

# Wildfire Restoration Handbook



This field guide was created after extensive fire restoration implementation and monitoring throughout the state of Colorado. The techniques described have been tested and found successful in burn scars including those resulting from the 2002 Hayman Fire and the 2012 Waldo Canyon Fire. This handbook is not intended to be an exhaustive guide to fire restoration techniques, but rather a resource for implementing the most common techniques.

This handbook is a collaboration of the Coalition for the Upper South Platte, Volunteers for Outdoor Colorado, and the Rocky Mountain Field Institute.



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*Special thanks to the Flying W Ranch, a Colorado landmark, for providing a location to test and refine these restoration techniques, and to the staff of Flying W that have made this all possible.*

## Burn Area Safety

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Restoration is important, but your and your volunteers' safety and wellbeing trumps everything. Please adhere to the following recommendations and to the attached Job Hazard Analysis (JHA), the link to which can also be found in the appendix. When considering the safety of volunteers and staff always use the, "Look Up, Look Down, Look All Around" concept; hazards and risks are everywhere within a burned area.

## Safety Briefing

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Hold a safety briefing before work commences. In the briefing, discuss the following:

1. Tasks and Objectives
2. Identify Leaders and Assignments
  - At a minimum, designate a safety officer/lookout, medical officer, and crew leaders
  - All leads should be in high visibility clothing (clothing with high reflectivity and/or bright, easily discernible colors) or other easily identifiable attire
3. Timeline
4. Identify the Hazards and Risks (Use JHA)
5. Emergency Plans and Protocols

## Personal Responsibility

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Whether working by yourself or with a large group, always assume responsibility for your own safety. If anything about a restoration site seems threatening, use your best judgment to avoid a potential accident. Do not wait for a leader to make safety calls for you.

## First Aid & CPR

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All leadership staff should have a minimum of First Aid and CPR training, and emergency first aid kits available. Wilderness First Responder or EMT trained personnel are highly desirable.

## Personal Protective Equipment

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At a minimum, the following personal protective equipment (PPE) should be worn by anyone entering a burn area:

- Hard Hat
- Long sleeve shirt
- Long pants
- Sturdy, above the ankle boots with good tread
- Gloves
- Eye protection (safety glasses or sunglasses)

## Environmental Hazards

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Burned areas are unforgiving. Wind, rain, and sun exposure are very common. With little to no shade, overexertion and heat exhaustion are significant potential risks. To reduce these risks, ensure everyone has ample water, sunscreen, opportunities for breaks, and that some shade has been identified and provided. In addition, be aware volunteers may not be adapted to high altitude environments, and adjust work loads accordingly. Advise volunteers coming from lower elevations or who live out-of-state to take it slowly as they adapt to the environment, stay hydrated, eat nutritious food, limit alcohol before being acclimated, consider altitude sickness medications if appropriate, and descend to a lower elevation in the event of altitude sickness.

## Project Areas

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To ensure no one ventures off and gets lost, flag project boundaries or provide other identifying landmarks (e.g.: "do not work past the stream, or that ridge top") to ensure compliance with work areas. Present maps if needed.

## Working Around Burned Trees

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The following guidelines help reduce safety risks when working in a burned area:

- Designate a Safety Zone and understand your Emergency Evacuation Plan (see Job Hazard Analysis in the Appendix)
- Never enter burn areas on windy days! Even if you have a large group ready, it is best to cancel to ensure everyone's safety if high winds are predicted.
- Always identify a "spotter" during operations. The sole job of the spotter is to watch the standing trees above those doing the restoration work. The spotter should notify others if they see trees swaying, or if winds are increasing and could escalate the overall falling risk. If the wind increases, everyone should move to a designated safety zone. See the [Beaufort Wind Chart - Estimating Wind Speed](#) in the Appendix.
- Assume every tree in a burn area and outside of the burn zone is a hazard tree; trees with obvious defects should be especially avoided. Use extreme caution when working in the vicinity (closer than 1.5 times the height of the tree) of dead and blackened trees or any trees with:
  - Less than 50 percent live foliage
  - Trunk injuries or large broken branches (widow makers)
  - Hanging trees
  - Lightning scars below the top fork
  - Root rot or significant root damage
  - Trees that look rotten or are otherwise compromised
- Consider flagging around obvious hazard trees in advance to make them more identifiable to anyone working in a burn area. This might be done by creating a ring of flagging tape at a safe distance around each identified hazard tree.
- Avoid any physical contact with hazard trees.
- Maintain personal awareness. If the wind increases, stop work and look up at the trees around you. If the trees are swaying or you are concerned about the falling risk, leave the area immediately for a pre-designated safety zone.



## Safety Considerations When Falling Trees

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*Important: Only those personnel properly trained and familiar with hazardous tree removal should undertake any tree removal activities. Trees compromised by fire are some of the most dangerous trees to cut. If a tree is above your skill level, please do not try and remove it; ask for help.*

Ensure all personal protective equipment (PPE) specific to this task is used. Falling trees represent the primary risk to individuals working in burn areas. Trees that were even partially burned may have weakened trunks and/or roots, and can fall at any time. This puts anyone on site at risk. Even unburned trees may fall unexpectedly due to increased exposure to wind after a fire. Consider all trees hazardous.

Removing all hazard trees at work sites prior to events is recommended. This is especially important when badly burned, dead trees are in the vicinity. It is advisable to hire a qualified tree faller to cut down these hazard trees. Partially burned or dead trees often contain rot in the stump sections, making tree felling especially hazardous. In addition to reducing the risk to life safety, removing hazard trees prior to planting also reduces the risk of damage to new plantings when the trees fall or are removed. Felled trees can also be used as log erosion barriers to control erosion in a planting area.

## Tripping/Rolling Hazards

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Steep, barren slopes in burned landscapes can be difficult to navigate. Always move with caution in burn areas, and be sure to not dislodge rocks or logs that could roll downslope into someone working below you. Conversely, do not work directly underneath anyone else on steep, unstable slopes.

If you ever dislodge a rock on a slope, immediately shout "ROCK!" to alert others to the danger. If you are working below a group and hear "rock", do not look up to see where the rock is coming from. Rather, crouch low behind a tree stump, rock, or berm until the rock is clear. Having a backpack and hard hat on (a hard hat is always required) can help to protect you in the event of a rock strike. Once the rock has cleared the work site, an "all clear" should be shouted along with a quick assessment of all participants.

Beware of hidden underground hazards where stumps have burned out in the fire, which leaves hollow areas underfoot that are tripping hazards.

## Storms & Lightning

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Badly burned hillsides may not effectively absorb rainwater. During a rainstorm, these slopes may become dangerous due to mudslides, rolling and sliding logs, rocks and other debris, and high volumes of running water. Avoid planting if significant rain is in the forecast and cease operations if heavy rains develop while working.

