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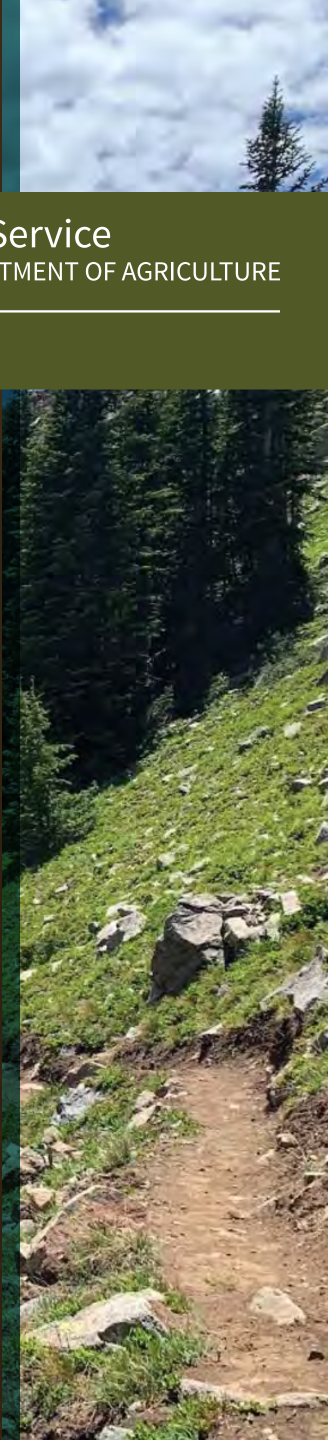
Trail Maintenance and Construction Notebook



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Trail Maintenance and Construction Notebook

2025 Edition

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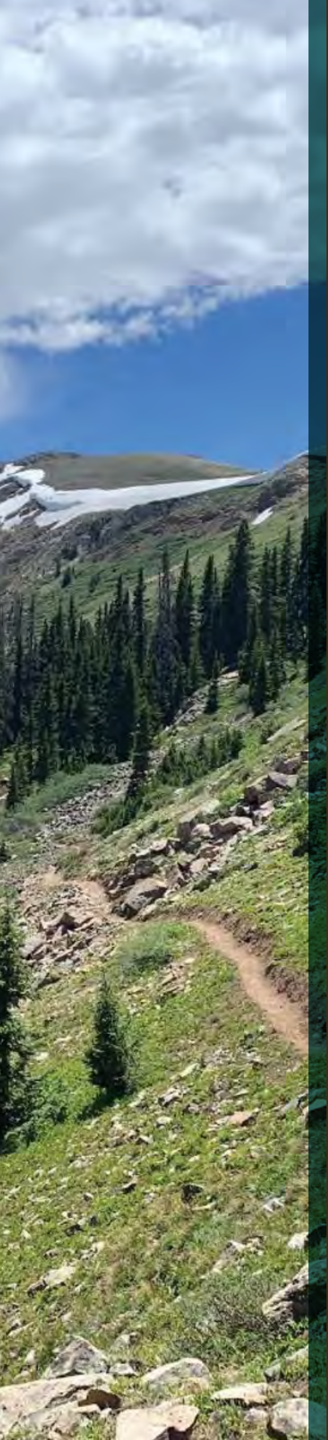


1 INTRODUCTION

1. INTRODUCTION

The U.S. Department of Agriculture (USDA), Forest Service manages the largest trail network in the world, with over 164,000 miles of trails. Continued access to these well-loved and much-needed trails depends on the shared stewardship of agency employees, Tribes, partners, volunteers, contractors, permit holders, communities, and everyone who loves trails.

This notebook is a practical reference for trail maintenance and construction written in an easy-to-understand fashion, with a focus on sustainable natural surface trails. It is not a policy document, and it doesn't cover everything a trail professional needs to know. After reading this notebook, the authors encourage you to learn more and seek knowledge from other people and resources. Attend a trail skills training, invite a trail professional from another area, or explore the documents and websites listed in the "Resources" chapter of this notebook.

Most importantly: get out there, be safe, and do good work.

2025 Edition

This notebook replaces the 2007 version of the "Trail Construction and Maintenance Notebook." The new title reflects where trail workers spend most of their time and resources—maintaining trails. This edition highlights the skill and experience it takes to construct and maintain trails, emphasizes collaborative trail planning, and underscores constructing trails with long-term maintenance in mind.

The notebook features eight chapters: **1. Introduction**, **2. Basic Trail Concepts**, **3. Maintenance**, **4. Structures**, **5. Signs**, **6. Construction and Decommissioning**, **7. Tools and Equipment**, and **8. Resources**. The "Maintenance" chapter describes general maintenance practices. Refer to the "Structures" chapter for maintenance tips about specific structures. The "Tread Construction" section in chapter 6 describes building new trail. The "Resources" chapter provides references and web addresses separated by topic.

Welcome to the trail community! The authors hope this notebook helps you care for the trails you love.

This notebook also draws on a few new resources.

High-resolution photos. Updated photos. Visit the online glossary on the trail terms web page to download high-resolution color photos.

Diagrams and 3D models. Diagrams based on engineer-approved Forest Service standard trail drawings. These are teaching aids and shouldn't be used for construction specifications. Some diagrams are also available as 3D models that can be viewed online (fig. 1–1). Visit the Forest Service Plans for Trail and Trail Bridge Structures web page or scan the QR code to access the 3D models and the full list of engineer-approved Forest Service standard drawings of trail and trail bridge structures.

Diagrams available as 3D models have the word "3D" and a QR code near the image.

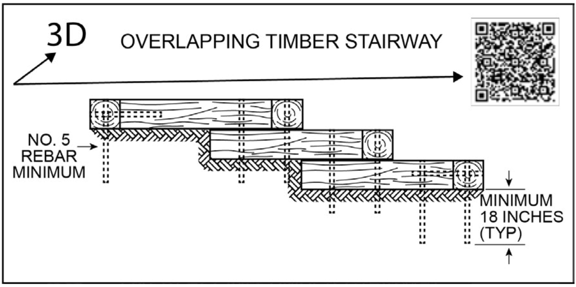


Figure 1–1. Some diagrams have a 3D model available; scan the QR code to access these models. More detailed diagrams of some structures and other resources are on the [Plans for Trail and Trail Bridge Structures web page].

This version of the notebook promotes understanding and problem-solving. Understanding why things are done a certain way is as important as doing them a certain way. If you know why something is happening, you'll figure out how to solve the problem. Soak up the core concepts. Be curious and don't be afraid to fail. Experiment and keep track of the results. Add new techniques and tactics to your bag of tricks. Get dirty and HAVE FUN!

Readers are encouraged to consult Forest Service directives and the trail program website. A companion publication to this notebook, “Trail Structures for Wet, Unstable, and Sensitive Areas,” provides an overview of techniques for building and maintaining trails in saturated soils. These publications are available on the Forest Service’s national publications page.

Before Starting Work

Before starting any new trail project, consider how the project fits with current priorities and line officer support. Project planning should include the scope of the project, how to determine if it’s successful, what environmental approvals you’ll need, needed resources, and the timeline for completion.

In the Forest Service, a “line officer” is someone with decision-making authority delegated from the Chief. Local trail managers typically work with district rangers, who are line officers.

Sample Project Planning Checklist

☐ Consider environmental, social, and economic sustainability in trail planning. Refer to chapter 2.

☐ Does the proposed route support current priorities for the trail program and align with applicable land management plans (forest plan, wilderness management plan, etc.)?

☐ Will the proposed alignment be physically sustainable considering local soils, hydrology, and terrain? Will it affect historic sites or sensitive habitat?

☐ How does the proposed route fit into the landscape and larger trail system, which may include nearby trails managed by other entities?

☐ Does the proposed route satisfy a need for multiple user groups? Consider seeking public input and community engagement on project ideas and engaging nontraditional groups for new perspectives and to attract new trail visitors and potential new trail stewards.

☐ How will the new construction and long-term maintenance be funded? Are grants and other funding sources reliable?

☐ Considering the current workload, can the current or future arrangement of employees, partners, and volunteers conduct annual maintenance on the proposed route?

All trails aren't perfect for all locations. Just because a location appears perfect for a trail doesn't mean a trail is appropriate in that location (i.e., there may be unseen cultural and natural resources). Involve line officers and environmental and cultural specialists before starting work.

Every action that Federal employees, partners, and volunteers take is guided by laws and policies. Before starting work, consider the impacts to the environment and compliance with any Federal, State, and local laws and policies.

Applicable Laws

The National Environmental Policy Act (NEPA) requires Federal agencies to assess the environmental impacts of every action they take and disclose the decision-making process to the public. Forest Service procedures for implementing NEPA are in Title 36 of the Code of Federal Regulations (CFR) Part 220. Line officers must approve and sign an environmental study document for some activities, such as decommissioning routes and constructing new trail. The NEPA "decision document" usually describes how, where, and when work will occur and any required mitigation measures. The local line officer may decide that some actions are excluded from documentation in an environmental assessment or environmental impact statement because they don't significantly impact the environment (categories of action excluded from environmental documentation, a.k.a. "categorical exclusions" are listed in FSH 1905.15, Section 32 – National Environmental Policy Handbook).

The following activities typically don't require a NEPA decision document or project file:

- Grading, cleaning, and maintaining drainage features.
- Grubbing, brushing, and removing downed trees.
- Repairing or replacing existing structures, including steps, retaining walls, puncheons, or bog bridges.
- Installing or replacing reassurance markers or informational signs (e.g., along a trail or at trail junctions, at trailheads and parking areas, or at overnight sites or bridges).
- Resurfacing to original condition, including native material cleanup, gravel replacement, or repaving.

A list of common trail maintenance and construction activities and associated required environmental analysis is available on the Trail Best Practices page of the National Trail Program SharePoint site *(Forest Service internal link)*. Conditions and resource needs vary, so consult the line officer or trail manager before starting work.

In addition to NEPA, other laws and regulations may apply such as the Clean Water Act, National Historic Preservation Act, Endangered Species Act, National Trail System Act, the Forest Service's Travel Management Rule. Working near water also requires special considerations to prevent disturbing sensitive riparian areas or adding sediment to the water source (a riparian area is the zone between the water body and dry land).

During trail maintenance and construction, the local trail manager must comply with all applicable laws and regulations and any mitigation measures described in the associated NEPA decision document.

Working With Partners and Volunteers

In many districts, partners (a.k.a. collaborators) and volunteers contribute substantially to trail work. Engaging partners and volunteers increases the capacity of trail managers to accomplish trail work and promotes public land stewardship. While some trail work requires years of hands-on experience and mentoring, other opportunities—some that don't require swinging tools or carrying heavy packs—engage people of any skill level and interest. The Forest Service invites people of all abilities to assist with gathering trail information, conducting trail inspections, sponsoring trainings, coordinating an event or project, or other less-physical tasks. Whatever task is assigned, partners and volunteers working on trails ideally have the experience or training in the type of trail work being done and the tools being used, are able to follow safe practices, and have approval of the agency trail manager.

Partners and volunteers working on National Forest System lands also need a written agreement signed by the local line officer. Partners typically work under a mutual benefit agreement. Individual and group volunteers work under a volunteer agreement, which provides workers' compensation, tort liability coverage, and coverage for personal property damage or loss. Visit the Forest Service's Partnership Resource Center website for more details.

Partners and volunteers can only work under formal agreement and authorization from the Forest Service. Working independently might cause irreparable cultural or natural resource damage, lessen future recreation access for everyone, and have legal ramifications.

Safety

Personal safety is paramount in trail work. Safe workers demonstrate use of necessary personal protective equipment (PPE), adhere to site and environmental safety precautions, maintain situational awareness, and know what to do in an emergency. Seasoned trail workers will tell you, "nothing we do today is worth being injured for" and "safety is everyone's priority." Consult the Health and Safety Code Handbook (FSH 6709.11). Chapter 20, "Work Projects and Activities," and chapter 50, "Employee Safety, Security, and Health" are particularly important.

Project Risk Assessment and Safety Briefing

Each project or task requires preparing a risk assessment. Three methods are common in the Forest Service: the risk assessment code (RAC) matrix, job hazard analysis (JHA), and green-amber-red (GAR) assessment tool (FSM 6710). Trail managers and work leaders are responsible for conducting or delegating a project risk assessment. The local line officer must approve the risk assessment for the particular task on an annual basis.

Review and discuss the risk assessment document with everyone working on the project before the work begins, when changing work sites, or if conditions change. The discussion should be documented in a tailgate safety form (FSH 6719.8 – Exhibit 06) and include:

- Itinerary (planned route of travel, destination, estimated time of departure/arrival)
- Names of crew members
- Forecasted weather conditions
- Work hazards and abatement actions (including working with specialized equipment and environmental hazards, such as lightning)
- Communication plan (check-in/check-out procedures and crew communication)
- Emergency evacuation plan (refer to the example medical incident report in chapter 8)

It is good practice to hold an after-action review (AAR) at the end of every shift. Example AAR discussion questions are on the back cover of this notebook.

Safety Equipment

A minimum set of PPE is required for all trail work (FSH 6709.11, chapter 70):

- **Forest Service-approved hardhat or helmet** that meets the American National Standards Institute standards (ANSI Z89.1). The line officer can also approve hardhats or helmets that are demonstrated to be at least as effective as the approved head protection.
- **Eye protection** with side protection that meets ANSI Z871.1 for any type of sawing or rock work.
- **Long pants and long-sleeved shirts** for most situations to protect from cuts and scrapes, insects, and sunburn. Short-sleeved shirts may be used based on the risk assessment.
- **Gloves** that protect against severe cuts, abrasions, and punctures.
- **Footwear** with nonskid outsoles that provide ankle support.
- **Other task-dependent safety items:**
  - Hearing protection when working near power equipment (louder than a vacuum cleaner or greater than 85 dB).
  - Dust masks for some types of rock work and in extremely dusty conditions.
  - Cut-resistant or leather laced boots when using a chainsaw or crosscut saw.

- o Chaps or cut-resistant leg protection when using a chainsaw or crosscut saw that meets the requirements of Forest Service 6170-4 or ASTM F-1897 (current version). Chaps must overlap boots at least 2 inches.

Other essential items

- **Personal items** such as foul-weather layers, hat, water, snacks, sunscreen, sunglasses, insect repellent, lip moisturizer, headlamp or flashlight with batteries, and personal medications.
- **Communication devices** such as a radio, cell phone, personal locating beacon—or all three.
- **First aid kit** that includes standard first aid supplies and bloodborne pathogen protective equipment (rubber gloves, face masks, eye protection, and CPR clear-mouth barriers).
- **Mission-essential gear** (not necessarily safety related but will make you more effective) such as trail tools, clinometer, map, compass, GPS unit, flagging, tape measure, notepad, pen, permanent marker, and this notebook.

Don't start the job unless you are properly equipped!

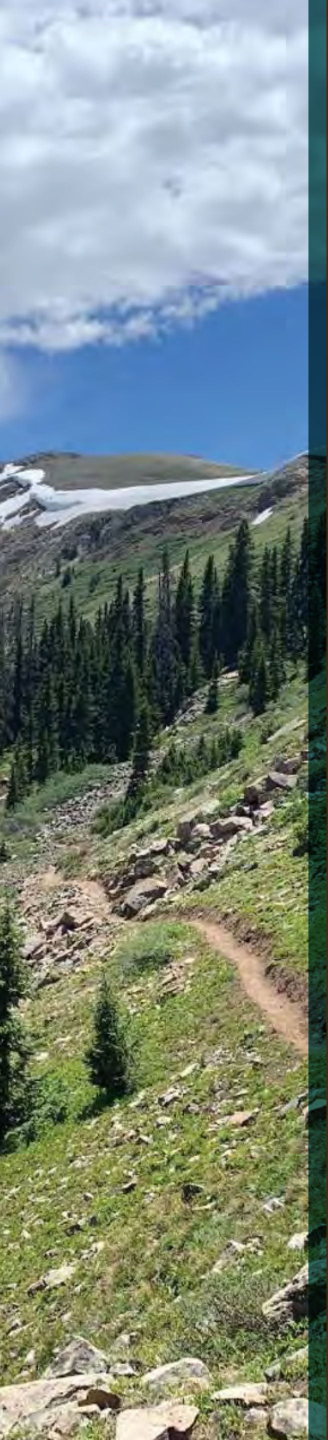
Now that you have authorization and you and your crew are trained and properly equipped, how do you decide where to start?

Project Prioritization

Often the amount of trail work exceeds the capacity of people or time available to do it. Setting priorities ensures that the most critical and impactful work gets done first. Give priority to maintenance work on popular trails that are creating unsafe conditions, and then address erosion or other impacts on approved or user-created routes that are damaging adjacent natural or cultural resources. Forest Service policy does not allow improvements or maintenance to unauthorized user-created routes. Consider the existing maintenance backlog and long-term maintenance needs before adding new trails and when accepting new trail proposals from the public or partners.

The national quality standards for trails (FSH 2309.18 chapter 10) and the trail management objective (TMO) for each trail will help you identify departures from the standards and what maintenance is needed. Refer to the "Management Objectives" section in chapter 2 of this notebook for more information about national quality standards and TMOs.

Also consider the level of use, trail development class, public safety, resource protection, and crew capacity when setting priorities for trail maintenance. Accomplishing small, specific tasks in the proper manner can be more impactful than completing a lot of marginal-quality work.



2

BASIC TRAIL CONCEPTS

2. BASIC TRAIL CONCEPTS

Trail management in the Forest Service means building and maintaining trails that support the agency's mission. Familiarity with a few basic trail concepts helps trail managers think critically about and make decisions regarding trails and trail systems. These basic concepts also give trail managers a common language that describes trails across the system.

Sustainability

Trail sustainability is based on three overlapping concepts: environmental, social, and economic sustainability. All three are important to identify a fully sustainable trail, both individually and as part of the trail network. A sustainable trail is planned, designed, constructed, managed, and maintained in a way that doesn't negatively impact the adjacent natural and cultural resources, meets trail visitor expectations, and is affordable, now and into the future. Sustainable trail construction and maintenance reduces long-term costs, while still delivering high-quality experiences to the public.

Environmental sustainability. Avoids or minimizes impacts to natural and cultural resources. The trail tread and infrastructure can physically withstand the expected effects of human and natural forces.

Social sustainability. Trail users and the community like the trail, use it, and support it.

Economic sustainability. Trained workers and sufficient funds are available to construct, maintain, and repair the trail.

Many National Forest System trails, as well as many user-created routes, are not sustainable in their current alignment (fig. 2–1). Many of these trails, often called "legacy trails," were once game trails, paths between villages and hunting grounds, or routes to access minerals and timber and were not designed or constructed with sustainable principles in mind. Legacy trails suffer from overly steep grades, poor alignment on the landscape, and are difficult to manage. They can also be causing substantial soil loss and trail widening that can lead to damage to natural and cultural resources, poor user experiences, and increasing maintenance frequency and costs. Some may have been incorporated into the forest transportation system as official routes without environmental studies and, in many cases, are not being used for their intended purpose.

Trail managers continue to deal with legacy trails for a variety of reasons—lack of staff to complete an environmental evaluation, lack of resources to accomplish a reroute, or the fact that the legacy trail is well-loved by the public. At some point though, trail managers should ask themselves if the cost of continuing to maintain an unsustainable trail exceeds the effort and cost to plan and implement a reroute.

Figure 2–1. The deeply rutted and abandoned trail on the left (solid line) was built without physical sustainability principles in mind. The trail on the right (dotted line) is nearby and is well-located on a hillside at an average grade appropriate for the prevailing hillside slope and with frequent grade reversals. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

Physical Sustainability

Physical sustainability is a subset of environmental sustainability. This notebook focuses mainly on physical sustainability concepts. The alignment of the trail and location on the landscape, as well as the prevailing soil type and the effect on surrounding natural resources, determine if a trail or trail segment is physically sustainable. The way the trail and trail features are designed determines how the trail will hold up under the impacts of users and anticipated extreme weather events and natural disasters. The most physically sustainable trails are constructed without needing trail structures, such as waterbars, steps, retaining walls, or tread armoring (fig. 2–2).

Figure 2–2. A physically sustainable trail doesn't depend on building drainage structures to drain water off the tread and resist erosion. It is aligned along the elevation contour with an undulating pattern of crests and dips, called grade reversals. Pike-San Isabel National Forests, Colorado. USDA photo by Dani Cook.

Characteristics of a Physically Sustainable Trail

- Requires only light seasonal maintenance.
- Has moderate trail grades less than 7 percent, is routed across sloping terrain, and, where soils and local rainfall patterns allow, may have short steeper segments with up to a 15–percent grade.
- Located on stable soils that are not easily erodible and with features that can withstand use with minimal erosion or damage to the trail tread. Designed to anticipate the effects of the type of severe weather events, wildfires, and other natural disasters most likely to occur in a given area.
- Is “hydrologically invisible” on the landscape. In most cases, the trail follows the contour of the hillside and does not disrupt the flow of water down the hillside or has reversals in grade (a.k.a. undulation) that forces water to drain off the tread without constructed drainage structures.

You are attaining physical sustainability where you can:
Keep water from running down the trail.
Keep tread material well-drained and on the trail.

Water Flow

Water has the power to shape landscapes by moving soil. Improperly managed water can incise tread, remove vegetation, destroy habitat, and deposit sediment into waterways. Water volume, velocity, and dispersion or concentration influence erosion potential.

Figure 2–3. Water and gravity join forces to erode a physically unsustainable trail. Los Padres National Forest, California. USDA photo by Scott Johnson.

Volume measures the amount of water at any given time. The right amount of water increases soil moisture and helps soil particles stick together, making trail erosion less likely. Too much or too little water can make a trail dusty or muddy. Dusty or muddy trails are vulnerable to soil displacement from water, wind, and use, along with other negative impacts.

Velocity measures the speed at which water moves. Water with low velocity can enter and exit the trail without eroding soil or pooling. The faster the water moves, the more the erosion potential. Water with no velocity (or standing water) can make a trail muddy and vulnerable to use-caused soil displacement.

Dispersed flow, or "sheet flow," describes the way water is dispersed down a hillside without being concentrated into channels. Sheet flow reduces the erosion potential of water (fig. 2–4). Physically sustainable trails are designed so they don't capture and concentrate sheet flow coming down the hillside (fig. 2–5).

Concentrated flow occurs when sheet flow is captured and concentrated on a trail that has become rutted or incised. In general, trail managers design trails to avoid concentrated flow because it increases water volume and velocity, making erosion more likely (fig. 2–6). Concentrated flow is appropriate in limited situations, such as the inside ditch of a switchback, a seep(s) (or small spring) in the backslope, or a culvert.

SHEET FLOW

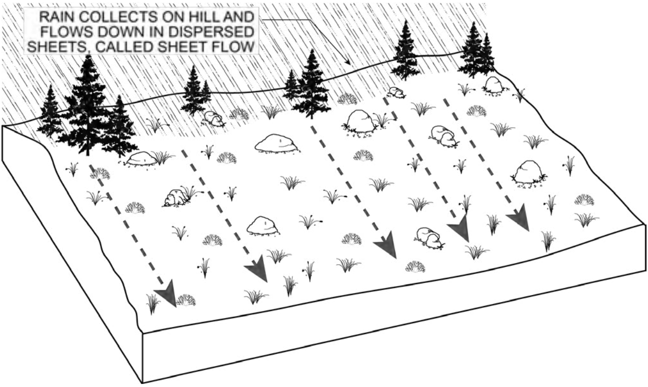


Figure 2–4. Sheet flow disperses across the slope when the soil is saturated.

SHEET FLOW ACROSS A TRAIL

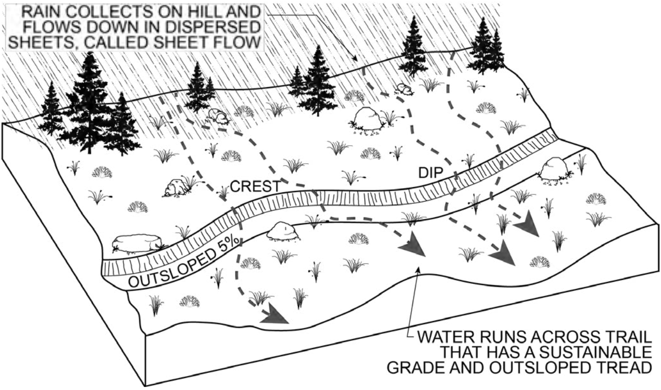


Figure 2–5. Grade reversals and outsloped tread are design elements of a rolling contour trail that promotes water “sheeting” across the trail. Sheet flow prevents water from being channeled down the trail where it will cause erosion.

Figure 2–6. Water has concentrated along the berm, causing erosion. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

Designing trail and trail structures that limit the time the water is on the tread is key to physical sustainability. More water carries more soil. Faster water carries even more soil. More soil loss and channeling leads to more and faster water that begins a cycle of increasing soil loss. The point is to keep water from running down the trail.

Soil

Terra trails are built on mineral soil. Most soils are overlain by an organic layer of twigs, leaves, and grass (a.k.a. duff) that has to be removed to uncover the mineral soil. Mineral soils are mixes of silt, sand, and clay. The percentages of the mineral material determine how a trail drains water and how it holds up under use. The mix greatly affects how trails are designed, maintained, and managed.

Protecting soil against erosion is critical in trail building. Since amending soil is impractical on a large scale, you're stuck with the soil you have. It's best to locate or relocate trails on stable soils that drain water well and hold up under use.

Soil types vary greatly from location to location. If you're not sure what soil exists in a certain area, you can ask a soil scientist or an experienced local trail builder and learn how to field identify different types of soils. The USDA Natural Resources Conservation Service web soil survey is a good source of information about soils common in your area; your local county cooperative extension service office can also provide helpful information.

Table 2–1. Soil types and suitability for trail work

Soil type	Feel or "texture"	Tips for trail work
Sandy	Grainy	Avoid in steep grades because the sand particles don't bind well together.
Silty	Floury	Avoid in low-lying areas that do not dry out as quickly.
Clay	Smooth	Avoid in low-lying areas that do not dry out as quickly.
Loam	Soft with some graininess	Best for trail work. Drains well while holding its structure.

Sandy soils are coarse with space between the particles, making them highly permeable and quick draining. The sand particles don't bind well together, so they compact poorly, displace easily, and should be avoided on steep grades. Over time, gravel and rock will pop out of the tread of sandy soils (fig. 2–7).

Figure 2–7. Sandy soils are easy to drain, but don't bind well together and are not desirable for trail building. USDA photo by Matt Able.

Silty soils are somewhat permeable. They hold some water and can become muddy and slick. They compact well and provide a stable surface when dry. In low-lying areas that are slow to dry out, structures may be required to provide a stable trail tread under heavy use. Silty soils can also be used to build trails with slightly steeper grades than in sandy soils. With sufficient gravel and rock, silty soils have moderate binding potential and reduce the frequency of rocks popping out of the tread (fig. 2–8).

Figure 2–8. Silty soils hold water when they are wet and are floury when dry. They are best suited for trail building when mixed with gravel and rock. USDA photo by Matt Able.

Clay soils compact very well when moist but become extremely sticky, slick, and susceptible to damage when wet. When occurring with adequate rock and gravel, clay soils can create a strong trail tread that resists erosion. However, when the clay is saturated, the tread can easily be displaced due to the swelling characteristic of clay (fig. 2–9).

Figure 2–9. Clay soils hold water and swell when wet. They can create a strong tread when combined with gravel and rock. USDA photo by Matt Able.

Loam is excellent soil for constructing trails. Loamy soil—a mixture of sand, silt, and clay—is the most desirable soil for constructing trails because it is permeable, compactable, and less of a mess when wet. Soil without a combination of clay, silt, or sand will fail in certain conditions (fig. 2–10).

Figure 2–10. Loamy soil is a mixture of sand, silt, and clay and is great for trail building. USDA photo by Matt Able.

Trail Use Impacts

Trail users affect the physical trail as well as surrounding plants, animals, and cultural areas. Different use types have different impacts (table 2–2). Trail creep, rutting, widening, and braiding are results of use compacting and displacing soil. Wildlife can also move out of an area due to noise and plants can be trampled. Greater access to public lands can also mean greater access to important cultural sites and sacred areas.

While water and soil characteristics determine physical and, in part, environmental sustainability, public satisfaction partially determines social sustainability. Savvy trail managers develop maintenance and construction strategies to balance impacts while providing a wide variety of trail opportunities for an equally wide variety of use types.

Compaction. The right amount of compaction, combined with good drainage, is necessary for a trail to hold up under use and to resist erosion. Too much soil compaction can decrease soil porosity, which limits infiltration and water drainage and leads to erosion and trail degradation. The resulting impacts are accelerated on steep trails with inadequate drainage. Too little soil compaction makes the trail tread loose and susceptible to displacement.

Displacement. Shoes, hooves, and tires flick muddy or dry and loose soil to the sides or even off the trail. Soil displacement will deepen trail tread over time, potentially trapping water, breaking down trail features, or causing users to create parallel routes.

Table 2-2. Common effects of different use types on natural surface (terra) trails

Use types	Common effects	Mitigation strategies
Foot travel	Trail widening (users avoid wet areas or travel side-by-side)	Reroute around low or wet areas; install causeway or drainage structure; use vegetation or barriers to constrict traffic width
Foot travel and equestrian riders	Trail “creeps” downhill (users travel on outside edge); trail damage in wet areas	Reroute around or fix wet areas; use barriers on outside edge
Mountain bike riders	Overly insloped or “banked” turns	Reroute to reduce frequency or severity of turns; armoring not recommended on bicycle trails
Motorized use	Rutted, wet soil; displaced rock in stream fords	Public education; remove large obstacles in stream fords; temporary closures for repair or maintenance

Management Objectives

The Forest Service manages many different types of trails. Some are minimally developed and challenging backcountry trails (fig. 2–11), others are highly developed and paved front-country trails. Providing a wide range of sustainable trails that are supported by the public requires the trail manager to think about what need or objective the trail is meeting. The purpose of this section is to describe how trail managers determine the trail design, based on the setting and desired uses and development scale.

Figure 2–11. A rough, narrow trail might be the right choice for foot traffic in a primitive area. Pike-San Isabel National Forests, Colorado. USDA photo by Adam Carroll.

Visit the Forest Service Plans for Trail and Trail Bridge Structures web page for more information about how to apply the design specifications for specific trail types and level of development. The Forest Service Trails Management Handbook, FSH 2309.18, also contains helpful information about trail design specifications.

All National Forest System trails are categorized per the list below. Trail managers use the information to determine the trail design (e.g., how wide to construct the trail or trail structure). They also use the information to establish maintenance standards (e.g., how far back to trim encroaching vegetation) (table 2–3).

- Visual and opportunity setting, also called the recreation opportunity spectrum (ROS) class (fig. 2–12 and table 2–4)
- Nonmotorized and motorized status
- Development scale, also called trail class (figs. 2–13 to 2–17)
- Uses, such as pedestrian or motorcycle

In addition, all trails are also required to meet the national quality standards for National Forest System trails, FSH 2309.18 chapter 10, section 15.

These categories and quality standards assure trails across the system are consistently constructed and maintained to meet the intended purpose of the trail. The design specifications for each trail are documented in a trail management objective (TMO).

Drafting a TMO is also a great way to communicate to line officers and specialists the basic characteristics of the planned trail. Note that standards may change along the length of the trail as appropriate for the landscape through which the trail traverses. For example, a trail that goes from a developed recreation site to a wilderness area would be less developed in the wilderness. In this case, the trail would have multiple segments with different management parameters in the same TMO.

Table 2–3. Design widths and heights for developed trails

Trail type	Tread width	Clearing height	Clearing width
Hiker/ pedestrian	18–36 in (46–91 cm)	7–8 ft (2–2.5 m)	3–5 ft (1–1.5 m)
Pack and saddle	18–48 in (46–122 cm)	10 ft (3 m)	6–8 ft (2–2.5 m)
Bicycle	18–36 in (46–91 cm)	8 ft (2.5 m)	5–6 ft (1.5–2 m)
ATV	60 in (152 cm)	6–12 ft (2–4 m)	5–6 ft (1.5–2 m)
Motorcycle	18–36 in (46–91 cm)	6–8 ft (2–2.5 m)	4–5 ft (1.2–1.5 m)

ATV = all-terrain vehicle

Recreation Opportunity Spectrum

Figure 2-12. Recreation opportunity spectrum (ROS) visual guide.

Table 2-4. Typical trail classes found in each recreation opportunity spectrum (ROS) setting

ROS class	Typical trail development class
Primitive	Minimally to moderately developed (trail class 1 and 2)
Semi-primitive nonmotorized	Moderately to highly developed (trail class 2 and 3)
Semi-primitive motorized	Moderately to highly developed (trail class 2 and 3)
Roaded natural	Developed to highly developed (trail class 3 and 4)
Rural	Developed to fully developed (trail class 3 through 5)
Urban	Highly developed to fully developed (trail class 4 and 5)

Trail Types

The Forest Service manages terra and water trails, and snow trails depending on the season.

- Standard or terra trails are on the ground.
- Snow trails are on snow or ice (and may be co-located on standard terra trails).
- Water trails are on water and may include land-based portages.

Common trail uses on terra trails. The Forest Service has developed design specifications for several trail uses, with more being added as needed. Other uses, including adaptive uses, are also welcome on trails managed by the Forest Service. Refer to the Trail Management Basics web page for more information about trail design specifications.

- Hiker/pedestrian
- Pack and saddle
- Bicycle
- Motorcycle
- All-terrain vehicle (ATV)
- Four-wheel drive vehicle >50 in (127 cm) wide

Trail Development Classes

The level of trail development is divided into five classes, with trail class 1 being the least developed. Tread material and width, presence of obstacles, clearing dimensions (a.k.a. clearing limits), and the amount and type of signs, bridges, and other trail structures vary depending on the development class, as illustrated in figures 2–13 through 2–17.

Figure 2–13. A minimally developed (class 1) trail has an inconsistent tread and native surface. White Mountain National Forest, New Hampshire. USDA photo by Deanna Eastman.

Figure 2–14. A moderately developed (class 2) trail has a rough and narrow consistent tread; obstacles can be continuous. Tonto National Forest, Arizona. USDA photo by Simon Cox.

Figure 2–15. A developed (class 3) trail has a consistent tread and less-frequent obstacles; imported materials may be present. Inyo National Forest, California. USDA photo by Jess May.

Figure 2–16. A highly developed (class 4) trail has a wide and smooth tread, trailside amenities, and likely meets accessibility guidelines. Chugach National Forest, Alaska. USDA photo.

Figure 2–17. A fully developed (class 5) trail has a firm and uniform tread, less than a 5-percent grade, and likely meets accessibility guidelines. Columbia River Gorge National Scenic Area, Oregon. USDA photo.

