



Contents

Chapter 4: Construction.....153

Trail Construction Options	154
Constructing a Trail with In-House Labor	154
Constructing a Trail with Volunteers.....	154
Pennsylvania Child Labor Laws.....	155
Pennsylvania Child Protective Services Law	155
Constructing a Trail with a Contractor	156
Public Bid	156
Award of Competitive Bid Contract	156
Purchases Below Bidding Limit	156
Constructing a Trail with A Combination of Options	157
Preparing to Build Trails	157
Trail Crews	157
Education	157
Crew Leadership Training.....	158
Crew Leaders	158
Leading a Work Outing.....	158
Safety Rules.....	158
Equipment Preparation.....	159
Estimating Work	161
Safety and Preparation.....	162
Personal Protective Equipment (PPE)....	162
Boots and Socks.....	162
Gloves	162
Eye Protection.....	163
Ear Protection	163
Hard Hats	163
Long Pants and Chain Saw Chaps ..	163
Dust Masks and Respirators	163
Rain Gear and Insulation	163
Other Considerations	164
Trail Construction Tools.....	164
Hand Tools	165
Trail Clearing Tools.....	165
Timber Tools.....	165
Rock Tools	165
Wood Structure Tools.....	166
Bark Removal Tools	166
Hoisting Tools	166
Power Tools	166

Mechanized Equipment	167
Excavators	167
Dozers	167
Loaders	167
Haulers	168
All-Terrain Vehicles and Utility Task Vehicles	169
Trail Construction Options	170
Field Layout.....	170
Scouting.....	170
Flagging	171
Final Design Work	172
Trail Clearing	172
Tread Construction.....	173
Trail Closures and Restoration	174
Construction Management.....	175
Inspection/Quality Assurance	175
Permit Compliance	176
Erosion Control	176
Final Inspection.....	176



Construction

As we build trails we strive to reduce the impact on the environment by ensuring they are stable, safe, and sustainable.

Trails can be constructed by volunteers, agency staff or contractors. Regardless of who constructs the trails, it is important to follow the trail design, layout, details, and specifications to ensure they are properly constructed.

Realize that trail construction and reconstruction is an on-going process because a trail is dynamic. Over time, use and environmental factors will wear on the trail. As time goes by you will find areas

that may need to be re-routed, reconstructed or otherwise improved to address a particular concern.

In this chapter we discuss:

- Trail Construction Options
- Preparing to Build Trails
- Leading a Work Outing
- Safety and Preparation
- Trail Construction Tools
- Trail Construction
- Construction Management



**Hoisting Rocks on the
North Country Scenic Trail**

Photo Credit: Andrew Bashaw



Trail Construction Options

Trails can be constructed in several ways. Before you can begin construction, you will need to determine how and who will be constructing your trail.

Options include:

1. Constructing a trail with in-house labor
2. Constructing a trail with volunteers
3. Constructing a trail with a contractor
4. A combination of the above.

Your organization will need to evaluate which option or combination of options will both meet your needs and local, state or federal requirements. If you are unsure whether you need to competitively bid your project, contact the local municipality or governmental organization having jurisdiction to advise you. Often the funding source will dictate whether or not competitive bidding is required.

Constructing a Trail with In-House Labor

To construct a trail with your organization's staff consider your capabilities:

- Do your employees have the required knowledge and experience, or can you provide them with the proper training in advance of construction?
- Does your agency have the proper equipment?
- Can you allocate the resources and time necessary to complete the project in the desired time frame?
- Can you obtain approval from local labor relations unions?
- Are or can the volunteers be properly trained?
- Do your agency's insurance policies cover volunteers?

If your answer is yes to each of the above questions, then your agency should be able to successfully construct the trail. Carefully and honestly evaluate your organization's capabilities. Assuming your staff has the knowledge, abilities, equipment or time without verifying these important considerations with them can lead to frustration and potentially a failure to complete the construction of the trail.

Constructing a Trail with Volunteers

If your municipality or organization will be utilizing volunteers to construct a trail you should also be able to answer the questions asked above. Further you need to ensure your organization has done everything within its powers to ensure the safety of the volunteers and minimize the potential for liability before you agree to proceed.



Manor Rail Trail
Manor Township
Lancaster County

Photo Credit: PA DCNR



This includes evaluating the need for and implementing:

- Release, hold-harmless, and indemnification agreements as discussed in Chapter 5 - Management.
- Insuring your organization with:
 - Nonprofit Directors and Officers Liability Insurance
 - Property Insurance
 - General Liability Insurance with volunteers as insured, with abuse/molestation insurance rider
 - Automobile Insurance with employees and volunteers as insured and non-owned auto liability coverage
 - Accident Insurance to cover injuries incurred by volunteers

When considering insurance policies consult with an attorney who can advise you on the types and amounts of insurance coverage you should retain.

Further, when working with volunteers it is important to follow these child labor and child protective services laws.

Pennsylvania Child Labor Laws

When working with trail crews and volunteers it is important to have an understanding of the Pennsylvania Child Labor Law and how it influences what a child can and cannot do.

The *PA DCNR Conservation Volunteer Manual* typically governs volunteer work conducted on Pennsylvania State Forest land or within State Parks. It requires parental or guardian consent before a minor is permitted to engage in volunteer work. However, when minors are part of a group or organization (e.g., scouting or church group) that is providing volunteer services, the organization may sign on behalf of its minors if the volunteer coordinator has ensured that the organization has obtained parental or guardian consent for the minors to engage in the activity.

Pennsylvania Child Protective Services Law

Pennsylvania Child Protective Services Law requires private and public agencies to secure both child abuse and criminal history background clearances for a broad range of individuals who are in paid employment capacities with children and youth. This clearance process is one mechanism used to address issues of child safety. The background clearances identify substantiated incidents of child abuse and any relevant criminal offenses.

Many private and public agencies also extend these requirements to volunteers and others for whom they are not statutorily required but who are involved in activities with children and youth. FBI clearances are also required for potential employees residing out of state.

PA Child Labor Laws

For more information on PA's child labor laws visit the PA Department of Labor and Industry website ***HERE***.

DCNR Conservation Volunteer Program

For more information on DCNR's Conservation Volunteer Program visit their website ***HERE***.