Approaching thunderstorms can also bring erratic, powerful winds and lightning. Be especially alert to the risk of falling trees in strong winds before a storm, and observe the 30/30 rule: if you hear the thunderclap within 30 seconds of a lightning strike, stop working outside until 30 minutes after the storm has passed. Vehicles or fully enclosed buildings provide the safest shelters.

## Manmade Risks

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Do not approach within 5 feet of electrical wire, fences, man-made structures or other physical property on the site. Risks in these areas include broken glass, nails, live electrical wires, severed barbed wire, hazardous materials, and jagged edges where structures have burned. Flag off hazards and mention “no go” areas in the safety briefing.



## Tool Safety

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All users of Pick Mattocks, Pulaskis, McLeods, shovels, sledges or other restoration tools should observe the following safety precautions:

- Do NOT use a Pick Mattock, Pulaski, McLeod, shovel, sledge or other restoration tool when you are fatigued.
- DO NOT use a Pick Mattock, Pulaski, McLeod, shovel, sledge or other restoration tool if you have not been trained on the proper usage.
- Do NOT use a Pick Mattock, Pulaski, McLeod, shovel, sledge or other restoration tool that is damaged, or is not completely and securely assembled.
- DO inspect tools before putting them into service (look at the handle - is it smooth with no cracks?; look at the cutting edge - is it sharp and solid?; look at the head connector - is it securely attached to the handle?) Ensure all tools are sharp and in a proper state of maintenance. If a tool is damaged, remove it from service, discard it, or fix it.
- DO use Personal Protection Equipment (PPE). PPE for the aforementioned tools include a hard hat, eye protection, gloves, boots, long pants, and a long-sleeve shirt.
- Carry a Pick Mattock, Pulaski or shovel by the handle, near the blade. When hiking, carry tools at hip level. If on a slope, carry Pick Mattocks, Pulaskis or shovels in the hand on the uphill side. Carrying the tool on the uphill side will ensure if you slide off the trail you will not land on the tool you dropped below. Never carry Pick Mattocks, Pulaskis or shovels behind your neck or over your shoulder.
- When using Pick Mattocks Pulaskis, or McLeods always clear the work area of material that could deflect the Pick Mattock. Your body should be distributed evenly on both legs, with your feet comfortably spread apart to retain balance. The body should be relaxed and free to swing and bend at the waist.
- Keep handles and gloves dry and clean.
- Maintain a 5 meter radius around all individuals working with Pick Mattocks, Pulaskis, McLeods, and sledges.
- Keep bystanders out of the work area.



When swinging a restoration tool such as a Pulaski, Pick Mattock, sledge or other restoration tool:

- Do not overreach, do not cut above shoulder height, and do not raise the cutting or hitting side of the tool above shoulder height. NO ROUNDHOUSE SWINGS.
- Strike at such an angle that the follow-through will not approach body parts (i.e. shins).
- Grasp the handle with hands close together near the end of the handle, with the leading/dominant hand in front (closer to the tool head). Position the leading foot slightly closer towards the work for proper balance. Bring the tool to the height of your shoulder, bending the leading arm's elbow as the leading hand slides up the handle towards the head. On the down swing, let the leading hand slide down the handle towards the back hand. At the end of the swing, the leading hand will again be next to the back hand.
- When swinging a Pick Mattock, McLeod, or Pulaski, be aware of the opposite side of the head. Always keep in mind these are double-sided tools.
- When swinging a Pick Mattock, sledge, or Pulaski, ensure the swing path is clear of possible obstructions that may redirect the tool.
- Be aware of the substrate when using a Pick Mattock or Pulaski. As soil is loosened, clear away the accumulation as needed. Be careful of the tool bouncing back up after hitting a hard surface (bounce-back).
- When using a Pulaski, use extreme caution when cutting small size brush and saplings. When cut, slender material may be whipped toward you or pull you off balance.
- When using a Pulaski to cut a limb under tension, be alert for spring-back to avoid being struck when the tension in the wood fibers is released.
- Use Pulaskis for chopping branches of smaller diameters (1 inch). Use handsaws for larger jobs.

## Re-vegetation

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Promoting growth of native vegetation is critical for restoring post-fire environments. Vegetation helps reduce erosion by stabilizing hillslopes, and is essential for reestablishing habitat and restoring ecosystem function. Reseeding denuded slopes is an important initial emergency stabilization step. Once native grasses are established from seed and are intercepting water, slowing it down and increasing absorption rates, burn scars are more amenable to other restoration efforts such as planting trees. Reforestation is only successful if the right trees are planted in the right conditions. Waiting to ensure areas are ready for saplings is critical for good survival rates and the promotion of healthy forest establishment.

### Seeding

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Ground cover is essential to ecosystem recovery. Seeding with native species is an economical and easy way to restore a disturbed ecosystem. Planting nurse crops such as triticale and sterile oats can serve as an effective method for establishing ground cover. Early seedling germination provides protection against raindrop and wind erosion, and as the ground cover becomes established, provides long-term stabilization of exposed soils and other ecosystem benefits.

Successful seeding is dependent upon proper technique and suitable weather conditions. Seeding during the proper time of year and with the correct technique can mean the difference between a successful and an unsuccessful restoration outcome. Both warm season species (start their growth when the weather warms up in late spring or early summer and produce seed by late summer or fall) and cool season species (grow primarily in the fall or spring when the weather is cooler and produce seed by mid-summer) can be seeded between late fall and early spring. Warm season species can also be seeded separately in the late spring or early summer. It is most important to ensure seeding occurs before moisture is present.



To reseed a disturbed area:

1. Use a **native seed mix** that takes into account:

- The goals of the restoration project
- Appropriate native vegetation for the ecosystem
- Approval of seed mixes by Federal land managers, if appropriate
- Diversity of species, including growth times and habitat benefits
- Ease of germination from seed and species' growth rates
- Species' ability to compete with invasive weeds
- Species' potential to control erosion
- Availability, quality, and cost of seed

2. **Prepare the seedbed** so the soil is loose enough for water and the seed's roots to penetrate the soil, but firm enough so the seed will be in contact with the soil and not easily washed or blown away.

- If appropriate, native topsoil may need to be spread to a depth of at least 6 inches. All disturbed areas should be loosened to a depth of 6 inches prior to spreading topsoil.
- Rake identified areas, ensuring the tines of the rake dig as deep as possible.
- Always rake on the contour of the hillslope. Never rake downhill! Raking downhill promotes erosion and will cause the seed to roll downhill.
- Re-contour any areas of disturbance such as equipment tracks or construction areas.
- Remove any weeds in the area.