Accessibility

The Forest Service has an obligation to design a system of trails that provide opportunities to people of all abilities, including trails that meet all accessibility guidelines (fig. 2–18), and adaptive trails designed to accommodate as many types of users as possible (fig. 2–19). Accessibility information about National Forest System trails is typically documented in the TMO for each trail and reflected on the Interactive Visitor Map. Forest Service Manual (FSM) 2353.17 governs trail accessibility requirements. The technical requirements for trails and trail-side features designed for accessibility are operationalized in two documents:

- "Forest Service Trail Accessibility Guidelines" (FSTAG)—technical requirements that the trail meet accessibility standards.
- "Forest Service Outdoor Recreation Accessibility Guidelines" (FSORAG)—technical requirements for constructed features at trail termini and along trails. The requirements apply to all installed features, regardless of their distance from a trailhead, or occurrence in congressionally designated wilderness.

These and other resources are available on the Forest Service Accessibility Resources web page.

Figure 2–18. A trail that complies with trail accessibility guidelines with firm and uniform tread. Sequoia National Forest, California. USDA photo by Scott Johnson.

The FSTAG apply to National Forest System trails and trail structures that meet all three of the following criteria:

- New or altered
- Designed for hikers and pedestrians
- Connects to a trailhead or trail that mostly complies with trail accessibility guidelines

Exceptions to these standards should be a last resort. If an exception is unavoidable, line officers should confer with an accessibility program coordinator.

Characteristics of a typical terra trail and associated constructed features (including trail bridges) designed to meet accessibility guidelines include:

- Firm and stable surface at least 3 ft (1 m) wide
- Passing spaces every 1,000 ft (300 m) (if the trail is less than 5 ft [1.5 m] wide)
- Few obstructions (none over 2 in [5 cm] high)
- Trail grade and trail cross slope less than 5 percent. Steeper grades allowed for short segments or where necessary for drainage (with resting intervals where grades exceed 5 percent)
- Openings in tread surfaces in the direction of travel (e.g., the space between deck boards) are less than 0.5 in (1.3 cm)

Figure 2–19. Trail users of different abilities enjoying a trail designed for adaptive uses. Lake Tahoe Basin Management Unit. USDA photo by Garrett Villanueva.

Location

The location of a trail affects how it interacts with the physical environment, meaning the soil it's built on, the slope of the hillside, and the frequency and amount of rain. The ideal spots for building trails are on hillsides with moderate slopes, stable soils, and limited stream crossings (fig. 2–20). Physically sustainable trails are constructed away from flat areas and ridgelines where draining water is difficult and to minimize the need for switchbacks, retaining walls, or other structures except where unavoidable. Good trails consider vistas and other interesting features while avoiding sensitive areas (fig. 2–21). Trail managers balance the popular desire to be near water with the disadvantages such as potentially allowing sediment flow into water sources, bank erosion, and other risks associated with recreation in riparian areas.

Figure 2–20. The ideal location of a trail is on a hillside with moderate slopes. Monongahela National Forest, West Virgina. USDA photo by Benjamin Shaffer.

Legacy trails—or trails that were not designed or constructed with sustainable principles in mind—are often too steep or too flat in areas and have required the installation of turnpikes, switchbacks, stairs, and other supporting features to make up for the poor location. These features can require frequent and costly maintenance. Prioritize rerouting these trails, especially those that could be damaging the environment, to more sustainable alignments. Install trail structures only as needed to stabilize the tread and limit environmental damage. Chapter 3, "Maintenance," includes tips to mitigate the impacts of unsustainable trails.

Figure 2–21. Well-designed trails take advantage of natural land features. Tongass National Forest, Alaska. USDA photo by Laurent Deviche.

Trail Grade

The steepness of the hillside and the trail segment determines how fast water flows down the hillside or trail. Erosion potential increases substantially with steepness—even in the smallest increments. An overly steep trail is one of the strongest contributors to maintenance issues on existing trails.

Trail managers typically use percent grade when measuring the angle of a trail or hillside. The trail builder can't control the hillside slope or rainfall and drainage patterns, but they can control the trail grade during design and layout of a new trail or reroute. Physically sustainable trail grades can be as steep as 7 percent; short, steep sections of trail can exceed the average grade. Knowing the grades that are appropriate for the soil types and weather and drainage patterns in your area will help you identify the target sustainable trail grade.

To get familiar with sustainable trail grades in your area, use a clinometer in the field to measure percent grade on a sustainable trail segment and compare the grade to an eroded segment. The comparison will give you an idea of the maximum threshold for trail percent grade. In the design process, use a computer mapping system (such as ESRI ArcGIS Pro) to plot potential routes at the target grade and then validate the grade with a clinometer in the field. Refer to the "Using a Clinometer" section in chapter 6 for more information.

How Steep Is That Trail or Hillside?

Percent of grade or hillside slope =

$$\frac{\text{Amount of rise (or vertical distance)}}{\text{Amount of run (or horizontal distance)}} \times 100$$

Know the lingo: The angle of the natural terrain is referred to as “slope” or “hillside slope.” The angle of a constructed trail is referred to as “grade” or “trail grade.” Both measurements are expressed as a percentage and derived using the “rise over run” equation above.

Trails in different development classes have different specified maximum grades. For example, grades on minimally developed (class 1) trails open to nonmotorized users can vary widely from 5 to 25 percent, where grades on fully developed (class 5) trails designed to meet accessibility guidelines shouldn’t exceed 5 percent. The target grade for a particular use and development scale is documented for each trail in the TMO. More information about target trail grades by trail type and development scale is also available on the Trail Management Basics web page.

Slope Ratio

The trail grade relative to the prevailing hillside slope is referred to as the trail’s slope ratio. Trail managers use the slope ratio calculation to estimate how closely a trail segment aligns with the fall line. An appropriate slope ratio is perhaps the single most important thing you can do to make sure your trail requires less maintenance and results in the least amount of environmental impact possible.

Slope ratio values range from 0 to 1, where trails with a slope ratio of 0 are routed horizontally across the hillside and perpendicular to the fall line or across flat ground. Trails with a slope ratio of 1 are straight up the hill along the fall line. Trail segments with high slope ratios (above 0.5) on a hillside will likely need steps, switchbacks, or other constructed features to reduce soil loss—these things take time and resources to construct and maintain. Trail segments with a high slope ratio across flat terrain (i.e., low landform grade and low trail grade) could lead to chronically saturated soils, depending on climate patterns. Either situation is undesirable and should be avoided.

$$\text{Trail slope ratio} = \frac{\text{Trail grade}}{\text{Hillside slope (a.k.a.landform grade)}}$$

Fall Line

The fall line is the path that follows the most direct route downhill. It climbs or descends perpendicular to the contour of the landscape. Fall line trails at or near 1.0 slope ratio are a hallmark of legacy trails that are eroded and channelized. Many of these trails followed the easiest route downhill and in the fall line and were not constructed to follow the contour of the hillside (figs. 2–22 and 2–23). Fall line trails take significant investment in structures and maintenance to maintain their tread (fig. 2–22). Better constructed and more sustainable trails cross the hillside perpendicular to or at a lesser grade than the fall line.

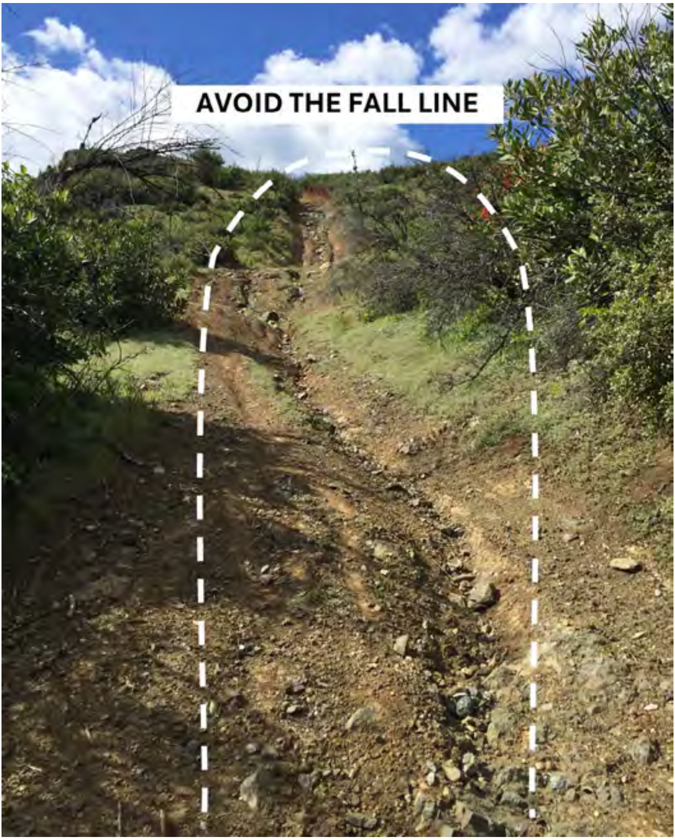


Figure 2–22. Avoid routing trails parallel to the fall line. Fall line trails easily erode, are expensive to repair, and often cause environmental damage. Las Padres National Forest, California. USDA photo by Scott Johnson.

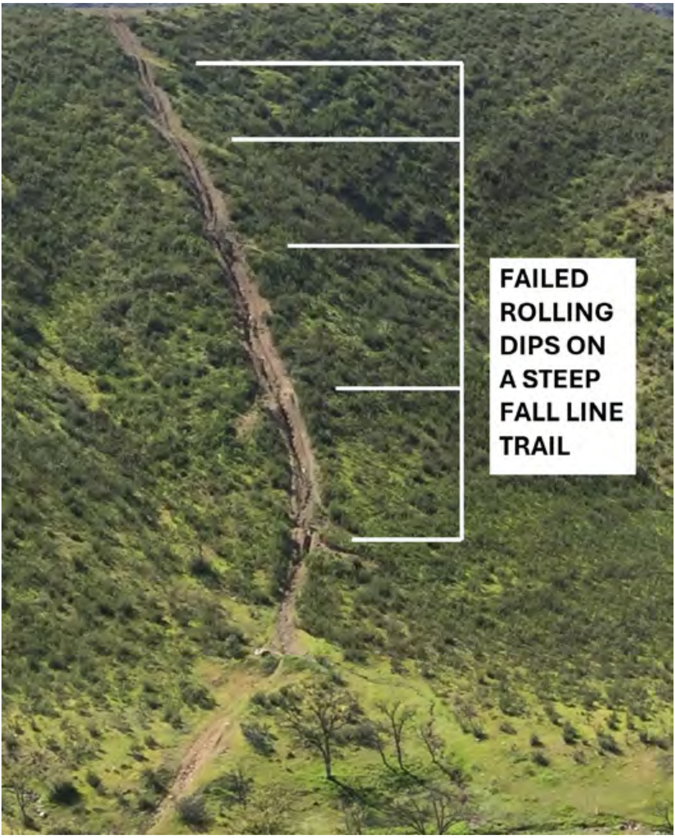


Figure 2–23. Heavily eroded fall line trail with several failed rolling dips. Mendocino National Forest, California. USDA photo by Scott Johnson.

The Half Rule

The “half rule” is a simplified version of slope ratio that refers to a practice of keeping a trail grade less than half of the hillside slope (or 0.5 slope ratio) (fig. 2–24). In general, water will more easily erode the tread if the trail is more than half of the prevailing hillside slope. The hillside slope measures the angle of the hillside where the trail is routed. The half rule becomes less relevant on hillsides with greater than 14 percent slope. The half rule doesn’t dictate that trails can’t be sustainably located on steep hillsides. Rather, in those situations, the half rule shouldn’t be used to determine the maximum sustained grade.

The half rule can be quickly calculated in the field during layout. For example, if you’re working on a hill with a 6–percent slope, your trail grade should be no more than 3 percent. Trails with grades more than half of the maximum hillside slope are considered “fall line” trails. Use your judgment and knowledge of local soils and other environmental conditions to establish the best trail grade that will sustain a stable tread over time.

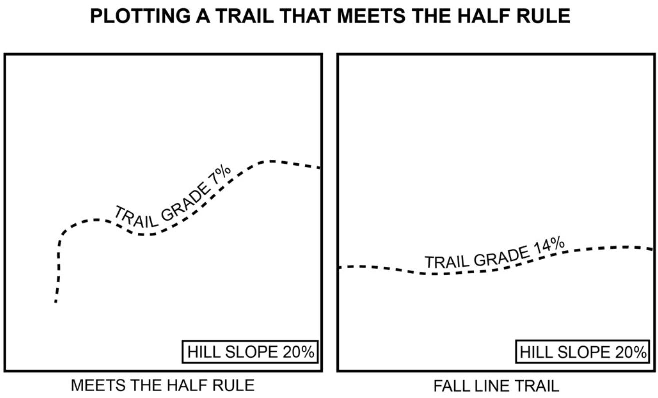


Figure 2–24. Plot a trail on the map with the half rule in mind. Trails with grades less than half of the prevailing hillside slope meet the half rule and will generally be more sustainable. Trail grades more than half of the prevailing hillside slope are fall line trails, will generally be prone to erosion, and require more frequent maintenance.

Rolling Contour Trails

Rolling contour trails are designed to be physically sustainable, requiring few to no drainage structures and the least amount of maintenance. The term "rolling" refers to the repeated reversals in grade or the rise (crest) and fall (dip) of the trail as it traverses the hillside (fig. 2–25). The combination of low slope ratios, repeated grade reversals, and outsloped tread directs water traveling down the hillside to flow off the trail without the need for constructed drainage features.

Trail managers in some places inslope trails to discourage stock from traveling on the outside edge. Check with an experienced trail builder in your area for local best practices for insloping or outsloping the tread.

Characteristics of a rolling contour trail:

- Follows the natural shape or contour of the landscape
- Low slope ratio
- Rolling grade reversals (refer to [chapter 6](#) for more information)
- Tread outsloped 3–5 percent
- A full-bench trail excavated from the hillside to create the trail tread (preferred). Refer to the "[Full-bench Construction](#)" section in chapter 6.

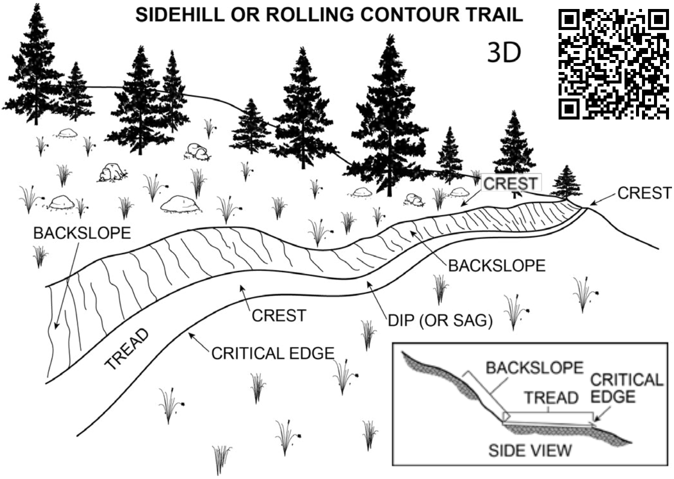
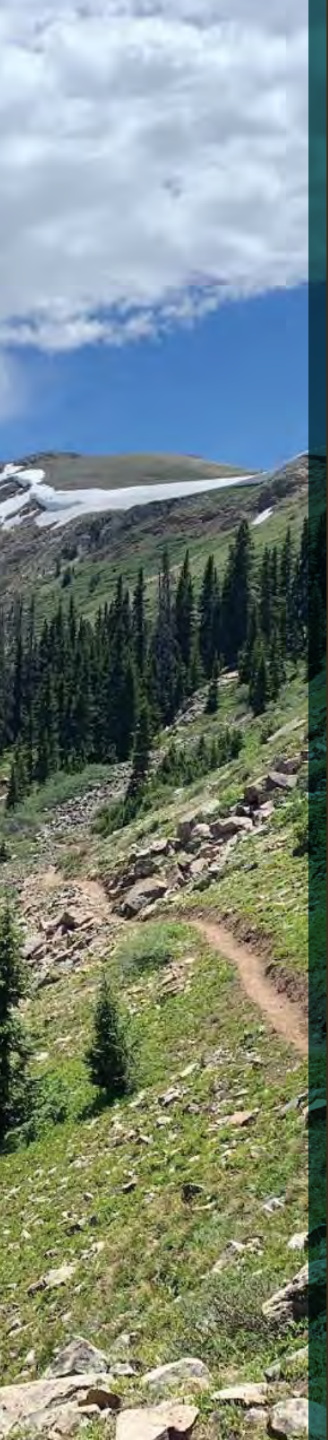


Figure 2–25. Anatomy of a sidehill or rolling contour trail.



3 MAINTENANCE

3. MAINTENANCE

For as long as a trail exists it will need some amount of maintenance. However, the more physically sustainable the trail, the less maintenance it will need. The goal of trail maintenance is to keep or return a trail to a condition that matches the design specifications for the use type and development scale, accounts for user safety and enjoyment, and minimizes environmental impact. We do this by treating the trail corridor and restoring the trail tread and associated features and signs. For more information about the design specifications for each trail, refer to the "Management Objectives" section in chapter 2. The trail management objective (TMO) lists the design specifications for each trail.

Maintenance should treat the problem, not just the symptom. When identifying a problem area on a trail that requires maintenance, find the source of the problem. For example, if a trail has a section that is puddling, figure out where the excess water is coming from. Often the source of the problem lies outside the trail corridor.

Prioritize maintenance projects based on unsafe conditions or where erosion or other impacts are damaging adjacent natural and cultural resources. A planned and prioritized maintenance program is essential to efficiently monitor, assess, report, prioritize, do the work, and document the accomplishments. Savvy trail managers also establish a system for trail workers and the public to report needed repairs or maintenance.

Accurate trail maintenance accomplishment reporting summarizes the need for adequate staffing and maintenance costs. Agency leaders also annually share national reports of crew time, type, supply costs, and miles of accomplishment with Congress.

Trail Assessments

Use the results of trail assessments and trail logs that document your observations and those of your crew and the public to inform your maintenance plan. The data collected also describe the national costs for maintaining trails and addressing deferred maintenance. The information is shared with agency leaders and Congress to help them make informed decisions about priorities and budgets.

The Forest Service uses an established methodology to inventory trail features, document conditions, and estimate needed maintenance costs and resources. The documentation is stored in a database available to employees and partners and volunteers who are granted access. Properly trained employees, partners, and volunteers collect information in the field and enter it into the database. Experienced trail workers use the records to develop an annual maintenance plan.

Before an assessment

Before assessing a trail, review the trail design specifications for the use type, development scale, and other relevant standards. The information is documented in the TMO for each trail. During the assessment, compare the intended design specifications to the current conditions and note any departures.

Refer to the discussion in the "Management Objectives" section of chapter 2 for more information about the design specifications for established Forest Service trail types and development scales.

Components of a good assessment include:

- Good notes that describe the conditions
- Ideas about the material, crew, and timing needed to address problems
- Georeferenced pictures (or pictures with embedded location information) of maintenance needs that correspond to your notes

Conducting an assessment

- Get training in the trail assessment and condition survey techniques approved by the Forest Service.
- Become familiar with prior assessments to understand the effectiveness of previous repairs. For example, why did a rolling grade dip work in one location but not another?

- Starting at the lowest end of the section to be assessed, traverse the entire section first to familiarize yourself with the trail and current features, and then record needs on the way back down.
- Use a clinometer to measure and document the trail grades in areas that are stable and those that are eroding.
- Take pictures of maintenance needs on the tread, retaining walls, steps, boardwalks, signs, bridges, adjacent vegetation, and other trail features (including downed and standing hazard trees).

Assessment tips

- Don't just assess the symptoms of larger drainage issues. Investigate the cause of trail problems, which is often uphill of the symptom or related to the location and alignment.
- Consider how fast brush grows and the effect on the trail corridor when determining how to meet clearing limit standards.
- Identify areas that may require more brushing to maintain line of sight in turns.
- Walk the segment during a rainstorm to discover what drainage issues you may have missed when it is dry.
- Identify drainages that are working and need to be maintained and drainages that aren't working and shouldn't be maintained. Add new drainages only in locations that meet the half rule.

- Consider how materials will be transported to the site and staged for needed repairs.
- Include time estimates for mobilizing materials, tools, and people.

Common mistakes

- Only assessing the trail in dry conditions, when it might not be apparent where water flows or collects.
- Guessing trail grades and hillside slopes instead of using a clinometer.
- Identifying maintenance needs on drainage features that aren't working or are prone to failing (for example a rolling dip on the outside of a turn).
- Not scheduling enough time to complete the entire trail assessment.

Maintenance Plans

Trail managers use maintenance plans to itemize and prioritize maintenance needs, propose solutions, identify the needed crew and materials, and establish project timelines. They also use these plans to spot and diagnose maintenance patterns. If the same type of maintenance is needed year after year in the same spot, then you may be only treating the symptom.

Annual maintenance plans also serve as communication aids. They help you clearly communicate to the public, decision makers, and crews about the problem, material, and effort it will take to finish the project. Being clear about maintenance needs helps decision makers allocate resources, helps you and the crew select the right tools for the job, and helps the public understand the work required to maintain public trails.

Common maintenance plan components

- Baseline inventory of all trails that includes development scale, major use types, typical percent grade, features, centerline locations, status as a national scenic, historic, or recreation trail, and other basic information.
- Results of trail logs, trail assessment and condition surveys, or problem area reports that identify work areas and help establish priorities.
- Identified priority maintenance projects to address safety issues, stabilize trail tread, and prevent resource damage.
- Determination of which project or project components need professional crews or are appropriate for trail partners and volunteers.
- Specialized tools, equipment, and materials needed for priority trail projects.
- Timing limitations for work.
- Documentation of project approval.
- Project status and accomplishments (for reporting).

Sign and Marker Maintenance

Maintain signs regularly by remounting loose or fallen signs, loosening screws as needed if mounted on trees, repairing or replacing signs, and resetting or replacing leaning, damaged, rotting, or missing posts. Regular trail assessments will help you establish sign maintenance priorities and frequency. Refer to the “Trail Assessments” section, above, for more information about how to conduct a trail assessment.

If a sign is missing, consider why it is missing. If signs are repeatedly stolen, use theft-resistant hardware or techniques to mount the replacement (fig. 3–1). If the sign was eaten by wildlife, consider less-palatable materials. If weather or natural events damaged the sign, consider stronger materials, a different location, or a different system for mounting the signs.

Figure 3–1. Bending the ends of through bolts can help prevent sign theft. Mt. Hood National Forest, Oregon. USDA photo by Meckenzie Helmandollar-Powell.

Sign Inventory

Take before-and-after photos to document what is happening to signs in the field and how new signs appear. A good sign inventory with photos makes it easier to order replacements for missing or damaged signs.

Check with the sign manager or trail manager for guidelines that will help you decide when signs should be replaced. Signs in poor condition invite vandalism. If possible, replace signs that have bullet holes, chipped paint, missing or illegible letters, incorrect information, cracked boards, splintered mounting holes, or missing pieces. Consider the consequences of not repairing or replacing deficient signs. Take photos to help portray the situation and record them in the sign inventory.

Corridor Maintenance

The trail corridor includes the tread and the area above and to the sides of the tread (fig. 3–2). Overgrown brush, hanging branches, exposed rocks, and fallen trees are common encroachments into the trail corridor.

Experienced trail workers attest to the singular will and incredible power of plants. No sooner is a trail corridor cleared of plants, than new plants rush toward the new avenue of sunlight. Plus, as trees age, contract disease, or burn, they become weak and are eventually knocked down by wind, snow, and gravity. Cutting this vegetation out is an important maintenance task. Sharp and properly maintained tools are essential for removing and pruning encroaching vegetation.

Only certified sawyers can use chainsaws and crosscut saws when doing work on National Forest System lands. Sawyer training, evaluation, and certification is available for Forest Service employees, partners, and volunteers. Visit the Forest Service crosscut and chainsaw program web page for more information about how to receive sawyer training, evaluation, and certification.

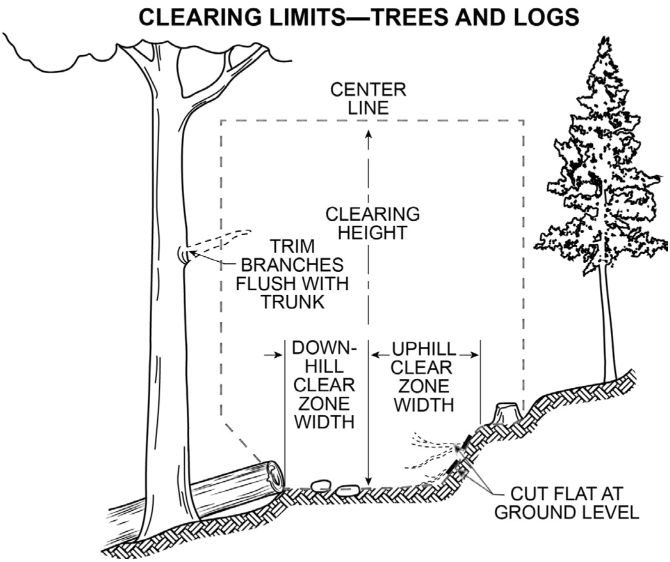


Figure 3–2. Corridor clearing height and uphill and downhill clearing widths differ depending on the type and development scale of the trail. Diagram based on Forest Service standard trail drawing STD 912–01.

Corridor Clearing Dimensions

The trail clearing dimensions (a.k.a. trail clearing limits) are determined by the trail type and development scale (see table 2–3), and objects are removed to a specified width and height. The widths of the trail corridor clearing limits will change depending on the trail type and development scale. The clearing specifications for the particular trail type, trail uses, and development scale are documented in the TMO, including the horizontal, shoulder, and vertical clearing dimensions. Check the TMO **before** heading to the field. Use the widest clearing limit suggested for the allowed uses of the trail (fig. 3–3). Prohibited and allowed uses are documented in the TMO for each trail. Go to the Forest Service Trail Management Basics web page for a full list of clearing limits for different trail use types and development scales.

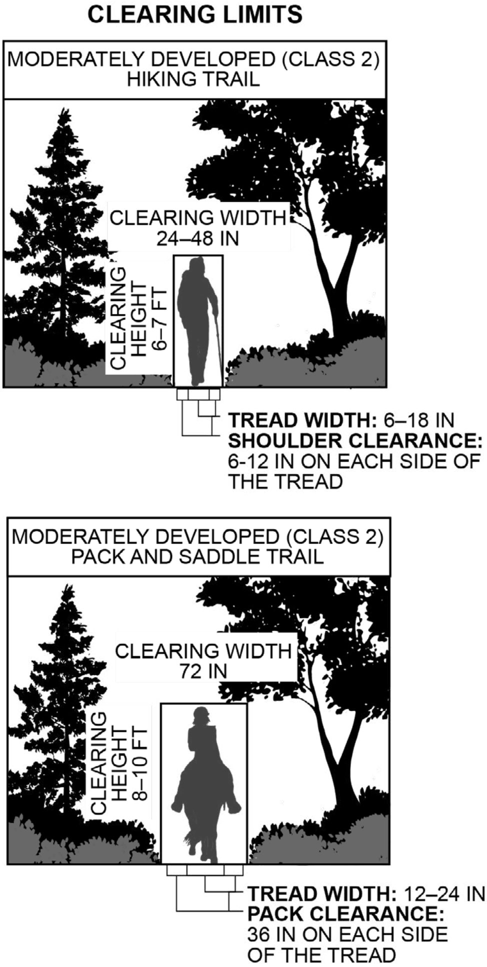


Figure 3–3. The clearing limit for a moderately developed (class 2) trail designed for pedestrians is narrower than a similar trail designed for equestrian users.

Sawyer Certification

Forest Service directive FSM 2358 governs the use of chainsaws and crosscut saws on National Forest System lands. Forest Service employees, volunteers, and partners (a.k.a. cooperators) can access consistent sawyer training, evaluation, and certification. The directives provide for properly qualified volunteers and cooperator groups to train and evaluate their members. Authorized partner organizations may also certify their members.

The Forest Service's "Developing a Thinking Sawyer" chainsaw and crosscut saw training emphasizes risk management, human factors, and sawyer safety. Volunteers and cooperator organizations working under an appropriate agreement can receive sawyer training, evaluation, and certification. Work with the local volunteer coordinator or saw program coordinator for sawyer training, evaluation, and certification opportunities. Visit the Forest Service crosscut and chainsaw program web page for more information.

Brushing

Plants growing into the trail corridor threaten a trail's integrity. Woody brush is a major culprit. Also, those cute little seedlings sprouting up through or adjacent to the tread eventually grow into pack-snagging adolescent trees. Seedlings are a lot easier to pull up by the roots when they are small than they are to lop when they grow up. Thistles, dense ferns, and other encroaching plants may make travel unpleasant or even hide the trail completely (fig. 3–4). If people have trouble traveling the trail tread, they'll move over, usually along the lower edge, or make their own trail. It is important to keep a good line of sight, especially when wheeled traffic is allowed.

Brushing is a common task to engage partners and volunteers. Provide training that includes appropriate brushing and pruning techniques and clear direction about target corridor clearing limits.

Figure 3–4. This trail needs to be brushed. Cut the vegetation out to the specified clearing width for the trail type and development scale. In this case, a nonmotorized developed (class 3) trail open to hikers and equestrian users should be brushed back about 3.5 ft (1 m) from the center of the trail. Flathead National Forest, Montana. USDA photo by Jess May.

Maintenance tips

- Maintain the clearing dimensions documented in the TMO.
- Trim back vegetation before it overtakes the trail. Cutting out an overgrown trail takes a lot more work than simple maintenance.
- On level terrain, keep the trail corridor clear an equal distance on either side of the tread's centerline.
- Cut intruding brush back at the base of the plant rather than trimming at the clearing limit boundary (fig. 3–5).
- Cut all plant stems close to the ground and flush—don't create a sharp end.
- On steep terrain, cut the vegetation and logs further on the uphill side.
- Drag the brush out of immediate sight of the trail and deposit it cut side facing away from the trail.
- With a large amount of brush, use the keyhole (or window) technique. Cut an opening in the brush on the downslope side of the trail that opens into a larger clearing and drag the brush into it.

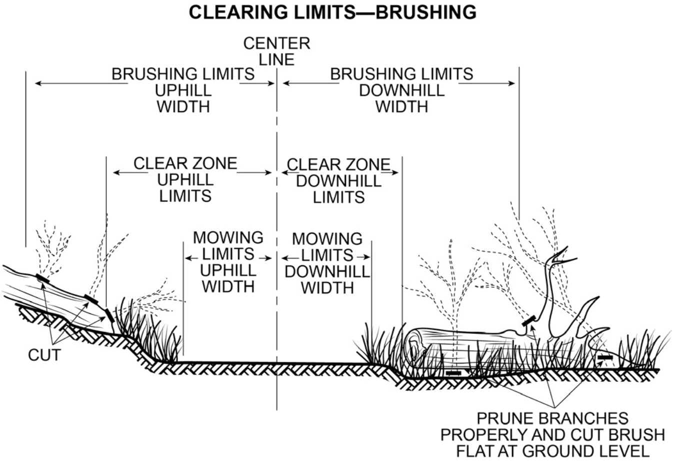


Figure 3–5. The trail corridor clearing dimensions change depending on the trail type and development scale. The clearing dimensions for each trail are documented in the TMO. Diagram based on Forest Service standard trail drawing STD 912–02.

Limbing

Trees in some environments grow faster than in others. Be selective with the branches you cut and prune them correctly (fig. 3–6). Pruning incorrectly can introduce disease and kill the tree. Use pruning to your advantage to create visual barriers that direct traffic and encourage users onto the inside or outside of the trail tread. Clearing more on the downhill side of the trail will help users to maintain an outslope on the trail tread.

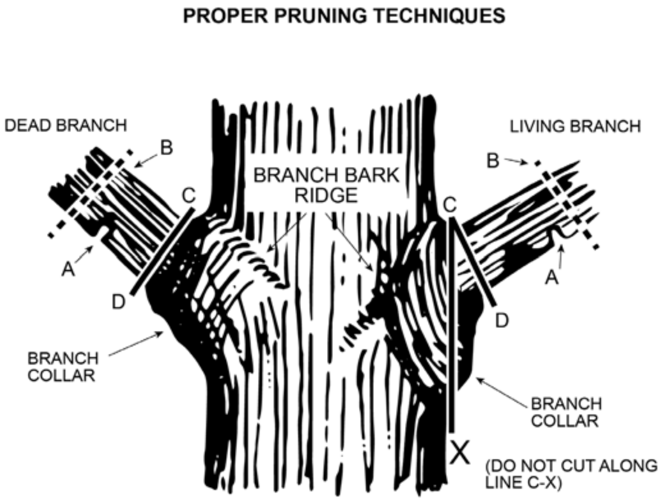


Figure 3–6. Use proper pruning techniques. Removing heavy branches is a three-step process. Make the undercut on the underside of the branch (A). Then make the upper cut (B), slightly to the outside from the undercut. Lastly, cut the remaining stob at an angle close to the branch collar (C-D). Drawing adapted from an illustration by the Arbor Day Foundation.

Maintenance tips

- Use the three-step pruning method (fig. 3–6).
- Use a hand saw (and pole saw for trails open to equestrian riders) to prune limbs correctly.
- Make a small cut on the underside of the branch first and then a second cut through the branch from the top. This will prevent peeling the bark on the tree trunk.
- Consider felling and removing the entire tree if more than half of it needs pruning (fig. 3–7).

- Limb trees in the rain during the growing season to find the branches that are sagging.
- Toss stems and branches so the cut ends lie away from the trail, out of sight, and generally downhill.
- Work with natural vegetation patterns to feather or meander the edges of your clearing work so you don't leave straight lines.

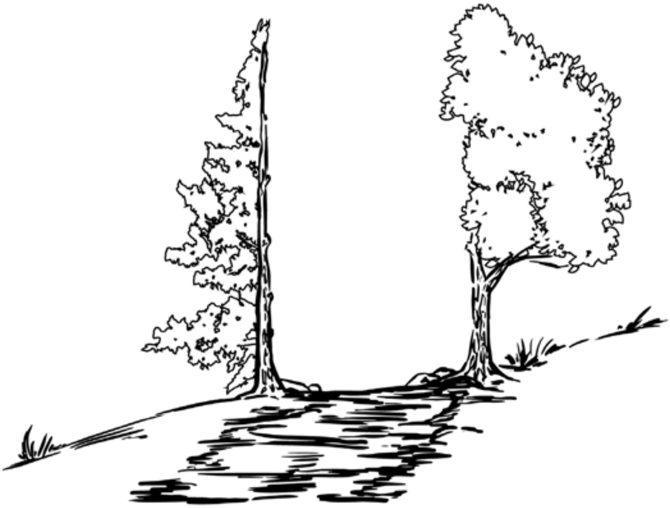


Figure 3–7. This is incorrect. Consider felling and removing trees at the edge of the trail that need excessive pruning.