These clearances typically include:

1. Pennsylvania State Police Request for Criminal Records Check (Act 34), available [HERE](#).
2. Department of Public Welfare Child Abuse History Clearance (Act 151), available [HERE](#).
3. Federal Criminal History Record Information (CHRI), available [HERE](#).

Constructing a Trail with a Contractor

If a project involves public funds you will most likely need to follow public bidding requirements to procure materials, or labor and materials, to construct your trail. Even if public bidding is not required there should be a competitive process.

Public Bid

In Pennsylvania, purchases by local governments fall into two general categories:

1. those where competitive bidding is required by law; and
2. those where competitive bidding is not required.

Depending on the value of the work, and the source of funding, there may be additional requirements. The following are examples of common requirements that often need to be met:

- Bid Bond
- Performance Bond
- Labor and Material Payment Bond
- Maintenance Bond
- Workers' Compensation
- Prevailing Wage Rates
- Davis-Bacon Act
- Steel Products Procurement
- Separations of Trades

Award of Competitive Bid Contract

When a materials and/or construction contract is procured through a competitive bidding process, the owner, if awarding a contract, should award it to the lowest responsible bidder.

Purchases Below Bidding Limit

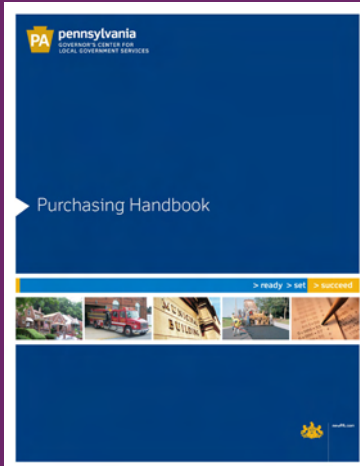
When utilizing public funds you are permitted to award non-bid contracts for small purchases. Refer to the PA DCED Purchasing Handbook for specific requirements and limits.

Non-Profit Organizations

There can be different requirements for non-profit organizations. These organizations should check with the program manager of their funding sources to determine the requirements they should meet.

Public Bidding Requirements

Detailed information on public bidding requirements can be reviewed in the *Purchasing Handbook* published by PA DCED Center for Local Government Services. You can download this handbook [HERE](#).





Trail Building Experience

When selecting a contractor and/or bidding a trail construction project, it is important to require contractors to have trail building experience.

A Combination of the Above Options

Trail construction can also be accomplished using a combination of the above options. Common arrangements include:

- In-house staff to construct the trail with materials procured through the public bidding process.
- Volunteers to construct the trail with materials procured through the public bidding process.
- Contractors to complete larger, more difficult tasks, and using in-house or volunteers to complete other portions of the trail construction.

Preparing to Build Trails

Regardless of whether you are constructing your trail with volunteers or with a contractor, the construction crew and the trail building techniques will be similar. The following sections provide basic information on each topic.

Trail Crews

Trail crews can consist of paid or volunteer staff. To work on a trail crew workers should be at least 16 years of age and in good physical condition; those younger than 16 can work if accompanied by an adult. Discourage volunteers from bringing children to participate in all-day trail building, as most have a short attention span. Crew leaders should be experienced in trail building, but no previous trail building experience is required for crew members.

Education

A crew leader should participate in crew leadership training and have previous experience as a crew member. Crew leadership training prepares individuals to begin achieving proficiency in the design, layout, construction, and leadership of recreational trails projects. While most courses are detailed and technical, they typically provide only an initial foundation on which to build proficiency through additional experience within volunteer, conservation corps, commercial, and agency trail construction and maintenance organizations.



**French Creek State Park
Tuesday Night Trail Crew**
Chester and Berks Counties

Photo Credit: PA DCNR



Crew leadership courses typically cover the following topics and have the following objectives:

Crew Leadership Training

Course Topics

- Design Concepts
- Trail Project Leadership
- Layout Principles
- Clinometer Orientation
- Topography Map Exercise
- GPS Exercise
- Field Layout Exercise

Course Objectives

- Understand the broad requirements for creating a recreational trail
- Understand trail corridor design concepts
- Understand trail tread layout principles
- Use a clinometer to determine gradients
- Use a GPS, or topographic map and ruler, to determine corridor parameters
- Layout and flag a trail project in the field.

Trail crew training may be available through local, state, and national trail associations such as PA DCNR, IMBA, Keystone Trails Association, and others. Refer to the websites of the respective organizations to determine where and when training may be available in your area.

Crew Leaders

Crew leaders should spend a considerable amount of time going over safety rules before each work outing.

Leading a Work Outing

Safety is the number one priority in all trail operations. Crew leaders are responsible for briefing crew members to maintain a safe working environment and instilling in them a sense of responsibility. Every work leader should learn and teach his/her crew safe work habits and see that these practices are adhered to. Every tool is a potential source of injury and everyone cannot be watched at all times. Therefore, the crew leader should establish ground rules at the beginning and teach by example.

Safety Rules

1. Carry tools in the safest way. Grip tools by the handle about 6 inches behind the head, or at the balance point, and carry it to the side, on the down-slope side of the body rather than over the shoulder or as a walking stick. This prevents injuries due to falling on the tool, since

Subaru/IMBA Trail Care Crew

Two teams of professional trail building experts travel year-round throughout the United States and beyond, leading trail work sessions that teach attendees how to design, layout, and construct sustainable trails. To learn more about this program visit their website [HERE](#).



Swatara State Park
Union and Schuylkill Counties

Photo Credit: PA DCNR



it can be easily tossed away when carried correctly. Carry tools with sharp blades by facing the blade to the ground, and equip with a sheath to prevent accidental cuts and to retain its sharp edge. Keep the sheath on the tool while carrying it to the worksite and only remove it when it is being used. Hold bulky or clumsy items with two hands or have two people carry them.