3. **Seed** uniformly at the determined rate with the native seed mix, ensuring you have enough seed to cover the entire pre-identified area.

- Lightly rake over the seed mix. Rake parallel to the contour (perpendicular to the slope). Never rake downhill!
- Lightly tamp the soil, which can be done by walking over raked and seeded areas, is also beneficial for promoting seed contact with the soil.

4. Add **mulch** to cover the seed.

- Various materials can be used for mulch. Weed-free straw or native wood mulch are often used.
- Mulch application rates will vary depending on the project.

5. **Water** the seeded area with buckets.

## Other considerations when seeding:

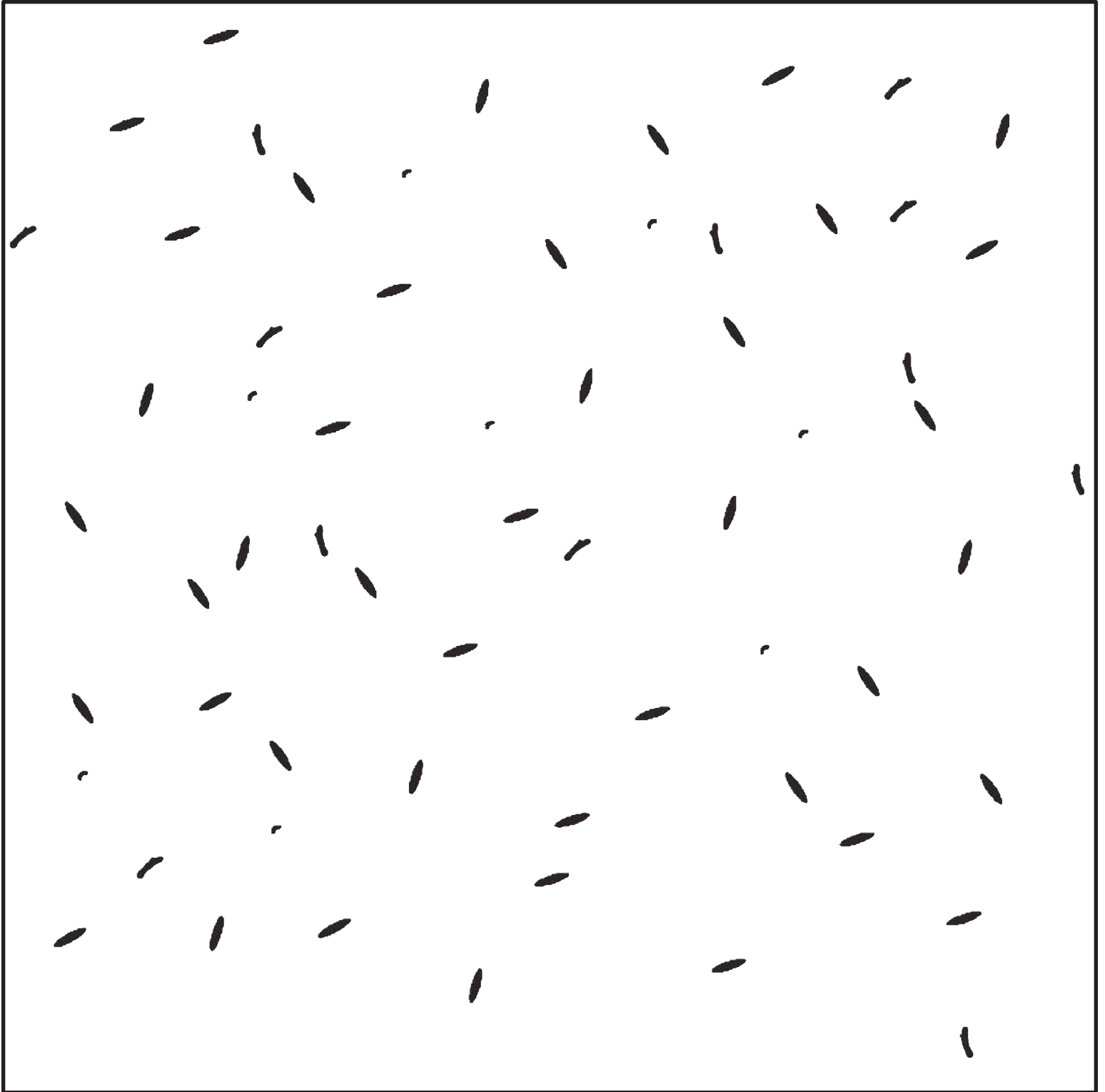
Consider **species acceptability** to the given site. Do not use a one size fits all approach, but rather consider ecological factors specific to the site (see above under native seed mix) when deciding on an appropriate seed mix.

Consider **approval of seed mixes**. If the project is on Federal lands, all seeds must be certified weed free and the species must be pre-approved.

Seeding on a **windy day** may be particularly challenging. Wind can carry seeds out of the work area, making seeding efforts futile and adding to the expense of the project. If you must seed on a windy day, apply the seed about 6-12 inches off the ground, and use the wind to help with distribution. If seed is being disbursed too far, wait until the wind calms down to continue seeding.

Seeding in a **rocky area** also presents challenges, but can be successful. Start by breaking up soil compaction to a depth of at least 4 inches, and then smooth out the seeding area. Spread seed uniformly at the determined rate across the seeding area. Raking may not be available in these rocky areas.





This 8x8 inch square represents a seeding rate of 80 seeds per square foot. Use it to “calibrate your eyes” to recognize this seeding rate.

## Planting & Transplanting

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Planting native plants in disturbed areas can accelerate recovery when plantings are done at an appropriate time and in the appropriate place. Planting large species, like trees, in a wildfire burn scar is only beneficial if the area to be planted has made a sufficient recovery first. In order to ensure high rates of survival, safe volunteer experiences, and the most effective reforestation, trees should only be planted after hillslope stabilization efforts, grass seeding, and hazardous tree felling operations have taken place. Planting methods will vary depending on the species and site.

General planting guidelines:

- Native species must be used. Seedlings must be derived from a source near the planting site to ensure the highest possible survival rates and the most benefit for long-term ecosystem health.
- Follow specific requirements detailing which species are suitable for different elevation gradients.
- Protect exposed roots from direct sunlight, and keep roots moist.
- Summer months are typically too hot and dry to establish plants successfully. However, planting during summer in higher elevations may be feasible.
- Intense sun, extreme heat, and lack of precipitation are much harder on a transplant than a container plant.
- Learn to recognize native plants, weeds, and endangered or threatened species. Never disturb a federally listed or rare species unless specifically directed as part of the project.
- Avoid using weak or sickly plants.
- Amendments such as compost or other organic matter may need to be added to planting areas or individual planting holes.
- Learn about the desired microclimate of the species you are planting and match plantings to that microclimate.
- Within the planting area, try to place plants in spots where rainwater or runoff collects or passes by.
- Look for features such as small rocks or downed logs that will collect moisture and provide some shelter from intense sun and wind. These features should not be so large as to shade out newly planted seedlings. Seedlings should typically be planted on the east side of these structure or upslope when planting on steep slopes.