Common mistakes

- Pruning with an axe.
- Over-pruning that harms trees or creates a visually unappealing setting (fig. 3–7).
- Not maintaining the vertical clearing limits and leaving branches hanging into the corridor that are a barrier to equestrian riders or others at certain times of year (ice and snow can weigh down branches during winter).

Bucking

Cutting out sections of a fallen tree to make smaller, more manageable sections is called bucking. Bucking is common when "logging out" a trail or clearing multiple fallen trees across or down a trail. Only cut out the width specified for the use type and trail development scale (fig. 3–8).

When deciding how and where to cut, keep in mind how bucking will affect water and use patterns. On occasion, a fallen tree can provide an opportunity to reduce the tread width back to the design width (fig. 3–9), for a forced uphill undulation, to create drainage, or to add an interesting bend in an otherwise straight section of trail. Refer to the Draining Water section in chapter 4 for more information about constructing a forced uphill undulation. Bucking trees consistently and thoughtfully also maintains the characteristics of the trail.

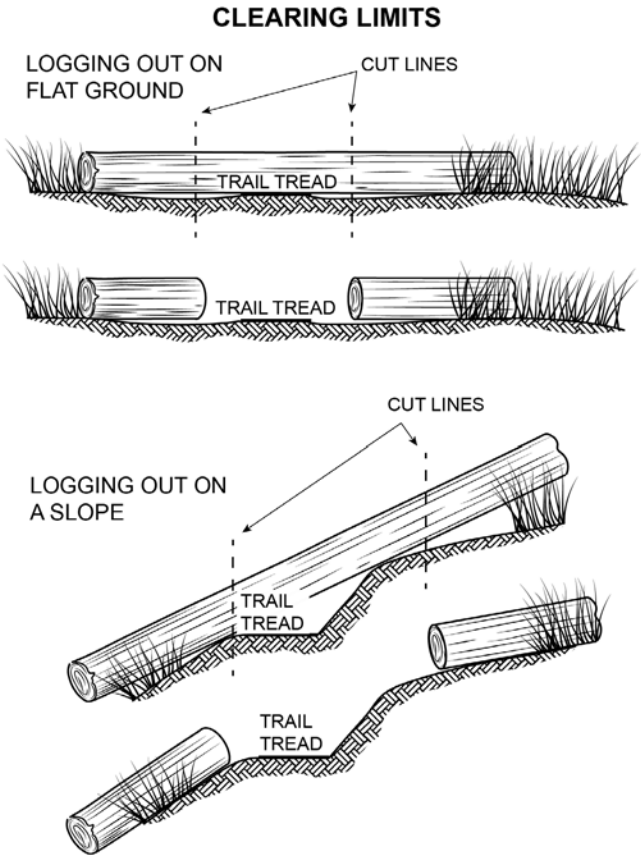


Figure 3–8. Clearing limits can change as the slope increases, particularly on trails open to motorized uses.

Figure 3–9. Cut logs help to keep the trail in place and the proper width. Refer to the TMO for trail design specifications, including appropriate trail width. Tongass National Forest, Alaska. USDA photo by Laurent Deviche.

Logging out a trail is also where you can use your creativity and refine your craft. Rub the fresh cut ends of trailside logs or stumps with soil to reduce their brightness. Cut stumps flush with the ground and cover them with soil, pine needles, or moss. Depending upon the situation, different cuts may be used for the safety of the sawyer, to prevent damage to the saw, and for efficient clearing (fig. 3–10). Compound cuts may be used so that the bucked section will roll away once cuts are completed without having to lift or move bucked logs more than necessary. Seek training and become certified for crosscut and chainsaw use on national forests and grasslands.

Use personal protective equipment, determine forces on the log, and plan the cut.

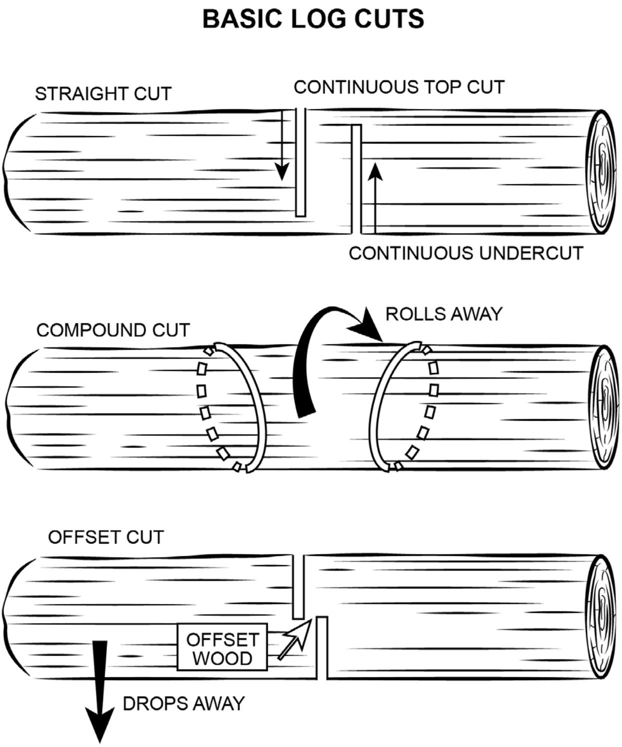


Figure 3-10. Basic log cuts for bucking logs.

Maintenance tips

- Consider using the log as an opportunity to create and stabilize a forced uphill undulation.
- On moderate to steep hillsides, cut logs on the uphill side further back to reduce potential for the log to slide into the trail or if the trail is open to motorized uses (fig. 3–11).
- Roll the log pieces off the trail and outside the clearing limits on the downhill side.
- Place cut logs on the outside of the tread on the downhill side (without creating a dam) to encourage users down the center of the trail.

Common mistakes

- Cutting above your skill level and abilities.
- Blocking drainage outflows by placing logs across or in them.
- Leaving logs perpendicular to the trail on the uphill side—these might roll or slide down onto the trail.

Figure 3-11. When logging out a trail on a hillside, make sure to clear the uphill side far enough off the trail in case the log slides down over time. San Juan National Forest, Colorado. USDA photos by Chris Bouton.

Tree Felling

A hazard tree is a standing tree that presents a visible hazard to people or property due to conditions such as deterioration of or damage to the root system, trunk, stem, or limbs or the direction or lean of the tree. Trail users assume inherent risks associated with outdoor environments. Not every hazard tree along a trail needs to be removed. Hazard tree mitigation should go up as the trail development scale goes up.

Leaners and hung-up trees presenting a hazard should be assessed for removal as skill level, time, and resources allow. If a tree hanging over the trail will be cut down, ensure the bucked section meets the minimum width for the trail type and development scale.

Once you've decided that a tree should be removed, the location of the trail can determine whether a chainsaw, crosscut saw, bow saw, or ax is a more appropriate tool. Using an ax to cut standing or fallen trees poses similar hazards to cutting with a chainsaw or crosscut saw. Gas- or electric-powered chainsaws, as well as other mechanized tools and equipment, are restricted in designated wilderness areas, as outlined in the Forest Service Manual (FSM) 2326. Learn more about traditional tools for working in designated wilderness areas in the Wilderness Connect website.

Regardless of the tool you use, remove root balls completely from felled trees within the tread width.

In certain circumstances, hazard trees that are hung-up or complicated can be removed with explosives to reduce risk and increase efficiency. Check with a trained and certified Forest Service blaster to learn where blasting is feasible. Refer to the Danger Tree Mitigation Guidelines for Managers publication for more strategies to remove hazard trees.

Figure 3–12. Walk away if you are not confident in your ability to safely cut a tree because of the hazards or your level of experience. Flathead National Forest, Montana. USDA photo by Michele Kiefer.

Tread Maintenance

Reestablishing a solid, outsloped trail surface is the main objective of maintaining the tread. Outsloping may not be needed in all situations—check the TMO to determine if it is appropriate for the trail type and development scale. Trail maintenance can be as simple as removing the sticks and stones that have fallen on the tread or started to poke up above the tread as the surrounding soil is removed by use or erosion. It can also be more involved and include repairing or reconstructing trail sections damaged by landslides, uprooted fallen trees, washouts, ruts, or boggy conditions.

Reestablish Tread and Stop Creep

Slough (pronounced “sluff”), berms, and tread creep are common tread maintenance issues that need to be addressed over time. Slough composed of soil, rock, and debris is moved downhill by water and gravity and deposited to the inside of the tread, narrowing the tread.

Excessive slough is often a symptom of an overly steep backslope. Restoring or improving the backslope angle will often fix the problem (fig. 3–14).

Berms are mounds of dirt that typically occur on the outside edge of the tread as water and the feet, hooves, or tires of trail users displace the soil (fig. 3–13). Berms can also be unintentionally created during construction if the trail tread isn’t properly compacted. Remove or break up continuous berms that trap water to allow water to flow across the trail (sheet flow) and not down the trail.

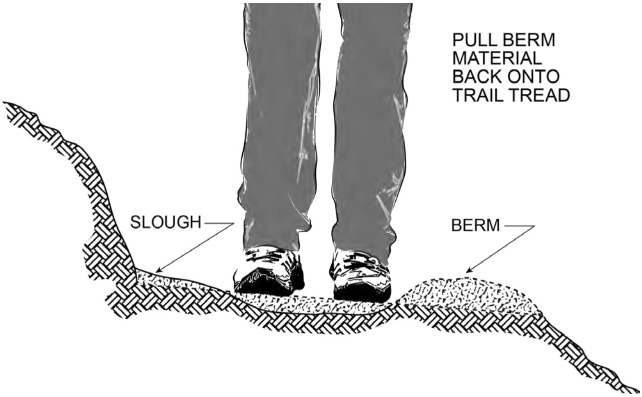


Figure 3–13. Remove the slough and berm, leaving the trail outsloped so water will run off.

Tread creep is often created by trail users or wildlife using the outside edge of a trail on a hillside. The outside edge of the tread will break down when users are forced to the outside by brush, slough, rocks, logs, excessive outslope, and other obstacles on the hillside adjacent to the trail. Pack animals typically travel on the outside regardless of how wide a trail is. This use pattern on the outside edge of the trail tread will slowly move the tread downslope as it becomes the flattest part of the tread, until the tread narrows and eventually fails.

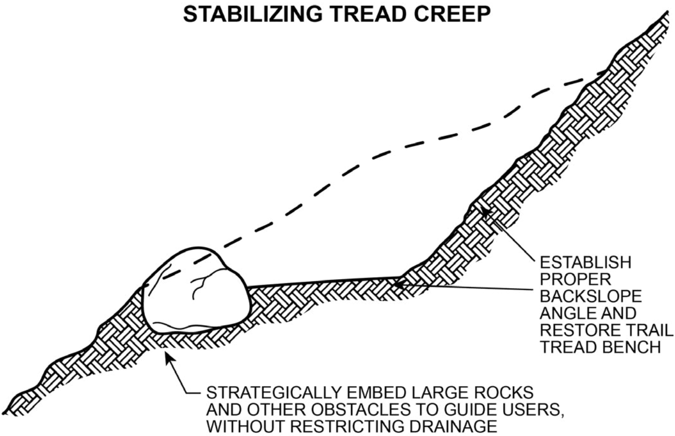


Figure 3-14. A properly installed guide rock or log end can help prevent tread creep. Do not create a continuous barrier that impedes water drainage.

Maintenance tips

- Pull berm material back on the trail and use slough from the backslope to reestablish the original location of the trail tread and tread width.
- Compact the critical (or downhill) edge of the tread to promote drainage and reestablish tread width.
- Place boulders or other objects along the outside edge in irregular locations to keep stock to the center of the tread. Ensure that these objects—also called gargoyles—don't block drainage (fig. 3–14).
- If berms persist, inspect drainage or consider reroutes that increase undulation.

Common mistakes

- Not removing slough during routine maintenance.
- Adopting the new location of the trail that has moved downhill from tread creep (although in some situations this can create a beneficial grade reversal that naturally sheds water off the trail).

Reestablish Outsloping

The outsloped tread on a trail on a hillside is lower on the outside or downhill side than on the inside or bankside. Outsloping allows water flowing down the hillside to sheet across the trail instead of being captured and focused to run down the trail. The technique allows the trail to be "hydrologically invisible," meaning it allows water to follow natural drainage patterns. Outsloping is often accomplished during berm removal. Reestablish the outslope to approximately 5 percent (fig. 3–15).

Maintenance tips

- Shape and compact all tread and sections of backslope that were reworked.
- If the excavated soil in the berm is good for compacting as tread material (not too much clay, not too much rock, no organics, and just the right amount of moisture) then compact the material back onto the tread and shape rolling grade dips.
- If it is not reasonable to remove the entire berm, remove sections at intervals that prevent water from causing tread erosion. Remove sections at least 10 ft (3 m) in length.
- Addressing loss of outslope is a common maintenance problem. Installing knicks in the trail can facilitate drainage without removing the entire berm and reestablishing the outslope. The "Draining Water" section in chapter 4 includes techniques for draining water off existing trails.

Common mistakes

- Using organic material mixed with mineral soil for the tread material.
- Not compacting the tread material well enough.
- Building rolling grade dips with soil that is dry and impossible to properly compact.

TREAD OUTSLOPE

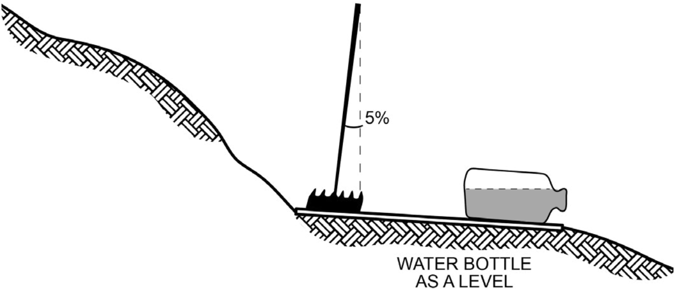


Figure 3–15. Maintain an outslope of 5 percent.

Maintain Drainage

Sediment and buildup of other debris frequently cause failed drainage features. If the drain clogs, the water either continues eroding its way down the tread or forms puddles that can create mudholes. The best drainage structures direct the flow of water at the appropriate velocity to wash sediment out of the drain, keeping it clear and requiring less frequent maintenance.

Maintenance tips

- Reestablish the outslope and width of the outlet to prevent clogging.
- Maintain a smooth transition into the outlet so water flows out of the drain fast enough to keep sediment suspended and slow enough to prevent headward erosion (a.k.a. a headcut) from forming (fig. 3–16).

- Remove the sediment buildup from the outlet and use it for reconstructing the crest or filling ruts above the drainage structure. Never help gravity and always move dirt uphill.
- Mulch the outlet to prevent users from mistaking it as part of the trail, although use care to not clog the outlet with too much.

Common mistakes

- Digging too deep into compacted native soil during maintenance in a way that promotes erosion.
- Making the initial sag and crest too small to accommodate the volume of water and use.
- Excavating outlets and drains too flat, allowing them to get clogged with sediment.

Figure 3–16. Headcut starting from water leaving the trail at too high of a velocity and creating a waterfall effect. Los Padres National Forest, California. USDA photo by Scott Johnson.

Walking in the Rain

A lot of learning takes place when you slosh over a wet trail in a downpour and during spring snow melt. Watch what the water is doing and how your drains and structures are holding up. If you notice a large volume of water flowing across the trail, follow it uphill to figure out where the water is coming from and assess where new trail drainage is needed to prevent erosion. Think about soil type, hillside slope, trail grade, distance of flow, and volume of water before establishing priority trail maintenance projects for the year.

Address Trail Widening

Trail widening commonly occurs in flat and muddy areas and on fall line trails. A small puddle can grow into a large mudhole as the traffic skirts the edge and breaks it down (fig. 3–17). In areas of open and moderate terrain with scarce natural barriers, users tend to travel side by side or pass others and cause tread widening.

Excessively widened or braided sections of trail may need to be rerouted; however, in cases where reroute is not approved or possible, install barriers to define the tread width. Use care when placing barriers to avoid pointed ends facing upward. Take care to bury logs and rocks to the widest diameter so that the barriers remain in place, appear natural, and don’t block drainage.

Figure 3–17. Trail users avoid puddles and widen the trail. Drain water before it finds the low spot of the trail. Chequamegon-Nicolet National Forest, Wisconsin. USDA photo by Kristen Thrall.

Maintenance tips

- Take advantage of large stationary objects (called guide structures) to prevent animals and people from travelling side by side and widening a singletrack to a doubletrack.
- Buck trees that have fallen across the trail to the desired trail width.
- Place the ends of logs, rocks, and stumps close to the downhill edge of the trail to keep users closer to the middle.
- In cases where curves are being straightened, partially bury a short section of log or rock on the inside of the curve to prevent straightening of the trail.

- Where users are circumventing a mud hole, consider rerouting around the low spot or elevate the tread with borrow material or a causeway.
- Repair braided trails by installing a causeway and positioning logs, rocks, and other natural barriers in the braided sections (refer to the "Causeways" section in chapter 4 for more information).

Common mistakes

- Blocking drainage or creating a berm.
- Decommissioning areas using branches, rocks, and other material that is too small and poorly secured.
- Removing intentional passing lanes.
- Leaving new barriers on top of the soil instead of partially burying them.

Other Maintenance Solutions

Trail sections with chronic issues require a lot of attention and resources. Try to determine how and why a trail segment is failing in the first place. This is critical to develop strategies for repair. Sometimes the problem can be resolved by addressing a drainage issue farther up the trail—evaluate the bigger picture before applying a temporary fix. Consider rerouting segments of trail that continue to have chronic issues. Better yet, design and build trails that follow more sustainable alignments to avoid this headache altogether (for tips, refer to the "Sustainability" section in chapter 2). It is paramount to build the best trail for the location, not the trail that is easiest to build.

The root cause of tread failure is commonly linked to a few situations:

- Fall line trail alignment
- Located in flat areas or ridge tops that capture runoff
- Located in areas prone to flooding
- Overly steep trail grades
- Lack of or infrequent grade reversals
- Lack of maintenance

Treat the problem, not the symptom!

Eroded Tread on a Steep Trail

Issue. Steep trails with failed or missing drainage features are often channelized.

Potential solution. Reroute the trail to a lesser grade. If rerouting isn't possible, stabilize the tread by removing the outside berm of the trail and reusing the material to create rolling grade dips. Install as many rolling grade dips as necessary to drain water and prevent it from running down the trail and channelizing the tread (refer to the "Rolling Grade Dips" section in chapter 4 for details). Unfortunately, this technique doesn't stop tread loss from overuse. In these cases, consider armoring the grade dips with rock in heavily eroded sections to create a durable drain and a stable tread surface. Refer to the discussion of draining water off existing trails in chapter 4 for more information about armoring techniques. In some cases, especially in very steep or loose soils that don't hold rolling dips well, drainage features with an anchor, such as a waterbar, may be necessary.

Wide, Braided, or Deeply Rutted Trail Going Straight Down the Hillside

Issue. A fall line trail that is wide, braided, or deeply rutted and going straight up or down a slope.

Potential solution. Reroute the trail to a lesser grade. A short section of fall line trail may not be a major problem, particularly if the surface has stabilized and new erosion is minimal, as some users appreciate these challenging sections. Refer to the TMO to verify if the section of trail is within the design specifications. If it isn't, reroute the segment.

Maintenance tips if rerouting isn't possible

- Minimize the length of the fall line section as much as possible.
- Construct drains sufficiently large enough above and below the fall line section to prevent erosion.
- Install barriers to prevent off-trail travel. Remember, users will find another way if the trail isn't the easiest path.
- Install surface armoring with riprap (small stones) or stone pitching (arranging vertical flat or angular stones) or install steps.

Muddy or Boggy Trail

Issue. Channelized flat section of trail that consistently holds water and creates mudholes. Users skirt the edges of the mudhole causing trail widening.

Potential solution. Install rolling grade dips or change the alignment to force the tread uphill briefly (called a forced uphill undulation) by realigning that section of trail uphill to allow the water to drain. If moving the trail isn't possible, constructing a causeway is another solution. A causeway (or turnpike without ditches) is an earthen structure that elevates the tread above the saturated area. Refer to the discussion of draining water off existing trails in chapter 4 for more information about causeways.

Stream Diversion

Issue. Trails that approach a stream crossing from below will divert streamflow in a high-water event, causing a stream diversion that channels water down the trail. This situation can cause extensive damage both on and off the trail in a single storm event.

Potential solution. Plan stream crossings carefully. Reroute the portion of the trail that intersects the stream at a place with an approach above the high-water mark. The approaches should descend to the stream instead of entering at an even grade.

Figure 3-18. Stream at flood stage diverting down a trail that is approaching from a lower angle. Inyo National Forest, California. USDA photo by Jennie Leonard.

Washed-Out Tread

Issue. Trail section in a valley bottom prone to episodic flooding.

Potential solution. Relocate the section. If you can't relocate the trail out of the valley bottom, then consider installing extra drainage features, armoring stream banks, and installing rock tread. In some cases, with the right construction and the right amount of maintenance, a trail can still perform even when flooding occurs if it is constructed to withstand the erosional forces of a stream for short periods of time.

Objects in the Trail Corridor

Refer to the trail design specifications for the use type and development scale before removing boulders, rockslides, large roots, stumps, and other obstacles. Is it a minimally developed (class 1) trail in a wilderness area or a wide, flat, fully developed (class 5) trail near a campground? The trail type and development scale will help you know what obstacles to remove and what should remain to challenge users. Large objects can sometimes be moved more easily with rigging. Rigging is a system of specialized ropes, cables, and hoists that makes moving heavy objects safer and easier. Safe use of rigging techniques requires training and experience. "Rigging for Trail Work: Principles, Techniques, and Lessons from the Backcountry" provides a thorough review of when and how to use rigging.

Rock Removal

Rocks may need to be removed when they fall onto the trail or when the tread is compacted causing rocks to protrude. Depending on the trail development scale, obstacles and protrusions in the tread may be acceptable. In some cases, they add character to the trail. Discuss with trail managers the acceptable protrusions and tread width for the trail.

Removing large rocks safely takes experience, especially where there is the possibility of dislodged rock rolling downhill. Trail managers use several techniques to remove or reduce the size of large rocks, or shape rocks for retaining walls or other guide structures (figs. 3–19 and 3–20).

Receive training and any necessary certifications on these techniques before trying them on your own.

Common methods and tools include:

- Rock bars and fulcrums
- Specially designed drills and wedges that can split a rock
- Lever chain hoists (Griphoist is a popular brand)
- Chemical expansion agents
- Motorized equipment with splitting or grinding heads
- Specialty tools (popular brands include Boulder Buster and BMS Micro-Blaster)
- Blasting with explosives by a trained and certified Forest Service blaster

Figure 3–19. Rock bar and fulcrum used to move a large rock. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

Figure 3–20. A boulder being split with plugs (wedges) and feathers. Coconino National Forest, Arizona. USDA photo by Kevin Kuhl.

Maintenance tips

- If you decide to manually remove the embedded rock, remove it to meet the trail standards to accommodate the use type and development scale.
- Prepare a location for the rock to be moved to and anticipate how it might roll before it is moved.
- Communicate with all crewmembers about how the task is progressing. Make sure crews are rotating among tasks to prevent overexertion and possible injury.
- Build a barrier to prevent any loose rocks from gaining momentum if people, trails, or other facilities are located below.

- Save rock that is removed or blown up to be used in wire baskets (called gabion baskets) or as fill material.
- Once a dislodged rock is moving—intentionally or by mistake—do not try to stop it! Yell “ROCK!” to warn anyone below.

Common mistakes

- Simply knocking off the top of a rock flush with the existing tread, which may leave another obstacle in the future after soil has eroded around the rock. (Remove the whole thing.)
- Not adequately repairing the tread after a rock or stump has been removed.
- Letting rocks roll down a slope regardless of size.

Be patient—when rocks are moved in a hurry they almost always end up in the wrong place.

The two most common injuries in rock work are pinched (or smashed) fingers and tweaked (or blown out) backs. Both sets of injuries result from using muscles first and brains last. High-quality rock work is almost always a methodical, even tedious task. Safe work is ALWAYS faster than taking time out for a trip to the hospital. Slow is smooth, smooth is fast!

Root and Stump Removal

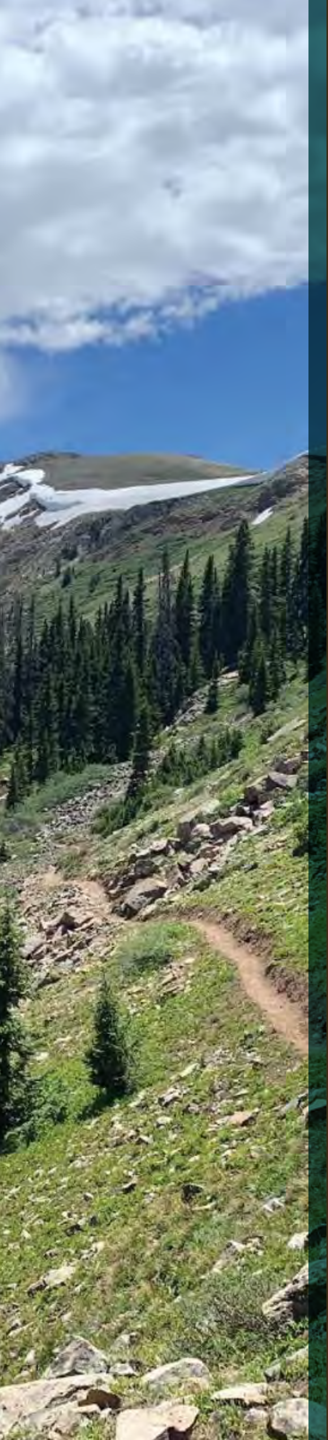
Removing roots and stumps is hard work. Explosives and equipment are good alternatives to manually removing stumps.

Maintenance tips

- Leave stumps tall to create a lever for removal. Use machines to push over smaller trees (instead of cutting) to avoid the need for stump removal.
- Use a sharpened pick mattock or Pulaski to chop away at the roots.
- Remove roots and stumps from the tread on developed to fully developed (class 3–5) trails.
- Before you remove a stump, consider whether other crews before you might have left it to keep the trail from creeping downhill or for a challenging feature (depending on the trail type and development scale).
- Remove roots that are parallel with the tread because they often funnel water down the trail and also create slipping hazards.
- Remove roots perpendicular to the trail when the root is fully exposed.

Common mistakes

- Removing large roots or too many roots and impacting the health of the tree.
- Not removing roots and stumps during trail construction. A new trail tread will compact and stumps, stobs, and roots that are simply cut at the surface will grow over time, causing hazards for users and maintenance issues the first season after the trail is constructed.



4

STRUCTURES

4. STRUCTURES

Trail structures are constructed features that support the trail. They can be earthen structures like rolling grade dips that shed water off the trail or rock walls that support the tread on a steep hillside. Constructed features require some degree of maintenance, so think about them critically before installing. Forest Service engineer-approved standard drawings for common trail structures are available on the Plans for Trail and Trail Bridge Structure web page.

Draining Water

Telltale signs of poorly designed trail segments with drainage issues are channelized, incised, rutted, or gullied tread. Erosion issues are caused by inadequate drainage uphill of the issue. Designing and locating trails that allow for shedding water off the trail at regular intervals protects the tread from this type of erosion. Your goal should be to treat the problem and not the symptoms. A well-designed trail takes drainage into consideration before construction by incorporating grade reversals in the alignment. Refer to the "Grade Reversals" section in chapter 6 for more information.

The trail and support structures are threatened by erosion when water is allowed to flow down or pool on the trail. Standing water often occurs in flat areas with poorly draining soils, where displacement or compaction has reshaped the trail causing water to be trapped and pooled. Mudholes often develop around pooled water in most soils (fig. 4–1). And as users avoid the muddy area, the mudhole grows.

Solutions for Draining Water Off Existing Trails

- Remove any berms that have formed.
- Outslope the tread or restore the outslope to 5–8 percent.
- Regularly maintain drainage features.
- Install new drainage features where they are lacking.
- Reroute the saturated segment of the trail uphill or downhill.
- Armor tread where soils are susceptible to rutting.

Before maintaining drainage features along a trail, take time to observe if the drainage features are well-located, self-cleaning, and optimally functioning. They should shed water off the trail at regular intervals and require only light maintenance to remove seasonally accumulating organics. If there is not adequate drainage, adding new ones or modifying existing drainages may resolve erosion and puddling issues.

Figure 4–1. Water pools in ruts created when the trail is saturated. Solutions for this include more effectively removing water from the trail, installing a forced uphill undulation, or hardening sections where rerouting isn't possible and draining is not effective. USDA photo.

Rolling Grade Dips

A rolling grade dip is a drainage feature that reverses the trail grade for a short distance so water sheds off the trail instead of flowing down the trail (fig. 4–2). A well-constructed rolling grade dip blends into the existing trail without abrupt turns or elevation changes and requires minimal maintenance. It will have little effect on the trail users' experience. Each rolling grade dip has a crest, a sag (also called a dip), and an outlet. The size and frequency of the crest, sag, and outlet will depend on the user type, trail grade, soil condition, hillside slope, and typical rainfall patterns.

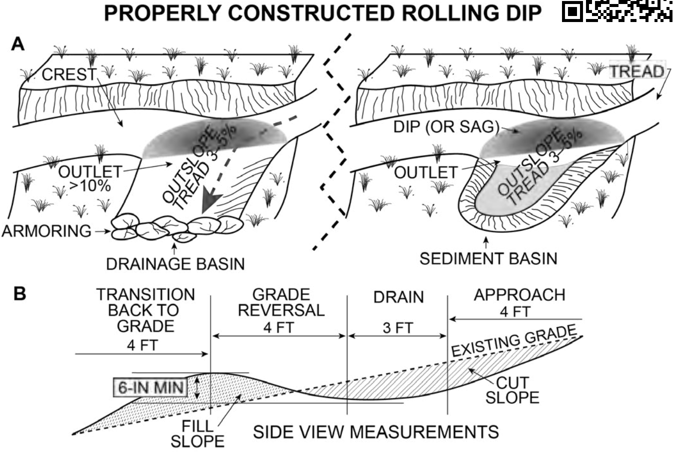


Figure 4–2. A properly constructed rolling dip can be a sustainable solution for a poorly designed or constructed trail. The side view measurements in the lower diagram are estimates from a hand-built hiking trail. Dimensions will change depending on user type, trail grade, soil condition, prevailing hillside slope, and typical rainfall patterns. Diagrams based on [Forest Service standard trail drawings] STD 927–01 and 927–02.

Construction tips

- Space rolling grade dips close enough to prevent water from building volume and velocity, which will transport soil downhill and wear the tread surface away. There isn't a formula to calculate the distance between drainage features; they can be as close as every 50 ft (15 m), or more typically every 200 ft (61 m). Observe other trails in the area and measure drainage spacing along stable sections of tread.
- Locate a rolling grade dip where surface water is being channeled into the trail. Below the top of the hill summit, within the midslope, and above the toe (or bottom) of the hillside are ideal locations. Installing a rolling grade dip above the toe of the hillside helps to mitigate muddy or loose conditions when the trail reaches the bottom.
- Reinforce the crest with material and construct it tall enough to divert anticipated water flows off the trail (without creating a jump).
- Outslope the tread in the sag 3–5 percent to drain water into the outlet. Extend outlets into a drainage or sediment basin.
- Ensure the outlet of the drain is shallow and wider and more sloped than the trail tread. The spoon or lens shape of the drain and outlet directs water off the trail in a thin sheet to prevent sediment deposition and avoid erosional rills or gullies from forming.
- Determine whether a sediment basin is needed to prevent sediment from directly entering a stream or

if soils in the outlet are easily eroded. The captured sediment can be used for maintenance of the structure or tread (fig. 4–3). Sediment basins require regular maintenance, or they will fail.

- If necessary, armor the area where the water leaves the drainage basin to help prevent headcutting.

Common mistakes

- Using rolling grade dips on steep sections of trail (greater than 15 percent grade).
- Locating the dip on the outside of a turn.
- Directing sediment into rivers, streams, and creeks.

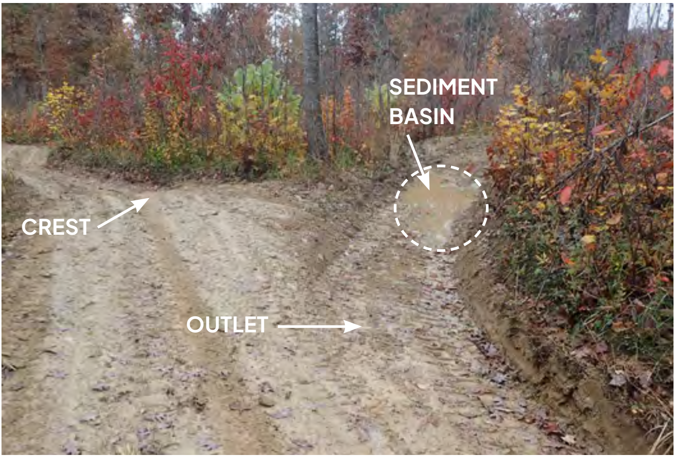


Figure 4–3. A sediment basin connected to a rolling grade dip catches eroded material that can be reused in routine trail maintenance. Consider increasing the number of rolling dips if the sediment basin fills in less than 3 years. Daniel Boone National Forest, Kentucky. USDA photo by Matt Able.

Use Topography To Force Uphill Undulation

Creating a grade reversal by moving a small segment of trail upslope or downslope can be a feasible solution to drain water from an existing trail (fig. 4–4). The upslope and then downslope pattern are referred to as undulation. This method may require additional environmental evaluation as the short reroute could be outside of the existing trail corridor (fig. 4–5).

Construction tips

- Layout the relocated segment either above or below the existing trail, with sufficient grade to force water off the trail. The length of the relocation will depend on the surrounding terrain.
- Smooth the grade transitions from the old tread to the new alignment with no abrupt turns, rises, or dips.
- Naturalize the old trail tread with rocks, debris, and plantings to discourage use.

Figure 4–4. On the right, a minor realignment uphill of an existing trail to create a grade reversal, also referred to as a forced uphill undulation. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

Figure 4–5. The old trail (solid line) was realigned uphill (dotted line) to create a grade reversal. Tennessee. USDA photo by Scott Johnson.