2. Leave plenty of room between volunteers for walking and working, generally 10 feet between crew members.
3. Crew members should always be aware of what others are doing and take full responsibility for their own safety and the safety of others.
4. The right tool should be used for the job.
5. Implement the “Scan-Shout-Swing” order of doing things. Crew members should look around to make sure no one is in harm’s way and to ensure there is plenty of room to swing safely. If necessary, clear brush or limbs first to avoid injury from a deflected tool. Second, communicate intentions and third, crew members may proceed when all is clear.
6. Remove trail hazards as they are encountered, or communicate their presence to other workers down the line, either verbally or with a temporary sign (for instance, a temporary sign could warn others of a nearby yellow-jacket nest or a poorly supported leaning tree). Remove hazards as soon as practical to prevent others from being harmed.
7. Dehydration, heat stroke, lack of energy, and hypothermia are life-threatening concerns. Keep first aid supplies on hand and ensure every crew member knows what is available and where it is kept. When working in remote locations, let someone, park ranger/local law enforcement, etc. - know the crew’s location and expected time of return.
8. Crew members should be aware of their physical condition and limitations. Weariness can lead to accidents.

Equipment Preparation

Select and inspect the correct tools for the job before using them. Ensure blades are sharp, handles are smooth, and heads are securely fastened. Properly care for tools and use them correctly. Crew leaders should demonstrate proper carrying and handling techniques before leaving the parking lot.

D & L Trail Tenders

Trail Tenders are dedicated men, women and youths who maintain and enhance the D&L Trail in Northampton, Lehigh, Carbon and Luzerne counties.

Tenders have a variety of responsibilities. They help maintain the ecological balance along the trail by eradicating invasive plants and replacing them with native grasses, wildflowers, shrubs and trees. They maintain the physical integrity of historic structures such as canal locks and railroad turntables, by performing regular site cleanups. And they build picnic tables, benches and bicycle racks for the benefit of trail users.



Trail Tenders

Photo Credit: Delaware & Lehigh National Heritage Corridor



Careful planning will prevent problems during the outing. A checklist of supplies and safety-briefing points is a must.

Sample Checklist

- Tools (list)
- First Aid kit
- Insect repellent
- High energy food (list)
- Water (adequate amount for conditions and crew members)
- Individual water containers
- Extra rain gear or plastic garbage bags
- Extra gloves
- Hard hats
- Eye & ear protection
- Other personal protective equipment
- Compass
- Topographic maps
- Project maps and plans
- Trail brochures
- Membership information
- Copies of “Safety Rules”
- GPS with extra batteries
- Cell phones/two-way radios

Tell potential participants what they are expected to bring prior to the work-day. Normally, participants are responsible for their own footwear, rain gear, and gloves. There will always be a few who need an item, so crew leaders should bring extra, if they are available.

Sometimes people will bring their own tools. This is fine as long as their tools are in good condition and appropriate for the project. Inexperienced workers, for instance, seem very fond of hatchets. They are ineffective for trail work when compared to loppers, bow saws and other trail tools. Crew leaders should be firm about leaving such tools behind, and should check all personal tools for soundness.

Just because people bring a tool from home does not mean that they know how to use it correctly. Take time to discuss proper use of all tools that are going to be used that day. If there are more tools than people, then determine which ones are really necessary and which ones should be left behind. In most cases crew members should not carry more than one tool, except when walking in to major project sites. An exception to this is when small tools such as wire cutters for old barbed wire can be carried in a pocket or day-pack. In addition to teaching basic rules, a crew leader should also discuss other precautions, such as being aware of poisonous pests or plants suspected in the work area.

Crew leaders should be aware of any signs of fatigue, dehydration, or heat stroke among crew members. If someone seems to be having trouble, crew leaders do not need to draw undue attention to it, but should not ignore it either. Crew leaders should ensure that everyone is getting enough rest periods and water.



Trail building should be a good experience for everyone. If the experience is positive, people will come back for the next work-outing.

Some agencies use non-skilled labor obtained through community service programs and/or prison work release programs to complete tasks such as brush clearing, mowing, etc. If you are interested in determining the availability of non-skilled labor through community service or prison work release programs, contact your local magistrate, Common Pleas Court and/or your local prison board administrator.

Estimating Work

Before a trail crew goes into the field to begin construction, crew leaders need to understand the goals and expectations for the crew's work, estimate how much work is required and how much work their crew can accomplish in a given time. Crew leaders assist organizational leadership with determining larger management plans and crew leaders should motivate their crews.

Many conditions influence the amount of work that crews can complete during an outing, including: ability of workers, availability of tools and materials, weather conditions, terrain, and time required getting to the work site. Estimating work is an acquired skill mastered with experience.

Visiting a site in advance of a crew's arrival is another essential part of estimating work. Crew leaders should visit a site to find answers to the following questions:

- How long will it take the crew to travel to the work site each day?
- What tools are required to complete the work and how will they be transported to the work site?
- What building materials are required and are they available on-site? If materials need to be moved, will the crew have wheelbarrows, motorized wheelbarrows, or rigging gear, and do they know how to use them?
- Will the trail sponsor have personnel on-site?
- Will the work site be closed to public use during construction? If not, the crew is likely to lose production time allowing trail users to pass through.
- When the work is complete how much time will be required to close down the project, clean up the work area, carry out tools and gear, and store or return equipment?
- Are there seasonal patterns of heat, cold, rain, or snow that will impact production?
- Can the crew complete the work safely?
- Will the project interest crew members and give them a sense of accomplishment?



- Where will the crew stay? Backcountry camp, modern camp, etc.? Will they transport tools and gear to their camp?
- Can the crew stay at the camp for the duration of the project?
- Is there a backup project for the crew if they finish their primary work ahead of schedule?

Crew leaders should take into consideration the age, fitness, ability, experience, and motivation of their crew members. Complex, intensive, or extensive projects may be right for an experienced crew, but too demanding for inexperienced crews.

Attention to the details of construction and clean up of the work site makes a great difference in the appearance and quality of the project. Trail crews often overlook this final 10 percent of a project in the haste to complete it. Crew leaders need to budget time to allow this work to be completed, to motivate crew members to take pride in their work, and to finalize the work in a manner that makes the crew proud.



AMC's Complete Guide to Trail Building & Maintenance

Appalachian Mountain Club

Safety and Preparation¹

Trail work can be challenging and exhausting, and danger is always present. Therefore, trail crews should be properly equipped and prepared to respond to the hazards of the work environment.

Personal Protective Equipment (PPE)

By using personal protective equipment (PPE) trail builders protect themselves from hazards and injuries. Having appropriate, functioning PPE for an activity should be at the forefront of any trail maintainer's mind before starting a project.

