

Pathways to Trail Building



**Tennessee Department of
Environment and Conservation**

**Recreation Educational Services Division
Greenways and Trails Program**

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To see this brochure online and download a copy, please visit: <http://state.tn.us/environment/recreation>



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INTRODUCTION

Tennessee is a state of outstanding biodiversity, scenic beauty and cultural history! The state has a long history of trails, starting from the first ones developed by the Native Americans before Tennessee became a state. Trails are a popular resource for users today and can lead to untold awe-inspiring adventures and discoveries for the young and young-at-heart. Recent research has also shown that getting outdoors and participating in an active lifestyle, including trail activities has health benefits and leads to improved physical fitness levels.

The intent of this 4th edition of a Tennessee Recreation Trails Manual is to help understand the dynamics of designing and building non-motorized trails. Trail builders will learn the joy of discovering new places and the feelings of accomplishment from walking back over a newly constructed section of trail. This manual is just one of many resources that government agencies and non-government organizations have developed to promote the art and science of trail building. An index of resources can be found at the back of this document.

The goal of trail building is to create a long-term relationship between humans and nature. This is only possible through a clear understanding of the needs of each trail related agency laced with a healthy dose of day-to-day reality. Planning and responsibility are the keys to success. Learning how to build a trail is an ongoing, never ending process with each section of trail to be constructed a new challenge. The trail designer/constructor learns over time the nuances of the forest, rocks and streams and how important it is to build a sustainable trail that is easy to maintain and becomes a natural part of the landscape. Sustainable trails minimize environmental impacts, are easy to travel and reduce future trail operation and maintenance costs.

Grassroots advocacy and trail user organizations are an important element in building new trails and keeping existing trails open and in good condition. However, government agencies play a critical role in both securing land for trails and for administering long-term oversight and funding. By working together in partnerships, new trails can be built and existing trails better maintained.

It is the hope of the Commissioner's Council on Greenways and Trails that this booklet will be used by anyone who is interested in constructing non-motorized trails of any type. The format for the booklet allows for use as an on site reference tools. Please use the blank pages to make field notes or sketches. With your help, walkers, runners, hikers, mountain bikers, equestrians and other trail users will continue to have opportunities to experience the natural essence of life in Tennessee. This guide will provide professional administrators, crew leaders and interested citizens with a starting point to assure well-planned and well-built trails with minimal impact to our natural resources and little maintenance for years to come. Of course, all trails building information could not appear in these few pages and thus referrals to additional resources are included. Additional inquiries for information on trails may be addressed to:

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615-532-0748

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GLOSSARY

Clinometer - Instrument that one looks through that can measure the percent slope either ascending (positive) or descending (negative).

GPS - Global Positioning System

GIS - Geographic Information System

IMBA - International Mountain Bike Association

MUTCD – Manual of Uniform Traffic Control Devices

RES – Recreation Educational Services Division

SORBA – Southern Off Road Bicycle Association

TDEC – Tennessee Department of Environment and Conservation

TDOT – Tennessee Department of Transportation

Trail Corridor – The cleared “tunnel” through the woods that allows the trail user to move unobstructed. Height and width varies with the type of trail use.

Trail Tread – The constructed (built) portion of trail at ground level generally 24” to 72” wide. Tread is constructed using fire rakes, pulaskis, mattocks or other trail building tools.

TVA - Tennessee Valley Authority

USGS – United States Geological Service

Water Dips - A reversal of trail grade to form a low section of trail where water will run off the trail instead of following the trail tread causing erosion.

WHERE TO BUILD A TRAIL

It is very important for the novice trail builder to work in partnership with the land managing agency or property owner when striving to build new trails. Parks or forests with large natural resource bases can be found at the local, state or federal level of government. These agencies may have predetermined technical specifications for trail construction, which must be followed. The agency staff in charge of trails operations and maintenance generally is very glad to have assistance carrying out their agency's mission of good land stewardship and providing recreation facilities. Many agencies have established programs that make use of volunteers for trail building and maintenance projects.