Knicks

Knicks are semicircular drains constructed to shed water off existing trails on hillsides (fig. 4–6). They are installed more quickly than a rolling grade dip and are essentially the sag portion of a rolling grade dip without the crest. They can be a viable choice when soil moisture is not adequate to compact the crest of a rolling grade dip. They perform best when installed to the inside of turns, where they can drain downhill.

Knicks are inserted into an existing trail by removing a thin amount of material in a 10–ft (3–m) semicircle and outsloping it up to 15 percent. When located thoughtfully, knicks can function for many years with little maintenance. However, most are not constructed carefully and generally require annual maintenance to reestablish and remove any collected sediment.

Figure 4–6. Installing knicks into existing trails will drain puddles from flat areas. This knick will require frequent maintenance because it's draining to the outside of a curve in the trail. Fishlake National Forest, Utah. USDA photos by Nathan Conder.

Waterbars

Waterbars are linear features made from embedded rock or wood used to direct water off the trail. They should only be used on less-developed hiking or equestrian trails. Waterbars are not favored on motorized trails and trails open to bicycles. They also require routine maintenance to remove trapped sediment from the drain and outlet. If neglected, the sediment accumulates, and water will overtop the waterbar or erode the sides (fig. 4–7). Although no longer favored by most, waterbars are still found on many trails. Consider installing a rolling grade dip, forced uphill undulation, knick, or a grade reversal with a short reroute instead of continuing to maintain a waterbar.

Construction tips

- Set the waterbar at a 45- to 60-degree angle across the tread and anchor it either into the backslope (if made of a log) or deep into the soil (if made of rocks). This will prevent the waterbar from being undermined and failing.
- Construct and maintain the outlet of the drain to be shallow, outsloped, and at least three shovel-widths across. The length and shape of the drain should slow the water down and direct it off the trail without letting the water ever reach the bar.

- Shape the drain at least as wide and steep as the outlet where the water drains off the trail to prevent sediment depositing and clogging the waterbar.
- Compact or reinforce the tread downslope of the waterbar to withstand concentrated foot traffic.

Dips Are In, Bars Are Out

In place of waterbars, install rolling grade dips and knicks to fix drainage issues where possible. Users commonly step or roll around waterbars, causing trail widening. To function properly, waterbars also require heavy recurring maintenance to reestablish the drain and outlet. You can build a good rolling grade dip or knick quicker than you can install a waterbar, and in most cases a rolling grade dip works better at shedding water from the trail and preserving soil. If you do install waterbars, limit their use to trails predominately designed for hikers and equestrian riders. They may be appropriate in a few situations, for example on trails with limited or shallow soils and in very rocky areas where other options are limited.

Figure 4–7. Waterbars fail for a variety of reasons and are not a preferred way to drain water off the tread. Water and sediment load have overwhelmed this waterbar and users have begun skirting around it. Carson National Forest, New Mexico. USDA photo by Kerry Wood.

Areas With Saturated Soil

Some trails in areas with consistently saturated soil require unique design, construction, and maintenance techniques to raise the trail surface above the surrounding grade to improve drainage and help to keep the tread dry and firm. Characteristics of seasonally and perennially saturated areas in the United States vary widely, depending on soil types, topography, and rainfall patterns. Misusing materials or misapplying these techniques can lead to more frequent maintenance needs and may negatively impact sensitive aquatic environments. Most techniques for fixing trails in saturated areas also require more crew time, materials, and other resources and need to be repeated frequently. Consider locating new trails away from saturated areas or relocating problem sections of trail.

This section covers simple mitigation measures to elevate or stabilize the tread for short segments of trails. Simple structures may be necessary to elevate the tread over an area of consistently saturated soil, move water from one side of the trail to the other in a culvert, or to span a small creek or riparian area with a trail bridge.

Trail building techniques on longer segments of saturated ground may require installing more complex structures that lower the surrounding water table, like turnpikes, or are built over the saturated area, like a boardwalk (fig. 4–8). Techniques for building structures over longer distances are covered in the "Trail Structures for Wet, Unstable, and Sensitive Areas" publication available on the Forest Service national publications page.

Figure 4–8. Standing water results in soft, boggy tread. Water is pooling in this flat trail segment. Ideally, the trail would be relocated onto the slope uphill. However, if relocation is not possible, the trail manager could install a drainage structure. Baltimore, Maryland. Maryland Department of Transportation photo by Cheryl Ladota.

Rock Underdrains

Rock underdrains (often called French drains) are a fairly complex rock and earthen structure that allows water from small springs or seeps to flow under the tread surface. Successful construction requires access to varying material sizes and an understanding of local soils, precipitation, and conditions. Large rocks with progressively smaller rocks on top are placed in a trench perpendicular to the trail, with the trail tread laid over top. Water percolates between the spaces in the large rock, while the smaller rock holds everything in place and provides a firm surface for the tread (fig. 4–9).

In many cases, trail managers pursue other solutions that are easier to construct and maintain, like open surface drains and drain dips or armored drainage dips. Refer to the sections on culverts and armoring the tread (below) for more information about these techniques.

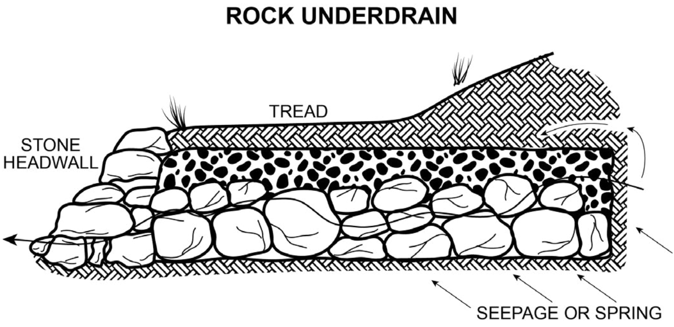


Figure 4–9. Rock underdrains allow water from low-flow springs and seeps to drain under the trail tread. Diagram based on [Forest Service standard trail drawing] STD 924-10-01.

Construction and maintenance tips

- Observe the greatest extent of the saturated area during the wet season. The width of the structure should capture the entirety of the wet area to be effective.
- Dig a trench perpendicular to the trail tread with a flat bottom and compact the bottom of the trench.

- If installing on a hillside, use large rocks or boulders to create a stone headwall along the outside edge.
- In the trench, create a solid base course of interlocking rocks with the largest rocks (greater than 8 in [20.3 cm]) placed along the bottom. The purpose is to create small voids between the larger rocks to allow for slow water flow. If erosion is a concern, establish a second course of tightly laid rocks with larger spaces to accommodate higher water flows.
- Layer smaller rock and gravel to establish an even surface.
- Place at least 6 in (15 cm) of suitable tread material to cap the rock underdrain.
- Maintain the tread to prevent surface erosion by restoring outslope and surface drains.

Causeways

A causeway is a turnpike without ditches. It is an earthen structure that elevates the trail tread in seasonally wet areas. It is not typically used where year-round groundwater saturation is a problem. Causeways can also be used to restore multiple parallel paths by replacing them with a single pathway (fig. 4–10). Constructing a causeway can be a moderate to big project, depending on the size. Even a small causeway will require staging of several tons of rock and soil. Consider the alignment, rock and soil source, and size of the disturbed area before beginning the project.

Causeways are not recommended in consistently saturated soils because the foundation can sink into the ground. This is particularly problematic in clay soils. Constructing a turnpike with lead-off ditches is better in that situation. Refer to the “Trail Structures for Wet and Sensitive Areas” publication available on the national publications page for information about building traditional turnpikes.

Figure 4–10. A suitable place for a causeway to raise the trail and drain the tread. Lake Tahoe Basin Management Unit. USDA photo by Garrett Villanueva.

CAUSEWAY WITH GRAVEL BASE

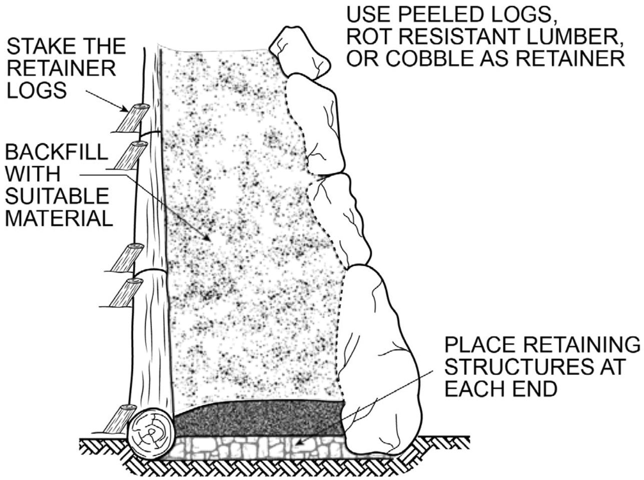


Figure 4–11. Causeways are turnpikes without ditches. They create an elevated, hardened tread and are best used across seasonally wet areas or to cover and replace multiple parallel paths. Diagram based on Forest Service standard trail drawing STD 932–20–01.

Construction tips for causeway foundation

- Dig down in the trail tread to stable mineral soil.
- Create a solid base course with the largest angular rock, 3–8 in (8–13 cm), placed along the bottom.
- Use smaller rocks to fill voids in the base layer and place another course of smaller rocks on top of that. Place fill material at the top to create a level foundation for the trail tread.

- Line the causeway with large rocks, timber, or log retainers. Large rocks (greater than 80 lb. [36 kg]) are preferable if available near the work site. Partially bury the retainer rocks two-thirds deep to anchor them so they don't move. Lay retaining timbers or logs in continuous rows along both edges of the trail tread. Logs should be peeled and at least 6 in (15 cm) in diameter. Use wood stakes or sapling stakes to hold the log retainers in place.
- "Broadcast" (or evenly distribute) woody material, partially bury rocks, and replant the disturbed areas along the sides of the causeway to discourage users from using old routes.

Construction tips for causeway trail tread

- Layer gravel or other well-draining soil on top of the fill to elevate the tread above seasonal water levels, which provides a stable trail tread and prevents trail braiding and muddy areas.
- Install a crown (or mound) in the center of the tread a minimum of 2 in (5 cm) above the side retainers or at a minimum of 2–percent grade so water will drain off the tread in either direction.
- Install armored dips, open rock drains, and other drainage features as necessary to prevent damming surface water.

Maintenance tips

- Recrown the tread where the soil has settled.
- Reestablish drainage features.

- Service retainer materials (e.g., rebury or replace logs, rocks).

Crossing Streams and Rivers

Stream and river crossings can range from a shallow stream ford to a trail bridge. The type of crossing depends on the trail type and development scale. For example, steppingstones are an appropriate water crossing on a minimally developed (class 1) hiking trail and a trail suspension bridge is appropriate for a fully developed (class 5) route designed for people using mobility devices.

Working in or near streams requires special consideration to not damage natural and potential cultural resources in the riparian area, including banks and flood plains. Permitting and coordination with environmental specialists is required. The U.S. Army Corps of Engineers evaluates applications and issues permits for all construction activities that occur in, under, over, or near all waters in the United States, including wetlands. An agency engineer or hydrologist can help evaluate if a permit is necessary.

Shallow Stream Fords

Shallow stream fords provide users with solid, level footing or driving surface at a consistent depth from one bank to the other without blocking passage for fish and other aquatic organisms (fig. 4–12). Most are designed to be used during low to moderate flows.

Install fords in wider, shallower portions of the stream, avoiding bends where water will undercut approaches on the outside of a turn. Well-constructed and well-located shallow stream fords require minimal maintenance.

Figure 4–12. Fords should be established in wider, shallower portions of a stream. Place steppingstones for hikers. Approaches should climb a short distance above the high-water line. Lake Tahoe Basin Management Unit, California. USDA photo by Garrett Villanueva.

The key is to maintain the hydrologic characteristics of the stream channel and bank in the ford. Changing these characteristics could change the channel volume during flood stage and lead to scour (or erosion caused by flowing water). The trail adjacent to either bank should immediately climb above the high-water line to prevent the streamflow from diverting onto the trail (fig. 4–13). Installing grade reversals on approaches above the high-water line minimizes sedimentation into the stream (fig. 4–14).

Figure 4–13. Bank armoring in the approach to a shallow stream ford. Lake Tahoe Basin Management Unit, California. USDA photo by Garrett Villanueva.

If appropriate, a shallow stream ford may be constructed to include well-spaced steppingstones. The steppingstones or other obstructions should be placed close enough together to be useful and far enough apart to prevent debris from getting trapped and altering water flow characteristics (figs. 4–12 to 4–14).

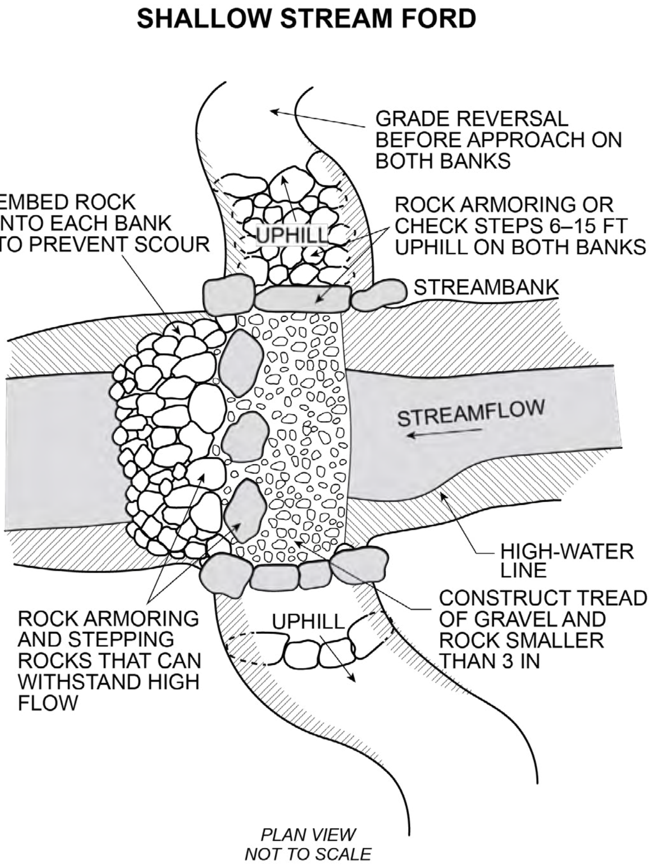


Figure 4–14. Shallow stream form. Diagram based on Forest Service standard trail drawing STD 917–20–01.

Construction tips

- Armor the banks and tread with steps or surface riprap to prevent stream bank scour and failure.
- Construct fords for hikers and pack stock, such as llamas and pack goats, no deeper than 16–24 in (41–61 cm), or about knee high during most of the use season.
- Place steppingstones or large rocks downstream from the tread. Rocks that are large enough to withstand flood flows and be embedded in the channel are generally larger than you think they should be. Interlock bedded rocks with steppingstones to withstand scour and movement of the steppingstones.
- Use care to minimize any construction that narrows or constricts the channel, causing higher water velocity and scour potential. Space the rocks far enough apart to prevent debris from becoming stuck, but close enough to step across.
- Work to retain or restore an even, shallow flow and solid footing.

Culverts

Culverts are structures placed in the ground that allow low to moderate flows under the trail. They can be made of metal, plastic, wood, or rock. Building culverts out of native materials is preferred and may be required in some areas (fig. 4–15). The size of the culvert depends on the maximum amount of storm runoff. An undersized culvert can easily clog with debris during large rain events, causing water to go around the culvert or increase the velocity at the outlet and erode the trail tread.

Figure 4–15. Rock culvert on the Lake Tahoe Basin Management Unit, California. USDA photo by Garrett Villanueva.

Traditional culverts are appropriate for higher flows and provide a stable tread surface over the ditch. In fire-prone areas, metal and rock culverts are preferred over plastic, as plastic culverts can burn or melt. Bottomless arch culverts require less vertical space and have a natural streambed bottom that is preferred for aquatic organism passage (fig. 4–16). All arches and round culverts require a level outlet.

Elevated outlets create a waterfall that may scour and headcut the channel. Work with hydrologists to determine the best type and size of culvert to fit your needs.

Figure 4–16. Arch culverts are a good option for moving water under a trail while keeping a natural stream bottom. Boise National Forest, Idaho. USDA photo by Scott Johnson.

Water flowing toward a culvert often carries a lot of silt and debris. Installing settling basins on the upstream side helps prevent culverts from clogging with silt and debris (fig. 4–17). Also, consider how water in the channel might overtop the trail during high-water flows when developing the finish tread and slope armoring. Trail segments should be shaped above the culvert so water that overtops the trail flows back into the channel. The goal is to keep the stream and any flow that overtops the trail in the channel and not down the trail. Culverts often plug during storm events because debris is swept into the stream. Consider where the water will go when the culvert plugs to prevent the stream from diverting onto the trail and causing a new channel to form.

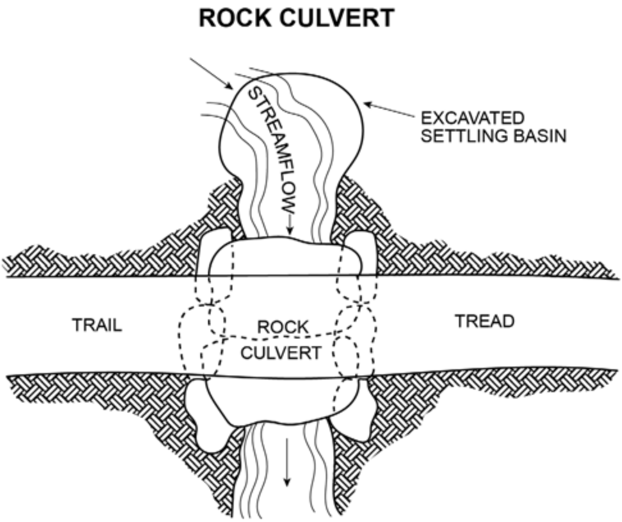


Figure 4–17. Settling basin on the upstream side of the culvert to prevent the culvert from clogging with silt and debris. Diagram based on [Forest Service standard trail drawing]() STD 921–30–01.

A properly constructed open-top drain (fig. 4–18) is one of the easiest drains to maintain and can sustain moderate flows without eroding the surrounding area. The open top should be wide enough to accommodate the water flow and narrow enough for someone to step over.

Construction tips for open-top drains made from rock (fig. 4–18)

- Dig a ditch across the trail that is wide and deep enough to accommodate the rock base and sides, and with an opening large enough for the highest predicted flow.
- For the base, embed large, smooth rocks (greater than 80 lb. [36 kg]) two-thirds into the ground with a 3-percent slope to the downstream side of the trail.
- For the sides, embed large rocks two-thirds into the bottom and sidewalls of the drain, while providing a flat surface for the trail tread.

Figure 4–18. Open-top drains can be made of rock or wood. Pike-San Isabel National Forests, Colorado. USDA photo by Adam Carroll.

Construction tips for rock culverts (see fig. 4–15)

- Follow the same tips as for open-top drains made from rock.
- Lay large, thick, flat stones slightly below the trail tread that are long enough to span the opening.
- Interlock the top tread rock with boulders at corners.
- Take time to prepare the channel and supporting rocks before placing the spanning rock.

Construction tips for metal or synthetic round or bottomless culverts (see fig. 4–16)

- Measure the channel width and depth and choose a culvert diameter that provides at least 100 percent volume of existing channel.
- The culvert length should be the width of the trail, shoulders, and any armoring.
- The ditch width should be the culvert diameter and enough space on either side of the culvert for tool compaction, about 8–12 in (20–30 cm) on either side.
- Embed the culverts below the channel grade approximately one-third the culvert height—this allows for the culvert to pass the stream bedload (streambed material) through the culvert and prevent damming at the culvert inlet.
- Place fill material over the bedded culvert in lifts (or multiple layers) and compact each layer.
- Place a minimum depth of 12 in (30 cm) of tread material above the culvert.
- Stack rocks around the inlet and outlet to protect or armor the fill of the culvert from washing out. Creating a rock funnel into the culvert inlet will increase the volume of water the culvert can carry.
- In locations with higher flows, install a rock-reinforced spillway on the downhill side of the culvert to reduce headcutting and washouts.

Common mistakes

- Constructing the end of a perched or “shotgunned” culvert projecting from the face of the fill or embankment, which creates a waterfall out of the culvert, destabilizes the natural stream channel, and can cause headcutting.
- Failing to bed and compact the culvert tightly to prevent water from eroding around the culvert (a.k.a. piping).

Trail Bridges

A trail bridge is a structure erected over a depression or obstruction such as a body of water, a road, a trail, or a railroad that provides a continuous pathway and that has a deck for carrying traffic or other loads. They range from a simple foot bridge to multi-span, suspended, and truss structures. Appropriateness of bridge types and materials vary depending on the trail type, development class, and the relative recreation opportunity spectrum (ROS) class. The information in this section is a simple overview of trail bridge terms. Forest Service Handbook 7709.56b, Chapter 100 has more information, as well as the Forest Service’s “Sustainable Trail Bridge Design” publication. Contact a Forest Service engineer if you think a trail bridge is a needed solution.

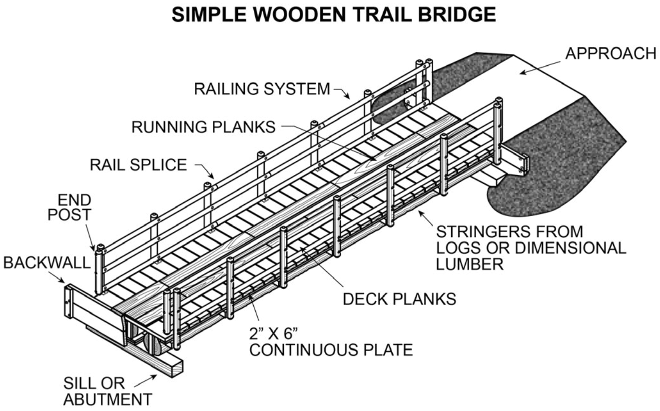


Figure 4–19. Basic trail bridge anatomy. Diagram based on Forest Service standard trail drawing STD 961–20–01.

Installation of new trail bridges, even simple log bridges, on National Forest System trails requires site-specific design approval from a designated engineer before construction. The Forest Service has standardized and approved trail bridge plans in AutoCAD and PDF preview files on the Plans for Trail and Trail Bridge Structures web page. The standard plans can't be modified without approval from the regional engineer.

The Forest Service categorizes trail bridges as minor, major, and complex depending on their length, construction material, and complexity (figs. 4–20 to 4–22).

Figure 4–20. Minor bridge:

- Requires training, but no certification to inspect
- Made of timber
- A single span less than 20 ft (6 m)
- Inspected every 5 years
- Appropriate for minimally to moderately developed trails (class 1–3)

Pike-San Isabel National Forests, Colorado. USDA photo by Adam Carroll.

Figure 4–21. Major bridge:

- Requires certification to inspect
- Made of timber
- Single span of more than 20 ft (6 m)
- Inspected every 5 years
- Appropriate for developed to fully developed trails (class 3–5)

Huron-Manistee National Forests, Michigan. USDA photo.

Figure 4–22. Complex bridge:

- Requires in-depth certification to inspect
- Truss, suspension, multi-span, and nontimber bridges
- Inspected every 5 years
- Appropriate for fully developed trails (class 5)

Bridger-Teton National Forest, Wyoming. USDA photo by Jay Sammer.

Common trail bridge material

- Pressure-treated wood
- Wood laminates
- Metal
- Concrete
- Fiber-reinforced polymers (FRP)

Approaches

The sections of trail on either end of a trail structure are referred to as "approaches" (fig. 4–23). The length of the approaches to a trail bridge or other structure depends on the difference in deck elevation and trail elevation.

Approaches should rise to meet the decking, and either be a ramp with grades from 2 to 8 percent or be a step(s) that climbs to the level of the decking. This creates drainage to prevent water from flowing and depositing soil and debris onto the bridge. When possible, construct straight approaches to funnel users onto the bridge without the need to turn and risk sliding.

Figure 4–23. Trail bridge approaches should climb at a 2– to 8–percent grade or be a step(s) that climbs to the level of the bridge deck. Carson National Forest, New Mexico. USDA photo by Kerry Wood.

Use compacted gravel, pavers, poured cement, or other durable material to transition smoothly from the trail to the bridge. Pavers are not recommended on trails used by equestrian riders. Buried concrete pavers are a good option where they can be transported to the site (fig. 4–24). Install the pavers at a downward angle so no edge appears as the tread wears down (fig. 4–25). The angle also locks the pavers in place. Take your time to align each paver so they create a uniform flat surface without rocking.

Figure 4–24. Concrete pavers are good for hardening trail structure approaches on trails designed for motorized use. The voids need to be filled with gravel, sand, or native soil and compacted. Sam Houston National Forest, Texas. USDA photo.

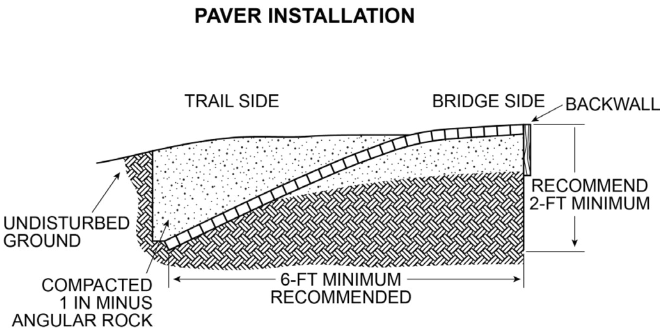


Figure 4–25. Angle the first course of pavers adjacent to the structure slightly downward. Place additional interlocking courses at a downslope and bury them to hold the first courses in place.

Handrails and curbs

User barriers on trail bridges can be curbs, railing systems, or a combination of the two. They are required on trail bridges, except foot logs and other minor trail bridges where user barriers are impractical or unnecessary. The amount of use and distance from population centers determines the type of railing. Curbs are appropriate in some cases if the potential hazards along the trail are the same or greater than the hazards of a bridge without a railing (fig. 4–26). Install a scupper block under the bullrail to create at least 4 in (10 cm) of clearance under the curb to let water drain and make removing leaves, sticks, and other debris easier.

Figure 4–26. Example of curbing made of dimensional lumber with bull rail and scupper blocks. Greenbrier State Park, Maryland. Maryland Department of Transportation photo by Cheryl Ladota.

Railings in urban and high-risk areas require a top rail and balusters less than 4 in (10 cm) apart. Railings in rural and moderate-risk areas require a top rail and balusters less than 6 in (15 cm) apart. Railings in remote and low-risk areas require a top and intermediate rail (fig. 4–27). Work with the local Forest Service bridge engineer to determine if handrails or curb railing are appropriate based on potential hazards, and the trail type, uses, and development scale (FSH 7709.56b section 82.4).

Figure 4–27. Trail bridge railing system with posts and top and intermediate rails. Huron-Manistee National Forests, Michigan. USDA photo.

Basic bridge maintenance and inspections

Following construction, all trail bridges require regular inspection by a qualified inspector every 5 years. Employees, partners, and volunteers can receive training to inspect minor and major trail bridges; only employees can be certified to inspect complex bridges. Trail managers can start an "adopt-a-trail-bridge" program and invite partners and volunteers to tighten bolts, clean between deck boards, sweep off debris, and conduct other routine maintenance.

Report issues to a qualified bridge inspector who can determine whether the bridge should remain open. Common things to pay attention to include:

- Rotting or insect-damaged wood
- Bent, broken, or disconnected components
- Large cracks, splits, or crushed components
- Exposed rebar or broken concrete with cracks wider than 1/16 in (1.5 mm)
- Erosion around abutments

Refer to FSH 7709.56b, Transportation Structures Handbook, chapter 100—Trail Bridge Operation for more information about trail bridge management.

Steep Trail Grades and Hillside Slopes

In some cases, steep trail grades or loose or unstable soils are unavoidable. Installing structures built with natural or imported materials may be necessary in areas with less–than-ideal conditions. Locate structures and anchor points carefully during layout to develop sustainable trail grades between them. Build structures with sustainable principles in mind and limit the number of structures that will have to be maintained in the future.

Turns in Steep Terrain

Climbing turns and switchbacks reverse the direction of travel on a hillside to gain elevation while still maintaining sustainable trail grades (fig. 4–28). Different types of turns are used depending on the user type and how much space is available for the turn. The main difference between switchbacks and climbing turns is a switchback has a flat landing at the turn. Most trail managers prefer to construct and maintain climbing turns, although both styles are difficult to design and labor-intensive to construct correctly. The Forest Service standard drawings provide detailed plans for climbing turns and two switchback styles.

The best way to learn how to build turns in steep terrain is to seek out an experienced trail builder with a reputation for designing and building well-designed climbing turns, switchbacks, or retaining walls. Invite experienced builders to work with your crew, or volunteer to work with the experienced builder and their crew and add to your trail-building skills.

It is a better practice to reduce the need for climbing turns and switchbacks by avoiding the routing of trails on steep slopes. Fewer turns means less maintenance. If difficult terrain is impossible to avoid, contour the trail along the midslope and minimize the number of switchbacks or climbing turns. Installing grade reversals before and after each turn is essential to shed water prior to the turn. Also, avoid stacking turns above each other, as the water draining off the turn above will erode the turn below. Staggering the lengths of the legs of your turn will improve drainage and provide a better experience for the user.

SWITCHBACKS AND CLIMBING TURNS

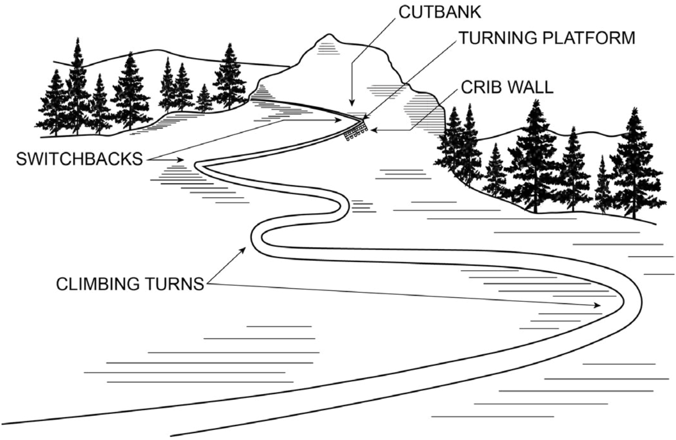


Figure 4–28. Climbing turns should be built on moderate slopes (less than 25 percent), whereas switchbacks can be constructed on steeper grades. Switchbacks require more technical construction techniques, such as installing crib walls.

Climbing Turns

Climbing turns are built on minimal to moderate hillside slopes when a change in direction is needed (fig. 4–29). The trail "climbs" through the turn at the same rate as the slope itself, as opposed to turning on a relatively flat surface or landing, as in a switchback or a modified climbing turn. Pack stock have an easier time negotiating a climbing turn than a switchback. Most trail managers also prefer constructing climbing turns over switchbacks because they require less maintenance and material to construct.

Build a climbing turn on hillsides of 25 percent or less or when a radius of 13–20 ft (4–6 m) is possible from the center of the turn.

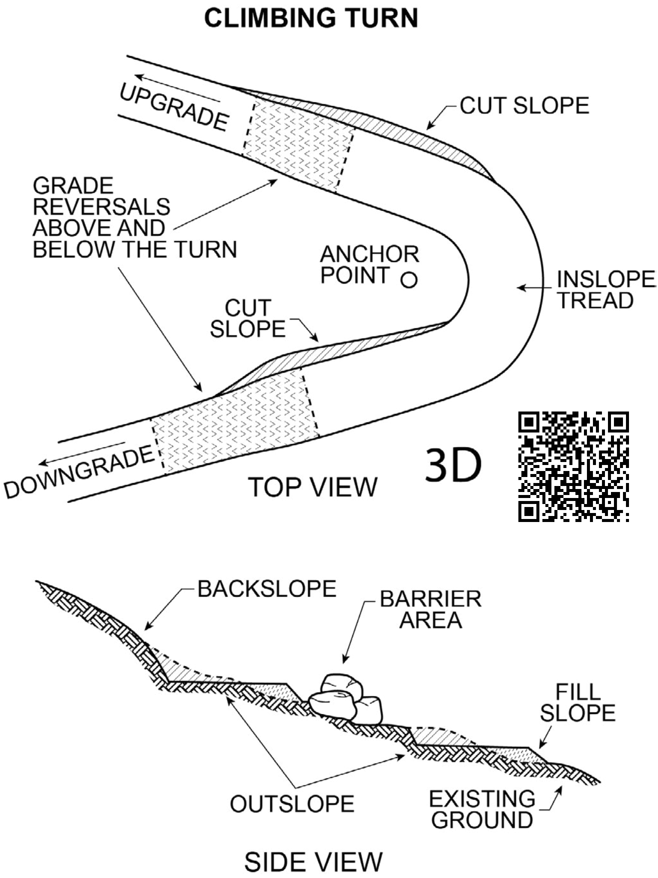


Figure 4–29. Climbing turn. Diagram based on Forest Service standard trail drawing STD 914-01.

Construction tips

- Lay out the turn so it wraps around a natural obstacle (anchor point) or place guide structures along the inside edge of the turn to prevent shortcutting (fig. 4–30).
- Use pin flags to designate the desired turn radius length and at various points along the turn to maintain a smooth radius.
- Always design grade reversals in both approaches to drain water before and after the turn. The reversal on the lower leg should capture flow from the upper leg.
- As the turn reaches the fall line, less material will be excavated.
- Inslope the turn toward the anchor point to contain users and stabilize the tread.
- Construct full benches at each end of the turn.

Common mistakes

- Constructing on a hillside slope that is too steep.
- Making the turn radius too tight or making the radius decrease through the turn (creating a "J" shape). The tight turn interrupts the forward motion of wheeled traffic through the turn and can cause riders to spin their tires.
- Providing inadequate grade reversals on the upper leg, causing the upper leg to drain onto the lower leg.
- Leaving rocks and roots in the trail tread.
- Positioning the upper and lower legs too close together, causing flat approaches to the turn, inviting shortcutting, and creating unnecessarily long approaches.

Figure 4–30. Use natural obstacles, like the tree at the top of this photo, as guide structures to prevent shortcutting. Wayne National Forest, Ohio. USDA photo by Scott Johnson.

Switchbacks

A switchback is typically constructed on steep hillside slopes (over 25 percent) when a change in direction is needed and the turning area is limited. The trail switches direction back and forth across the hillside in a zigzag pattern (fig. 4–31) to gain elevation in a short distance. Switchbacks are usually limited to nonmotorized trails, as motorized users will have a tough time with the small turning radius.