Boots and Socks

Well-made, sturdy leather boots are one of the most important pieces of gear a trail worker should have. Boots suitable for hiking will last much longer and provide better protection than traditional hiking boots made of lightweight material. Steel toe boots offer an additional layer of protection, but can be uncomfortable for long hikes.

Gloves

Sturdy gloves can help protect hands from potential injury. Although certain tasks require finger dexterity that is limited by using gloves, it is important to wear gloves for most trail activities. Trail workers often choose leather gloves over cotton gloves, because they withstand heavy use and provide better protection from injury.

¹ Adapted from AMC's Complete Guide to Trail Building & Maintenance, Appalachian Mountain Club: 2008



Eye Protection

Safety goggles and glasses provide an inexpensive, lightweight protective barrier during trail construction. It is important to choose ones that are shatterproof and impact-resistant, as well as meet or exceed ANSI Z87.1-2003 standards. Helmet mounted, mesh facemasks may also serve as eye protection while operating a chain saw or brush cutter. When using a chainsaw, users should wear an additional pair of safety glasses underneath a mesh face guard.

Ear Protection

Ear protection is required during some trail activities that include the use of chain saws, rock drills, and other forms of gas-powered equipment. Plastic earmuffs and foam earplugs are two types of ear protection designed to reduce external noise to a level that prevents or limits hearing loss. It is important to know the decibel level of a piece of equipment to choose the appropriate hearing protection. Use hearing protection that meets ANSI S3.19-1974 standards or higher.

Hard Hats

Wear hard hats when doing trail work activities, especially in situations where there may be falling or flying objects. Hard hats should meet all OSHA-ANSI Z89.1-1997 safety standards in their design for an intended activity. Only wear helmets designed or approved for construction activities. Remember to replace damaged hard hats or those that have met their expiration date.

Long Pants and Chain Saw Chaps

When maintaining or building a trail, it is important to wear long pants to protect from cuts, scrapes, and bruises. During warmer months, consider hiking to the work site in shorts and changing into longer pants before beginning work.

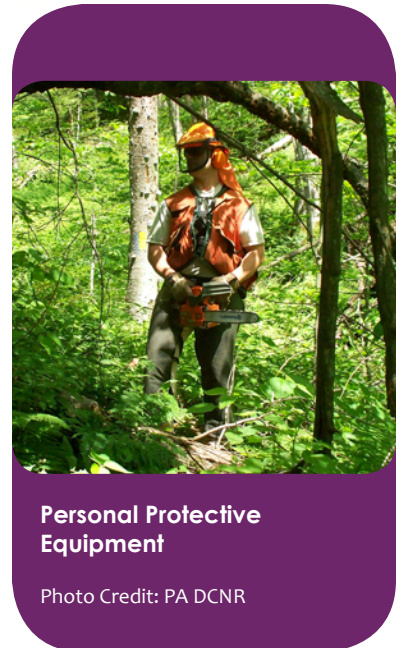
Wear chain saw chaps over pants, covering a person's legs and torso to prevent cuts or more serious injuries from occurring. The fibers of chaps will clog drive sprockets and stop chain rotation quickly, before a serious injury can occur.

Dust Masks and Respirators

It is important for trail workers to wear dust masks and respirators to protect against breathing undesirable contaminants from the air. Moreover, trail workers should receive training on hazardous material identification and safety practices to choose the proper mask. For example, dust or particle masks filter airborne particulates, while respirators have a filtration component that filters hazardous fumes.

Rain Gear and Insulation

Prepare for all types of weather during the construction or maintenance of a trail. Pack rain gear and insulating layers appropriate for your location,



Personal Protective Equipment

Photo Credit: PA DCNR



Clearing the Tread along the McCune Trail
Fayette County

Photo Credit: PA DCNR

activity, and worst-case weather scenario. This might require packing several layers of clothing, hats, and gloves even during summer months. Choose synthetic or wool blends designed to keep warm even when wet.

Other Considerations

Clean, inspect, and store all personal protective equipment on a yearly basis. It is a good idea to label and date all PPE at the time of purchase and keep records of the number of uses and stress placed on equipment. Replace personal protective equipment when an item has reached its expiration date or sooner, depending on wear and tear.

Every trail crew or worker should have a first-aid kit handy at all times. Its contents should be based on the hazards posed by the work, remoteness of location, and number of crew members. It is important to become educated on local poisonous plants and pests. Bring soaps, repellents, snake bite kit, and other kits for individuals susceptible to allergic reaction from bee stings and poisonous plants.

Workers who stay properly hydrated are safer, happier, and more efficient. Bring plenty of food and water on the trail and eat it. By eating and drinking appropriate amounts, it is easier to avoid hazardous health risks including exhaustion, heat stroke, hypothermia, impaired judgment, and injuries.

Trail Construction Tools

By planning and preparing for work outings ahead of time, you will be able to estimate the type and quantity of tools necessary to complete the work. Trail construction tools fall into one of three categories:

1. Hand Tools
2. Gas/Electric Powered Hand Tools
3. Mechanized Equipment

The type of tool you use will depend on the type of work you are performing. Typically, agencies and organizations responsible for trail construction will use hand tools, and/or gas/electric powered hand tools. Professional trail builders, contractors, and sometimes municipal parks departments, will use mechanized tools and equipment where appropriate.

Determine what tools to bring with you ahead of time. Plan what work your trail crew will perform and where the work is located. Focus on one task during each outing and only bring tools required to complete that task. Bringing too many different types of tools or trying to accomplish too many tasks will reduce the crew's efficiency and slow down construction.



Towing Tools to the Work Site

Photo Credit: Valley Mountain Biking Club



Before heading to the work site:

- Select high quality tools
- Ensure crew members are properly trained to use the tools
- Review with crew members the safety requirements and procedures related to the tools
- Review the recommended personal protection equipment that should be worn when operating the tools

Hand Tools²

The following is a summary of the various hand tools and the respective tasks that can be accomplished with them.

Trail Clearing Tools

- **Swizzle Stick:** Also known as a weed whip. It is used in a swinging motion, like a golf club, to clear brush and low growth.
- **Lopping Sheer:** Essential for trail corridor brushing involving nipping small branches and clipping vegetation flush to the ground.
- **Machete:** Most effective when wielded with a vertical stroke to clear brush and vegetation.

