECPs). RECPs are effective in reducing erosion and sedimentation when properly implemented. RECPs are either synthetic or organic and come in a variety of materials including coconut, wood excelsior, or straw. New RECPs include net-less blankets with biodegradable stakes. Each manufacturer and distributor has a variety of products available depending on specific site considerations.

RECPs are used to stabilize heritage sites that require immediate soil cover. Key design considerations include run-on from adjacent areas, bedrock areas with low infiltration and high runoff, high-burn severity areas, and presence of water-repellent soils.

Construction Specifications

1. Make the soil surface stable, firm, and free of rocks and other obstructions.
2. Follow manufacturer's published installation requirements for the specific RECP purchased.
3. Apply seed or fertilizer to the site prior to installing RECP if seeding is recommended by the archeologist and soil scientist.
4. Unroll the RECP parallel to the primary direction of flow and in direct contact with soil surface.
5. Avoid stretching the material.
6. Overlap edge of adjacent RECPs by 2 to 4 inches.
7. Follow the guidelines for number of stakes or staples to prevent seam separation.
8. Overlap roll ends of joining RECPS 2 to 6 inches in the direction of the flow.
9. Photograph and document the area with a site map after completing the treatment.
10. Monitor the site after the first significant storm event to evaluate the treatment and ensure the mats are functioning as designed.

Log Deflectors

Log deflectors are used primarily in first-order channels where accumulated sediments or debris may direct overland flows towards heritage sites. The channel change is often caused by a sediment fan that deposited in the first-order channels or filled the previous channel. The build up of a sediment fan or channel infilling develops when the time span between wildfires can be measured in centuries. Key design considerations include delineation of the vulnerable area, probable routing locations (where the overland runoff will come from), slope of the area, and a nonthreatening fluvial path to route the runoff (Ruby, unpublished paper). As in any channel modification, the potential to exacerbate the fire's effect can occur if a deflector is not carefully designed by the hydrologist and archeologist.

Construction Specifications

1. Identify storm runoff pathways.
2. Construct log deflectors across a fluvial path at an angle and gradient that does not accelerate runoff and cause soil erosion.
3. Intersect the log with the diversion point at approximately 120 degrees to achieve a safe change in the runoff's direction without erosion.
4. Have the outlet empty into a well defined channel approximately 100+ degrees.
5. Place the log deflectors along the slope simulating the new channel area before digging the trench.
6. Ensure that the deflectors are placed at an angle that approximated the natural channel pattern. If the angle is too abrupt or too gentle the flows will circumvent the log deflector.
7. Ensure that logs are 6 to 9 inches in diameter on the small end, and straight enough to make secure contact with the soil surface for the entire length of the log.

8. Construct a shallow trench in the soil above the deflector to accommodate the channel flow. The trench may eventually become a part of the permanent channel system as the log deteriorates and the channel stabilizes.
9. Map and photograph the site.
10. Monitor the site during or immediately after any runoff event to evaluate the treatment is functioning as designed (Ruby, unpublished paper)

Protecting Human Remains

Design and Construction Specifications

1. If a feature has been uncovered by a fire, take the following steps:
    a. Map the site or feature to define the limits.
    b. Locate and mark the length and width of the padding limits with flagging.
    c. Photograph the site before, during, after padding to maintain a photographic record.
    d. Use GPS coordinates to document its location.
    e. Cover the site with loose native material without packing it.
    f. Cover the feature with 3 to 6 inches of loose soil.
    g. Add another lift of soil that is 6 inches deep and moderately packed.
    h. Place another 2 inches of loose soil in the area as the landform is worked to restore it to the adjacent area with no apparent depressions or runoff paths.
    i. Photograph the padded site.
    j. Armor the site with available rock or organic material.
    k. Leave approximately 2 to 4 inches between rocks to allow for vegetation growth.
    l. Use seed in the area between the rocks to stabilize the site over time.
    m. Cover the seed and site with any unburned vegetation or partially burned vegetation to disguise it. Ensure that the camouflage method does not make the site more visible.
    n. Use a rolled erosion control product to cover the site if no vegetation is available. Jute netting or a netless erosion control product can be used.
    o. Photograph the site after completing the treatment.
    p. Monitor the site after the first storm runoff event to evaluate the treatment in regard to soil erosion stability, vegetation stability, and site visibility (Ruby, unpublished paper).

Tools, Equipment, and Material

This work is done with hand crews and requires an archeologist to be onsite assisting in the design and project implementation.

Tools

- Rakes or McLeods
- Shovels
- Hand seeder
- Wheelbarrow
- Chain saw

Equipment

- Camera
- GPS

Material

- Flagging and staking for treatment areas.

Safety

Stabilizing heritage sites can be hazardous. Consider all the hazards and review and update daily to avoid injuries. Include the following in the JHA.

- Chain saw operation and tree felling
- Hazard trees within treatment areas
- Stump holes and unstable footing

Treatment Monitoring Recommendations

Implementation

- Was the project implemented as designed?
- Did the treatment disguise the site?
- Did the treatment modify the soil surface to disrupt or remove any erosional paths?

Effectiveness

- Did the treatment stabilize the site?
- Did the treatment disguise the site over time?
- Were erosion and storm runoff pathways identified and treated?
- Was the site pilfered or vandalized?