Reviewing the existing master or management plan for the site is the beginning point for building trails. Most park or forest master plans will have a section on trails and the master plan map will have trails shown as stand alone resources or ways to connect two park facilities or areas together. If you are just starting out, you may need to learn about trail construction by joining a trail club and volunteering on a trail maintenance crew. Once your skill level increases, you can help by adopting a trail within a park or forest.

Studying trail maps from different parks can increase your understanding of where trails need to go and can serve as reference sources for discovering the different attractions each trail has to offer. By following the trail map as you hike, the connection between the trail and the actual resource becomes stronger.

I. SELECTING A NEW TRAIL ROUTE

A. Interpretation and Use of Maps and Aerial Photographs

- 1. Maps:** Although they cannot substitute for detailed field reconnaissance of potential routes, the USGS 7.5 minute Topographic Quadrangle (quad) maps are the most useful tool a trail planner can use. These are available through the TDEC's, Division of Geology, at <http://www.state.tn.us/environment/tdg/county/>. Other sources of USGS quad maps are the TVA office in Chattanooga or outdoor shops in a number of different cities. **See Figure 1 for an example of a quad map.**

These quad maps are the best maps available for field use and enable the trail planner to select tentative trail routes. They also are used to pick control points, determine locations of scenic overlooks, find historic sites and locate geologic phenomena such as caves, sinkholes, cliffs, etc. These maps can be used to identify steep slopes and level areas and can be used to calculate side slopes the trail planner will encounter in the field. The original quad map should stay in the office and it is helpful to make black and white copies of the maps for taking field notes.

USGS Topographic Quadrangle Map

TOPO! map printed on 08/31/06 from "Untitled.tpo"