Timber Tools

- **Axe:** Double bit, single bit, and three-quarter axes are effective for making deep cuts when felling trees and chopping through logs.
- **Brush and Bow Saw:** Suited for making vertical cuts involved in clearing modest-sized logs from trails and bucking firewood in camp.

Trail Tread Tools

- **Pulaski:** Preferred by many trail groups for loosening compacted soil, grubbing tread, chopping roots, and removing slough.
- **Fire Rake:** Suited for cutting, pulling, and scraping debris, mulch, leaves, small roots, and small bushes when clearing a trail.
- **Hoe:** Useful for breaking up sod when constructing a new trail or when leveling an existing trail tread.
- **Shovel:** A spade shovel is most effective for digging holes, moving loose dirt, and digging in tight spaces. As a rule, the longer the sleeve the stronger the shovel will be.
- **Mattock:** Versatile tool for digging, prying, and moving dirt, especially when unearthing rock, digging through roots, and breaking through rock.

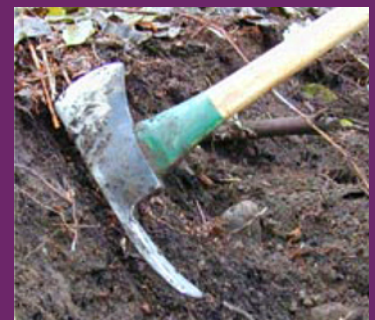
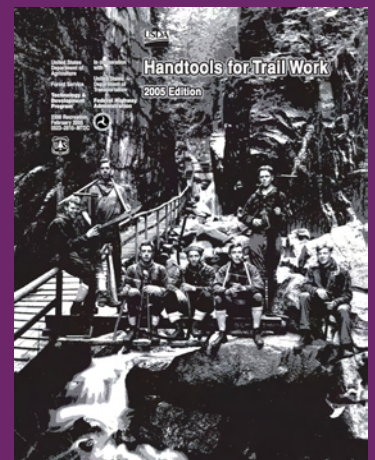
Rock Tools

- **Rock Bar:** The rock bar, also known as a crowbar, is necessary in heavy trail work to obtain enough leverage to move large boulders and unearth rocks.

Additional information can be obtained from the U.S. Forest Service publication:

Handtools for Trail Work:
2005 Edition

Available **HERE**.



Pulaski (above)
McLeod (below)

Photo Credit: PA DCNR

2 Handtools for Trail Work, US Forest Service 2005 Edition: Updated 2012



Grip Hoist

Country Scenic Trail

Photo Credit: Andrew Bashaw

- **Hammer:** Hammers for shaping rock may have a wedge-shaped peen needed to easily chip away parts of a rock.

Wood Structure Tools

- **Broad Axe:** The beveled head of the broad axe cuts with the grain and hews a flat face in a log.
- **Splitting Wedge:** Wedge for splitting firewood or for laying open logs to support walkways, usually made of soft steel or aluminum.

Bark Removal Tools

- **Drawknife:** When pulled toward the body, this tool is useful for easily removing dry, hard bark and shaving wood.
- **Barking Spud:** One of the safest tools for removing bark, the spud is valuable for removing green bark.

Hoisting Tools

- **Grip Hoist:** A lightweight tool capable of dragging tremendous weights on wire rope in rigging systems designed for moving timber, rock, and other building material.
- **Ratchet Winch:** Useful for moving rocks and logs, as well as pulling stumps.

Power Tools

- **Chain Saw:** A motorized tool effective for felling and bucking trees without the use of an axe.
- **Gas Powered Brush Cutters:** Similar to a heavy duty string trimmer, with a metal blade for cutting wood. A brush cutter can be useful for extensive trail clearing through young/heavy growth.
- **Rock Drill:** Useful in specific construction applications for drilling holes in rock for pinning rock, installing metal rungs or ladders, or splitting rock with feathers and wedges.



Transporting a Chain Saw by Bike

Photo Credit: PA DCNR



Mechanized Equipment³

Excavators

The most common excavator configuration is a boom and shovel with a dozer blade mounted below the boom. A tracked undercarriage is usually used. The primary earthworking implement is the bucket used to dig and move earth. If the excavator is equipped with a small blade, the blade is useful in grading off excess material, leveling and back filling. Most excavator manufacturers have grubhoes or different size buckets available as attachments. The smallest excavator has a track width of 19 inches and the largest has an overall width of 63 inches. On some models the track width is variable and can be adjusted depending on trail conditions and operator experience. Horsepower rating varies between 3.5 hp and 43.4 hp.

Dozers

Dozers are self-propelled machines mounted on either a wheeled or crawler tractor to exert a push/pull force through a blade, drawbar, or ripper and are used to move objects or materials. The primary trail building implement is the dozer blade. Dozers are machines with a width under 72-inches, not including the width of the implement.

The advantages and disadvantages of dozers compared to excavators are listed below. Other advantages/disadvantages may be observed depending on use, terrain, and locale.

Advantages

- Large dozer blade is faster cutting a rough trail tread than a backhoe bucket
- More stable than the backhoe because the center of gravity remains constant. These machines are usually wider than the compact backhoe thus making them more stable
- Moving large boulders or tree stumps is easier with a dozer. The larger engine available in these machines makes pushing obstacles out of the way faster than digging them out
- The auxiliary hydraulics available makes the dozer an excellent platform to power other hydraulic implements

Disadvantages

- Larger than most compact backhoes; and cuts a wider trail
- Larger trailers and towing vehicles are required for transport to the job site

Loaders

Loaders are mounted on either a wheeled or tracked undercarriage. These machines have loader buckets up front with engines mounted in the rear. Loaders are ideal for moving rocks, soil, or other trail building material to the



Mini-Excavator

Photo Credit: PA DCNR



Loader

Photo Credit: PA DCNR

³ Mechanized Trail Equipment, US Forest Service: 1996



job site. They are not designed to cut trail tread; however an angled blade and a york rake attachment are available for that purpose. The smallest loader has a width of 35.5 inches, the largest width of 74.1 inches. Some loaders come standard with wheels, but a track to fit over the wheels is available.