SWITCHBACKS

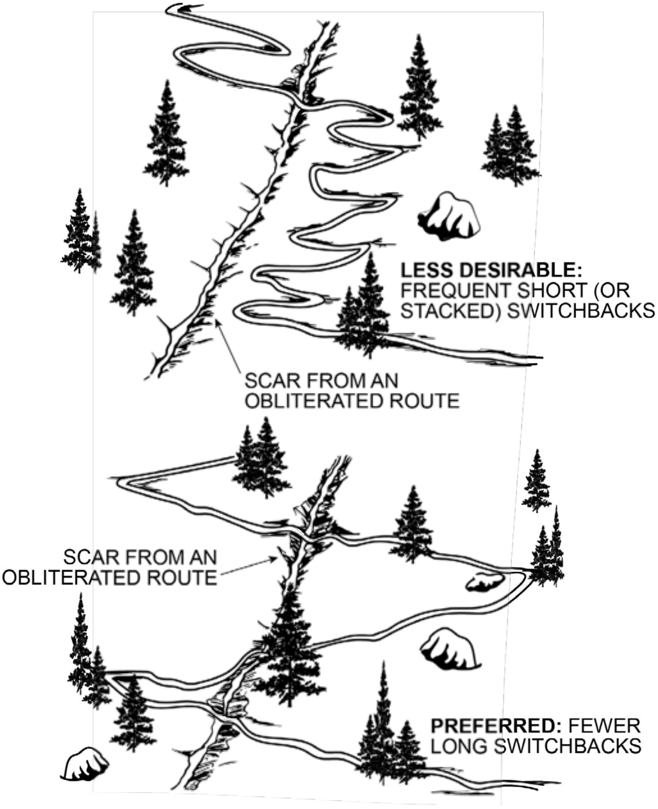


Figure 4–31. Long sections of trail between switchbacks are better than short sections that require more switchbacks with more opportunities to shortcut. Fewer switchbacks also means less construction and maintenance.

Trail managers use several different techniques to build switchbacks, mostly depending on the user type, topography, and obstacles. The circular landing style takes up the least space (fig. 4–32). The radius landing style is preferred for trails open to mountain bikes, where riders can flow through the turn without heavy braking. Rectangular landings are often used on trails that comply with accessibility guidelines.

In either style, drain features are installed above and below the turn. The upper leg is insloped to drain water away from the turn. Crib walls and other retaining structures are often necessary on switchbacks with steep hillsides in poor soil types.

Build a switchback when the hillside slope is greater than 25 percent with limited area for turn radius and the trail is open to nonmotorized users or built to meet accessibility guidelines.

Construction tips

- Avoid stacking turns (called corkscrews) that can increase the likelihood of water draining off upper trail sections onto lower trail sections (see fig. 4–31).
- Attempt to locate the turn on a relatively flat area or natural bench on the slope.
- Install grade reversals to drain water on the upper and lower legs before and after the turn.

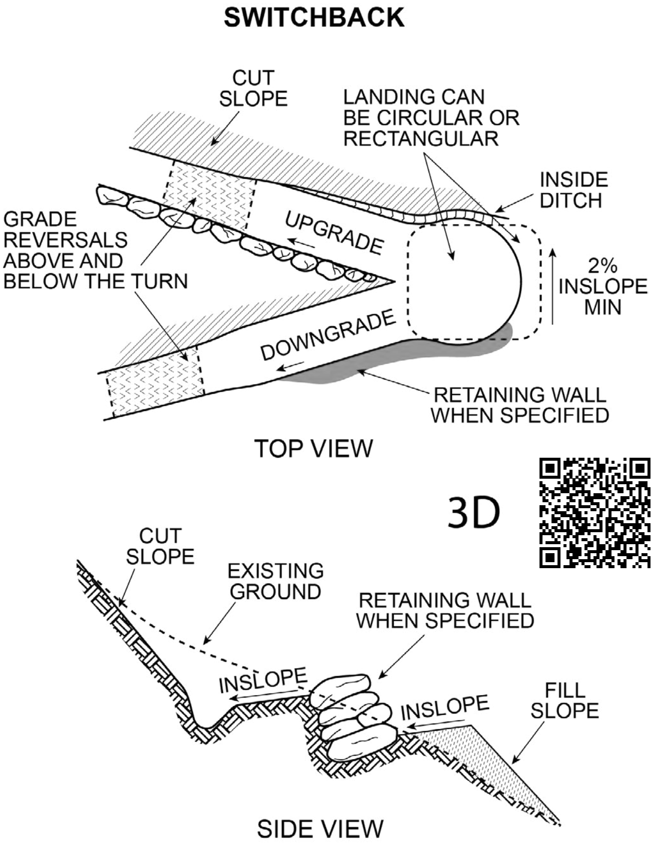


Figure 4–32. Switchback with a circular or rectangular landing. Diagram based on [Forest Service standard trail drawings](#) STD 931–20–01 and 931–30–01.

- Drain the landing or turning platform by insloping or outsloping the area 2–5 percent.
- Install an inside ditch if insloping the platform.
- Reserve excavated material from the upper leg to use as fill on the lower leg.
- Build retaining or crib walls to support either leg.
- Create barriers to discourage users from crosscutting between legs (fig. 4–33).

Common mistakes

- Not designing approaches and turns to accommodate the allowed uses.
- Creating a turn steeper than the desired level of difficulty.
- Having a disjointed or rough grade transition leading to the landing.
- Positioning the upper and lower trail legs too close together.
- Constructing the upper leg with inadequate insloping and not having a self-cleaning drain.

Figure 4–33. Rocks on the inside of the turn help prevent crosscutting the switchback. Rocks in the tread provide inside drainage before the turn. Pike-San Isabel National Forests, Colorado. USDA photo by Adam Carroll.

Radius Switchback

A radius switchback, also called a modified climbing turn, is like a climbing turn constructed on hillside slopes steeper than 25 percent. The turning area is "flattened" in a modified climbing turn so the steepest trail grade through the turn is approximately 20 percent. Flattening the turn is accomplished by building up the lower leg and cutting down the upper leg to reduce the grade on the turn. The turning radius ranges from 5 to 10 ft (1.5 to 3 m) wide—on the wider side if the trail is open to wheeled traffic or used by long pack stock strings (fig. 4–34).

Just as in a traditional climbing turn, grade reversals before and after the turn are essential. The grade reversals on the lower leg should capture flow from the upper leg.

Figure 4–34. Pack stock navigate around a guide structure on a modified climbing turn. Nez Perce-Clearwater National Forests, Idaho. USDA photo by Ella Bradley.

Characteristics of a good radius switchback

- Turn is insloped toward the radius anchor point to contain users and stabilize the tread.

- Natural anchor points create barriers between the upper and lower legs to discourage crosscutting.
- Grade reversals shed water before and after turns where the grade reversal on the lower leg captures flow from the upper leg.

Figure 4–35. Modified climbing turn with rock retaining walls on the upper and lower legs. Inyo National Forest, California. USDA photo by Jess May.

Retaining Structures

Ideally, trails are located and constructed in suitable soils and on gentle slopes. Unfortunately, that's not the reality in many locations. When the slope gets steep or the tread material is not ideal, trail workers construct crib and retaining walls, steps, and armoring to keep soil in place. Many of these projects require a heavy investment in time and resources to construct and maintain. Weigh whether the work is necessary to stabilize a trail and prevent erosion and consider if an alternative route would provide the solution without a heavy investment in building retaining structures.

Retaining structures hold back material or create a solid foundation. They are useful for keeping loose rock on scree slopes from sliding down and obliterating the tread, for keeping streams from eroding abutments, and for holding trail tread in place on steep hillsides (fig. 4–36). Any retaining structures over 6 ft (2 m) tall require engineering approval.

Rock Retaining Walls

Well-constructed rock retaining walls (also called dry masonry walls because no mortar is used between the rocks) can last for centuries. Rock is more durable than wood and recommended for most applications if there is an adequate supply near the project area.

Figure 4–36. A rock retaining wall can be used to support the trail tread or hold back the backslope. Inyo National Forest, California. USDA photo by Jess May.

Selecting the rocks. The key to a good retaining wall is a solid foundation and correct placement of rocks of acceptable size and shape. Before getting started, ensure an adequate supply of rocks to construct the retaining wall. The best rocks are rectangular with flat surfaces on most of the sides and 100 lb. (45 kg) or heavier—the bigger and heavier, the better (fig. 4–37). Quarrying, cutting, or shaping may be required to generate suitable material (fig. 4–38).

Figure 4–37. Rock wall foundation using quarried and cut rock. Lake Tahoe Basin Management Unit, California. USDA photo by Garrett Villanueva.

Figure 4–38. Shaping rock with rock chisels. Coconino National Forest, Arizona. USDA photo by Kevin Kuhl.

Plan your wall. Properly constructed retaining walls start out with a plan that includes location of the base, the height of the wall, and the angle of the wall face or "batter" (fig. 4–39). Aim for the angle of the batter (the amount that the wall leans into the hillside) to be at least 1:0.5, which means a 1-ft (30-cm) rise in height for every 0.5 ft (15 cm) of inward tilt. The batter should never be less than 1:0.25 without the use of cement, internal anchors, or both.

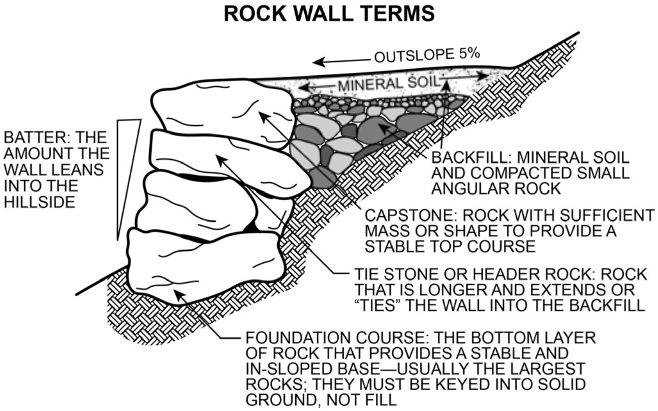


Figure 4–39. Terms used to describe rock retaining walls. Diagram based on Forest Service standard trail drawing STD 935–20–01.

Laying the foundation

- Excavate the wall footing to firm, stable soil or solid rock, preferably 6 in (15 cm) below grade.
- Tilt or inslope the excavated foundation into the hillside so the wall will lean inward to create a wall batter.
- Lay foundational or keystone rocks (often the largest rocks in the wall).
- Place and fit each rock to eliminate gaps and wobble or movement.
- Install rocks with many contact points along the outside of the wall. Mid and inside contact points will cause rocks to move by creating a fulcrum point.
- Compact behind each layer of rock with crushed gravel to tighten the wall layer by layer (fig. 4–40).

Figure 4–40. Use smaller rock to backfill and compact behind the larger rocks to stabilize the rock wall. Pike-San Isabel National Forests, Colorado. USDA photo by Adam Carroll.

Building the wall

- Once the foundation layer or course is completed, set successive courses:
- Use adequately sized and shaped rocks. Don't skimp by using inadequate material.
- Break joints by overlapping the seams between rocks in each course so the seams or joints don't line up in the courses above or below.

- Set each rock so it has a minimum of three points of contact set in a triangle, with two points toward the front edge of the stone.
- Shape the stones to improve fit on the front. Use smaller stones or shims to improve contact or fill gaps on the backside and negative space, as necessary. Never use shims on the face of the wall that can be worked out over time.
- As each course is completed, place and compact backfill in the remaining space with crushed rock (0.5–1 in [1–2.5 cm]), keeping organic material out.
- Place each course slightly farther into the hill to create the desired batter.
- Place tie stones and header rocks or long rocks perpendicular so that they extend deep into the hillside in each course. Using header rocks is particularly important if the wall's cross section widens as the wall gets higher.
- Use large, flat rocks as capstones for the top course of the wall. The heavier the better. Ensure capstones are shaped and placed to prevent trail users from loosening them.
- Backfill the capstone course with gravel and crushed stone a few inches below grade, then cap backfill with a minimum of 6 in (15 cm) of mineral soil.

Log Crib Walls

Log walls, called crib walls, are mostly used to support trails on steep hillsides, to hold back steep backslopes, in areas with loose or poor soils, or where adequate rock is not available. Wooden crib walls made of strong and naturally rot-resistant wood may work better for longer spans and in areas where rock cannot be anchored (fig. 4–41).

Figure 4–41. Where no large rocks are available, log crib walls may be a viable solution. Columbia River Gorge, Oregon. USDA photo by Nathaniel Brodie.

Selecting and preparing logs

- Use rot-resistant logs from native tree species (typically hardwoods) if available and permissible. Species vary depending on location. Avoid aspen, cottonwood, true fir, spruce, birch, and other soft and rot-prone wood species.

- Logs should be straight and consistent in overall shape and diameter.
- Peel logs past the cambium layer (the layer between the bark and the sapwood) to prevent premature rotting.

Notching the log. The purpose of a notch is to add stability and strength to a wall. The notch holds the upper log to the lower log and prevents horizontal rotation. The notch is cut into the bottom side of the upper log to reduce the water absorption into the cut area. Anywhere end grain of wood is exposed, water is wicked into the wood and the moisture promotes rot. "Lightly on the Land: The SCA Trail Building and Maintenance Manual" is a good resource for information about different notching methods. The notch type depends on the crew skill, tools, and time. There are three common notch types (fig. 4–42):

- A saddle notch, the preferred type, requires specialty scribing tools that refine the notch and a higher degree of patience and skill. Saddle cuts are accomplished by scribing the shape of the log below, making vertical cuts perpendicular to the scribed line, knocking out the cut blocks, and then using a single-bit ax or chisel for final shaping.
- A V-notch is not optimal but may suffice in low-consequence situations. This notch may be simply cut with a saw or an ax. It is just as the name implies: the cuts intersect at a single point at no more than one-third deep into the log. This notch may also be partially rounded to create a more secure connection.

- A square notch can be accomplished more quickly than a saddle notch by creating two vertical cuts and then chopping out the middle to create a flat bottom. In this notching style, both the top and bottom log are notched to create a flat mating surface. However, because the notched top of the lower log creates a surface, the logs will rot more quickly (fig. 4–43).

Construction tips

- Excavate the wall footing to firm, stable soil, or solid rock where possible. If establishing a solid footing is not possible, anchor or pin the sill and the first course face logs with deeply buried posts or 0.5-in (13-mm) or greater rebar driven a minimum of 24 in (61 cm) into the ground.
- Lay sill logs perpendicular to the direction of travel and alternate tiers of face logs and header logs (also called deadmen) (fig. 4–44). The purpose of the deadmen is to anchor and hold the wall to the slope.
- Interlock face and header logs with well-scribed and fitted notches on the bottom of the logs (see fig. 4–42). Pin logs at junctions with 3/8-in (10-mm) rebar or larger.

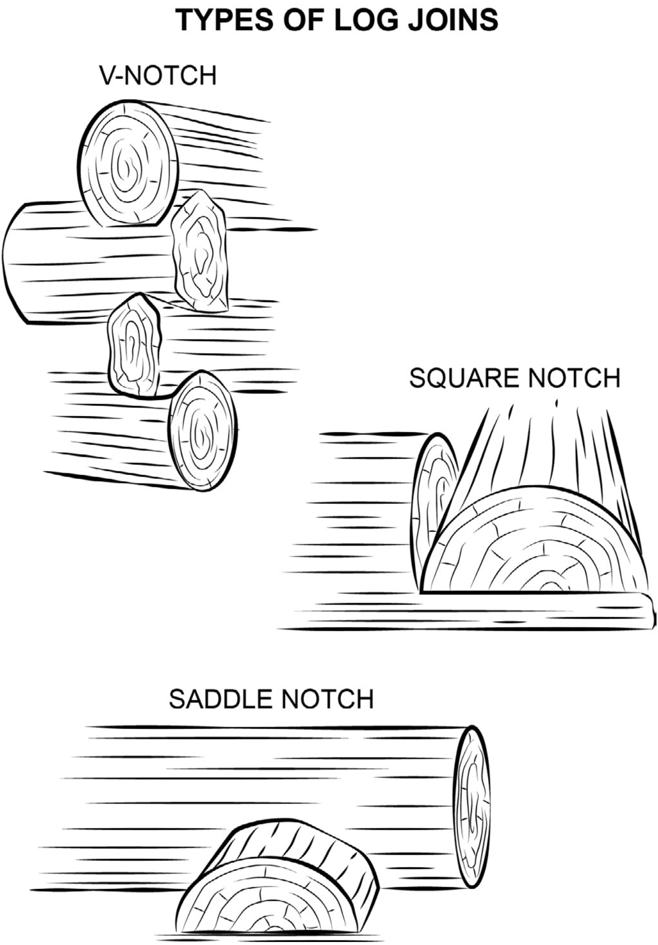


Figure 4–42. Types of log joinery.

Figure 4–43. An example of a square notch on timber steps. Inyo National Forest, California. USDA photo by Jess May.

- Pin the interior end of the header logs or deadmen to provide added anchoring and resistance to downward and outward forces.
- Place filler logs between the face logs or wedge larger rocks from inside the structure to plug the spaces between the face logs and retain the backfill.
- Like retaining walls built with rock, backfill log walls with gravel or crushed stone and avoid using organic materials. Backfill after each successive tier or after the wall is completed.

- Set each successive tier at enough of a batter angle to resist creep pressure from the slope and to reduce pressure on the face logs from the backfill.
- Cap the backfill with mineral soil (minimum of 6 in [15 cm]) to prevent dislodging or displacing and to provide a smooth tread.

Construction tips common to retaining and crib walls

- Outslope the tread to keep water from saturating the fill and excavation. Water should not cascade off the wall, as it will erode and undermine the structure. Drain water away from wall sections.
- Place riprap or other material at the wall base to prevent the foundation from being scoured.
- Embed large boulders or logs or other guide structures randomly along the outside edge to keep traffic off the edge of the tread—without creating a dam. Dig these into the tread so they don’t get kicked off.

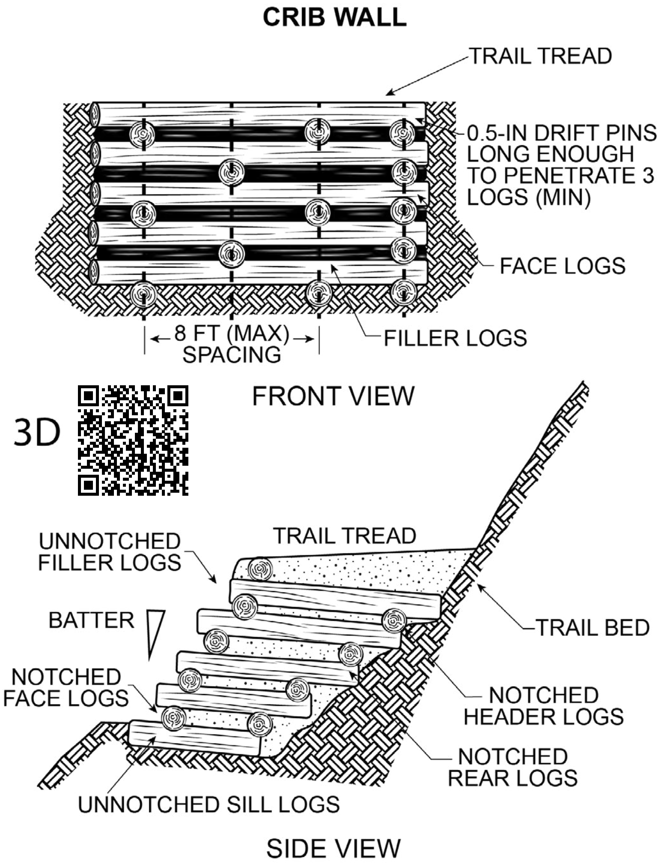


Figure 4–44. The characteristics of a log crib wall. Rot-resistant logs are recommended. Diagram based on [Forest Service standard trail drawing] STD 935–10–01.

Wire Basket Retaining Walls

Often called gabions (derived from an Italian word meaning “big cage”), wire baskets offer an alternative to rock or crib walls and other built structures in areas with shallow bedrock or where there is an insufficient supply of large rock or logs, but smaller rock is plentiful. The wire baskets are wired or welded together and filled with well-placed smaller rocks at a sufficient batter (fig. 4–45). Gabions are prone to fail if not constructed properly—particularly gabions made from twisted wire (fig. 4–46). Depending on the type of wire used and the climate, even well-constructed gabion walls may not last as long as a traditional rock wall. Some trail managers and users feel that gabions appear more artificial than a rock wall. Get help from someone with experience building long-lasting gabions if you use this type of structure.

Figure 4–45. Gabion retaining structure. Ashley National Forest, Utah. USDA photo by Nathan Emer.

Figure 4–46. Place rock tightly to avoid failure. This failing gabion was constructed with inadequately sized material and without sufficient batter. Shasta-Trinity National Forest, California. USDA photo.

Steps

Steps are used to gain a lot of elevation in a short distance. Rock steps are preferrable, but they can be made from wood depending on the availability of material. Steps are commonly found on legacy hiking trails where rerouting, paving, or other alternative stabilization means are not feasible due to terrain, need for elevation gain, and other factors. They are generally avoided on trails designed for equestrian riders and wheeled uses.

Figure 4–47. Installing overlapping rock steps with side retainer rocks. Lake Tahoe Basin Management Unit, California. USDA photo by Garrett Villanueva.

Constructing quality, durable steps requires a high degree of skill and experience, particularly if rock needs to be shaped (figs. 4–48 and 4–49). Steps can be constructed individually or grouped and in different styles depending on the location, alignment, trail grade, and available building materials. The width of trail structures, including steps, changes depending on the trail type and development class. Consult the trail management objective for the particular trail for a list of minimum structure widths.

Figure 4–48. Splitting rock with a stone sledge. Coconino National Forest, Arizona. USDA photo by Kevin Kuhl.

Figure 4–49. Cutting rock with a gas-powered rock saw. Coconino National Forest, Arizona. USDA photo by Kevin Kuhl.

Common step types

- **Overlapping steps** are constructed with timber or stones large enough to make up the needed rise and run proportions and placed on top of each other in a stairway (fig. 4–52).
- **Individual steps** can also be constructed with large stones as a single step or in a series where the bottom of each step lays underneath the top of the step below it, often with fill material separating them (fig. 4–51).

- **Check steps** are used when tread is rutted, and the step material is embedded in the tread and both banks to elevate the tread and retain fill.
- **Boxed steps** have a riser with an associated retaining wall on one or both sides to hold fill.
- **Riprap steps** will always include multiple steps and are installed so that each riser rock touches the back of the run rock below (which may be the same as the riser rock) instead of overlapping it on top like an overlapping step.

Components of a step

- "Rise" is the height of the face of each step.
- "Run" is the distance from the edge of one step to the base of the face of the next step (also referred to as the step tread).
- Retainers are side rocks (also called edge stones, gargoyles, or corrals) that hold the fill in place, increase contact between step rocks, and prevent erosion around the sides of the structure.

Steps on highly developed trails (class 4+) typically have a rise of 6–10 in (15–20 cm), minimum run of 14 in (35.5 cm), and do not vary more than 1 in (2.5 cm) in any direction between steps (fig. 4–50).

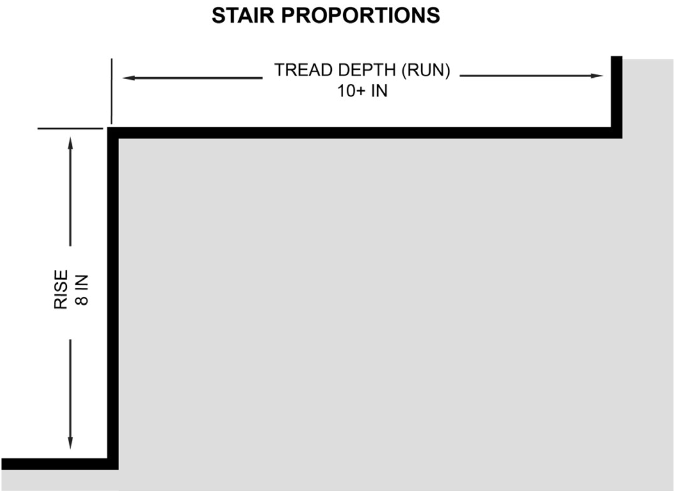


Figure 4–50. Risers range 6–10 in (15–25 cm) and treads are a minimum of 10 inches (25 cm) depending on the trail type and development scale.

Construction tips

- Gather material that matches the desired dimensions of the step for the trail type and development scale. Rocks should be larger than the desired dimensions to account for some of the rock being set into the ground.
- Start with constructing the bottom step "at grade" (i.e., the bottom of the incline) on a solid, excavated footing.
- Install a drainage feature above the top of the staircase to keep water from flowing down the steps.
- Incorporate drainage in the stairway—to keep water from pooling in landings—by making a longer run and building a waterbar into the stairway.

- Avoid using shims or small rocks to set or level steps, especially on the front end or above grade, as these will move over time. Shimming from the backside is strongest if the backfilled material is very well compacted to continuously push the shim into place.
- All steps should be level, solidly positioned, and free of wobbles or rocking.
- Backfill individual steps with crushed rock that is fist-sized or smaller, and cap with at least 2 in (5 cm) of compacted mineral soil.
- Place large, irregular stones or other material adjacent to the steps to discourage users from going around.
- Bury the bottom rock or timber step at least 1/3 of the object height (2/3 is preferred). Rocks and timbers in steps should also be well-anchored (fig. 4–52).
- For overlapping timber steps, use heavy timbers with at least a 6–in (15–cm) diameter for an overlapping stairway (fig. 4–53).
- For crib steps, use minimum 3 x 12 in (7 x 30 cm) lumber or 12–in (30–cm) diameter timber for the riser and embed the first step at least 6 in (15 cm) (fig. 4–54).

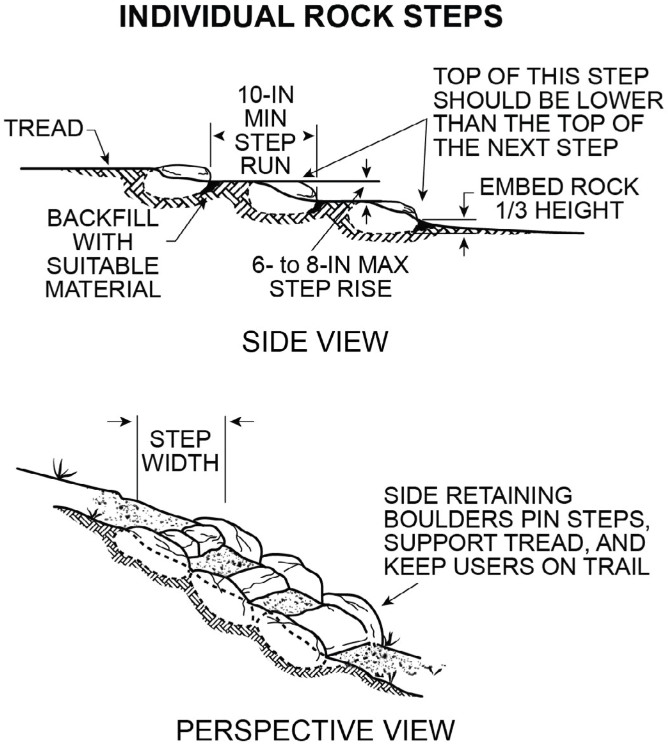


Figure 4–51. Side and perspective view of individual rock steps. Diagram based on [Forest Service standard trail drawing] STD 936–10–02.

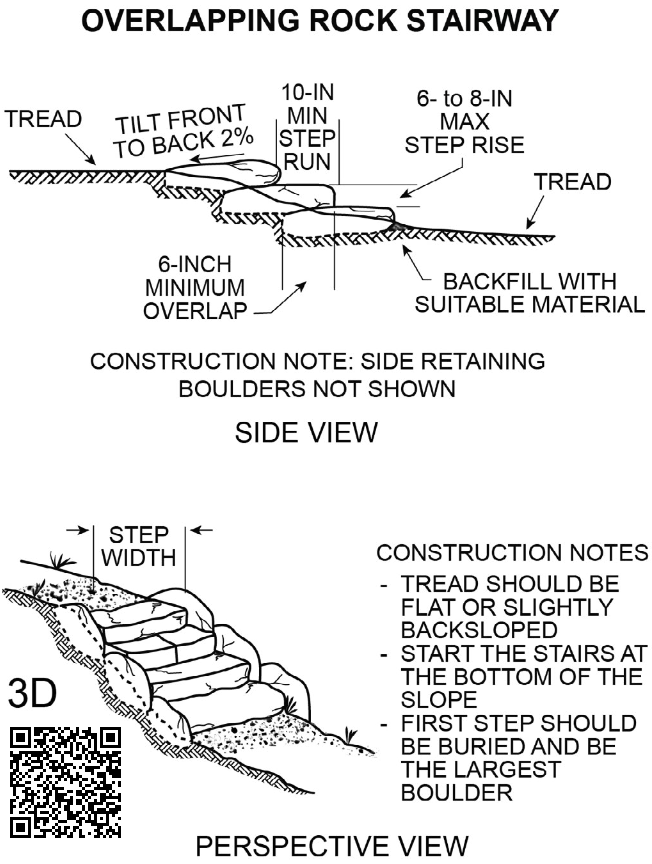


Figure 4–52. Side and perspective view of overlapping rock stairway. Diagram based on [Forest Service standard trail drawing] STD 936–20–01.

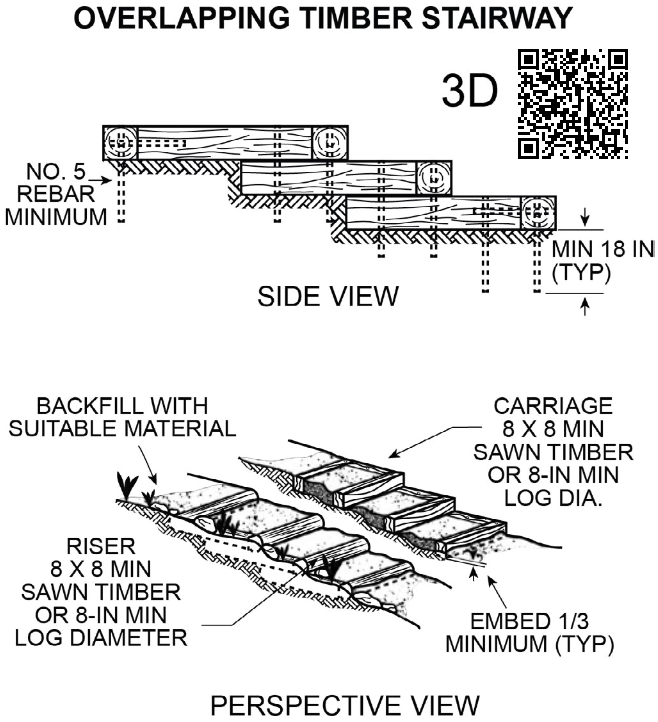


Figure 4–53. Side and perspective view of overlapping timber stairway. Diagram based on [Forest Service standard trail drawing](#) STD 936–20–02.

Figure 4–54. Overlapping timber steps being constructed on a hiking trail. The steps will be filled with crushed rock and overlain with fill material. Willamette National Forest, Oregon. USDA photo by Christopher Beitner.

Armoring the Tread

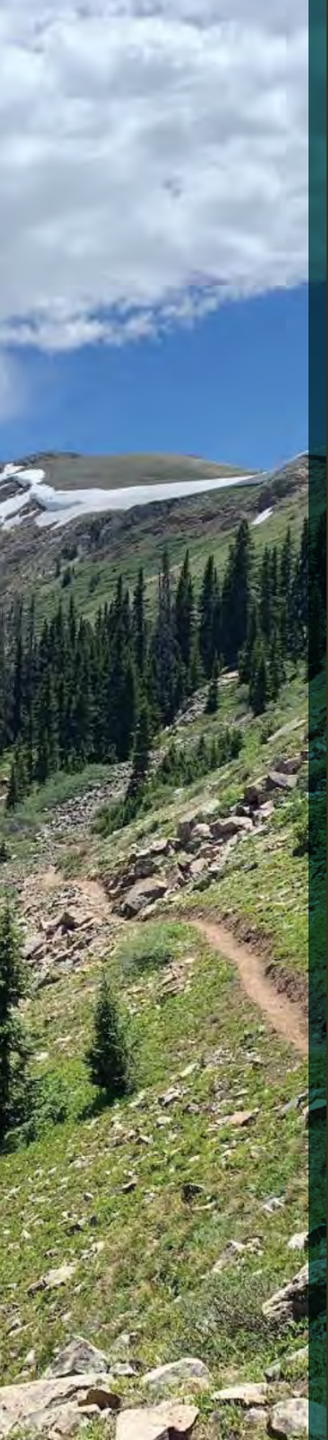
In limited cases, a segment of trail can require an exceptionally durable tread. Trail armoring creates a hardened segment of tread that resists erosion, compaction, and displacement. This labor-intensive approach requires a high degree of expertise and an adequate source of rock that may have to be split or shaped onsite.

Do not apply this technique as a bandage if the real problem is poor design, layout, or construction. In those cases, consider options to mitigate the problem or move the trail segment. Also, consider that armoring will fail if not routinely maintained and if users consistently disturb and erode the soil around it. Because users will follow the path of least resistance, ensure the armoring is as pleasing to the user as possible and install scree rocks or transplant vegetation to prevent people from avoiding the armored area.

Typically, armoring can be done in two ways depending on the size and shape of the available material. Pavestone or paving uses large, heavy rock with big faces, where each rock is buried so only the upper face is visible (fig. 4–55). Stone pitching is often used when rocks are not heavy enough to withstand use forces if laid flat. Instead, each rock is “pitched” or stood on the long axis and buried deeply to provide greater anchoring and strength (fig. 4–56). Either technique requires starting at grade and anchoring with the largest stones. When complete, all stones should be stable with no wobbling.

Figure 4–55. Rocks can be used to armor sections of heavily used trail. Coconino National Forest, Arizona. USDA photo by Kevin Kuhl.

Figure 4–56. Rock pitching used to protect a steep section of trail. Grand Canyon National Park, Arizona. USDA photo by Kerry Wood.



5

SIGNS

5. SIGNS

Trail signs provide essential information about trails for the safety, enjoyment, and convenience of national forest and grassland visitors, and Forest Service volunteers, partners, and employees. The Forest Service standards for trail sign design, construction, placement, and installation (including requirements for signs in designated wilderness) are described in the engineering manual "Sign and Poster Guidelines for the Forest Service." Nonstandard signs should be consistent with the Forest Service "Built Environment Image Guide" and should be approved by the regional forester. Before purchasing signs from a manufacturer or making them yourself, consult any local sign plan and the local trail manager for the correct sign type and design.