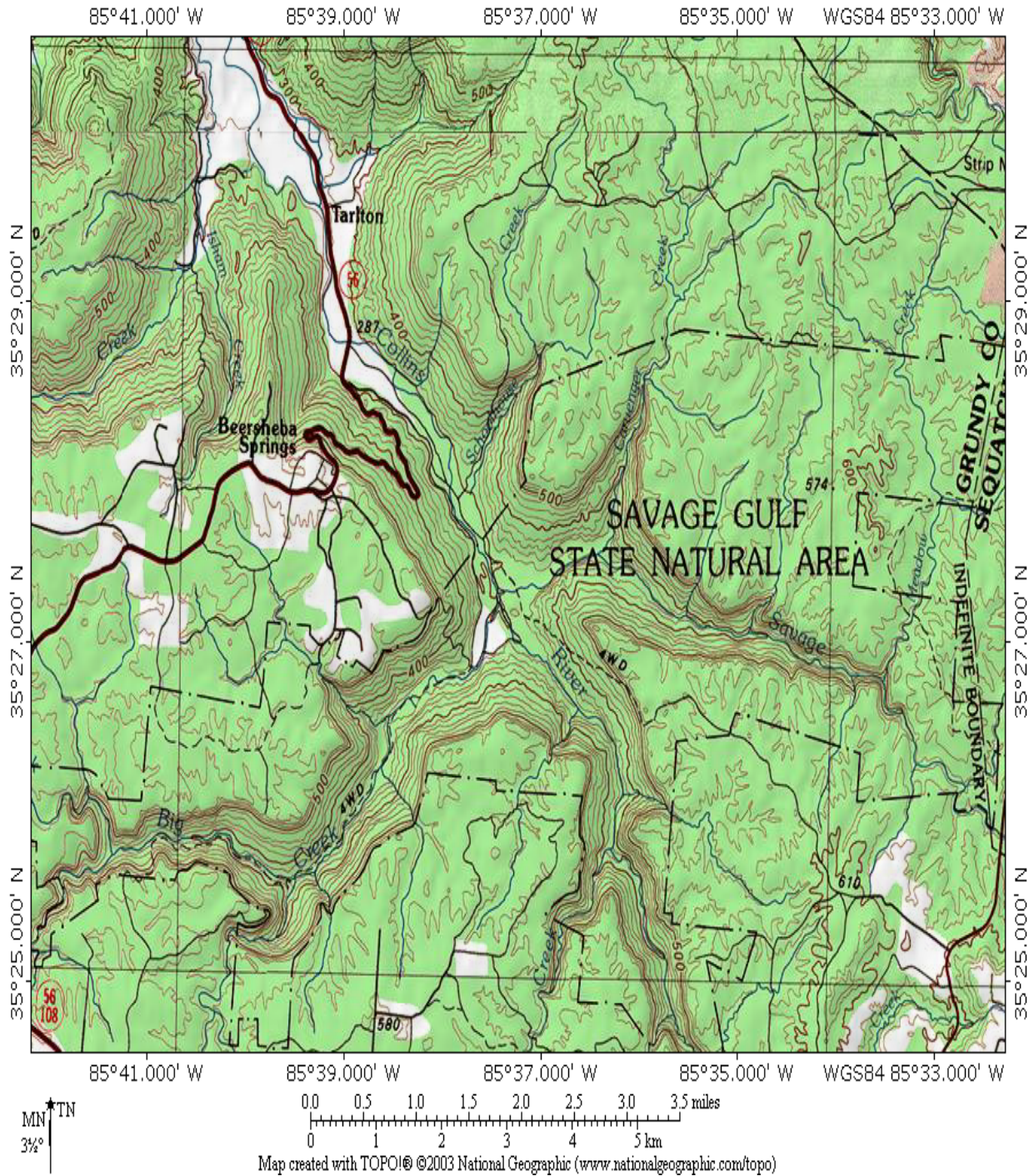


Figure 1

After studying the maps and marking the tentative trail route, it is time to go to the field to locate the following possible features or control points:

- Major obstacles such as river or stream crossings needing bridges or steep bluffs or gorges that have steep side slopes
- Peaks or bluffs to avoid or include as overlook sites
- Long winding ridges or streams which make for easy trail routes
- Locating control and access points such as road crossing, stream crossings, logging roads that intersect the trail route, stream junctions or bluff overlooks

2. **Aerial Photographs:** The Internet is changing the way trail reconnaissance is performed through satellite or aerial photography. Trail planning generally works best if the photographs are taken during the winter when the leaves are off the trees. **See Figure 2 for an example of an aerial photograph.** Some of the more important uses of aerial photography are:

- Spotting interesting cliffs, rock formations, streams, cascades and waterfalls. The trail planner may want to incorporate these natural features into the trail route or avoid them.
- Locating old logging roads or railroad grades that were not shown on the quad maps.
- Location of distinctive tree cover (pine plantations, hardwood forests, etc.) and other landmarks such as old home sites that enable the trail planner to reference their location in the field.



**Aerial photograph of Shelbyville, TN
Figure 2**

The trail planner can also check with the local city or county GIS or planning department to see if they have aerial photographs available. Aerials can be viewed on Google Earth and there are sites that sell aerial photographs, such as Terraserver and <http://terraserver.com/>.

- 3. Global Positioning Systems (GPS):** Handheld GPS units can be very useful once the trail route is tentatively identified and control points are set. GPS units work with satellites and the latitude and longitude of the location is stored in the GPS unit. This makes returning to that specific location much easier. Manufacturers of GPS units include, but are not limited to, Garmin, Magellan, Trimble, Thales, etc. The cost of a GPS unit runs from \$100 to tens of thousands of dollars depending on the degree of accuracy needed.

There are computer software programs that convert GPS data into Geographic Information System (GIS) shape files, which can be stored on the agency's computers. These files can be compared to other agency data to avoid defined wetlands, rare or endangered plant or animal species, floodplain areas, etc.

The software most used for GIS is produced by ESRI, Inc. Go to <http://www.esri.com/> to check out their website and to download a free copy of ArcExplorer. Other GIS resources can be found at county or city websites.