The size of the machine dictates the width of the trail on which the machine can operate. Tracks on the vehicle provide more traction because of a large contact area with the ground. The larger contact area also provides better resistance to inadvertent slipping, making it more stable. The larger contact area also provides more “float” over plastic soil conditions. The damping action provided by the pneumatic tires gives the wheeled vehicle a smoother ride. The vast assortment of available attachments for these loaders makes them versatile trail machines. Loaders can be used to haul or move trail materials closer to the job site.

The advantages and disadvantages of the loader compared to the excavator, dozer, and hauler are:

Advantages

- With the available attachments the loader performs many other functions. Able to move large volume of material
- Higher travel speeds reduce cycle time
- Parts and service are widely available

Disadvantages

- Performance is compromised when used as other than a loader or hauler
- Additional cost to procure attachments

Haulers

The basic hauler has two components: cargo area and power unit. The cargo area of the haulers range from a polyethylene tub to a hydraulically tilting dump bed. The power units range from an electric motor to a 4-stroke, liquid-cooled 90°V-Twin.

Haulers are used to haul material to and from a job site. The hauling capacity and travel speed becomes important when hauling to and from a remote location. Although these machines were designed to traverse unimproved areas, in most cases the machines travel on trails being maintained or trails with a rough cut tread.



Hauler

Photo Credit: PA DCNR



The advantages and disadvantages of mechanized haulers versus hand haulers are:

Advantages

- Greater hauling capacity with shorter cycle
- Reduced physical demand to the user
- Reduced injury due to manual labor
- Traverses rougher areas than a garden cart or wheelbarrow

Disadvantages

- Requires more maintenance
- Requires transport
- Need to carry gasoline or batteries
- High initial capital investment when compared to manual methods

All-Terrain Vehicles (ATV) and Utility Task Vehicles (UTV)

There are many ATV and UTV models on the market. The models come in either a two or four wheel drive. Both typically have a high ground clearance, and ATVs typically have a short wheel base. Consult with land owner before using these types of vehicles.

ATVs are versatile trail machines used for hauling material and shuttling personnel to and from the job site. An ATV can tow a trailer to haul material and equipment to the job site. There are numerous attachments which can be purchased or fabricated to adapt the machine to all sorts of tasks. The ATVs are used with a drag/plow or a harrow to groom trails. Accessory kits are also available to improve the performance of ATVs and UTVs.

Advantages

- ATVs can be fitted with implements used for trail building
- Readily available
- Most ATVs are small and rugged and can travel over rough unimproved terrain or narrow trails
- Able to haul larger loads
- Higher travel speed thus covering a larger area. When used to haul tools and material, the higher travel speed reduces the cycle time

Disadvantages

- Need to transport
- Need to carry fuel
- Operator has to be trained to operate and handle the machine



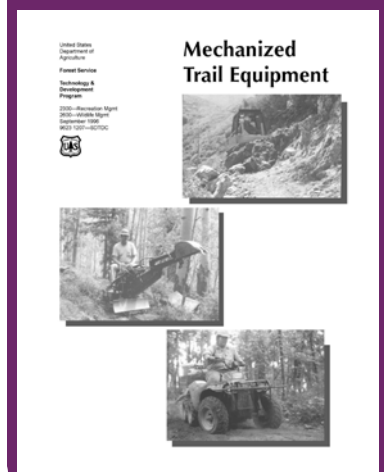
All Terrain Vehicle (ATV)

Photo Credit: Pashek Associates

More information can be obtained from the U.S. Forest Service publication:

Mechanized Trail Equipment

Available **HERE**.





Trail Construction

When designing trails, often it is difficult to lay out the trail without having problems in achieving a sustainable route. Especially in mountain environments, it is very difficult to determine a route that follows the lay of the land, encountering few risks of erosion and saturation. Long, steep slopes are a common issue. Designers should compromise in these circumstances and build contour trails while incorporating climbing turns or switchbacks to overcome changes in grade.

When laying out your trail for construction follow the techniques and best practices for laying out a sustainable trail. At this point your trail is ready to be constructed.



Laying Out the Trail

Photo Credit: PA DCNR

Field Layout

The objective of a field layout aims to provide safety, protect the environment, improve recreation, and minimize conflicts with adjacent properties. After mapping and scouting a future trail route, establish the flag line. A flag line marks where trail builders will cut down trees and brush, excavate a trail's treadway, and construct the trail.

During the planning and design process, as described in Chapters 1, 2 and 3, many small decisions and considerations determined the final location of the trail corridor. Therefore it is important to accurately lay out the trail in the field. The details of layout ultimately determine the quality of a trail. A trail's layout should be safe, appealing, and free of conflicts. When a new section of trail opens, it introduces new pressures to primitive lands, so it is important to keep pressures as light as possible.

Trail layout is generally not complicated. Through a trial and error process, trail designers eventually settle on the most stable, sustainable, and attractive route. Using planning maps, first scout for and flag feasible lines through the woods. Then on return trips, add more flags to refine the line of the trail. Finally, coordinate with agency partners to adjust and approve a final trail route. Most likely the trail corridor has already been flagged during its planning and design. The following is a summary of the field layout process.

Scouting

The best time of year for scouting is when trees are bare throughout the fall and spring. During these times, an entire sweep of the proposed route can be seen that otherwise may be hidden by foliage during warmer months. Avoid scouting when the ground is snow covered because the quality of soil and drainage underneath are not visible. Its best to scout during the wet season to determine where the ground may be too wet to support a stable treadway.



As discussed in Chapter 1 - Planning, it is important for designers to study maps of the area before scouting in order to confirm all property boundaries discovered during planning. Recent advances in satellite technology have provided trail designers with a new design tool known as handheld global-positioning system (GPS) units. This tool calculates the user's position in latitude, longitude, and elevation by timing signals from satellites maintained by the United States. To prepare to scout a new location, upload flag locations to your GPS unit. The GPS unit will guide you to these locations in the field.

Fieldwork can be dangerous, especially when alone. Scouting is easiest with two or three people who can walk on and assess terrain in multiple areas. By analyzing various routes, as well as taking field notes, designers are able to discover a route that provides the best continuous course.

Flagging

Trail flagging is essential for accurate trail layout. Flagging is the process of tying plastic ribbons around trees to indicate the center line of a route. Surveyor's flagging tape may be used to wrap around living trees and branches, while wire flags are commonly used in open, treeless terrain. Both surveyor's tape and flags come in various colors and lengths, allowing designers to choose colors that contrast with the prevailing foliage.