Signs are primarily installed at trailheads and at trail and road junctions. Wilderness boundaries, trail termini, popular features, and interpretive opportunities may call for special sign types and installation. Trail and trailhead signs and kiosks can also be translated into multiple languages where appropriate. Contact the Forest Service's limited English proficiency program staff in the Office of Civil Rights for more information about translation services.

Trail signs can display the route name, number, distance, allowed or prohibited uses, national scenic and historic trail markers, and a self-locator map. The amount of information depends on the trail type and development scale. If a destination is identified on a guide sign, the destination should also be identified on all subsequent guide signs until the destination is reached. Don’t include mileage on signs in designated wilderness.

Mount signs on posts or trees so that the bottom of the trail sign is a minimum of 5 ft (1.5 m) above the trail tread.

Figure 5–1. An example of a guide sign on a nonmotorized trail. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

The typical speed of users and whether the trail is used at night also influences the size of a sign. Signs can’t alert visitors to every inherent risk associated with the area, but warning signs may be used to make people aware of known hazards that, relative to the recreation opportunity spectrum (ROS) setting, are unusual, unexpected, or not readily apparent.

Signs are made of wood, metal, plastic, and other materials, depending on the ROS setting class, nonmotorized or motorized status, use type, and development scale. Think about environmental conditions when choosing your sign material. Consider using fire-resistant material for signs in areas prone to wildfire. Signs designed to fit on a single post are less likely to sustain damage from wildlife and snow loads.

Figure 5–2. Signs in remote areas are made of wood (or material appearing like wood), similar to the image on the left. Huron-Manistee National Forests, Michigan. (USDA photo.) Signs on routes designated for motor vehicles are retroreflective as shown in the image on the right. Custer Gallatin National Forest, Montana and South Dakota. (USDA photo by Charity Parks).

Placement

At the trailhead or junction, set the signpost back from the trail entrance by a few feet (approximately 1 m) to clearly mark the intended trail(s). Place signs at the right edge of the trail tread, perpendicular to the trail entrance. Install additional signs along the trail perpendicular to the tread (fig. 5–3). Different trail types require signs to be set back at varying distances from the tread. On hiking trails, leave at least 3 ft (1 m) of space between the tread edge and the nearest sign edge. Consider additional clearance for trails used by pack stock.

Trail or road junctions. Install signs where trails cross each other or roads. Consider the route type, sight distance, stopping speed of the typical user type, and applicable State laws when placing. Also, set signs far enough back to avoid snow berms when roads or trails are plowed. At trail junctions on moderately to highly developed (class 2–4) trails, place self-locator map signs or a map clearly displaying the trail system and the sign location.

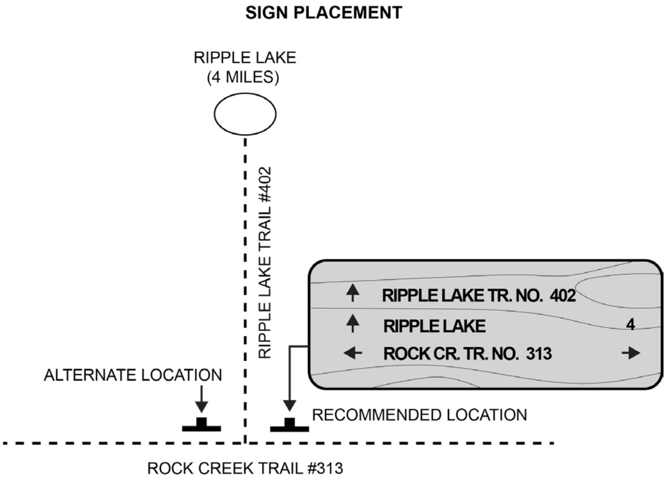


Figure 5–3. Sign placement example on a trail not designated for motor vehicle use.

Posts

Signposts are most often made of wood, steel pipe, or U-channel. Select the best post material for local conditions. Wooden posts of onsite (native) material are usually less expensive and appear less artificial, especially in a primitive setting, but they may have a shorter useful life. Purchased posts should be pressure-treated, as their longer lifespan will offset the higher initial investment. Round posts appear less artificial than square posts and provide more options for custom alignment of signs at trail junctions. Round posts should be at least 6 in (15 cm) in diameter.

Installation tips (fig. 5–4)

- Dig a hole at least 20–24 in (50–61 cm) deep and 6 in (15 cm) wider than the post.
- Fill the bottom of the hole with small rock to prevent pooled water from damaging the base of the post.
- Place spikes or lag screws at the base of the post to improve anchoring and prevent theft .
- Seat the post in the hole and keep it vertical while dropping rocks into the hole to secure it.
- Tamp these rocks with a rock bar or tool handle to jam them into place. Continue to place rocks and soil in the hole, tamping as you go.
- Top off the hole with mounded soil to account for settling and to prevent water from puddling around the post.

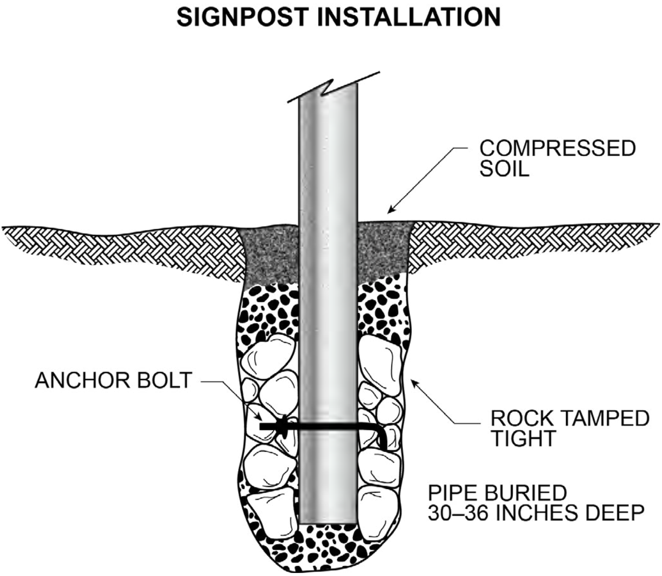


Figure 5–4. The key to placing solid signposts is to tamp the rock and soil with a rock bar as you fill the hole. Diagram based on Forest Service standard trail drawing STD 951–02.

In rocky areas or very soft soils, signposts can be supported with a rock cairn (see the route identification section below) or a gabion basket (fig. 5–5). Place horizontal spikes or lag screws at the base of these posts as well. Refer to the "Anchoring Trail Markers and Signs in Rocky Areas" publication for tips on installing signposts without using heavy tools and equipment.

Figure 5–5. Gabion foundation for a signpost. Coconino National Forest, Arizona. USDA photo by Kerry Wood.

Affixing the sign to the post. Affix the sign so the bottom edge is 5 ft (1.5 m) from the ground, high-water line, or average snow height. Purchased signs typically have predrilled holes. Level each sign and secure it with galvanized washers and lag screws or through-bolts that have a bolt head and washer on one side and a washer and nut on the other. Galvanized hardware, washers, and fasteners reduce rust stains on the sign.

Tip: Apply wood preservatives before installing sign hardware. Some preservatives, like alkaline copper quaternary (ACQ) compound, are highly corrosive to aluminum and carbon steel. The brushed-on preservative may discolor or corrode metal signs and fasteners, making it difficult to remove fasteners for sign repairs.

Designed for Accessibility

Trails that comply with trail accessibility guidelines require special signage. In addition to the standard trail signpost with the trail identity and destinations at the beginning of the trail, these signs should include:

- Typical and maximum trail grade
- Typical and maximum tread cross slope
- Minimum clear tread width
- Tread surface type and firmness
- Any major height obstacles (as appropriate)

Forest Service accessibility guidelines, including the Forest Service Trails Accessibility Guidelines (FSTAG) and the Forest Service Outdoor Recreation Accessibility Guidelines (FSORAG) contain more information about signing on trails designed for accessibility.

Reassurance Markers

Trail managers use different types of reassurance markers to reconfirm the route when the tread is indistinct, often across meadows and scree fields, where the ground is covered with snow or commonly obscured by fog and heavy rain, or when the route is confused by multiple trails. Depending on the trail development class, space the markers closely enough that the next marker is visible in either direction from any given marker. Position the markers on small rises, not in swales. The best time to decide where to place a marker is during a day with poor visibility.

Reassurance markers can be made from metal, plastic, or wood, or cairns made from rock. Trail managers prefer metal or natural materials, particularly in fire-prone environments, as plastic melts and can introduce microplastics into the environment over time. Some are made from blazes cut into trees, although this method risks opening the tree to disease. Check with your local trail manager to learn what's appropriate

Blazes

The Forest Service uses colored blazes to mark the trail and indicate the type of trail (table 5–1). Blazes can include an arrow that indicates the trail direction. They are typically plastic or metal triangular-shaped tags, although they can be painted, branded, or routed, and mounted on posts or trees at least 3 ft (1 m) above the ground, high-water line, or average snow depth. If mounting on trees, use aluminum nails and allow 0.5 in (1 cm) or so behind the tag for additional tree growth (fig. 5–6). Some trail managers use painted blazes carefully created with a template of the correct size and color.

Table 5–1. Approved reassurance marker colors and sizes for common trail types

Trail type	Color and reflectivity finish	Minimum size
Hiker, pedestrian, and pack and saddle	Gray, white, natural	5 x 7 in (13 x 18 cm)
Cross-country ski (urban setting or night skiing)	Blue (retroreflective)	5 x 7 in (13 x 18 cm)
Cross-country ski	Blue	5 x 7 in (13 x 18 cm)
Bicycle	White on brown background (retroreflective)	6 x 6 in (15 x 15 cm)
Water	White on brown background	3 x 3 in (7 x 7 cm)
ATV and motorcycle	White on brown background (retroreflective)	3 x 3 in (7 x 7 cm)
Snowmobile	Orange (retroreflective)	5 x 7 in (13 x 18 cm)

ATV = all-terrain vehicle

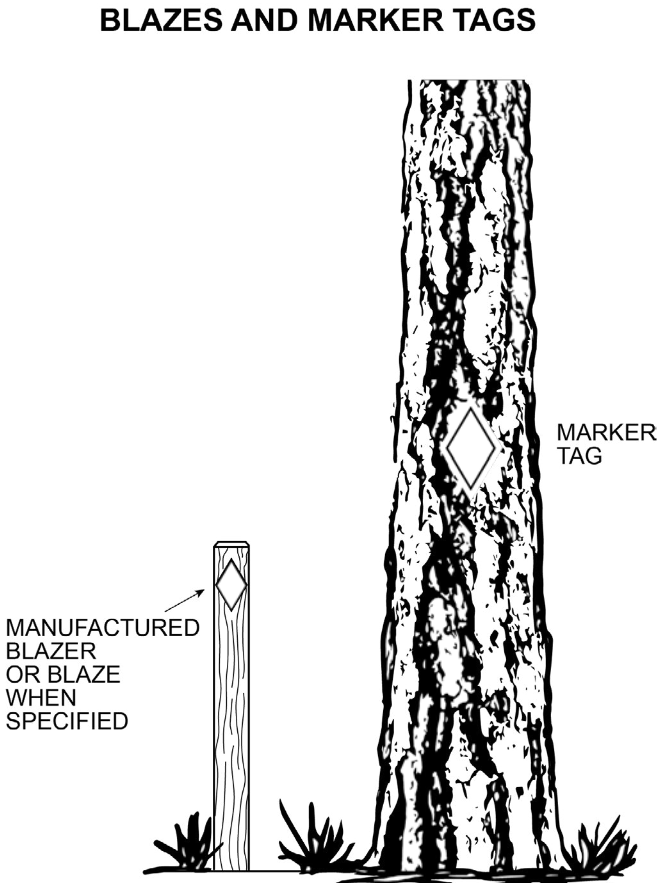


Figure 5–6. Most trail managers use reassurance markers nailed to posts or trees. Blazes are no longer cut into trees in many parts of the country. If it is still a practice in your area, blaze the tree on both sides. Cut the blaze no deeper than needed for clear visibility. Diagram based on Forest Service standard trail drawing STD 953–01.

Flexible Fiberglass Markers

Many trail managers use signs and markers made of flexible fiberglass, also referred to by the brand name Carsonite (fig. 5–7). The lower cost, slimmer size, and damage-resistant material make them a great option where local conditions warrant. Their slimmer size allows the flexible signs to be located closer to the trail tread and not constrict the trail. Installation requires specialty pilot hole and post drivers.

Figure 5–7. Flexible fiberglass trail reassurance marker. Manti-La Sal National Forest, Utah. USDA photo by Charity Parks.

Cairns

A cairn is a stack of rocks that can mark less-developed trails in open areas where low visibility or snow cover makes it difficult to follow the tread or where the tread is rocky and indistinct. Cairns are not a few stones piled one on top of the other (sometimes called a rock duck), which can easily be kicked over. Properly constructed cairns are similar in construction to rock walls and consist of circular tiers of stones (fig. 5–8). Check with an experienced trail manager in your area to determine the appropriate style of cairn.

Make the base of the cairn wide enough for each subsequent tier to be narrower than the one below it. In deep snow country or if building in areas with loose, angular rock (called talus), use a 6.5–ft (2–m) guide pole in the center to distinguish the cairn from other piles of rock or snow-covered mounds. A pipe built into the center of the cairn allows the guide pole to be removed and reinstalled with the seasons.

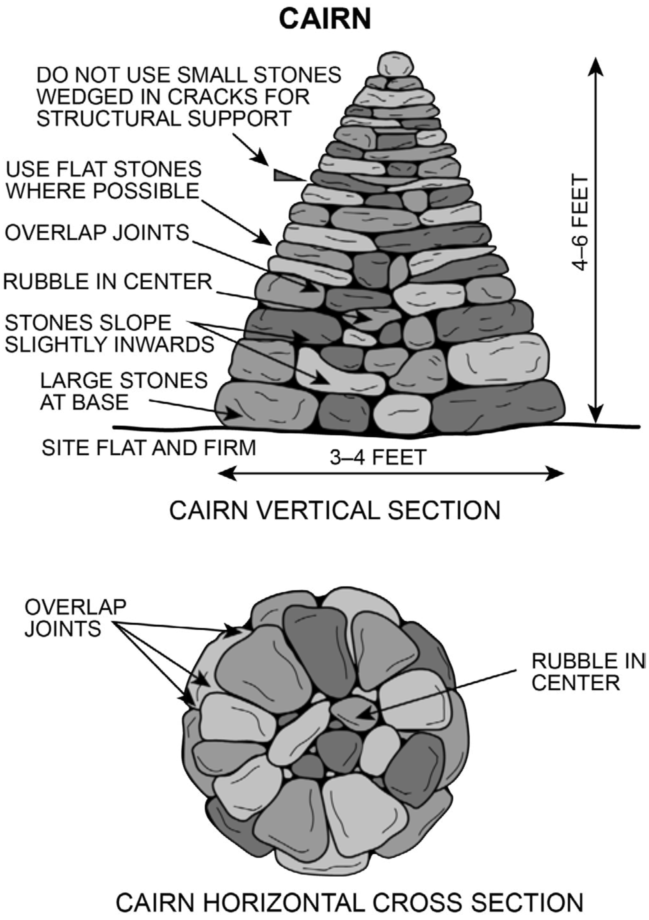


Figure 5–8. A cairn is constructed of circular tiers of stones. Illustration adapted with permission by the Appalachian Mountain Club's Trail Adopter Handbook. Diagram based on Forest Service standard trail drawing STD 955–01.

National Trails

Specially designed triangle markers indicate national scenic, national historic, and national recreation trails. Each national trail is managed by either the Forest Service, National Park Service, or the Bureau of Land Management (fig. 5–9). The designated national trail marker should appear below the trail sign at the trailhead, at road crossings, and on guide signs and reassurance markers. Visit the [Forest Service's America's National Trails website] for more information about national scenic and national historic trails administered by the Forest Service. The [American Trails nonprofit] supports management of national recreation trails (fig. 5–10).

Figure 5–9. Individually designed trail markers for the Nez Perce National Historic Trail and the Florida National Scenic Trail.

Fig. 5–10. Special marker for national recreation trails.

6

CONSTRUCTION AND DECOMMISSIONING

6. CONSTRUCTION AND DECOMMISSIONING

Trails are costly to construct and maintain. Trail managers think strategically before constructing a new trail, adopting a user-created route, or accepting a proposal for a new trail from a partner or community. A trail manager may choose to construct a new segment of trail to relocate a physically unsustainable portion or construct an entirely new trail within the trail system in response to an unmet public need. Many managers use a screening process to evaluate the new trail proposal. The PACE It! tool is a good example (available on the Forest Service's National Trail Program SharePoint (internal site). The tool quantifies how the proposed trail aligns with the desired outcomes for sustainable recreation on the local unit.

An abundance of user-created routes could be a symptom of a lack of trail maintenance, inadequate signing, or an unmet public need for new or different trails. Trail enthusiasts often create their own route when the official trail system doesn't suit their need or offer convenient access to a desirable area. Official trails should be more obvious, easier to access, and more enjoyable than the alternatives.

Relocation

Repeatedly "fixing" short sections of poorly located trail consumes valuable time and resources. A crew can spend an entire season reinforcing trail tread on a short section of physically unsustainable trail, only to come back every few years and do it again. Or they can spend a season or two decommissioning the trouble spot and rerouting it to a new sustainable trail that requires little maintenance for a decade or more. Before beginning the relocation, review the requirements for appropriate authorization outlined in chapter 1.

A trail relocation may involve a short segment to improve undulation or even an entire trail realignment of where the trail has become wholly unmaintainable, causes substantial environmental impacts, or requires major yearly investments in time and resources to fix. Trail sections following the fall line are examples of unsustainable and unmaintainable situations where relocation may constitute the preferred long-term solution. Reducing trail grade and incorporating grade reversals and other sustainable elements creates longer trail segments than the segments they replace (fig. 6–1).

As you consider rerouting the trail, pay close attention to the conditions that caused the maintenance issue in the first place. Don't repeat the same mistakes in the new trail alignment. If the new alignment options won't resolve the underlying issues, then don't reroute. Spend your time and resources to repair the existing trail.

If relocation is the chosen option, invest time in scouting for suitable places to relocate and work with specialists to review maps and data on soils, hydrology, and environmentally and culturally sensitive areas. The relocated trail or trail segment should have the same character and be designed for the same uses and development scale as the rest of the trail. Relocated segments should connect to the original trail with smooth transitions and no abrupt turns.

Develop a construction plan for the reroute that incorporates all the elements of a rolling contour trail discussed in chapter 2. Follow the steps to close and rehabilitate the old trail tread, as discussed below, to prevent further erosion and use.

Some short sections of eroded trails may not be a major problem and are appropriate for minimally to moderately developed trails. If the trail surface is rocky—and water, use, and slopes are moderate—the section could stabilize itself. These segments provide challenging elements sought by some users. A short section of eroded but stable trail may cause less environmental damage than constructing a longer rerouted section. Weigh your options wisely.

TRAIL RELOCATIONS

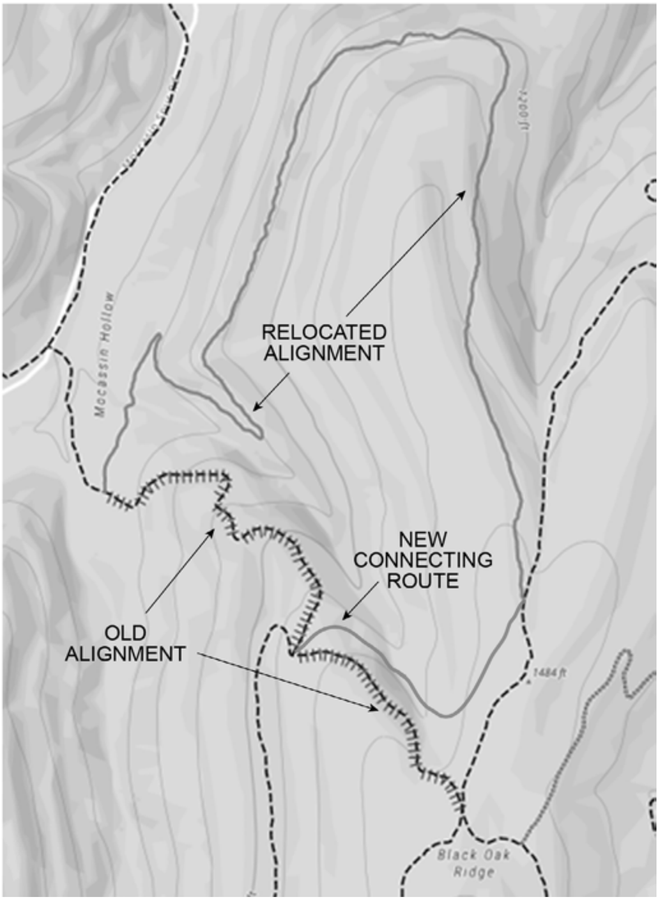


Figure 6–1. Trail relocations are often double (or more) than the length of the segment of trail they are replacing to allow for lower average grade, sufficient grade reversals, and other physically sustainable design elements.

Preparing for Construction

The preparatory work to construct a new trail or trail segment ensures the project will succeed and the trail will be sustainably built. The focus in this step is to work with others to determine the best type of trail and trail location to fulfill the management objectives. During this step, trail managers communicate the need for a new trail or trail segment and gain the support of the line officer. They also work with Forest Service specialists to determine the most sustainable route that minimizes negative impacts to environmental and cultural resources. Drafting a trail management objective (TMO) for the proposed trail is a good way to share information about the proposed trail.

New Trail Planning

A good trail may appear completely natural, but that appearance belies an incredible amount of work in planning, scouting, design, layout, construction, and maintenance (fig. 6–2). There is an art to the way a trail interacts, respects, celebrates, and acknowledges the landscape and the user.

Planning considers why the new trail or trail section is needed and informs the trail design. Most trail managers document the design in a trail construction plan.

A trail that is well-designed but poorly built can be saved, but a trail that is poorly designed and well-built is destined for failure.

Considerations for successful planning and design of a new trail:

- **Describe the project purpose, need, and feasibility,** including the local conditions and how the trail fits into existing trail system opportunities.
- **Ensure the project aligns** with the land use plan.
- **Engage the line officer** and ensure they support prioritizing specialists' time to conduct environmental analysis.
- **Identify correct trail design specifications** for the user type and development scale, such as the target trail grade, width, surfacing, corridor, and presence of obstacles. This information will be documented in the TMO.
- **Share a conceptual map and description** of the trail with stakeholders and specialists.
- **Incorporate stakeholder and resource specialist input** into the design (often part of National Environmental Policy Act [NEPA] or another formal environmental review process).

- **Estimate project costs,** including how long-term maintenance will be accomplished.
- **Share the final proposed trail alignment with the resource specialists.**
- **Document environmental decisions and permits.**
- **Layout the approved route in the field** and identify locations of planned trail structures and equipment staging areas. Most trail managers use stakes to identify these areas.
- **Develop the construction plan** that describes needed materials, tools, equipment, workforce (including staff, contractors, partners, and volunteers), and the project timeframe.
- **Secure funding** from prioritized appropriated funding, grants, or other sources. Note that large projects may span multiple seasons and fiscal years.
- **Notify the public of trail access impacts,** if necessary.
- **Prepare the route for work to begin,** including finalizing route flagging (and/or staking) in the field, digging test pits, marking specific obstacles to be left or removed, and marking the location of new structures and features on the ground.

Figure 6–2. Design and construct your trail to be a part of the landscape. Flathead National Forest, Montana. USDA photo by Cassidy Bender.

Plotting the Proposed Trail on a Map

Being a "trail artist" requires the highest quality craftsmanship to design, scout, lay out, and build a trail that ties into the landscape. The process starts with thinking about what the user will enjoy most from your trail—features such as beautiful vistas, giant rock formations, and water views—while still adhering to physical sustainability principles.

Incorporating these features into your trail integrates spatial and field-collected data. Digital maps allow you to overlay multiple data layers to help inform where the trail should and should not go. Geographic information systems like Google Earth or ArcGIS offer good options for displaying aerial, satellite, and lidar imagery. Using digital maps allows you to overlay the area with topography, water bodies, watershed boundaries, roads, other trails, recreation infrastructure, and other features to start planning the trail alignment. Digital maps also help you communicate with resource specialists and the public about the proposed route.

Anchor points (also called positive control points) are places where the trail should go (e.g., trailheads, desirable destinations, scenic overlooks or other points of interest, water crossings, and other natural features). Anchor points help you narrow down the possible routes and make sure you don't miss anything important or exciting in a project area.

Avoidance areas (also called negative control points) include, but are not limited to, noxious weed infestations, threatened and endangered species, critical wildlife habitat, cultural sites, safety hazards, and property boundaries. Forest Service specialists can help you identify these areas. Avoid or minimize segments in poor soils, flat areas, steep hillsides, ridgelines, the bottom of slopes, and other areas that are difficult to drain. Trails through wetlands and bogs require special permitting. Routing trails through avoidance areas requires advanced planning and design and is more costly to construct and maintain.

Target trail grade represents the grade percentage appropriate for the desired trail type and development scale. A good guideline is to plot on a map a trail grade 2–3 percent less than the target trail grade to allow flexibility in maintaining a sustainable grade during field layout. Staying within the technical guidelines for trail type and development scale isn't always possible. You'll likely have short segments with steep grades (called maximum short pitches) to avoid obstacles like rock outcroppings, while the remaining trail segments meet the target grade.

Steps to plan the route on the map

- Plot any known anchor points and avoidance areas.
- Connect the anchor points with a draft line, skirting avoidance areas and following contour lines that keep the route at the desired grade and outside the fall line.
- Consider drawing multiple draft alignments so you have options when scouting the route in the field.
- Use the digital files to gather feedback from resource specialists and the public about the proposed route.
- Bring the map with you into the field, either on a device or in printed form.

Using a Clinometer

A clinometer (or "clino") is a handheld device that you can use to measure the grade (percent) or angle (degree) of a trail segment or hillside (fig. 6–3). Clinometer apps for smart devices are also available. Grade and degree values are on either side of the viewfinder. Always double check which scale you're using. The units tend to be printed on the bottom of the scales. Most trail managers use the percent side. The lingo can be tricky—trail managers say "percent slope" when referring to the incline or decline of the natural terrain, and "percent grade" when referring to the incline or decline of the constructed trail. (Refer to the "Trail Grade" section in chapter 2 for additional information.) Both measurements use the percent value from the same side of the clinometer. Refer to the table of grade and degree conversions in the "Resources" chapter.

Never lay out a trail without a traditional or digital clinometer.

Finding a grade with a clinometer is called "shooting a grade." Always use a clinometer to find grade; never eyeball it. Assuming or guessing the grade will cause problems from the start of your new trail or trail assessment. A trail professional always has a clinometer when they go to the field.

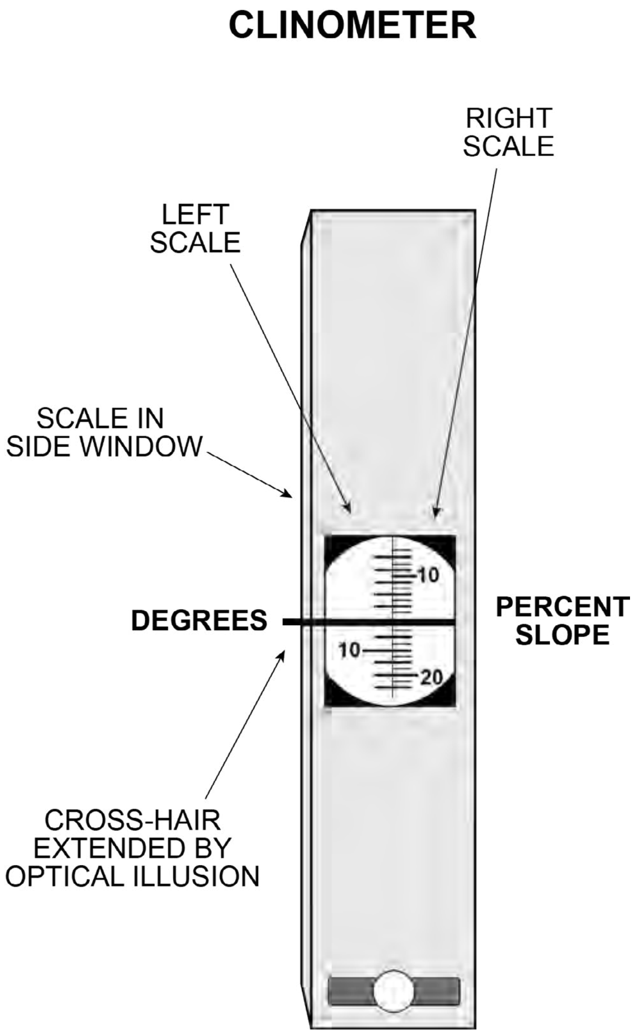


Figure 6–3. Diagram of a clinometer.

How to use a clinometer (fig. 6–4)

Step 1. Hold the clinometer sight hole to your dominant eye. Keep both eyes open. Look through the viewfinder and find the percentage scale. Use the horizontal line in the center of the viewfinder to measure the percent grade.

Step 2. Work with a partner to determine a "zero" grade. Working with someone of similar height is easier. Stand toe-to-toe on level ground. Keep your head level and look straight ahead. Hold the clinometer to your dominant eye, keeping both eyes open. Notice where the horizontal line crosses your partner's face or body. This will be your reference spot when shooting a grade. Some trail managers also use a surveyor's pole, short avalanche probe, or stick with a flagged mark at zero grade. This allows your partner to move the aim point up and down the hill with ease and the color mark is easier to spot in thick vegetation.

Step 3. Practice by facing your partner on uneven ground at least 15 ft (4.5 m) apart. Hold the clinometer to your dominant eye, keeping both eyes open. Look at the same reference spot on your partner's face or body (or flagged pole) and record the percent grade. Uneven terrain, thick vegetation, and different people shooting the grade affect the accuracy of the reading. Consistently having the same person shoot the grade will increase accuracy. It is also common to average the readings of two people.

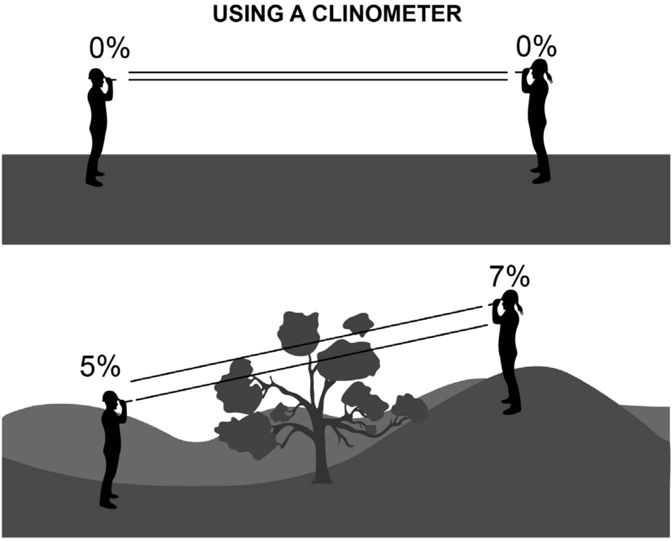


Figure 6–4. The easiest way to use a clinometer is with a partner. Use the steps above to determine the percent of the grade.

Scouting the Route

The goal of scouting and layout for a new trail or trail segment is to refine the route and flag the final corridor for review by specialists. Field scouting requires solid knowledge of navigating and interpreting the map you made in the office. Start the layout process by bringing your draft corridor map or device into the field and scout the area where the proposed trail will go. A GPS-enabled tablet loaded with the conceptual routes, anchor points, and avoidance areas saves time. Keep detailed field notes of potential routes, control points, and avoidance areas. Field scouting is an iterative process and trail standards may be modified based on field conditions

Some specialists may prefer you flag the corridor for their review while you are scouting the route; others prefer you flag it during field layout. Check with the specialists for their preferences, then adjust accordingly and flag the final route.

A variety of useful apps for trail scouting and layout are available on smartphones and tablets, including social network trail apps, digital notepads, clinometers, and apps for measuring and leveling.

Objectives for scouting the route

- Verify that the route can be constructed within the design specifications for the use type and development scale and within the guidelines of a physically sustainable trail.
- Locate known anchor points and avoidance areas and identify additional points and areas.
- Modify the office-based draft corridor to create the best alignment.
- Establish a flag route or routes on the ground and update digital files for specialist review (flagging techniques are described below).
- Identify areas that will need trail structures to support the tread or create drainage.

Steps for scouting the proposed route

- Use the map or track feature on a GPS unit to follow the route you developed in the office.
- Validate the hillside slopes.
- Take detailed and organized notes of the information you collect during scouting and refine the route location.
- Measure segments of the proposed trail grade with a clinometer (see above for the steps to use a clinometer).
- Try different routes until you find the best continuous route between control points, considering the positive and negative control points on the ground.
    - Consider the smaller features along the desired corridor, such as an interesting tree or root ball that subtly enhances the user experience and can increase the physical sustainability of the trail.
    - As much as possible, avoid switchbacks, water crossings, and routes that intersect flat terrain, ridgelines, and the bottoms of slopes that are difficult to drain. Don't flag the route adjacent to large trees to avoid damaging the root ball.
- Identify breaks in grade and locations for drainage features.
- Walk the route at least three times and in both directions to refine and adjust the flag line using a clinometer.
- Record the GPS coordinates of these locations in a field notebook or mapping app:
    - Riparian vegetation, seeps or soggy ground, and other indicators of high ground water

    - Patches of sparse vegetation that could indicate shallow bedrock
    - Draws and natural drainage to construct grade reversals
    - Where a maximum short pitch grade will exceed the target grade
- Update your digital files with the scouted corridors and any new anchor points and avoidance areas.

Tools for scouting the route and laying out the trail (fig. 6–5)

- Clinometer
- Compass and altimeter
- GPS or smartphone
- Diameter tape (also called forester or logging tape)
- Multiple colors of flagging
- Wire pin flags
- Roll-up pocket surveyor's pole
- Permanent marker to write notes on the flagging or stakes
- Notebook
- Probe to check soil depth to bedrock
- Maps

Figure 6–5. A few essential tools for scouting and laying out a trail: clinometer, flagging, diameter tape (also called forester tape), pocketknife, and folding handsaw. Tongass National Forest, Alaska. USDA photo by Laurent Deviche.

Layout

Once you have the draft alignment identified in the field, mark the center of the trail corridor using flagging tape. This represents the alignment that specialists will analyze. Most trail managers request that specialists review at least 25–30 ft (7.5–9 m) on either side of the flagging line to allow for minor adjustments to the alignment during construction.

Objectives of field layout

- Identify the center line of the final trail corridor for environmental evaluation.
- Hang enough flagging so the resource specialist can follow the flagging when they conduct their analysis.