## Willow Planting

Post-fire erosion and flooding have devastating effects on waterways and riparian areas. Planting willows along streambanks helps stabilize streambanks, improves habitat, reduces erosion, improves water quality, and enhances aesthetics. A basic understanding of what a riparian area is and looks like is needed for successful willow planting.

To plant willows in a riparian area:

1. **Harvest willows** in areas where they are abundant and healthy, creating a 'bank' of willow slips for transplant.
  - Prepared slips should be greater than 1 inch in diameter and 12-18 inches long, cut diagonally on the bottom and flat on top.
  - Willows slips can typically be stored up to 2 weeks if kept in a bucket of water in a shaded area.
2. **Transplant slips** with 60 inch rock bars, shovels, or in some cases, an auger.
  - Plant willows only in areas where other willows naturally occur.
  - Spacing depends on proximity to water, slope, and soils.
  - Assess where the water table is and plant willow slips deep enough to be in contact with the subterranean water for a good amount of time. Typically, this means planting the pointed end of willow stake at least 6 inches deep with at least 4 inches remaining above the ground surface. Willow planting success rates increase greatly when stakes are planted deep enough to access a consistent water supply.
  - Cut any split tops horizontally to create a crack-free surface.
  - Watering with a bucket and the creek may be required.



Willow planting is quick and inclusive of people of various ages and abilities

## Erosion Control Structures

Erosion is one of the most damaging longterm impacts following a wildfire. When high-intensity wildfires sweep through the forest, they leave behind areas of denuded slopes and scorched soils. The impact of erosive forces such as rain and wind are magnified in these exposed landscapes. Erosion robs the land of the fundamental building block of forests as soils slough off barren slopes. Erosion also threatens other values by impairing water quality as sediment enters downstream waterways, increasing the damage caused by post-fire flooding, disturbing and altering habitats, and threatening infrastructure. Controlling erosion using a variety of proven techniques is a critical part of wildfire recovery.



## Understanding Slope

Different types of slopes will require different types of protection from erosion. The land's slope is measured in percents, degrees, or described by a ratio of run:rise. For example, a rise in slope of one foot per ten feet of horizontal distance is described as a 10% slope (rise [1] divided by run [10] x 100 = 10%). Expressed as a ratio, it is 10:1. The degree of a slope is the angle of the slope. A 90° slope would be a vertical cliff face, 0° slope would be flat ground, and a 45° slope is in between the two. As the percent or degree increases, the slope gets steeper. As the slope gets steeper, the ratio decreases. For example, a 4:1 slope (=25% or 14°) is typically a gentle slope, compared to a 2:1 slope (=50% or 25°) that is fairly steep. Generally, a slope equal to or steeper than 3:1 (33% or 18°) will require some type of mulch or erosion control on it. Also, areas that concentrate the flow of water during rainstorms or snow runoff, such as gullies or streambanks, may require extra reinforcement through the use of check dams, drainage control structures, and materials called erosion control blankets.



## Erosion Control Blankets

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Erosion control blankets are used on slopes, streambanks, or other areas of concentrated runoff to provide a protective cover for the soil from rain and runoff. These fibrous blankets can also act as mulch, holding moisture and shading germinating seeds.

Installing erosion control blankets:

1. A restoration professional will **choose a blanket or mat** appropriate for the site and goals of the project.
  - Mats or blankets should be made of 100% natural and biodegradable materials such as straw, coconut fiber, aspen shavings, jute, or combinations of such fibrous materials. Blankets made of plastic or other synthetic materials, even if photodegradable, will not completely degrade and can have negative effects on ecosystems.
  - Straw breaks down the quickest, so is suitable for relatively gentle slopes with no gullies, such as a 4:1 or 3:1 slope.
  - Woven coconut fiber blankets are hardier and are better for areas where erosion potential is very high, including stream banks, gullies, and other areas where water velocity is concentrated and constant.
2. **Seed and rake** the soil in the designated area to promote germination of native seed appropriate for the project.
3. **Smooth and moisten the soil** area that will be below the erosion control blanket.
4. Establish a **perimeter anchor trench** at the outside perimeter of all blanket areas.
  - Dig a 6 inch deep trench across the top of the slope where the mat will start and place the excavated soil upslope of the trench.
  - Fold over the edge of the matting, and place it into the trench.
  - Anchor the erosion control blanket with wooden stakes, about every 2 feet.
  - Backfill the trench and tamp down the soil.



5. **Install the blanket** in full contact with the soil underneath.
  - Remove all large rocks and branches to ensure there are no gaps or voids between the blanket and the soil. If part of the blanket does not touch the ground, water may run underneath the blanket and erode away soil rather than running over the blanket, which protects soil underneath.
  - Unroll the matting down the slope, straightening any folds or kinks.
  - Position and pin the edges of the matting with staples every three feet in staggered rows.
  - At the lower edge of the mat, dig another 6 inch deep trench and secure the matting the same was as at the top.
  
6. Use **joint anchor trenches** to join rolls of blankets together.
  - Join the blankets longitudinally and transversely unless they are on a slope where concentrated flows are not present. In that case, the trenches will only need to be along the perimeter for all blankets except 100% straw, which may use an overlapping joint.
  - Overlap edges by 6 to 12 inches.
  - Anchor the erosion control blanket with wooden stakes every 2 feet.



## Log Erosion Barriers

Log Erosion Barriers (LEBs) are used to intercept water running down a slope, trap sediment, and encourage native species reestablishment. The effectiveness of this treatment depends on the intensity of precipitation and correct installation. Felling of burned trees is very hazardous and should only be completed by trained sawyers. LEBs are used on moderately to severely burned slopes with steepness of 20% - 60%. Depending on the slope, availability of trees, and the burn severity, 60-120 trees per acre is recommended.

### Installing Log Erosion Barriers:

1. **Fell trees** directionally on the contour.
  - Utilize trees no smaller than 6" and no larger than 12"
  - Fell trees to achieve a proper spacing.
  - Leave the stump high to help secure the tree.
2. **Cut a shallow trench** for the log to lay in when dropped.
3. With the tree on the ground, **limb most branches**, leaving any on the downhill slope that may help to stabilize the tree when placed.
  - Limbs that are cut and not used can be spread on the contour above the LEB. This coarseness helps to reduce the water's velocity.
4. Cut branches at 2-4 foot lengths to use as **stakes**. One side should be cut flat and the other side should be cut with a spiked end.