- B. Trail Design:** Trail design is one of the most important factors to insure that the route offers optimum scenic, geologic, historic, cultural and biological sites to provide a variety of diverse habitats for the trail user to experience. Trail design is the critical connection to make the trail sustainable, to reduce impacts to the natural environment, and to minimize future trail maintenance.

The National Park Service definition of a sustainable trail is:

- Supports current and future use with minimal impact to the area's natural systems.
- Produces negligible soil loss or movement while allowing vegetation to inhabit the area.
- Recognizes that pruning or removal of certain plants may be necessary for proper trail construction and maintenance.
- Does not adversely affect the area's wildlife.
- Accommodates existing use while allowing only appropriate future use.
- Requires little rerouting and minimal trail maintenance.

-- From the National Park Service, Rocky Mountain Region, January 1991

The trail planner should consider the following features for inclusion.

- 1. Ridge lines:** Ridgelines offer prime opportunities to avoid the high cost of trail construction with steep grades on side slopes. Ridgelines also can provide panoramic views of the surrounding countryside.
- 2. Bluffs and Cliffs:** These steep sided gorge edges offer trail routes with few construction problems except for where large streams cut through the bluff edge. High cliffs, deep ravines and rock outcrops covered with lichens and mosses offer attractive vistas along the trail route. Main trail routes should stay away from the edge of the cliffs with an occasional short side trail

to an overlook location. Overlooks should be at one-half mile to one-mile intervals if a good view is available without having to cut any trees.

3. **Stream Bottoms:** Streams offer both opportunities and challenges. The additional moisture in riparian environments creates conditions suitable for many plants and wildlife species not found in the surrounding upland areas. These high moisture conditions can make the trail tread muddy and will generally require the placement of stepping-stones or raising the trail tread with boardwalk structures. Trails in stream bottoms should avoid thick vegetation areas such as canebrakes, saw briar and grapevine thickets. Areas of wet or poorly drained soils also should be avoided. Advantage should be taken of any natural “benches” or terraces running along the bottoms of a gorge that may be adjacent to a stream.
4. **Points of Interest:** A well-designed trail should include as many points of interest as practical and feasible along the length of the trail. Some points of interest may include:
 - Geologic features such as bluffs of sandstone or limestone
 - Hydrological features such as ponds or lakes
 - Cascades or waterfalls
 - Historic and cultural features
 - Large or interesting trees

If potential overuse of these sites is an issue, routing the main trail away from the feature and providing access with a spur trail will reduce the amount of impact to these points of interest.

5. **Areas to Avoid:** Some problem areas to avoid include:
 - Active farmland
 - Old home sites with wells or cisterns
 - Construction problem areas that include very rocky or steep slopes
 - Wetlands or swampy areas
 - Areas of exotic invasive vegetation such as privet or multiflora rose thickets
 - Stay at least 25’ from the edge of a stream to prevent impacting the resource
 - Property boundaries – stay 100 feet away from adjacent landowners if possible

C. Trail Layout: This section deals with the equipment needed and procedures for selecting, marking and identifying the trail route in the field. Trail sustainability is the primary goal of trail layout with ease of construction as a secondary goal. If constructed properly, trail tread stability can be maintained indefinitely, even over steep slopes and rocky areas.

1. **Materials and instruments:**

- a. **Plastic surveyors tape** - Different colors (orange, red, blue and white) are useful for trail marking purposes. Use the blue to mark the main trail, red to mark control points such as road/trail junctions or stream crossings and orange for points of interest such as overlooks, waterfalls or unique natural features. Carry a black permanent marker to write notes on the tape if needed. This type of tape can be found in some hardware stores and can be ordered

from companies like Forestry Suppliers, Ben Meadows, etc. Check the picture on the front cover to note the white flag between the 2nd and 3rd trail workers.