- Identify and adjust the route accordingly when you find impassable terrain, additional control points, guide structures, and obstacles that weren't discovered during scouting.

Flagging

Trail managers use flagging for a variety of purposes—identifying trail alignments, drawing attention to anchor points and avoidance areas, and indicating areas to stage supplies. Most trail managers also use stakes if they plan to contract the work. Different colors, or a combination of colors, is helpful to communicate different things. Make sure the color or colors you're using are not already used locally for some other purpose and that they stand out from the vegetation and surrounding landscape.

How to flag a route

- Always use a clinometer to measure grades.
- Record your field alignment with a GPS unit.
- Establish the preliminary line (P-line) by tying flagging to the branches of live trees or bushes at eye level about every 30 ft (9 m). At least two flags should be visible in either direction.
- Tie knots with a girth hitch or one-sided bow that can be easily untied because you will likely adjust the flag line.
- Use pin flags instead of flagging if you are working in an open area without trees or shrubs.
- Update your digital files with the flagged center line.

Two or more people flagging

- Standing on the P-line, direct your partner ahead about 30 ft (9 m).
- Shoot a grade with your clinometer and have your partner adjust their location higher or lower on the hillside to meet your desired grade.
- Determine the desired alignment and have your partner adjust the P-line flagging or tie a new piece of flagging on live vegetation, then you both move ahead.
- Stand at the newly placed flagging and shoot another grade.
- The process repeats to refine the P-line to be at the desired grade.
- A third person can be scouting ahead for obstacles and control points.

One-person flagging

- Stand on the P-line and tie flagging at eye level.
- Move ahead 25–75 ft (8–23 m) and shoot a grade back to the flag you just tied.
- Move up or down the slope to meet your desired grade.
- Tie another piece of flagging at eye level.
- Leave larger spaces between flags, as you'll likely have to adjust the flag line on your second pass.
- Fill in the gaps with more flagging and make minor adjustments as you go.

Don’t scrimp. Flagging is cheap compared to the time spent locating the route. Flagging that is close together helps trail workers visualize the flow of the trail. The technique also accounts for animals carrying off flags or the wind blowing them down.

Marking the final alignment. Pin flags work well to mark the exact location of the trail tread and direct novice trail builders where to dig (fig. 6–6).

- Place pin flags on the trail’s centerline or on its uphill or downhill side. Opinions vary on which is the best; just make sure the crew knows where the trail will be relative to the pin flags.
- Place pin flags every 10 ft (3 m) or so. More is better. Remember to collect all the material from the pin flags after construction.

Figure 6–6. Pin flags mark the exact location of the trail tread and give you a good feel for the flow of the trail. Cibola National Forest, New Mexico. Courtesy photo by Jenny Blackmore.

After flagging, run, walk, or ride the proposed route and imagine how the intended user will feel on it. This will give you a good feel for the flow of the trail. Adjust by moving flags if a turn feels too sharp or a section has too much straightaway.

Tread Construction

This section assumes completed environmental studies and that all parts of the project have been approved and permitted. The section applies to trails built by hand or by mechanized trail-building equipment.

Optimally, trails and trail features are designed with physical sustainability principles in mind. A trail built with a full bench, low slope ratio, and rolling contours is the most physically sustainable trail that requires the least amount of maintenance. Remember, every constructed feature you build will require maintenance. Weigh your options carefully.

Trails are constructed with these common attributes:

- **Trailway.** The area that contains the trail tread, excavation, and embankment.
- **Tread.** The surface that traffic moves on (including water and snow). It can be made of native or imported material depending on the trail type and development class.
- **Crest.** A short portion of trail elevated above a dip (or sag) on either side.
- **Dip (or sag).** A short portion of trail that dips or sags down below a crest on either side.
- **Backslope.** The area uphill from the tread that is typically steeper than the prevailing hillside.
- **Clearing.** The horizontal and vertical area that is cleared of vegetation.

- **Constructed features.** A range of structures, such as a causeway or steps, made of native or imported material that support the trail.

The features, tread, and clearing widths depend on the trail type and development scale. The specifications are described in the TMO for each trail. An overview of these concepts is in chapter 2, "Basic Trail Concepts." Visit the Forest Service Trail Management Basics web page for a full list of trail design specifications and clearing limits for different use types and development scales.

Sample Preconstruction Checklist

These steps are strongly encouraged before cutting any vegetation or removing any soil (local conditions may warrant additional steps).

All projects:

- ☐ Resource specialists have documented their review of impacts to natural and cultural resources and the project conforms to a forest land and resource plan.
- ☐ The authorized officer has approved the project (district ranger or forest or grassland supervisor).
- ☐ Trail crew members are trained, have the skills, tools, and personal protective equipment necessary to do the job safely, and the proposed work is documented in a project risk assessment.
- ☐ A crew member is assigned to take photos of the work and record and report accomplishments.

Construction projects. Planned trail alignments are physically sustainable and match the technical guidelines for the intended trail type and development scale.

Maintenance projects. Maintenance activities are intended to bring the trail back within the technical guidelines for the intended trail type and development scale.

Best Practices for Construction

There are a few basic things to consider before implementing any trail construction project.

Construction plan

The trail construction plan will guide the trail development process. Discuss the plan with the crew before starting work. Minimum information should include:

- Trail location and proposed structures
- Appropriate trail design specifications for the user type and development scale (as documented in the TMO)
- Locations of staging and work areas
- Drawings of planned structures and features
- Proposed timeline for the project
- Mitigation measures and other considerations from the NEPA decision document or supporting materials
- Needed workforce and materials
- Safety plan for trail workers and the public, including considerations for public and construction access during the project

Clear the corridor

Clearing the corridor opens the footprint of the trail in preparation for the excavation phase of the project.

- Following the approved corridor (commonly a flag line), start by removing standing trees, brush, and duff (leaves, sticks, and other organic material above the mineral soil layer) to a width and height per the target trail design specifications.
- Mitigate hazard trees, loose rock, holes, and safety issues as soon as possible for worker safety.
- Remove boulders that could protrude above the tread as appropriate for the trail type and development scale. Obstacles and obstructions are appropriate on less-developed trails and add to the challenge and desired user experience.
- Only cut trees if the environmental evaluation allows it. Generally, avoid cutting larger live trees greater than 4 in (10 cm) diameter at breast height (DBH) when possible, especially in areas where shade is important.
- Leave high stumps on felled trees within the tread. This will make stump removal easier when you dig them out later—roots and all. Do not "low stump" trees within the tread, as they will eventually stick up after the tread compacts. Cut stumps outside the tread flush with the ground so no one gets hurt if they fall.
- Place all debris far away from the corridor with cut ends facing away from the trail. Scatter the debris evenly downhill to prevent material from rolling onto the trail.

- Preserve organic material to naturalize disturbed areas and to prevent erosion. For example, save leaf litter, pine needles, mulch, and woody debris to naturalize the impacted area adjacent to the work site. Preserve the roots of plants for replanting in disturbed areas.
- Refine the alignment and finalize construction needs once the initial vegetation clearing is completed.

Borrow pits

Consult with specialists to identify appropriate places to dig borrow pits as needed for fill, gravel, and other material. Fewer large borrow pits are better than multiple smaller borrow pits. Rehabilitate the borrow pits. Fill deep pits with unused soil or material unsuitable for trail construction that is mixed with organics. Restore a natural contour to the pit and cover the disturbed area with topsoil and debris. Partially bury logs and rocks on top to appear natural and protect germinating seeds. Finish by spreading needles, leaves, other woody debris, and smaller rocks over the disturbed area.

Imported materials

Favor using native material wherever possible, although imported material may be necessary if native material isn't available or suitable. Local line officers should approve the use of imported material in advance of work. Soil, gravel, rock, and other material from borrow sites or quarries should be prescreened by a qualified botanist for invasive weeds before the material is purchased or transported.

Invasive weeds are extremely difficult to eradicate and can permanently alter the local ecosystem.

Pressure-treated wood designed for use in wet environments needs to be cleaned. The chemicals bond with lignin within the wood, but the carrier oil has to be removed to prevent toxins from entering surface or groundwater.

Grade reversals

Grade reversals are areas along a trail where the trail grade reverses or changes in the opposite direction—up or down. Trail managers use grade reversals combined with outsloping tread to keep water moving across the trail instead of down it, not disturbing the natural flow of water down slope and making the trail “hydrologically invisible.” The reversal or rise (crest) and fall (dip) of the trail are repeated as it traverses the hillside (fig. 6–7). The crest must be tall enough to divert anticipated water flows off the trail while not creating a trail jump. Grade reversals are also called by various names—grade dips, terrain dips, break in grade, undulations, or swales.

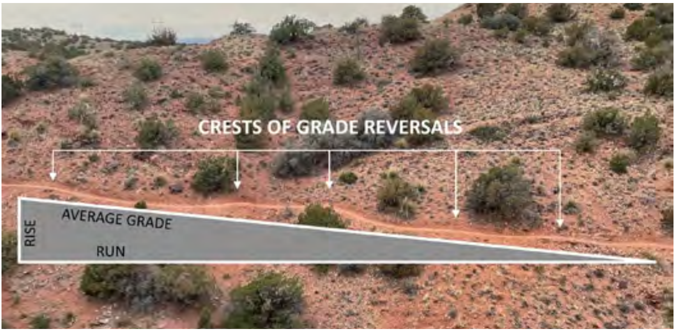


Figure 6–7. Grade reversals are much more effective than constructed drainage features. Grade reversals in this image are where the trail rises and falls. Water from the slope above will run off the trail in these areas instead of down the trail. Cibola National Forest, New Mexico. USDA photo by Kerry Wood.

The beauty of grade reversals compared to constructed drainage features is they require little maintenance and can complement the terrain and go unnoticed by the user. Trails sustainably designed with low slope ratios and multiple grade reversals are called rolling contour trails. Review the "Rolling Contour Trails" section in chapter 2 for more information.

Hillside slope, trail grade, soil type, and trail development scale affect where and how often grade reversals should be incorporated into the trail. More frequent grade reversals are needed on trails with less-cohesive soils and steeper grades. Less frequent grade reversals are needed on trails with good soil cohesion or lower grades. Study the average distance between grade reversals on physically sustainable segments of nearby trails with similar grades.

Where available, use natural dips in the terrain to help you add reversals. Otherwise, grade reversals can be designed in the layout. Reverse the trail grade for about 10–15 ft (3–5 m), then “roll” back or resume the trail grade (fig. 6–7). Grade reversals enhance the trail user’s experience by providing an up-and-down motion, curving the trail up and around the high side of large trees (fig. 6–8) or winding it around boulders.

Figure 6–8. Enhance the user’s experience and improve drainage using grade reversals by going above trees and rocks. Cibola National Forest, New Mexico. Courtesy photo by Jenny Blackmore.

Compaction

Compaction is crucial in trail maintenance and construction to ensure durability and stability. It is particularly important on high-traffic sections and in areas prone to erosion. The process involves compressing the trail surface, often using tools like tampers or rollers, to reduce soil porosity and increase load-bearing capacity. This helps prevent the trail from becoming uneven or developing ruts and reduces maintenance frequency. By creating a firm, stable surface, compaction enhances user safety and preserves the trail's integrity against weather and wear when combined with good drainage and appropriate trail grades.

Full-Bench Construction

Most trails constructed on hillsides (or "sidehill trails") use full-bench construction. They are constructed by cutting the full width of the tread into the exposed mineral soil on the hillside (fig. 6–9). Full-bench construction is more durable and requires less maintenance, although it requires more excavation and leaves a larger backslope than partial-bench construction. Use full-bench construction whenever possible.

Construction tips

- Excavate the full width of the trail from the hillside.
- Evenly distribute the excavated material on the downhill side or use it for nearby features during construction. Always distribute and stockpile soil away from water bodies.

- Consider constructing a wider bench for passing before difficult sections.
- Ensure tread is not being supported by excavated material.
- Construct the backslope angle to match the prevailing hillside slope as much as possible to prevent slough.
- Compact tread and backslope, removing loose materials that may roll onto tread.
- Anticipate settling after compaction that might expose obstructions or affect the outslope and drainage of the trail.

Common mistakes

- Not sticking to the flag line, referring to the design standards, or consulting the trail designers.
- Leaving obstacles in the cutslope that push users to the critical (or outside) edge, causing failure.
- Piling excavated material next to the tread or negatively impacting nearby resources like waterways or vegetation.
- Leaving roots and other obstacles just under the tread surface so that they emerge and become obstructions as the tread continues to compact.
- Building the easiest trail and not the right trail.

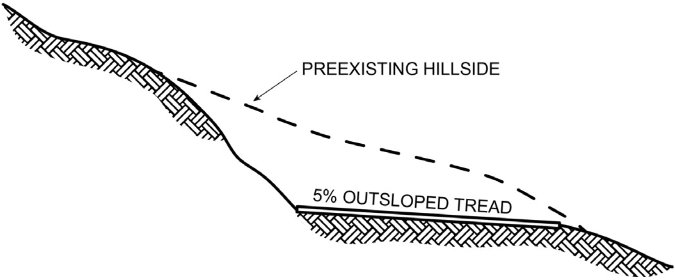


Figure 6–9. Construct a full-bench trail by cutting the full width of the tread into the hillside. Outslope the tread 3–8 percent (or maximum 5 percent on trails designed for accessibility). Diagram based on Forest Service standard trail drawing STD 911–01 (A section).

The design width of a single-lane developed (class 3) hiking trail outside of designated wilderness is 18–36 in (46–91 cm). The length of the handle of a typical pick mattock or similar tool is 36 in (91 cm).

Partial-Bench Construction

Partial-bench construction is another method to cut in a trail (fig. 6–10). This technique isn't recommended for hand-constructed trails: It is difficult to compact the soil enough without the right equipment and often requires building additional retainment structures.

Construction tips

- Once the vegetation is removed, material is excavated from the hillside to construct part of the bench. The excavated material is then used to create the remaining portion of the tread to the desired width. This portion is called the fillslope. Water and compact the fillslope material to improve the soil strength.
- If you can't water and compact the fillslope sufficiently, consider constructing a retaining or crib wall to reinforce the trail tread, for example when constructing a trail around an outcropping vertical rock escarpment.

Common mistakes

- Not compacting the fillslope well enough, resulting in failure of the shoulders of a partial bench trail, potentially within the first season. When the fillslope fails, the trail tread is lost and may require an expensive, intrusive, and complex retaining wall.
- Constructing a partial bench with poor soil where retaining the soil isn't possible.

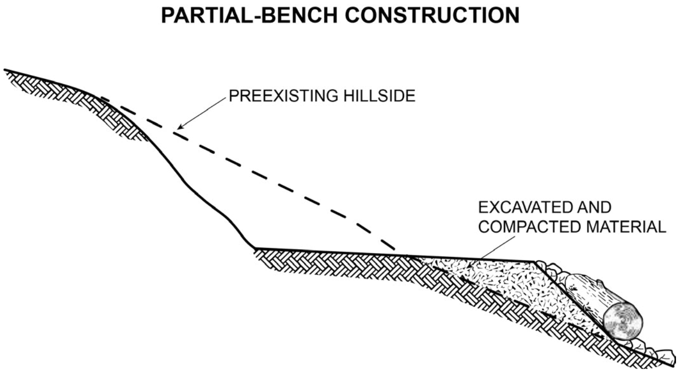


Figure 6-10. The tread on a partial-bench trail is part hillside and part fill material and is outsloped at least 5 percent. This technique is less desirable than the full-bench construction technique, as uncompacted fill will more easily erode and cause the trail to narrow over time. Diagram based on [Forest Service standard trail drawing] STD 911-01 (B section).

Backslope

The backslope is the excavated, exposed area above the tread surface of trails constructed on hillsides. Excavate and compact enough of the backslope to prevent the slope failing and sloughing onto the tread. Well-excavated and stable backslopes encourage users onto the center of the tread, whereas steep, unstable slopes often push users onto the weaker outside edge.

The backslope should match the angle of repose of the parent material. The "angle of repose" refers to the steepest angle at which the material stabilizes on its own.

You may come across trail specifications calling for 1:1 backslope (fig. 6–11). This means the hillside slope has a ratio of 1 unit of vertical rise to 1 unit of horizontal run. A trail that has a completely vertical backslope is unfinished and a sign of poor craftsmanship.

Most soils are stable in a 1:1 backslope. Solid rock can have a steeper 1:0.5 backslope, while less-cohesive soils may need a longer, 1:2 backslope. When the hillside slope is steeper than 1:1, the backslope will be overly steep and you'll likely have to frequently remove slough to keep the trail open.

Examine slopes in the surrounding landscape and identify areas with stable soil. Create a somewhat gentler backslope than you think is necessary. Initially exposing more raw soil is worth keeping the backslope stable so it can start revegetating. Angle the backslope until loose material stops falling onto the trail tread. Stabilize the entire backslope by compacting it with the back of a McLeod tool (also called a rake hoe). Chapter 7, "Tools and Equipment," lists common trail tools.

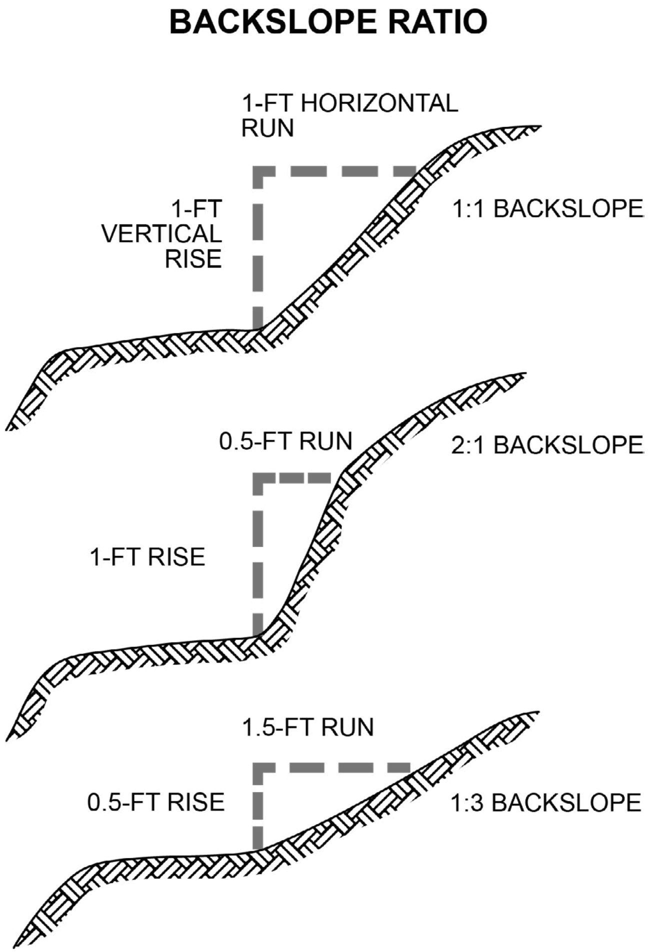


Figure 6–11. Backslopes are described by the ratio of vertical rise to horizontal distance or “rise to run.”

Figure 6–12. A sidehill trail that is being made more physically sustainable by excavating the backslope. Note the bushes encroaching on the trail in the background. Boise National Forest, Idaho. USDA photo by Scott Johnson.

An alternative to huge backslope excavations is constructing a retaining wall. Retaining walls reduce sloughing when you are constrained to steep backslopes. Cutting a trail into a slope already at the angle of repose will cause slough to fall onto the tread. Retaining walls on the uphill slope may be helpful to reduce long-term maintenance needs for slough removal (refer to the "Retaining Structures" section in chapter 4 for more information).

Hand-Built

Suggested steps for constructing trails by hand (fig. 6–13).

1. Lay out the route and excavate the bench.

- Follow the preconstruction steps and best practices for construction described above.
- Place pin flags to keep the trail workers on course and ensure the crew knows where the trail should be in relationship to the flag line (above, below, or in the center).
- Excavate the trail tread to the specified width while following the pin flags. Broadcast excavated materials evenly downhill.

2. Excavate backslope, including loose material.

- Excavate backslope out of the cutbank behind the tread, including removal of loose materials that may roll onto the tread later. The backslope should blend with the general slope of the hill. A properly cut backslope won't disrupt the natural water flow.
- Broadcast excavated materials evenly downhill or save the material for revegetating and naturalizing borrow pits.

3. Refine the backslope and outslope the tread.

- Round the backslope by smoothing the hard edge where the backslope joins the hillside, and outslope the tread grade by 3–8 percent.
- Rake excavated materials off the tread and broadcast evenly below the trail evenly, ensuring no berms or piles remain.

- Compact tread and backslope to help keep soil in place.
- Redistribute organic material over the broadcasted material downslope to encourage revegetation and reduce the potential for erosion. Use caution to not create berms or piles. A light sprinkling of leaf litter may be applied to the fresh treadway to reduce splash erosion.

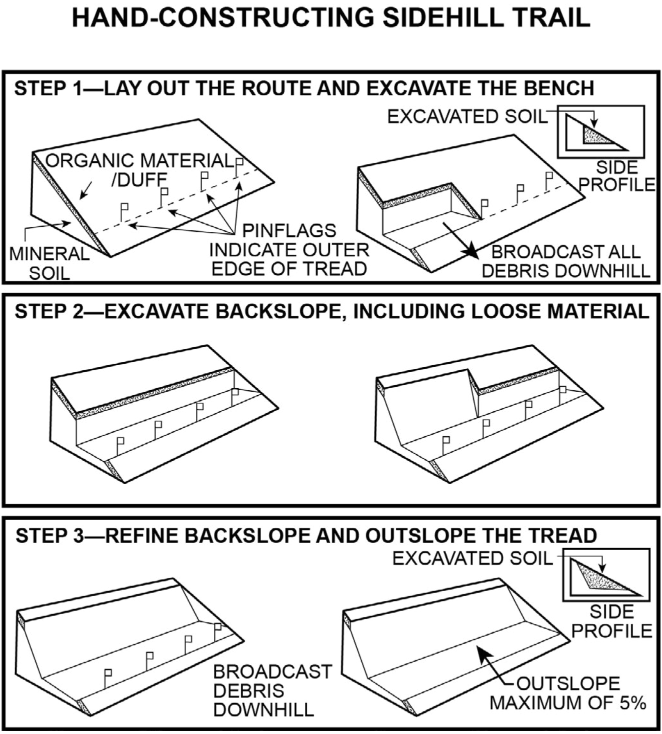


Figure 6–13. Steps to construct a sidehill trail by hand. Adapted from a drawing by the Appalachian Trail Conservancy.

Outsloping

The recommended outslope for most contouring sidehill trails is 3–8 percent grade to encourage proper sheet flow, with a goal of about 5 percent. An outslope of 5 percent is barely perceptible to most users and to most new trail builders, who tend to exaggerate the outslope beyond 5 percent. A 5-percent outslope is often accomplished simply by pulling excavated material to the outside of the tread on a newly constructed bench. Another tip is to work parallel to the trail rather than perpendicular when refining the tread to improve your vantage point. A bottle of water or a McLeod are also helpful for judging the outslope (fig. 6-14).

TREAD OUTSLOPE

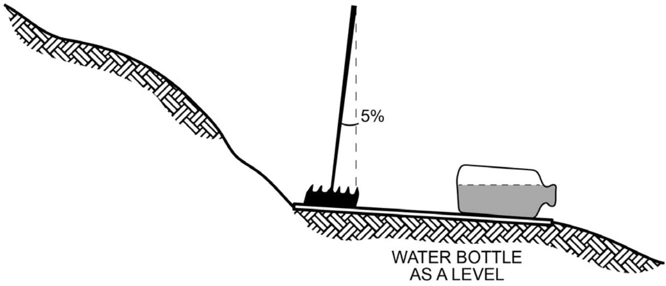


Figure 6-14. The outslope of 3–8 percent should be barely detectable to the eye. A partially filled water bottle makes a good level, or you can stand a McLeod on the trail tread—the handle should lean downhill.

Machine-Built

Trail dozers, mini excavators, and other specifically designed trail building equipment can save you time and energy where they are allowed. However, trail construction with equipment creates more disturbance and requires more cleanup and finish work. Furthermore, building trails using machines isn't appropriate in all settings, such as in designated wilderness areas or areas where the design calls for a light footprint.

The work of machines can be combined with hand construction to remove rocks and refine the tread and backslope. The work follows the same basic steps discussed above for building a trail completely by hand. Using equipment for trail work requires training (typically a certification) and experience. Partners and volunteers can also receive training to work with Forest Service equipment. Work with well-trained operators or professional trail builders—inexperienced operators can cause a lot of damage very quickly. Discuss the training requirements and availability in your area with the agency trail manager.

Best practices for trail building with machines

- Be certain the corridor is wide enough to accommodate machinery. Assess any snags that have the potential to fall on the machine and the operator.
- Follow the flag line and know what the flag line means (above, below, or in the center of the trail).

- Depending on the soil type and rock content, use a trail dozer, mini excavator, or other mechanized equipment to establish the bench; always keep the machine on a stable surface.
- If needed, drive or “track” the machinery around areas where hand construction has been identified as the appropriate method.
- Track over the bench cut multiple times and use the weight of the machine to compact the soil and create the desired outslope.
- Use a mini excavator to lay back the cut bank to the appropriate backslope and remove debris from the fill slope.
- Refine the tread by hand or with a drag pulled behind an all-terrain vehicle (ATV) to remove rocks and debris.

Decommissioning

The goal of decommissioning or obliterating a trail is to return the area to as natural a state as possible, reduce further impacts, and prevent further use.

Know the lingo: National Forest System trails are “decommissioned.” User-created routes are “obliterated.” You can’t decommission something that wasn’t approved in the first place.

Planning for Success

Reclaiming a trail is hard work. Machines make the work easier and get better results, but even that doesn't guarantee long-term success. A well-thought-out plan is essential to effectively close and rehabilitate an unwanted trail, trail segment, or user-created route—and keep it closed. Start with considering why the trail needs to be decommissioned and weigh the environmental, social, and managerial factors before committing resources. Plan to eliminate completely all abandoned segments that are visible from trails that remain open. Monitor the area and continue work as needed until evidence of the old trail is gone.

Environmental. Evaluate each site for its potential to regrow and heal. Simple decommissioning may consist of blocking entry and exit points and allowing the vegetation to recover on its own. This works best on sites that are moist and relatively flat. More common complex restoration in other areas can include obliterating the tread, obscuring the unwanted route, recontouring the slope, and planting native species. Dry, steep sites take a lot of work to decommission successfully.

Social. Weigh the users' needs with the resource damage that may be occurring. Decommissioning projects are more likely to succeed when the trail users have a better alternative that meets the trail standards, provides a higher quality opportunity, and the new trail has less resource impact than the original trail. Obliterating a user-created route without addressing the potential unmet need can be a recipe for failure.

Managerial. Decommissioning an existing National Forest System trail or obliterating a user-created route requires input from a Forest Service line officer. The local trail data manager will also need to change the trail status to "decommissioned" in the Forest Service trail data system. Trails marked as decommissioned won't show up on the Interactive Visitor Use Map and invite unintended use. Data managers should attach the signed environmental decision document authorizing the project to the trail database record. Trail managers should also work with public affairs officers to communicate changes in trail opportunities, including updating agency web pages.

Refer to the Decommissioning Trails web page (on the Trail Skills Project website) for more resources or refer to the "Wilderness and Backcountry Site Restoration Guide" available from the Forest Service.

Steps To Decommission or Obliterate a Trail

Project preparation

- Evaluate the likelihood of successfully decommissioning or obliterating:
  - Evaluate how effectively you can "naturalize" an area.
  - Consider why the route was created and if the need can be met elsewhere. Provide an alternative route before decommissioning work starts.

- Ensure you have authorization to proceed and adhere to any mitigation measures.
- Disguise or install signs closing both ends of the trail to avoid user and worker conflicts.

Naturalize the old trail

- Restore the natural contour of the slope, if necessary, by pulling fillslope material back into the cut.
- Loosen soil 8–10 in (20–30 cm) to promote seed germination, increase water filtration, and reduce the likelihood of erosion.
- Install log or rock check dams where trails are gullied. Steeper grades require more check dams. The top of one check dam should be level with the bottom of the next if installed on a slope (refer to the "Check Dams" section below).
- Partially bury logs and rocks, particularly at trail junctions, to create a natural-appearing barrier.
- Cover the disturbed area with native mulch and organic debris from the surrounding area to retain moisture, protect soils, and promote seed germination. In dry areas with slow vegetation growth, consider transplanting resilient species from the local area into the disturbed area (commonly known as vertical mulching) if allowed by planning documents.
- Use branches, rocks, and other native materials to further camouflage and discourage use of the former trail.

- Leave the hinge connected on trees that have been felled across the trail.

Revegetate the corridor

- Consult trail managers in your area to understand which native plant species have the best transplant survival rate.
    - o Use grass pelts, brush, and even small trees to jumpstart revegetation.
    - o Replanting just before or during the wet season is helpful.
    - o Watering may be necessary for successful reestablishment, especially in arid regions.
- Fill in the visual or vertical opening of the corridor by planting shrubs and trees, even dead ones (fig. 6–16).

Keep it closed

- Keeping closure signs up after the restoration is complete may be helpful, although it can also draw attention for users seeking for the old route.
- Monitor the area and adjust if needed to repair damage.

Figure 6–15. A candidate trail for a causeway structure or decommissioning and rerouting. Flathead National Forest, Montana. USDA photo by Jess May.

Figure 6–16. Completely block off abandoned trails. Plant native grasses and shrubs or place deadfall and other large debris to fill the opening left by the abandoned trail. Pike-San Isabel National Forests, Colorado. USDA photo by Scott Johnson.

Check Dams

Check dams are constructed features of earth, log, or rock that hold surface water long enough for the water to percolate into the soil and deposit the sediment it is carrying (fig. 6–17). They are commonly used in a series to stop erosion and hold material in place during restoration of abandoned and trenched tread. The sediment fills in the trench over time. On a trail with 25 percent grade, check dams placed every 65 ft (20 m) is typically sufficient. Install more dams closer together on steeper grades. Check dams can be used as a last resort with existing rutted tread and to slow or prevent additional soil loss.

Installation tips

- Install a drainage feature at the top of the slope leading to the trenched tread to drain water away from the trail and reduce erosion.
- Install check dams with a level top or a low point in the middle to prevent erosion around the low sides.
- Embed at least one-third of the diameter of the log or timber into an excavated footing that extends into the sides of the gully.
- Backfill each check dam with tamped gravel or rock to aid drainage and support the structure.
- Construct the top of the check dam to be above the bottom of the next check dam uphill.

Common mistakes

- Not monitoring the site to catch and repair “blow outs” early.
- Not burying or anchoring the sides deep enough into native soil. Water will undermine or bypass check dams not sufficiently embedded into native soil.
- Leaving the old trail visible.
- Not accounting for the decomposition of broadcasted vegetation originally used to obscure the old tread. It takes a long time for a trail to revegetate, and you may need to block the old tread if the vegetation used decomposes too quickly.

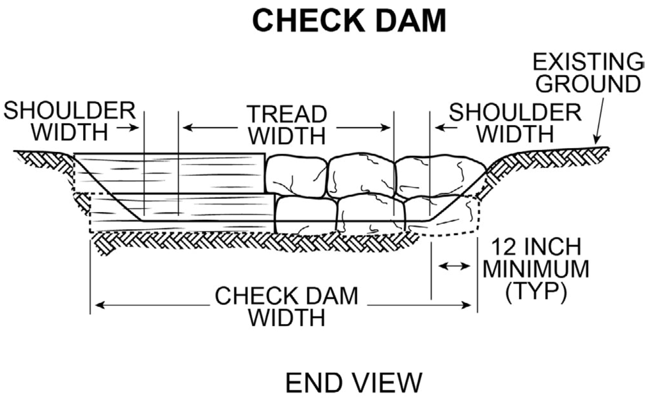


Figure 6–17. End view of a check dam that allows soil to rebuild on eroded trails. Diagram based on [Forest Service standard trail drawing] STD 928–10–1.

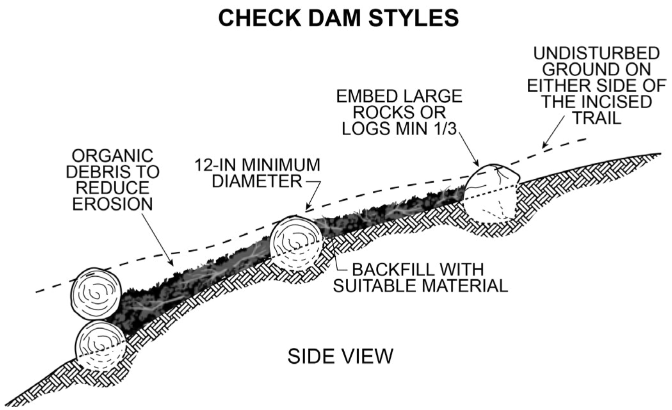
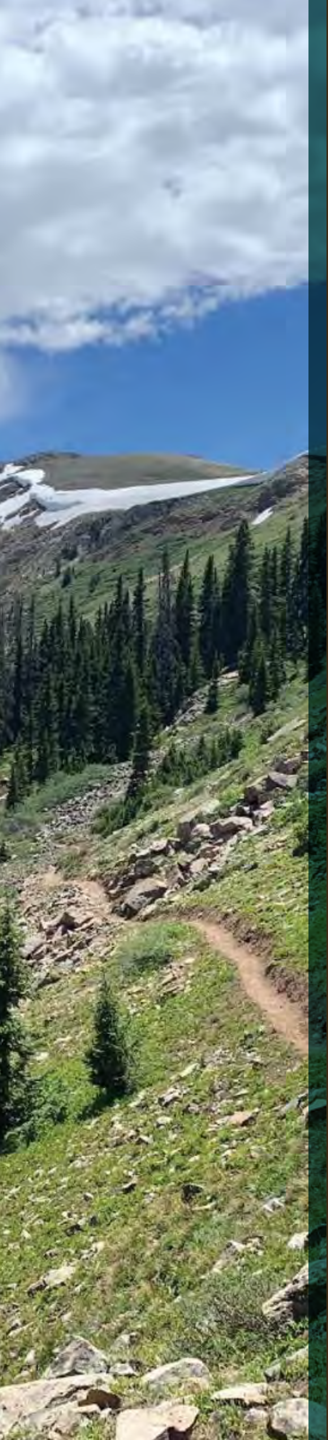


Figure 6–18. Side view of a series of check dams. The bottom of each dam should be level with the top of the next lower dam. Check dams aren’t suitable on grades steeper than 40 percent. Diagram based on [Forest Service standard trail drawing] STD 928–10–1.