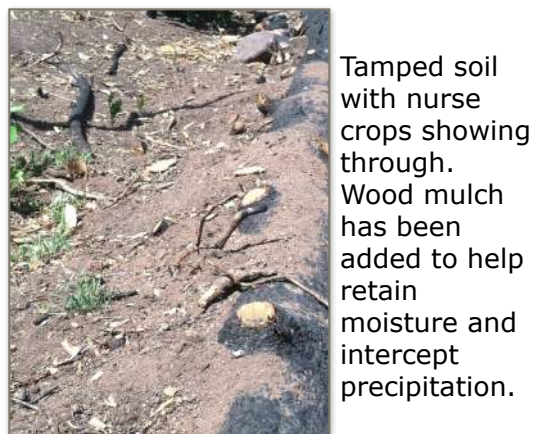
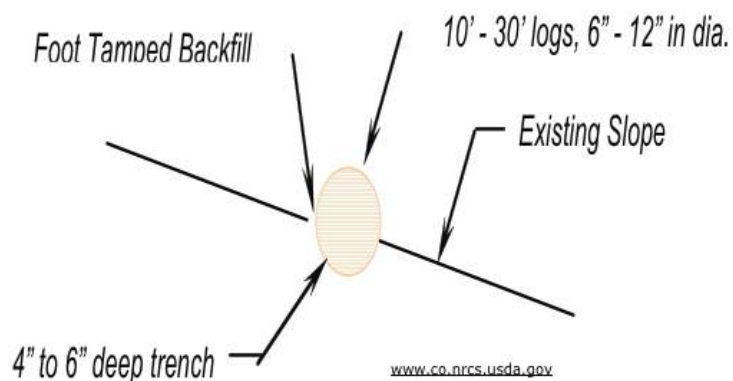
5. **Fill voids** on the uphill side of the tree.

- In some instances (where soils are too rocky or the tree does not sit flat), you can utilize erosion control fabric to fill voids. Fabric should be dug in and attached to the log with small roofing nails.
- If fabric is not suited for the conditions or is not available, use native materials such as branches or rocks to fill any voids on the uphill side of the tree.



6. With voids filled, **backfill with native soils** excavated from the trenching. **Tamp all soil, spread native seed and rake smooth.**

- You should not be able to see any sunlight or any gaps between the log and the existing grade.



Slope steepness (percent)	Burn Intensity	
	Moderate	Severe
	Spacing (feet)	
10 - 20%	60	40
20 - 50 %	30	20
> 50%	15	10

[www.co.nrcs.usda.gov](http://www.co.nrcs.usda.gov)

## Sediment Control Logs/Wattles

Sediment control logs, or wattles, are cylindrical bundles of excelsior, straw, compost, or coconut material designed to form a semi-porous filter and withstand overtopping. These logs trap sediment and reduce the velocity of water running downhill in the same manner as LEBs.

Installing Sediment Control Logs:

1. **Place the log** on the contour of the slope.
2. **Trench** the log into the ground at a minimum of 2 inches.
3. **Stake** the log securely into the ground with wooden stakes.
4. **Fill voids** on the uphill side of the tree.
5. With voids filled, **backfill with native soils** excavated from the trenching.



## Logfalls

Logfalls help mitigate erosion by addressing headcuts and preventing them from continuing to migrate upwards. According to the United States Department of Agriculture, Agriculture Research Services, a “headcut is the sudden change in elevation or knickpoint at the leading edge of a gully. Headcuts can range from less than an inch to several feet in height, depending on several factors. These factors include soil properties, such as density, moisture content and erodibility, as well as factors affecting the flow hydraulics, such as flow rate, overfall height, and tailwater conditions can have a large impact on the headcut advance rate” (USDA, 2008).



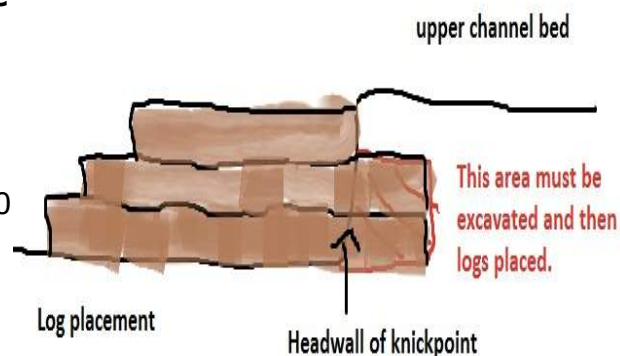
### Installing Logfalls:

1. **Square up** the headwall, sidewalls, and bottom of the channel. **Eliminate the scour pool and any irregularities** (rocks, roots, or indentations) in the channel bottom, sidewalls, or headwall.
2. Use a shovel, spade, Pick Mattock, or crowbar to **shape the site**. Save sod clumps, grasses, sedges and vegetation for use later.



3. After the headcut is "squared up," **excavate** underneath the far headcut wall to facilitate the installation of the first course of logs.

- The excavation of the lower headwall of the knickpoint should be the width of the knickpoint and then cut back 8 to 10 inches. In this diagram, we show only one headcut, however, for multi-step headcuts this should be done at step 1 and step 2 of the headcut to ensure that no undercutting or piping occurs.



4. **Install logs.** Utilize native materials cut to the proper length.

- Always size the material appropriately with the logs increasing in size as they move farther from the headcut lip. The first course of logs should be of the greatest length and largest suitable diameter for the length of channel to be treated. All subsequent layers of logs should be shorter than the last and smaller in diameter so that a slope of 3 to 6 degrees can be created when the log structure is backfilled with topsoil.



5. Use excavated soil to **fill the gaps** and secure the first layer. Tamp all soils into place.

6. With the first layer complete, **measure for the next course** and size the logs larger than the first layer.

- As the work continues downstream toward the main drainage, the logs should become increasingly larger in diameter and in length. Logs are set in place securely with smaller material used as chinking.



7. As the layers, moving from the top down, are finished, work to **re-slope the walls** to the angle of repose.





8. **Tamp** all completed work.

9. **Cover all work.**

- Place sedge mats and native plants where appropriate and cut and re-slope wall angles.



**Before**

Headcut is causing increased erosion and will continue to migrate upslope.



**After**

Base has been hardened, land re-contoured & stabilized. Minimal disturbance of surrounding land.

## Log Cross-Vanes

Log cross-vanes “provide grade control upstream of the structure. Field observations indicate that the use of log cross-vanes is effective at providing bank stability and grade control within the project area” (Billmeyer et al, 2011).