Detailed flagging of the trail alignment is critical at this stage. To remind trail builders of elements critical to the design, write notes with a permanent marker on the flags. Walk along a trail route using a measuring wheel and note where important structures, drainage, as well as notable features such as boulders and streams are located along the trail route.

Do not skimp on delineating the final flag line. Tie flags frequently, approximately every ten feet. This also provides backup should flags be removed or blown away. Use different colored flags when flagging alternative routes. During layout, flag carefully at junctions and switchbacks to make the footpath the shortest, easiest, and most logical route for trail users. Use distance, rugged terrain, or vegetation to prevent shortcutting through these areas. Also place flags and label them where features will be constructed.

Small and large obstacles sometimes lead to significant changes in the trail route and can result in a reroute well ahead or behind an obstacle. Willingness to keep making changes to this route often distinguishes the best trails and their designers. The more patience you have in aligning the route, the more likely you will achieve a more sustainable, higher quality location for the trail.

Always attempt to locate a line that keeps the final treadway free of structures such as waterbars, cribs, steps, and other rock and log



improvements. Allow the treadway to maintain a primitive quality by laying out the trail center line in a location that will require minimal maintenance over time. For instance, locate treadways upslope of large trees so excavation does not damage the root system. Large roots extend downslope of trees near the surface, making it difficult to excavate the edge of the treadway.

Sometimes there is no other choice than to navigate treadways through steep terrain that may require heavy trail work. This may occur in areas with a narrow corridor or those surrounded by steep slopes. When this occurs, consider including steps, waterbars, puncheon, and cribs in the layout.

When laying out accessible sections of a trail, exclude the above-mentioned elements within the design. Locate a center line that allows trail builders to excavate a sidehill treadway with grade dips to provide drainage. When constructing accessible trails, anticipate use by designated users and even trespassers that may negatively affect a trail's appearance and accessible character.

Once flagging is finished, a local management partner should review and, if necessary, adjust a flag line. The local management partner should give a trail its final approval, which sometimes includes an environmental assessment. Agency partners are responsible for protecting the environment and should survey the site to ensure that adjacent plants, animals, and other resources are not affected.

Final Design Work

Before construction begins, walk the flag line with the trail builders to make sure they understand a trail's overall layout. Ensure the crew leader and all trail builders understand the important aspects of the layout. Without the establishment of good communication, a trail will most likely differ from what was originally proposed.

Trail Clearing

The first step of construction is the clearing of a trail corridor to adhere to a specific project's design. Cutting new trails can be dangerous, therefore follow all safety procedures.

Trail crew leaders and their crews should understand that clearing too much can create as many problems, if not more, than clearing too little. Clear a trail corridor to the appropriate design specifications to provide an adequate clearance buffer along the edges of the trail tread. Further, the crew leader needs to understand and communicate to the crew that the designer used trees and other features to accentuate turns, limit speeds, prevent trail widening, and screen adjacent trails from view. Therefore it is critically important for them to follow the established flag line.



Before clearing the trail corridor, install all temporary and/or permanent erosion control features that the designer specified for the trail. Clearing involves removing blow downs and brushing the corridor. During the clearing process, avoid cutting large trees to minimize the need for stump removal. Trees left on the side of the trail define the trail and often are stabilizing the soils. Whenever you need to remove a sizable tree consider using the trunk as material for bridges, retaining walls, or other rustic features.

To clear the corridor the trail builders should use the door technique. The door technique involves walking the trail and imaging you are carrying a door vertically, like a shield, along the corridor. The size of the door corresponds to the vertical and horizontal clearing requirements identified in Chapter 2. Everything that falls within the outline of the door should be removed. Look for branches or limbs that touch the door. They should be removed as well to reduce future maintenance requirements. Once the corridor is cleared and brushed, the tread can be constructed.

Tread Construction

At this point your trail corridor should be clear so you can safely and easily work on the tread. To construct the tread the ground should be cleared of organic materials and topsoil so the mineral soil can be shaped into the trail tread. It is necessary to remove the organic materials and soil to provide a firm base for the trail tread. On very flat trails it may be necessary to fill the void created by removing this material, or if borrow material is not available it may be necessary to leave the organic material and soil so the tread is not entrenched into the surrounding grade.

To remove organic material and soil use a mattock, fire rake or other scraping tool. Be sure to mark the sides of the treadway and follow the marks to ensure a consistent tread width. Remove all roots exposed during this process with a fire rake, or a root ax.

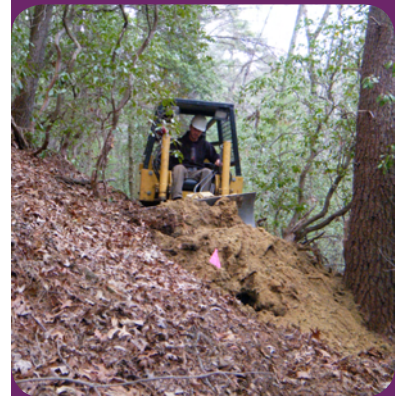
All organic matter should be placed on the downslope side of the trail, far enough way from it that it does not impede drainage. If the trail is near a stream, intermittent water course, or other body of water, transport the organic material away from the tread and the watercourse to ensure it does not enter the water.

Where the designer has specified the use of geotextile, and/or specifies a form of tread hardening, remove saturated mineral soil to firm soil.

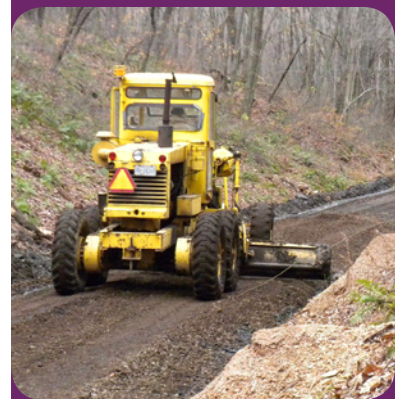
After exposing the mineral soil follow the prescribed tread cross section as selected by the designer. You may be constructing the trail on the existing grade, or you may need to construct a bench to accommodate the trail. If a bench construction is prescribed by the trail designer, ensure that all organic material and soil has been removed so you have a sound foundation to work from.