A recommended method of marking the trail route with flagging tape is to wrap the tape around the tree twice and tie the knot on the side of the tree the trail will pass. Leave a tail (piece of flagging tape 12-18" long) to help identify the knot. Whatever method to mark the trail is chosen, be consistent, so there are no questions where the trail route is located and tread construction is to take place.

- b. A **compass** is still a useful tool to guide the trail planner for topo map orientation and to find control points and determine which ridges or stream valleys to follow.
 - c. A **clinometer** with a percent scale is used to determine the percent grade ascending (positive) or descending (negative) as the trail route is marked.
 - d. A **25-foot tape measure** is used to determine trail corridor width and to calculate tread width on graded trails.
2. **Field Reconnaissance:** Maps and other equipment are only tools to assist in the on site visit to a potential trail location. Exploring the area through which the trail is to be routed is very important and needs to be done several times before selecting the preliminary route. Important items to concentrate on when exploring the area include the following:

- a. **Points of interest** – Interesting features may be identified on the map and located by on-site inspection. Draw in the additional interesting features that are not on the map.
- b. **Crossings** - Stream and road crossing(s) need to be researched thoroughly due to the potential dangers and importance of these points on the trail route.

Streams are subject to water fluctuations sometimes as much as 5-10 feet or more and a bridge may be necessary to cross a creek. Extensive scouting to find the best location for the bridge site is very important and the lowest part of the bridge should be 5-10 feet above the highest flood level. The managing agency must approve any bridge design that would be built on the trail.

Careful location of road crossing(s) is very important. Visibility on road crossings with heavy traffic should be a minimum of 500 feet in both directions. Check with the managing agencies or the Tennessee Department of Transportation when considering a road crossing.

- c. **Level areas** - Since long straight trails are not aesthetically pleasing, design slight right and left curves into the trails to avoid a highway effect. Sight distance should be 50-100 feet ahead of the trail user.
- d. **Steep hillsides** - Steep areas present situations where careful trail location and design is essential. When possible, avoid locating trail routes on steep slopes. However, where soils are deep and side slopes are not excessive (greater than 25%), few problems are likely to occur on well-designed and constructed trails.

3. Techniques of Trail Layout: Conditions from level to steep will affect the way a trail route is determined. Side slopes of 0 - 5 % do not require side hill construction. Side slopes over 5% need side hill construction know as “trail grading” (see section 3.b.). General techniques for trail layout are as follows:

a. Level Terrain (non-graded trail sections):

- Avoid long straight sections of trail. Long meandering right and left curves and changes in direction will help alleviate trail monotony.
- Avoid obstacles such as trees greater than 3 inches in diameter, areas with numerous dead trees, wet or low lying areas and areas infested with exotic species such as privet, bush honeysuckle, kudzu, multiflora rose, etc.
- Route the trail near interesting or unusually large trees, patches of wildflowers, rock formations and water sources such as springs and small creeks.
- When approaching cliffs or bluffs, do not directly route the trail along the edge of the bluff. Instead, route the trail 50-100 feet back away from the edge, and extend a short spur trail to a scenic overlook area. Overlook areas should be naturally open to minimize the need for cutting of trees or pruning branches to get a view. Signs at the trail junction should warn the trail user of the high bluffs and a warning sign should be located at the overlook.
- Do not route the trail along old roadbeds or jeep trails except where they are impassable to motor vehicles.
- Instead of following the ridge crest, the trail should meander from one side to the other to add variety to the user experience and take advantage of potential scenic overlooks.

b. Layout of trail on ascending or descending grade:

- When locating sections of trail on a side slope, first define the percent of rise or fall, example 5%. 10% grades are used for short sections (20-50 linear feet) to avoid large trees or rock outcrops. As much as possible, locate the trail route on the uphill side of trees growing on slopes to prevent damage to the root systems.