Installing Log Cross-Vanes:

1. **Install two log vanes** extending from the bank to meet at a 20° to 30° angle out from the streambank toward upstream.
2. Ensure the top **elevation** of both vanes decreases from bankfull elevation toward the center of the channel at a slope of 5 to 15 percent.
3. **Key the vanes into the bank** 12-24 inches.
  - Rock may be used to provide additional support. Rock may also be used downstream of the V to prevent scour in steeper gradient streams ( $\geq 7^\circ$ ).



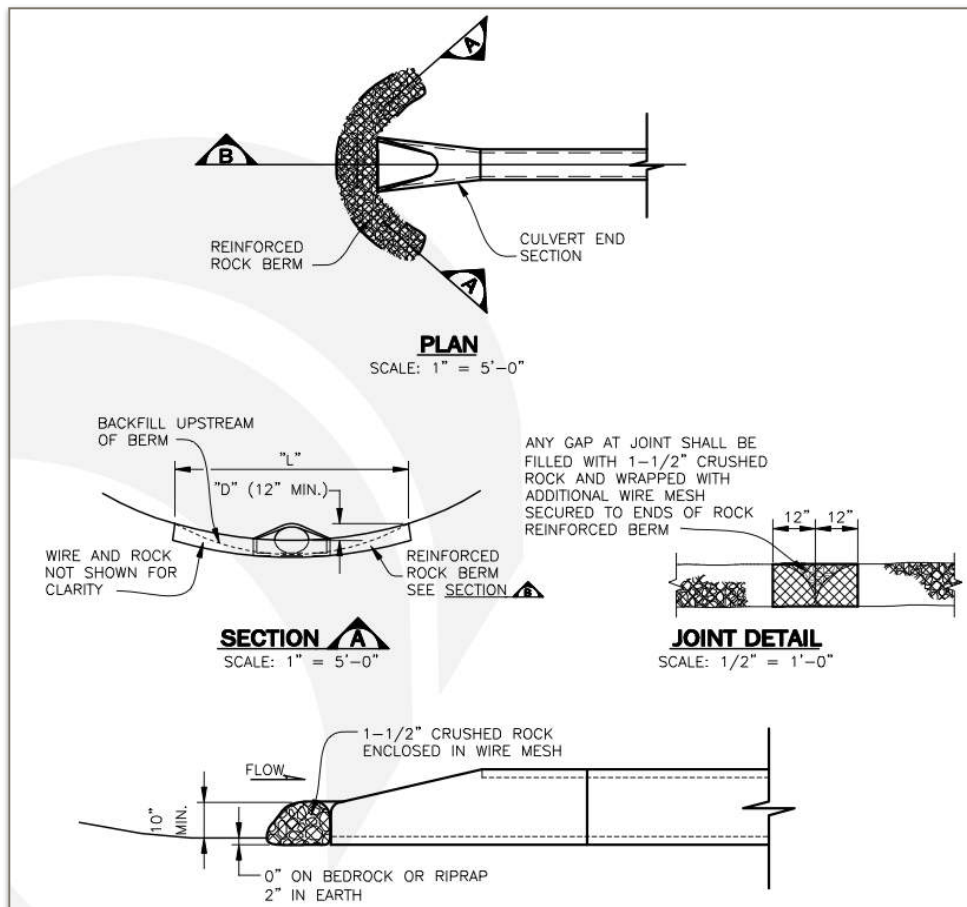
## Reinforced Rock Berms

Reinforced rock berms are useful for protecting culverts by reducing sediment in runoff approaching the culvert.

### Installing Reinforced Rock Berms:

1. Ensure crushed rock is **fractured face** (all sides) and complies with **gradation** as required for drainage size and area.
  - Recycled concrete meeting the correct gradation may be used as well.
2. **Secure 'chicken wire'** (wire mesh made of 20 gauge wire with a maximum opening of 1 inch, with a roll width of 48 inches) using 'hog rings' or wire ties at 6-inch centers along all joints and at 2 inch centers on the ends of the berm.
  - For concentrated flow areas, ensure the ends of the reinforced rock berm is 12 inches higher than the center of the berm.

Reinforced rock berms will be inspected, repaired, and cleaned out as necessary.



## Check Dams

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Check dams are structures designed to span gullies and slow the erosive force of water. As the water slows down at the check dam, sediment will be deposited behind the dam, hence building up a terrace of soil behind the structure. In this way, gullies can be filled up, instead of continually deepening with each new rainstorm or snowmelt. At the same time, check dams allow water to seep into the soil instead of flowing over the land.

The materials and methods used to construct check dams will vary depending on access to the site and the availability of local materials. Structures can be made of locally collected rock or logs, or from purchased materials such as straw bales or straw wattles. Check dams are particularly useful for closing old eroded roads and trails, or on severely eroding hillsides.

The spacing between check dams is determined by the steepness of grade. In general, the steeper the slope, the closer together the check dams.

### Installing a Log Check Dam:

1. **Obtain a log** roughly 18 to 24 inches longer than the area needing a check dam.
  - The diameter could vary from 6 inches to over 12 inches. Use larger diameter logs for areas with deeper gullies or steeper terrain, and smaller diameter logs for shallow gullies.
2. **Dig a trench** and gauge the depth based on the lowest point in the gully.
  - Gullies tend to be deeper in the middle, rather than flat across the bottom.
  - Dig slightly shallower and narrower than the length of the log. If the trench is too big, then water can easily flow around the ends, making the check dam useless, or possibly even accelerating erosion.
  - If the trench is too deep, then you will lose above-ground height of the check dam.
3. **Extend the trench** 9 to 12 inches into each bank of the gully.
4. **Dig out the ends** of the trench to match the depth of the middle of the gully. Be conservative when digging initially, and remember that it is better to dig more later than to try to fill it back in later.

5. **Place the log** tightly in the trench.