Tread Construction by Hand



Tread Construction with Sweco



Rail Trail Tread Construction with Road Grader

Photo Credits: PA DCNR



With the mineral soil exposed, begin cutting the bench by starting on the uphill side, and pulling excess mineral soil to the downhill side of the tread. Continue working your way across the tread until you have achieved the desired elevation and width for the tread. Ensure the stability of both the upslope and downslope banks you are constructing on the trail.

Typically the sideslopes supporting the tread should be no steeper than 2:1, 50% slope - less is better. As you construct the sideslopes carefully smooth and finish them. Time spent fine tuning their shape will reduce future maintenance requirements. Once you complete construction of the tread, and the sidehills are finished, cover them with humus and leaf litter, or seed them with a native seed mix. This step begins the revegetation process, and in the meantime stabilizes the soils to reduce rilling and splash erosion.

As you progress along the length of the trail follow the designer's specifications and install drainage features such as dips, drainage lenses, culverts, and any other trail structures.

Once the tread has been established it should be finished. This means you may need to rake the tread smooth while maintaining the specified cross slope to direct water off of the tread. Or it may mean the tread is ready to receive a specified cross section to harden its surface.

Follow the specified requirements for compacting the tread base when installing geotextiles, and/or when hardening a tread.

Once construction is completed review the construction with the trail manager and address any areas that are unstable, unsafe, have eroded, or that otherwise do not meet the designer's specifications. Complete any required remedial work as quickly as possible.

Ideally, natural surface trails should not be opened immediately following construction to improve long term stability. The tread should be allowed to settle and bond before use. Ideally the new trail should remain closed to use for three months.

The process is the same whether the trail is constructed by hand or with mechanized equipment.

Trail Closures and Restoration

The closure and restoration of degraded trails allows for the rehabilitation of the landscape, provided humans cannot access these previously accessible areas. Detailed restoration plans require the planning and implementation of long-term environmental repair efforts. These efforts include monitoring, site and soil preparation, planting vegetation, maintaining the closures and restoration improvements.



Compacting an Aggregate Tread

Photo Credit: Penn State Dirt and Gravel Road Program



Take these steps before closing or rerouting degraded trails:

1. Talk before rerouting
2. Educate trail users
3. Design a sustainable, more enjoyable trail
4. Design a smooth intersection
5. Break up the old tread
6. Control erosion on the closed trail
7. Transplant vegetation
8. Disguise the corridor
9. Redirect trail users
10. Block the corridor – Last Resort

Construction Management

A construction management team is essential for a successful trail building project. This team may consist of an individual or team whose skills are specifically tailored to meet the construction observation requirements of a project. Additionally, the team should have an individual with strong skills in soil identification, soil preparation and soil compaction. This is especially important if the construction plans for a trail are not overly detailed.

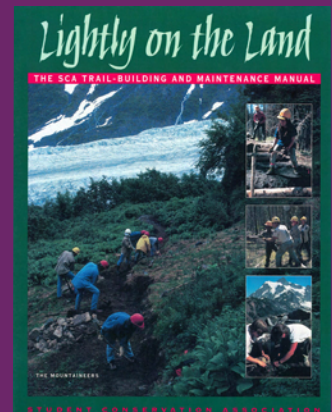
The construction management team represents the agency responsible for the trail and serves as a liaison between the design team, the contractor, and/or volunteers. The construction manager is responsible for ensuring that the materials, procedures and workmanship conform to the appropriate standards and specifications. The construction manager should also ensure that the contractor or volunteers maintain a clean, safe work environment.

Inspection/Quality Assurance

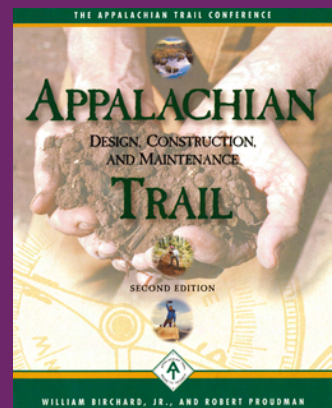
The objective of quality control is to provide a safe, functioning and lasting project, with an acceptable appearance. The trail manager and the trail designer should provide continuous inspection as necessary to ensure the field crew's performance of work meets the standards required. The degree of inspection will depend on the experience of the crew, the complexity of the job, and the specific task being accomplished.

There are several resources available that provide detailed and in-depth information on trail construction, they include:

- *Lightly on the Land: The SCA Trail Building and Maintenance Manual*⁴



- *Appalachian Trail Design, Construction and Maintenance, 2nd Edition*⁵



- *AMC's Complete Guide to Trail Building*⁶

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- 4 *Lightly on the Land: The SCA Trail Building and Maintenance Manual*, Student Conservation Association, 1996
 - 5 *Appalachian Trail Design, Construction and Maintenance, 2nd Edition*, the Appalachian Trail Conference, 2000
 - 6 *AMC's Complete Guide to Trail Building*¹, published by the Appalachian Mountain Club, 2008



Trail Construction
Black Diamond Trail
Luzerne County

Photo Credits: Delaware & Lehigh
National Heritage Corridor

Permit Compliance

The trail manager should have a copy of all permits that have been issued for the project. In addition to ensuring compliance, the construction manager should monitor completion of reporting requirements. The trail manager should also coordinate and facilitate inspection by permit-issuing agency personnel, such as Conservation District personnel, DEP staff, and local municipal code enforcement officers.

Erosion Control

Proper installation of temporary erosion control measures during construction not only protects the environment, but also protects new construction until permanent measures have been established. The construction manager should frequently inspect temporary control measures to ensure they are functioning properly, particularly after storm events. Conservation District or DEP personnel may periodically inspect the project site to determine if selected best management practices are effectively controlling soil erosion. Best management practices that have failed or are not effectively controlling erosion as intended, should be replaced or repaired. Alternative measures may be required.

Final Inspection

When construction is nearly complete, the trail designer, the trail manager and the trail builder should make a final inspection as applicable. The inspection party should walk the trail on foot. A “final punch list” of items to be completed or corrected should be prepared and agreed upon by the inspection party. Upon correction of the items on the punch list, the contractor should complete and submit “As Constructed” plans.