You must have a 2-person crew to perform this layout. First person (#1) is the instrument operator (using clinometer) and the second person (#2) is the range pole holder. Standing on level ground, the range pole is marked with flagging tape at the eye level of the instrument operator. Once at the trail location, #1 stands on the trail route and #2 moves forward along the trail route approximately 25-30 feet from #1. #2 moves up or down the slope in order to obtain the required grade incline and marks that spot. #1 moves forward to that location and the process is repeated.

Grade reversals (water dips) should take place along the trail route every 100 linear feet to route water off the trail. Every 600-800 linear feet of ascent or descent, a level

section of 100-200 linear feet is needed to provide a rest from the climb or descent.

- Side hill construction of trail tread is required if the slope of the hill the trail transverses is more than 5%. The way to measure the side slope of a hill or ridge is to lay a tool on the ground and then take the clinometer and place it on the handle of the tool. The percent slope will determine the depth of cut to construct the trail tread “all in cut”. All in cut refers to the process of not using any fill material for the width of the trail tread. See **Figure 4** on page 26.

c. General guidelines for graded trail layout on side slopes.

- The optimum trail gradient on slopes is 5 – 10% (5 to 10 feet change in elevation per 100 feet in horizontal distance). Grades steeper than 10 % have much higher erosion potential, should only be used for short distances and may require special construction techniques such as steps made of stone.
- The length of space available to construct a trail section on grade is important. A gentler grade can be maintained on a broad mountainside compared to one in a narrow hollow.
- If the length of a graded section of trail is 1,000 feet or more, keep the slope gradient of the trail as low as possible and use reverse grade dips as a way to move water off the trail at regular intervals.
- All efforts should be made to avoid switchbacks. However, where space is limited or obstacles are present, construct switchbacks in areas of sufficient soil depth to maintain the trail to bypass boulders or rock outcrops.
- Ideally, switchbacks are located in dense brush or through other obstacles to prevent trail users from shortcutting the switchback. Avoid short switchback sections of less than 500 feet. Grades can be increased up 20% for short distances entering and exiting the switchback to increase the elevation change and broaden the distance between the upper and lower trails.

Once the preliminary route has been marked, 1 or 2 additional trips should be made to finalize the route. Only when the route has final approval from the managing agency should trail construction begin.

II. TRAIL DESIGN CRITERIA

The goal of these criteria is to make a trail that “fits” into the landscape and the recommendations given below generally apply to most cases of trail construction.

A. Single file backcountry hiking trails

Single file backcountry-hiking trails are commonly found in Federal and State Parks and consist of a 4-foot wide by 8 feet tall trail corridor zone. Trail tread width is constructed 24 inches wide and over time the trail tread reduces back to 18 inches wide. Vegetation should be cleared from the trail corridor zone several times per year as needed in order to keep the trail open and user friendly.

In areas of open space the trail needs to be defined by identifying the tread, the example below is from the Roan Mountain Highlands area. This type of trail construction also reduces the environmental impacts of the trail by preventing trail widening around wet areas.



**Backpacking at the Roan Highlands on the
Appalachian National Scenic Trail**

B. Nature trails

Double file nature trails are generally found in State and local parks usually near nature centers. They consist of a 6-foot wide by 8-foot tall trail corridor zone. They commonly have a trail tread width of 3 feet with larger cleared areas (12 – 16 foot diameter circle) located where groups pause and the trail's features are discussed. Sometimes, interpretative panels may be located at those cleared areas. Old wagon roads can often be used for Nature trails.

Agency staff use these type trails for environmental education programming although a self-guided brochure may also be developed for the trail. These trails may be natural surfaced or have some type of mulch covering such as wood chips or bark.



**School group looking at a spider web
in Bowie Nature Park, Fairview, TN.**

C. Mountain Bike trails

Mountain bike trails are generally designed and built as “single track” trails and follow the standards for backcountry hiking trails. A single-track trail will consist of a 6 foot wide by 8 foot tall trail corridor. Trail tread width is constructed 24 inches wide and over time the trail tread reduces back to 18 inches wide.