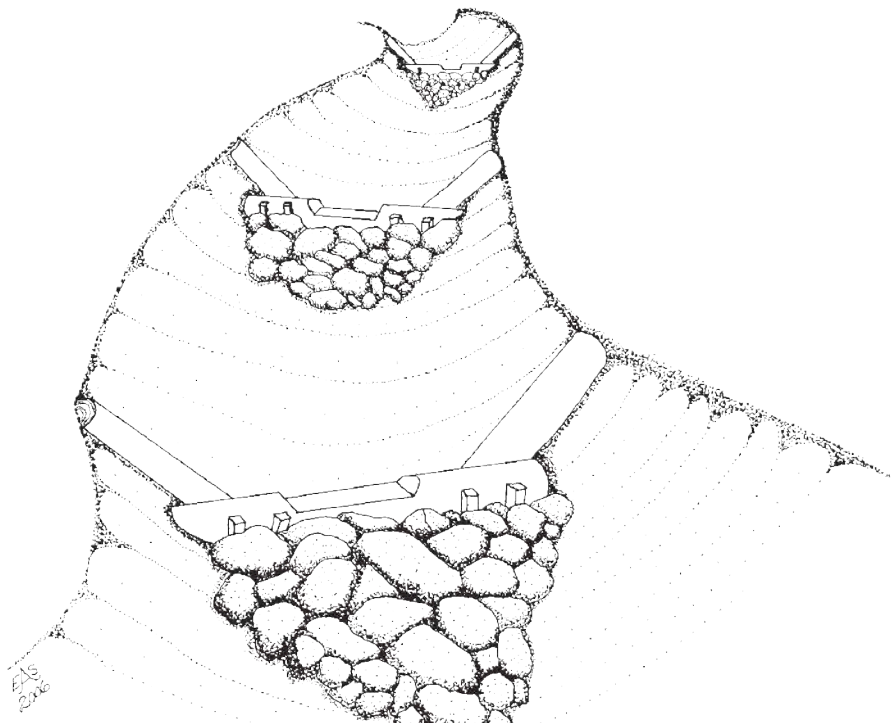
- Install the logs as level as possible, perpendicular to the fall line. Otherwise, water will just flow to the low end of the check dam, reducing effectiveness and eroding the upslope edge along the check dam.
- For large diameter logs in wide gullies, notch the logs at the center of the gully to direct water through the center of the check dam instead of around it. For larger check dams, also build an apron of rock around the outflow of the notch to prevent a plunge pool from forming at the outflow of the dam.

6. **Secure the log check dam** with small rocks wedged in on the downhill side.

- Use logs or rocks to reinforce the gully banks at the sides of the log check dam to keep water from eroding around the dam.

7. On the uphill side of the log, **backfill and tamp** with loose dirt one quarter of the way up the log. Take care not to fill the entire uphill side of the log, as this is where sediment will be trapped in future runoff events.

- For high water flow situations, add reinforcing logs on either side of the gully, upstream of the check dam, to prevent flow from cutting around the check dam.



## Installing a Rock Check Dam:

1. **Pick out a rock** or rocks for the check dam.
  - Whenever feasible, use one large blocky rock with a flat edge to span the entire gully to eliminate the chance of water flow between rocks.
  - If a single rock is not available, use smaller blocky rocks (with a median stone size of 10 inches) with adjoining surfaces that match up as tightly as possible. Small gaps between rocks can be filled with small rocks and soil.
2. **Dig a trench** all the way across the gully to key in the rocks.
  - Plan to trench the rock(s) into the ground a minimum of 8 inches to 1 foot.
  - Try to dig the trench according to the rocks chosen.
  - Be conservative when digging initially.
3. **Extend the trench** 4 to 6 inches into each bank.
  - Ensure the ends of the check dam are a minimum of 6 inches to 1 foot higher than the center of the check dam.
4. **Place the rock(s)** tightly in the trench
  - If using multiple rocks, match up rocks' adjoining surfaces as tightly as possible, and fill gaps with small rocks and soil.
  - Rocks can also be shingled or overlapped in the trench, much like tiles on a roof, to create a more impervious barrier.
5. **Secure the rock check dam** with small rocks wedged in on the downhill side. Fill in the uphill side with packed soil no more than 1/4 of the rock face.

The sediment that accumulates upstream of the check dam will be removed when the sediment depth reaches within half of the height of the crest of the check dam.

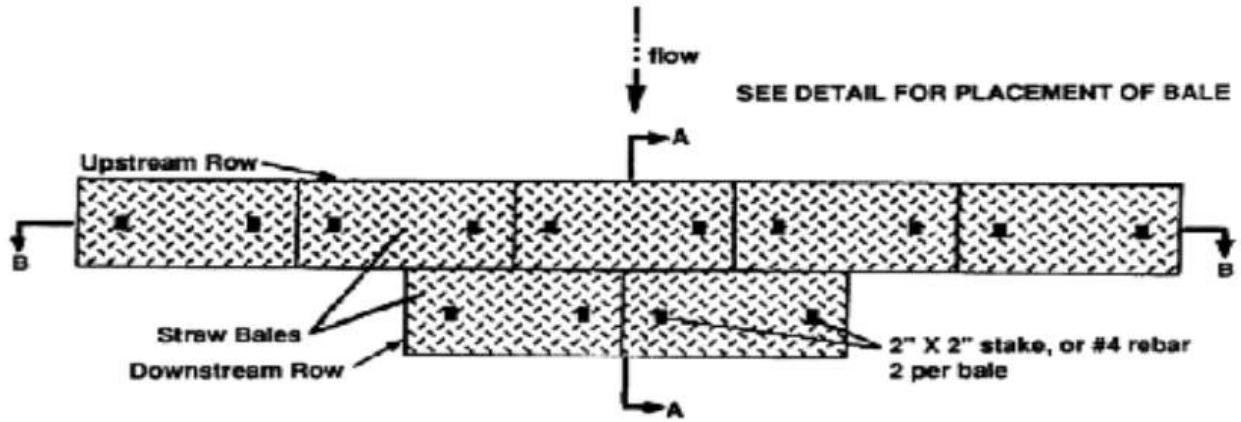
## Installing a Straw Bale Check Dam:

1. **Dig a trench** and gauge the depth based on the lowest point in the gully.
  - Gullies tend to be deeper in the middle, rather than flat across the bottom.
2. **Dig out a trench for the bales** to lay in, about 6 inches deep.
  - Try to dig the trench with a low point at the channel centerline, so the bales can be set into the trench in a wide V formation (if looking at a cross section of the gully) to create a low flow spillway.

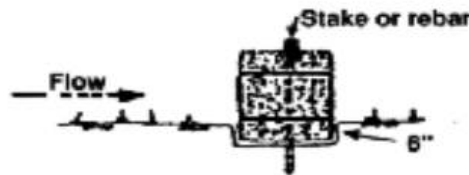
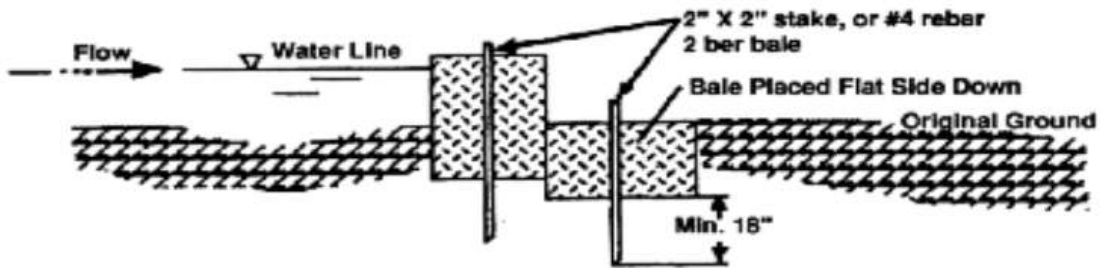
3. **Extend the edges of the trench** at least to the high water mark, if it is noticeable.
4. **Place bales** in the trench in two rows. The first bale should be stood on its higher side. Place bales in the first row on end, width wide. Place bales in the secondary row, or the anchor row, directly behind the first row. Bales in this row are placed short side up and anchored. The secondary row should be approximately 406 inches lower than the first, front row.
5. **Anchor** the straw bales using 2"x2"x3" wood stakes.
  - Make sure the stakes go all the way through the bales and adequately into the soil for anchoring.
  - Up to 4 stakes can be used for each straw bale check dam, but less may be needed.
6. **Create a rock apron** by gathering any gravel or cobble-sized rock in the vicinity of the check dam and placing it on the downslope side of the dam.
  - This rock apron will protect against localized scour and should ideally extend across the 3-foot bottom width of the swale and approximately 1-foot downstream of the check dam.
7. If additional brush is available, **place some brush** on the upslope side of the dam.
  - The brush will help break up the force of major storm flows before they come in contact with the dam.