7

TOOLS AND EQUIPMENT

7. TOOLS AND EQUIPMENT

This chapter describes common tools and mechanized equipment for trail work. For additional publications and websites about trail tools, refer to the "Tools" section in chapter 8.

Mechanized Tools

The term "mechanized" refers to any machine that uses mechanical advantage (or has gears) or is powered by gas or electricity. Mechanized tools, equipment, and transportation are restricted in designated wilderness areas. The prohibitions include wheelbarrows, mountain bikes, motorized equipment, and electric hand tools. The integrity of designated wilderness areas is being preserved through the use of traditional skills. Learn more about motorized equipment or mechanical transport in designated wilderness areas in Forest Service Manual (FSM) 2326 and the Wilderness Connect website.

Digital tools

One tool that most people carry daily is a smartphone. There are a variety of digital apps that make trail planning easier, including apps for mapping, trail locating, GPS tracking, measuring, notetaking, and taking pictures. Avoid using a personal device for work, as they could be subject to Freedom of Information Act (FOIA) requests.

Tool Safety

Choosing the right tool

- Your most important tool is your brain—use it.
- Choose the least complex tool for the job.
- Make sure you know how to use the tool properly and you are using it for its intended purpose.

Carrying and storing tools

- Carry tools on your downhill side. Grasp the handle at the balance point with the sharpened blade forward and down. Throw the tool clear if you fall.
- Cover the blade of any cutting tool with a sheath when carrying, loading, or storing it. Fasten down or secure tools carried in vehicles.
- Keep cutting tools sharp. A dull tool makes your work harder and more dangerous.
- At the worksite, lay tools on the uphill side of the trail with the business end farthest uphill. Place the handles far enough off the edge of the trail so they are not a tripping hazard. Never sink double-bit axes, Pulaskis, mattocks, or similar tools into tree trunks, stumps, or the ground where the exposed portion of the tool will present a hazard.

Using tools safely

- Always use proper hardhats, gloves, safety glasses, and other personal protective equipment (PPE). Refer to the "Safety" section in chapter 1 for a list of common PPE.

- Follow the risk assessment or similar approved safety plan.
- Carefully inspect each tool. Make sure the handles are solid, smooth, and straight and that the heads are tight.
- Survey the site before you start working. Think about the potential hazards. Observe crew member spacing. Consider if people are using the right tool for the job.
- Clear away any brush or limbs before you start swinging a tool.
- Posture is important. Stand comfortably. Adjust your stance and tool grip continually to prevent slipping and to avoid glancing blows. Be especially careful when working in wet, slippery conditions.
- Think about the consequences of every move, especially when working with a rock or log. Think ahead so you aren't standing in the wrong place when it moves. Be ready to toss your tool aside and jump free. Avoid cutting toward any part of your body and watch out for your coworkers. Use skill, not brute force.
- Maintain at least 10 ft (3 m) between workers when using individual chopping and cutting tools.
- Pace yourself. Take rest breaks, drink plenty of water, and keep your mind on your work. Trade off on work tasks occasionally for relief from repetitive stresses.

Brushing

Lopping shears and pruning shears. Lopping and pruning shears (fig. 7–1) are similar in design and use. Lopping shears have long handles and may have gears to increase leverage to cut thicker stems. Pruning shears are small enough to be carried in one hand and are designed to cut small stems and branches. Cutting edges vary, but generally one blade binds and cuts a stem against an anvil or beveled hook. The hook and blade shear for overhead cuts is recommended because the curved blades transfer the weight of the shears to the limb. Lopping and pruning shears do a better job than hand saws or axes of making a nice clean cut.

Figure 7–1. Lopping shears. USDA photo by Matt Able.

Power weed cutter. Motorized weed cutters, also referred to as brush cutters or weed whackers, use rotating plastic line or metal blades to cut weeds. These can be a good option for mowing grass and encroaching weeds.

Chopping

Common ax types are double-bit (fig. 7–2) and single-bit (fig. 7–3).

Double-bit axes have two symmetrically opposed cutting edges. One edge is maintained at razor sharpness. The other edge is usually duller and used to chop around rocks or in soil. Mark the duller edge with a spot of paint.

Figure 7–2. A double-bit ax. USDA photo by Laurent Deviche.

Figure 7–3. A single-bit ax. USDA photo by Matt Able.

Before chopping with an ax, check for adequate clearance for your swing. Remove any underbrush and overhanging branches that might interfere. Be sure your footing is stable and secure. Chop only when you are clear of other workers.

Using an ax proficiently requires practice. Inexperienced users and dull axes can cause serious accidents. In general, placing the ax accurately is more important than the force of the swing. Always chop away from your body. Stand where a glancing blow will not strike you. If the situation makes you cut toward yourself, "choke up" on the handle with both hands and use short swings for more control.

The Forest Service offers ax training as part of its national crosscut and chainsaw program. Also refer to the publication "One Moving Part: The Forest Service Ax Manual."

Digging and Tamping

Digging and tamping bar. A digging and tamping bar (fig. 7–4) is about the same length as a rock bar, but much lighter. It is designed with a chisel tip for loosening soil or rocks and a flattened end for tamping. These bars are not prying tools.

Figure 7–4. Digging and tamping bar. USDA photo by Matt Able.

Shovel. Shovels are available in various blade shapes and handle lengths (fig. 7–5). The common or round–point shovel weighs 5-6 lb. (2.5-2.7 kg). The head measures about 8 x 12 in (20 x 30 cm). If a shovel feels too heavy or large, choose a smaller version—remember, you have to lift everything the head holds.

The square shovel is a flat-bottomed model intended for shoveling loose materials, not digging.

Figure 7–5. Square and round-point shovel heads. USDA photo by Matt Able.

When scooping materials, lift with your legs and glutes while holding your core tight in a neutral position. Push the end of the shovel handle with your thigh. This makes the handle an efficient lever and saves your energy and your back. Don't use the shovel to pry objects out of the trail—that's a job for a pick and a pry bar.

Grubbing

Hoes. Use a grub hoe or hazel hoe (fig. 7–6) to break up sod clumps during new trail construction or when leveling an existing trail tread. These hoes are also useful in heavy duff. They generally work better than a Pulaski.

Figure 7–6. Grubbing hoe. USDA photo by Laurent Deviche.

Mattock (pick or cutter). The pick mattock (fig. 7–7) is often the standard tool for trail work for many applications. Its pointed tip is used for breaking up hard soil and digging up rocks, while the grubbing blade works on softer materials, making the tool more versatile than a Pulaski. Use the grubbing blade to cut roots or remove small stumps. Tamp soil and loose rocks or smooth new tread with the edge of the tool.

Pry rocks with a pick mattock without fear of breaking the handle. Two people working with pick mattocks may not need to carry rock bars.

Figure 7–7. Pick mattock and cutter mattock heads. USDA photo by Matt Able.

Maintain good cutting edges on mattocks. Sharpen grubbing blades to maintain a 45–degree edge bevel on the underside. Sharpen pick ends as you would a pick and maintain factory bevels on cutter blades.

McLeod. The McLeod (fig. 7–8) combines a heavy-duty rake with a large, sturdy hoe. It works well for constructing trails through light soils and vegetation or for reestablishing tread when material from the backslope sloughs onto the trail. A McLeod is essential for compacting tread and is helpful for checking outslope. To avoid the bolt impression left in your freshly compacted tread, remove the bolt that secures the toolhead and weld the head to the mounting plate. McLeods are inefficient in rocky or heavy brushed areas.

Figure 7–8. McLeod. USDA photo by Matt Able.

Pulaski. The Pulaski (fig. 7–9) combines an ax and a grub hoe into a multipurpose tool. It is a popular trail tool, mostly because it is widely available and easier to carry than several single-purpose tools. It isn't as good as a hoe or mattock for grubbing, nor is it as good as an ax for chopping. It also isn't meant to be used as a prying tool because of how the head is hung on the handle.

When using the hoe end of a Pulaski, stand bent at the waist with your back straight and parallel to the ground, knees flexed, and one foot slightly forward. Hold the handle with both hands so the head is at an angle to your body, and use short, smooth, shallow swings. Let the hoe hit the ground on its corner. Use the ax end to chop large roots after the soil has been cleared by the hoe.

Figure 7–9. Pulaski. USDA photo by Matt Able.

Carry the Pulaski at your side. Grip the handle firmly near the head and point the ax end away from your body and down.

Sharpen the cutting edge of the Pulaski's ax as you would any other ax. When sharpening the Pulaski's hoe end, maintain the existing inside-edge bevel. Never sharpen the top of the hoe.

Lifting and Hauling

Canvas bag. Heavy-duty canvas bags (fig. 7–10) are great for soil, small rocks, and mulch. They are more durable than similarly styled shopping bags.

Figure 7–10. Heavy-duty canvas bag. USDA photo by Matt Able.

Hoist. Hand-operated cable hoists (fig. 7–11) make moving large boulders and logs possible with mechanical advantage. They come in different styles, sizes, and capacities.

Figure 7–11. Hoist. USDA photo by Matt Able.

Motorized carrier. Consider a motorized carrier (fig.7–12) to efficiently carry heavy materials. They come in a variety of sizes and capabilities and typically feature a dump body. A trailer pulled behind an all-terrain vehicle may be an alternative to a motorized carrier.

Figure 7–12. Motorized carrier being used to transport rocks. Tongass National Forest, Alaska. USDA photo by Laurent Deviche.

Measuring

Tips for measuring

- Mark off commonly used measurements on your tool handles.
- Know the length of your feet, arms, fingers, and other rulers that are handy on the trail.
- Know the length of your pace so you can easily estimate longer distances.

Clinometer. A clinometer (fig. 7–13), called a “clino” by trail workers, is a simple instrument for measuring grades. Digital clinometer apps are available. Verify their accuracy before depending on them. Most clinometers have two scales, one with percent of slope, the other with degrees. Don’t confuse the readings (it is easy to do). Percent slope is the most-used measure, and the values are on the right side of the scale on most standard clinometers. Percent slope is derived from the relationship of rise or drop in grade over a horizontal distance. You can derive your own slope value with this equation:

$$\text{Percent of slope} = \frac{\text{Amount of rise}}{\text{Amount of run (horizontal distance)}} \times 100$$

For example, a section of trail 100 ft (30 m) long with 10 ft (3 m) of difference in elevation would be a 10 percent grade ([10/100]x100=10). A 100 percent grade is equal to 45 degrees.

Figure 7–13. Standard clinometer. USDA photo by Kerry Wood.

Global Positioning System (GPS) unit. Most trail managers use GPS units to receive a signal from GPS satellites for accurate trail location, inventory, and contract preparation. Accuracy depends on a clear view of the sky. The reading can be off under a heavy canopy.

Tape measures. Standard tape measures are handy for measuring lumber and logs. A forestry tape (also called diameter tape) is better for measuring longer distances. One side of the tape also has marks to measure the diameter at breast height (DBH) of a tree. (DBH is measured about 4.5 ft [1.4 m] above the ground).

Mechanized Trail Building Equipment

Excavator. A mini excavator (fig. 7–14) can excavate the bench, shape the tread and backslope, and move building material, debris, and rocks from place to place. This flexibility makes the mini excavator particularly popular for trail work.

Figure 7–14. A mini excavator. Weber Basin Job Corps, Utah. USDA photo by Scott Johnson.

Dozer. Dozers come in a broad range of sizes, including trail-sized dozers (fig. 7–15). The trail dozer is commonly used to cut in full-bench trails, during heavy maintenance to repair trail tread and reconstruct rolling dips, and during decommissioning to reshape and naturalize the old trail tread.

Figure 7–15. A trail-size dozer. Boise National Forest, Idaho. USDA photo by Scott Johnson.

Stand-on skid steer. The small skid steer (fig. 7–16) comes with a variety of attachments for pushing, shaping, and lifting. The narrow tracks and weight are well-suited for building and maintaining narrow trails. The versatility makes the skid steer the "Swiss Army knife" of mechanized trail equipment. It is also lighter than other pieces of trail equipment and towing doesn't require a commercial driver's license.

Figure 7–16. Stand-on skid steers being used on the George Washington and Jefferson National Forests, Virginia. USDA photo by Scott Johnson.

Peeling and Shaping

Drawknife. A drawknife (fig. 7–17) works best to peel dry logs. Position the log about waist high. Grasp both handles so the beveled edge of the blade faces the log. Begin each stroke with arms extended and pull the tool toward you while keeping even pressure on the blade. Keep your fingers clear of the blade's corners.

Figure 7–17. Drawknife. USDA photo by Matt Able.

Chainsaw debarking attachment. This attachment (fig. 7–18) fits onto a chainsaw for debarking, planing, jointing, and notching logs.

Figure 7–18. Chainsaw debarking attachment.
USDA photo by Tim Farris.

Pounding and Hammering

Sledgehammer (single or double). A sledgehammer (fig. 7–19) has a head forged from heat-treated, high-carbon steel weighing 2–5 lb. (0.9–2.3 kg) for single and 8–20 lb. (3.6–9 kg) for double. Heat treating, also known as hardening, makes the metal more resistant to deformation but more brittle. For more information on hand drilling, refer to "Hand Drilling and Breaking Rock for Wilderness Trail Maintenance."

Figure 7–19. Single jack hand-drilling hammer and double jack hand-drilling hammer. USDA photo by Matt Able.

Rock Work

Rock bar. Use a rock bar (also called a pry bar) for lifting, flipping, or sliding large, heavy objects (figs. 7–20 and 7–21). These bars are heavy duty. They have a chisel tip on one end. The other end can be rounded or pointed.

Figure 7–20. Rock bar. USDA Matt Able.

BAR AND FULCRUM

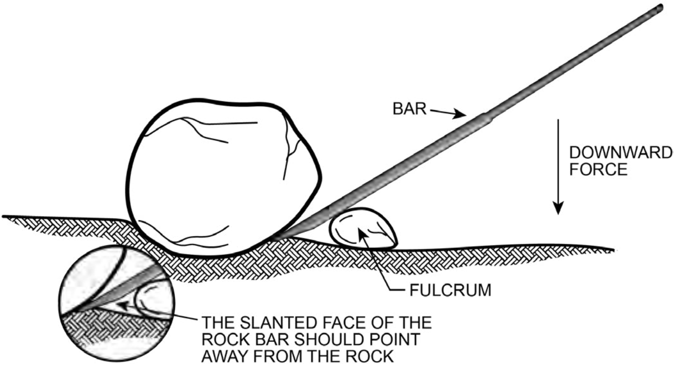


Figure 7–21. Rock bar and fulcrum used to move a large rock.

Place the tip of the chisel under the object to be moved with the slanted face pointing away from the rock. Wedge a log or rock between the bar and the ground to act as a fulcrum. Press the handle down with your weight over your palms. Never pry with the bar between your legs or near your collar bone. When the object raises as much as the bite allows, place blocks under it and use a larger fulcrum or shorter bite on the same fulcrum to raise the object farther. This kind of maneuver requires a tool with high tensile strength—use a high-quality rock bar and don't settle for a cheap digging bar.

The rounded end of a rock bar is great for compacting material into rock cracks when armoring the trail. You can also use the pointed end to break large rocks by jabbing the point into a crack and twisting.

Other tools for rock work

- Pick mattock
- Gravel box, rock bag, rucksack, rock litter—all useful for carrying rocks of various sizes
- Winch and cable systems, such as grip hoists or come-alongs
    - o Some rocks can be dragged or lifted into place—this work requires special training; check with your local trail manager to determine the skills required
- Motorized equipment, including rock drills and rock breakers
- Hammers (fig. 7–22) and chisels (for shaping)
- Stone feathers and wedges (for splitting)

Figure 7–22. Heads of common hammers for rock work (left to right): engineer's hammer, cross peen (a.k.a. blacksmith hammer), and mason's hammer. The mason's hammer is made of soft metal designed to be hit with a sledge for rock shaping. USDA photo by Jess May.

Sharpening

Inspect all tools before use. Sharpening makes tools last longer. A small scratch that is ignored could lead to a serious crack or nick in the blade. Wear gloves when sharpening cutting edges.

Use a file or grindstone to remove metal from a dull edge. A touchup with a whetstone will restore the edge bevel if there are no visible nicks. Whetting the edge removes very small bits of metal from the blade and causes the remaining metal to burr slightly on the cutting edge. This burr is called a feather or wire edge. Remove this weak strip by honing the edge on the other side. A correctly honed edge is sharp, does not have a wire edge, and does not reflect light or show a sharpening line.

Restoring the blade bevel (fig. 7–23) requires coarser grinding tools to reshape worn cutting blades. Reshape blades with a hand file, sandstone wheel, or electric grinder. Remove visible nicks by grinding the metal back on the blade. Remember that a correct blade bevel requires maintenance. If using an electric grinder to reestablish edges, be mindful of overheating the metal and losing the temper. If the shape can't be maintained, either discard the blade or have a blacksmith recondition the toolhead.

A hand-tool sharpening gauge (or bevel angle gauge) that provides the correct angles is helpful.

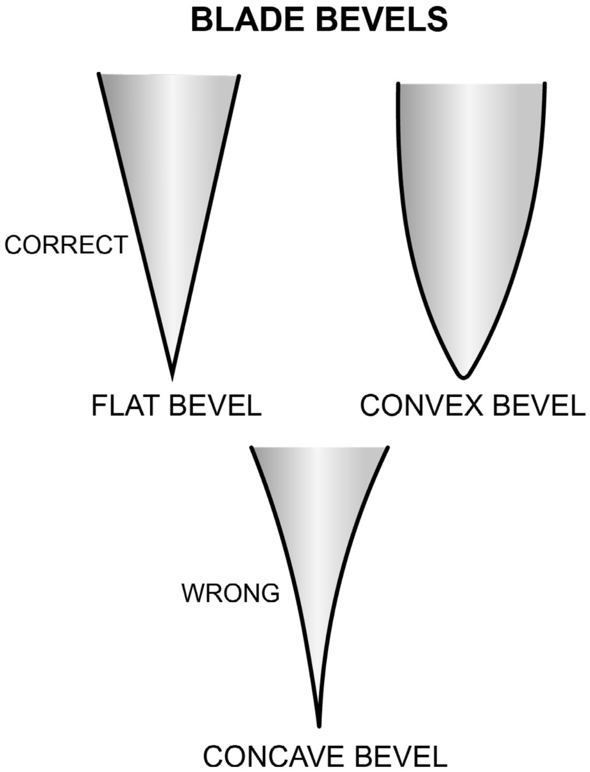


Figure 7–23. Illustration of correct and incorrect blade bevels.

If a cutting edge is nicked by a rock, it may be "work hardened." A file will skip over these spots and create an uneven edge. Use a whetstone or the edge of a bastard file to reduce the work-hardened area, then resume filing. Alternate using a whetstone and the file until the file cuts smoothly over the entire length of the edge.

Files. Files come in single or double, curved or rasp cuts. Single-cut files have one series of parallel teeth angled 60 to 80 degrees from the edge; they are used for finishing work. Double-cut files have two series of parallel teeth set at a 45-degree angle to each other; they are used for restoring shape. Curved files are used for shaping soft metals. Rasp-cut files are used for wood.

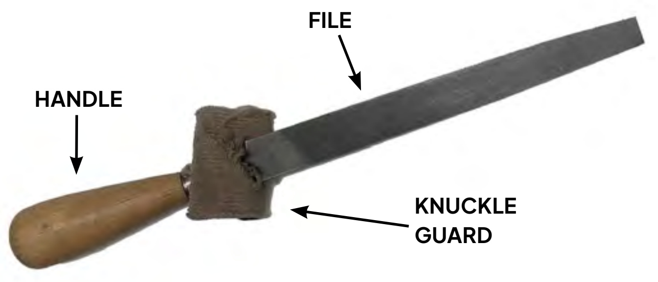


Figure 7-24. A hand file with a handle and a knuckle guard made from an old fire hose. USDA photo by Kerry Wood.

Files are measured from the point to the heel, excluding the tang (the tip used to attach a handle). File coarseness is termed "bastard," "second cut," or "smooth." The bastard is the coarsest file available for files of the same length. A 10-in (25-cm) mill bastard file is good for all-around tool sharpening.

Before filing, fit the file with a handle and knuckle guard (fig. 7-24). Always wear gloves on both hands. Secure the tool so both hands are free for filing. Use the largest file you can. Remember that files are designed to cut in one direction only. Apply even pressure on the push stroke, then lift the file up and off the tool while returning for another pass.

Store or transport files so they are not thrown together. Protect them from other tools as well. An old piece of fire hose sewn shut on one end makes a great holder for several files, a guard, and a handle.

Sawing

Chainsaw. A chainsaw (fig. 7–25) can make short work of your cutting tasks. Stay within your training and certification limits when operating. Both gas- and battery-powered chainsaws are available in a variety of bar sizes, powerhead sizes, and chain types for different applications. Using a sharp chain is essential for safe and efficient cutting; know how to sharpen chains in the shop and in the field.

Figure 7–25. A gas-powered chainsaw. USDA photo by Matt Able.

Crosscut saw. Symmetric crosscut saws that are designed for a sawyer to hold at either end come in two basic patterns (figs. 7–26 to 7–28). Felling crosscuts are 4–12 ft (1.2–3.6 m) long, light, and flexible, with concave backs that conform easily to the arc of the cut and the sawyer's arm. The narrowed distance between the teeth and back leaves room for sawyers to get wedges into the cut quickly. Stay within your training and certification limits when operating.

Bucking crosscuts have straight backs and are heavier and stiffer than felling saws. They are recommended for most trail work because they are more versatile. Bucking saws come with short blades (3–4.5 ft [1–1.4 m]) and a single handle so they can be used solo. The blade is asymmetrical with a D-shaped handle on one end. Holes at the point (tip) allow for attaching a supplemental handle.

Figure 7–26. One-person crosscut saw. USDA photo by Matt Able.

A sharp crosscut saw is a pleasure to operate, but a dull or incorrectly filed saw is a source of endless frustration and is known as a "misery whip" for good reason. Never sharpen a saw without a saw vise and the knowledge to use it. Field sharpening ruins crosscut saws.

Figure 7–27. Ribbon-style felling crosscut saw with handles. USDA photo by Kerry Wood.

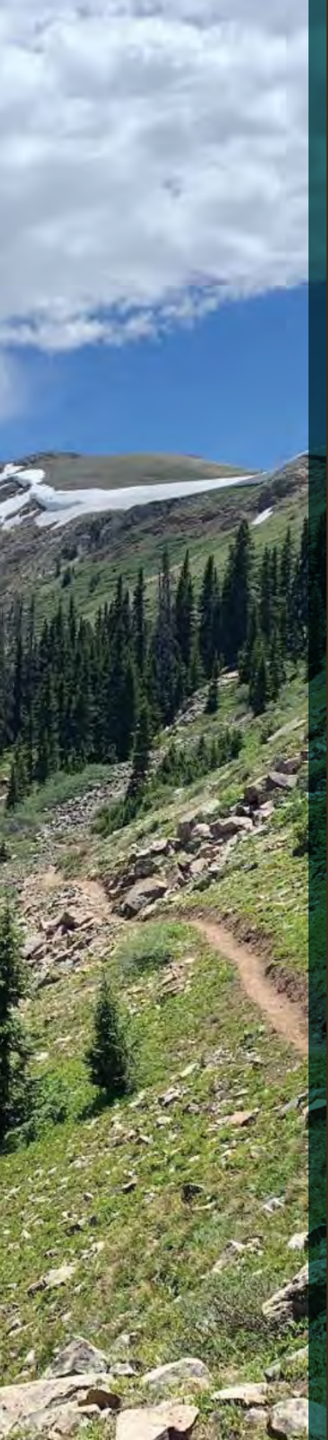
Figure 7–28. Blades of bucking (top) and felling (bottom) crosscut saws. USDA photo by Matt Able.

Pruning saw. A pruning saw (fig. 7–29) is useful for limbing, some brushing, and removing small downfall, especially where space is limited, and cutting is difficult. A folding pruning saw can easily be carried in a pack. Some pruning saws cut only on the pull stroke.

Figure 7–29. Folding pruning saws come in many sizes. USDA photo by Jess May.

Pole saw. A pole saw (fig. 7–30) can be used to prune back high branches from the trail corridor. Manual, electric, and gas-powered versions are available.

Figure 7–30. Manual pruning saw (top) and electric pruning saw (bottom). USDA photo by Scott Johnson.



8

RESOURCES

Forest Service Trail and Trail Bridge Policy

The Forest Service is required to provide an adequate system of trails to meet recreation demands and promote a wide variety of trail opportunities and experiences for people of all ages and abilities (16 USC §532 and the Architectural Barriers Act of 1968). There are National Forest System trails on nearly every forest and grassland unit in the United States, including Puerto Rico. These include thousands of miles of congressionally designated national scenic and national historic trails, administratively designated national recreation trails, and trails through congressionally designated wilderness. Visit the National Forest System Trails website to learn more about trail management and maintenance in the Forest Service.

Forest Service trail-related policy

- Trails Management Handbook (FSH 2309.18)
- Trail, River, and Similar Recreation Opportunities Manual (FSM 2350)
- National Scenic, Historic, and Recreational Trail Management (FSM 2353.3)
- Forest Service Standard Specifications for Construction and Maintenance of Trails (EM-7720-103)

- Sign and Poster Guidelines for the Forest Service (EM-7100–15)
- Recreation Opportunity Spectrum (ROS) (FSM 2300, chapter 10)
- Forest Service Health and Safety Code Handbook (FSH 6709.11)
- Travel Planning (FSM 7700, chapter 10)
- Bridges and Structures (FSM 7722 and FSM 7736)

Websites and Publications

Accessibility

Forest Service accessibility resources website. www.fs.usda.gov/managing-land/national-forests-grasslands/accessibility/resources.

Forest Service Interactive Visitor Use Map. www.fs.usda.gov/ivm/index.html.

Forest Service Trail Accessibility Guidelines (FSTAG). www.fs.usda.gov/sites/default/files/FSTAG-2013-Update.pdf. A “pocket version” can be found at www.fs.usda.gov/t-d/products.php.

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Condition Assessments

PACE It! trail assessment tool. https://usdagcc.sharepoint.com/sites/fs-r09-rhw/SitePages/Recreation-Tools-and-Products.aspx (internal link).

USDA Forest Service. Trail Inventory & Assessment web page. https://www.fs.usda.gov/managing-land/trails/trail-management-tools/tracs.

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OHV Trails

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Clean Water Act, particularly Section 404—regulation of the discharge of dredged and fill material into waters, including wetlands: www.epa.gov/cwa-404/overview-clean-water-act-section-404.

Endangered Species Act, particularly Section 7—project actions don't result in jeopardy to the continued existence of an endangered or threatened species: www.fws.gov/media/endangered-species-act

National Environmental Policy Act (NEPA) Compliance, Code of Federal Regulations (CFR) 36 CFR Part 220: www.ecfr.gov/current/title-36/chapter-II/part-220?toc=1.

National Historic Preservation Act, particularly Section 106—preservation of historic properties: www.achp.gov/.

National Trail System Act, particularly section 4 —extends workers' compensation, tort, and personal property damage or loss coverage to include qualifying cooperators' volunteers: www.fs.usda.gov/managing-land/trails/trails-stewardship-act.

Travel Management Rule—requires the Forest Service to designate which trails are open to motorized use: www.fs.usda.gov/science-technology/travel-management.

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Helmandollar-Powell, M.; Johnson, S.; Villanueva, G.; Wood, K.; May, J.; Gabor, M. 2025. Trail Maintenance and Construction Notebook. FS-1262. Washington, DC: U.S. Department of Agriculture, Forest Service. XXX p.

This notebook describes techniques used to construct and maintain trails. It is written for trail crew workers and is intended to be taken along on work projects. Numerous illustrations help explain the main points. The notebook was printed in 1996 and has been revised during four reprintings. This edition has restructured information and expanded trail sustainability concepts. Trail construction techniques and references have also been updated.

Keywords: sustainable trails, accessibility, climbing turns, drainage, fords, grade reversals, puncheon, reclamation, resilience, signs, switchbacks, trail construction, trail crews, trail maintenance, training, turnpikes

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Common Conversions and Comparisons

Table 8.1. Angle (degrees) to grade (percent) conversions

Angle (degrees)	Grade (percent)	Angle (degrees)	Grade (percent)
1	1.75	27	51
3	5.2	30	57.7
6	10.5	33	64.9
9	15.8	36	72.7
12	21.3	39	81
18	32.5	42	90
21	38.4	45	100
24	44.5		

Common Metric Conversions

0.04 inch = 1 millimeter
1 inch = 2.5 centimeters
1 foot = 0.3 meters
1 yard = 0.9 meters
1 mile = 1.6 kilometers
1 ounce = 28.3 grams
1 pound = 0.5 kilograms
1 quart = 0.9 liter
1 gallon = 3.8 liters

1 inch^2 = 6.5 centimeters^2
1 foot^2 = 9.3 decimeters^2
1 acre = 0.4 hectare
0 °Fahrenheit = -17.8 °Celsius
32 °Fahrenheit = 0 °Celsius
100 °Fahrenheit = 37.8 °Celsius

Common Length Comparisons

- A **millimeter** is about the **thickness of a dime**.
- **6 inches** (152.2 cm) is the **length of a dollar bill**.
- **36 inches** (1 m) is the **length of a typical Pulaski tool handle**.

This notebook is 7.5 in (19 cm) long and 4 in (10 cm) wide.

Sample Day Pack List

- ☐ First aid kit
- ☐ Radio, cell phone or smartphone, or personal locating beacon (or all three)
- ☐ Map and compass or GPS unit (or both)
- ☐ Personal protective equipment (will change depending on the type of trail work)
- ☐ Tools (will change depending on the type of trail work)
- ☐ Foul-weather gear
- ☐ Hat/sun protection
- ☐ Headlamp or flashlight and extra batteries
- ☐ Personal items (including gloves, water, and food)
- ☐ Clinometer
- ☐ Tape flagging and pin flags
- ☐ Notepad, pen, permanent marker
- ☐ Your copy of the "Trail Maintenance and Construction Notebook"

Sample Medical Incident Report

Some trail managers use the "8–Line" medical incident report in the National Wildfire Coordinating Group's Incident Response Pocket Guide (PMS 461) to train their crew about the process they should follow in a medical emergency. Contact a Forest Service trail manager familiar with the form or fire personnel if the terms or acronyms are unfamiliar.

Remember, when using a radio, speak calmly and clearly. Think about what you need to say before speaking and hold the "talk" button for 1–2 seconds before you begin talking (to avoid initial transmission cutoff).

For a nonemergency incident, work through your chain of command to report and transport injured personnel as necessary.

For a medical emergency: identify on-scene incident commander by name and position and announce, "**medical emergency,**" to initiate response from dispatch.

Use the following items to communicate the situation to dispatch.

1. **Contact dispatch.** (Verify correct frequency prior to starting report.) E.g., *"dispatch, [state name, call sign, and/or work unit]. Stand-by for emergency traffic."*

2. **Incident status.** Provide incident summary, including location and number of patients. E.g., *"Dispatch, I have a red-priority patient, unconscious, struck by a falling tree. Requesting air ambulance to Forest Road 1 at [lat./long.]. EMT Smith is providing medical care."*

Severity of emergency/ transport priority

Red/Priority 1—Life or limb threatening injury or illness. Evacuation need is **immediate**, e.g., unconscious, difficulty breathing, bleeding severely, 2nd–3rd degree burns more than 4 palm sizes, heat stroke, disoriented.

Yellow/Priority 2—Serious injury or illness. Evacuation may be DELAYED if necessary, e.g., significant trauma, unable to walk, 2nd–3rd degree burns not more than 1–3 palm sizes.

Green/Priority 3—Minor injury or illness. Nonemergency transport, e.g., sprains, strains, minor heat-related illness.

Nature of injury or illness and mechanism of injury *Brief summary of injury or illness (e.g., unconscious, struck by falling tree)*
Evacuation request *Air ambulance, short-haul, hoist, ground ambulance, etc.*
Patient location *Descriptive location, lat./long. (WGS84)*
Incident name *Geographic Location Name + Medical (e.g., Trout Meadow Medical)*
On-scene incident commander *Name of on-scene supervisor or medical provider*
Patient care *Name of medical provider (e.g., EMT Smith)*

3. **Initial patient assessment.** Complete this section for each patient (start with the most severe patient).

Patient Assessment: See IRPG page 118
Treatment:

4. **Evacuation plan**

Evacuation location, if different than current (descriptive location [drop point, intersection, etc.] or lat./long.). Patient's ETA to evacuation location:
Helispot/extraction site size and hazards:

5. **Additional resources or equipment needs**

Example: Paramedic/EMT, crews, immobilization devices, AED, oxygen, trauma bag, IV/fluid(s), splints, rope rescue, wheeled litter, HAZMAT, extrication

6. **Communications.** Identify State air/ground EMS frequencies and hospital contacts as applicable.

Function	Channel Name/#	Receive (RX)	Tone/ NAC	Transmit (TX)	Tone/ NAC
Command					
Air-to-ground					
Tactical					

7. **Contingency.** If primary options fail, what actions can be implemented in conjunction with primary evacuation method? Think ahead.

8. **Additional information.** Updates, changes, etc.

Remember:

- Confirm ETAs of resources ordered.
- Act according to your level of training.
- Be alert. Keep calm. Think clearly. Act decisively.

Tailgate Safety Session

Overview

- **Project location and goals,** including type of work and transportation to and from worksite
- **Introductions** (welcome new people, medical conditions, experience level, first aid training)

Safety

- **Tasks, potential associated hazards, and mitigation measures**
- **Personal protective equipment** needed for the project
- **Anticipated environmental conditions** (weather, terrain, vegetation, wildlife, disaster potential)
- **Locate first aid kits**
- **Tools** and safety practices (carrying, using, storing)
- **Communication** (check-in/check-out, passing on the trail, loose or rolling rock, overhead swing, when to stop work and warn others, giving positive feedback)
- **Emergency evacuation plan** (identify the nearest road/trail head, communications, when to evacuate, contingency plan)
- **Questions, clarifications, or concerns?**

The tailgate safety session is based on information in the project risk assessment. The discussion should be documented on an official FSM 6719.8 – Exhibit 06 form.

After-Action Review

Tips for a helpful after-action review (AAR)

- Perform the AAR as soon as possible after the event.
- Take a few deep breaths.
- Don't make it personal and don't take it personal.
- Supervisors model open and honest discussion about what happened. Respectful disagreement is okay.
- Everyone participates.
- Leave with a strong desire to improve proficiency.
- End the AAR on a positive note.

Questions during an AAR

- What was planned?
- What actually happened?
- Why did it happen?
- What can we do next time?

A trail crew on the Inyo National Forest, California. USDA photo by Keith Dawley.