However, for trails that may have 2-way mountain bike traffic or have multiple types of use, the sightline clearance needs to increase to 30-50 feet so the trail corridor and tread will need to have wider clearance.

For a more definitive description of building mountain bike trails, please refer to the IMBA trail construction guide, Trail Solutions. Go to <http://www.imba.com/trailsolutions/index.html> for more information and to order the book.



**SORBA Chattanooga trail construction project at TVA’s Raccoon Mountain facility.
Flowing turn with out sloping trail and reverse grade water dips.**

D. Equestrian trails

Equestrian trail design needs to consider both the horse and its rider. The trail corridor zone for equestrians should be 8 feet wide and 10-12 feet tall. Horse trails can be found on old logging roads or jeep trails and sometimes all that is needed is to clear out the corridor if the old road or trail is located in a forested area. If the trail is located in an old field or logging operation, the trail tread will need to be cleared. Using heavy equipment is the easiest way to do this operation.



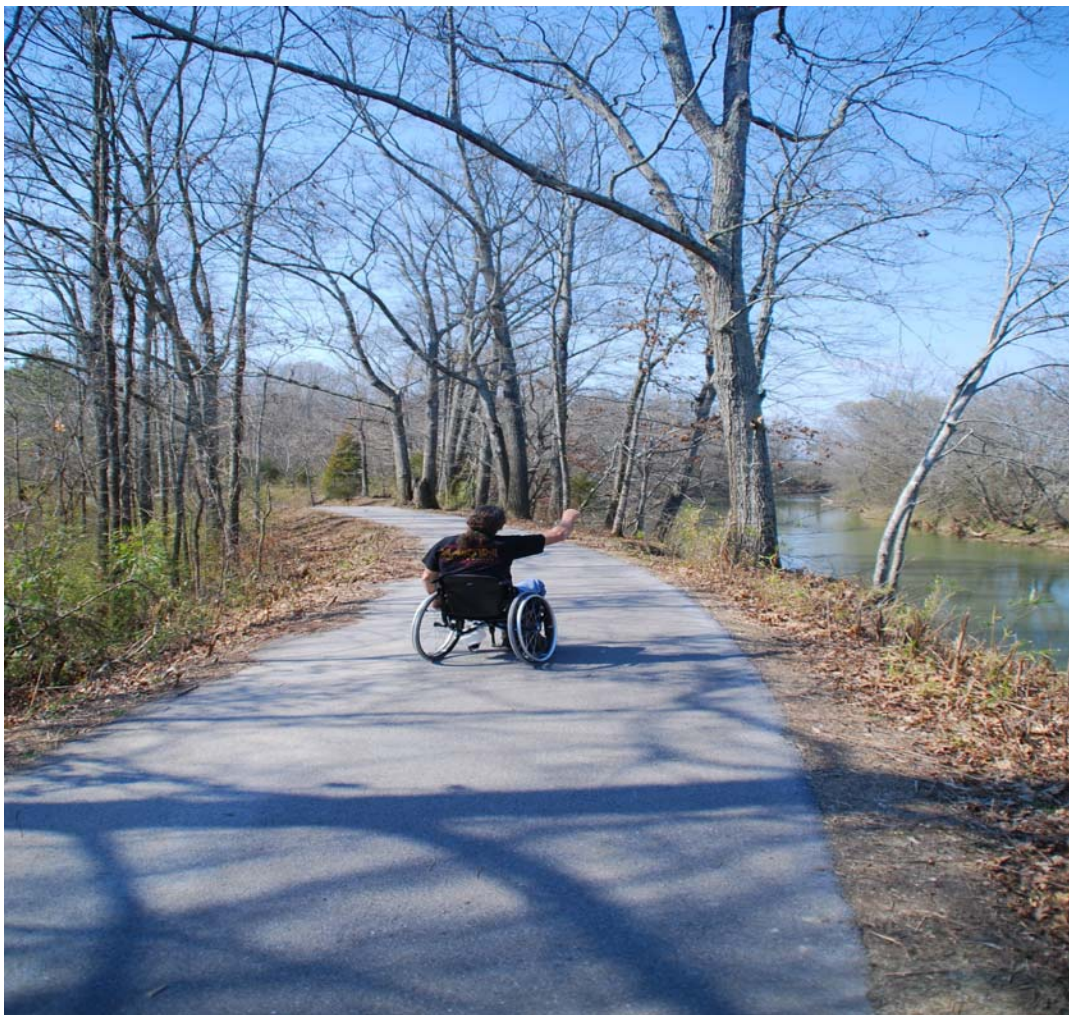
Old Dug Equestrian Trail clearing at the Cherokee National Forest