### Plan - Typical Straw Bale Check Dam



### Section A-A



PLACEMENT DETAIL  
UPSTREAM ROW

REMOVE #4 REBAR  
AFTER STRAW BALES  
ARE NO LONGER  
IN PLACE

### Section B-B

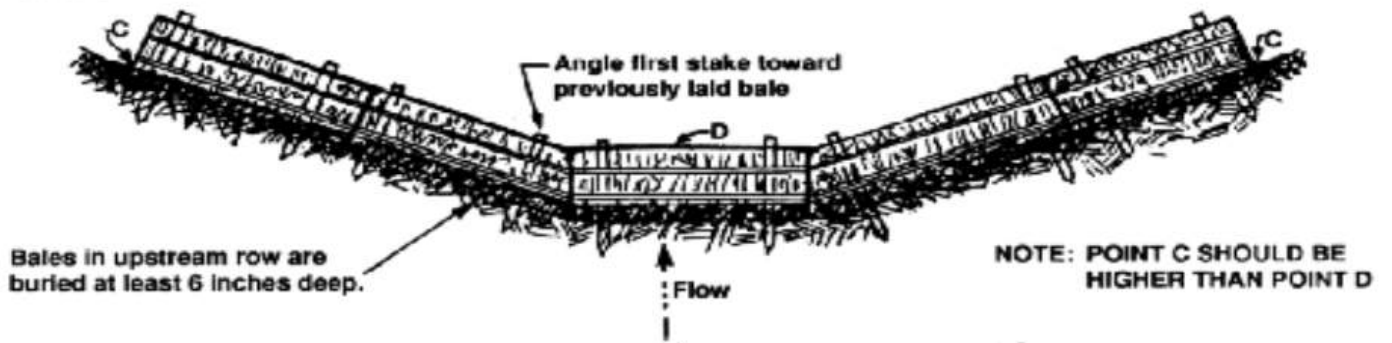


Diagram from: [Natural Resource Conservation Service 2012 Straw Bale Check Dam Fact Sheet](#)



## Resources

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This handbook was created by:

*Coalition for the Upper South Platte*  
38000 Cherokee Ave  
Lake George, CO 80828  
719-748-0033  
<http://cusp.ws>

*Volunteers for Outdoor Colorado*  
600 S. Marion Parkway  
Denver, CO 80209  
303-715-1010  
[www.voc.org](http://www.voc.org)

*Rocky Mountain Field Institute*  
815 S 25th Street, Suite 100  
Colorado Springs, CO 80904  
719-471-7736  
[www.rmfi.org](http://www.rmfi.org)

## References

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Natural Resources Conservation Service. (2012) *Log Erosion Barrier Fact Sheet*. [www.co.nrcs.usda.gov](http://www.co.nrcs.usda.gov).

United States Department of Agriculture, Agricultural Research Center. (2008) *Headcut Erosion*. Stillwater, Oklahoma. <http://www.ars.usda.gov/Research/docs.htm?docid=4115>.

Volunteers for Outdoor Colorado. *Guide to Basic Ecological Restoration Skills*. Denver, Colorado.

Zeedyk, B. And Jansens, J. (2006) *An Introduction to Erosion Control*. Earthworks Institute. Sante Fe, New Mexico.

# Appendix

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## Colorado Native Seed Companies and Material Suppliers

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Colorado Seed Laboratory (seed testing facility)

Mail samples to:

1170 Campus Delivery

Ft. Collins, CO 80523-1170

970-491-6406

970-491-1173 (fax)

<http://seeds.agsci.colostate.edu/seedlab/home-2/>

Granite Seed Company

490 East 76th Unit A

Denver, CO 80229

720-496-0600 (office)

720-496-0601 (fax)

[www.graniteseed.com](http://www.graniteseed.com)

Pawnee Buttes Seed

605 25th St.

Greeley, CO 80631

970-356-7002

[www.pawneebuttesseed.com](http://www.pawneebuttesseed.com)

Western Native Seed

P.O. Box 188

Coaldale, CO 81222

719-942-3935

[www.westernnativeseed.com](http://www.westernnativeseed.com)

## Material Suppliers

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Bowman Construction Supply, Inc (Suppliers of Erosion Control Fabric, etc.)

10801 E. 54th Ave

Denver, CO 80239

303-696-8960

[www.bowmanconstruction.com](http://www.bowmanconstruction.com)

White Cap HD Supply Construction & Industrial (Suppliers of Construction, Erosion Control, etc.)

Several suppliers in the Denver Area

303-534-0661

[www.whitecap.com](http://www.whitecap.com)

Granite Seed (Suppliers of Erosion Control Blankets, Wattles, Mulch, Tackifiers and Silt Fencing)

490 East 76th Unit A

Denver, CO 80229

720-496-0600 (office)

720-496-0601 (fax)

[www.graniteseed.com](http://www.graniteseed.com)

## Technical Resources

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Technical resources available at [www.wphfi.org/?p=1178](http://www.wphfi.org/?p=1178)

NRCS Fact Sheets

[Contour Wattles](#)

[Erosion Control Mats](#)

[Grade Stabilizers \(Cross Vanes\)](#)

[Hand Raking](#)

[Log Erosion Barriers](#)

[Rock Check Dams](#)

[Seeding Fact Sheet](#)

[Technical Notes on Seeding](#)

[Straw Bale Check Dams](#)

[Willow Planting](#)

[Colorado State Forest Service "Vegetative Recovery after Wildfire"](#)

[Beaufort Wind Chart - Estimating Wind Speed](#)

[Printable Job Hazard Analysis \(JHA\)](#)

[Example Liability Release](#)

[Example Volunteer Sign Up Form](#)