E. Greenway trails

Greenway trails are relatively new on the trail scene and started being developed in the 1990's when funding began available through the Intermodal Surface Transportation Efficiency Act (ISTEA). Tennessee has 12 to 15 million dollars annually to grant as part of the Transportation Enhancements program. Go to <http://www.tdot.state.tn.us/local/grants.htm> to find out more about this grant program.

Go to <http://www.tdot.state.tn.us/local/grants.htm> to find the **TDOT** Bicycle and Walking Path standards. Minimum width for walking paths is 5 feet and this width will require a sign prohibiting bicycle use on the path. Recommended width for a two-way pedestrian path is six feet wide.

Minimum width for a one-way bicycle path is 6 feet. Recommended width for two-way, shared use path is ten (10) feet. There have been several communities who have built 12 foot wide greenway trails due to the multiple uses by walkers, bicyclists, rollerblading, moms with strollers, people walking their dogs, etc.



Greenway trail along South Chickamauga Creek

F. Americans with Disabilities Act (ADA) compliance

The American's with Disabilities Act (ADA) of 1991 provided legislation to improve access to buildings, parks and trails as well as many other aspects of life. Providing access to meet ADA compliance issues includes much more than just having a trail or walkway wheelchair accessible. Pedestrian trails are the only trails that are required to be ADA accessible.

Trail surfaces for ADA accessible generally should not exceed 5% slopes and have a cross slope of greater than 2%. ADA accessible trails also are required to have a firm and stable surface. Most ADA compliant trails have a paved concrete or asphalt surface, but a hard packed dirt surface without obstructions can be an accessible surface. For more technical specifications about trails, go to <http://www.access-board.gov/outdoor/outdoor-rec-rpt.htm> .



**Hamilton County Department of Education,
Office of Visual Disabilities hike on the Cumberland Trail
Rock Creek trail section**

III. TRAIL CONSTRUCTION

A. Trail Safety

Trail construction and trail maintenance work can be a rewarding experience, but when working with people in the outdoors using tools there are safety risks. Proper training and knowledge about trail construction techniques can reduce these risks. Always wear the proper personal protective equipment for any type of trail construction.

Two basic rules to follow: 1) Plan your work. 2) Do not work alone. With proper planning you will know the task, know the tools you need, and the potential hazards you may encounter. Always work with others and never by yourself. It is safer and more enjoyable to work with other trail building volunteers.

Gear to bring – Along with the tools and safety gear, it is recommended that you bring food, a quart or more of water, rain jacket, and first aid kit. If you have any allergies, bring your medications. It is recommended that you or someone in your group bring a cell phone or other communication device so that you can contact emergency help if needed.

Proper clothing – Trail construction is work, so dress in proper clothing. Dress in layers so that you can adjust for temperature changes. Long pants, preferably steel toed boots, & gloves are a must for basic trail work. If you move rocks to build the trail, wear hard hats, safety glasses and leg protection.

Weather – Be aware of the weather forecast and plan your day accordingly. In cold weather, bring extra clothing and a warm hat. If the forecast is for rain, bring a rain jacket. The walk to the work area can be slippery, especially on newly constructed trail, so walk carefully and wear proper footwear. If rain continues so that the trail becomes muddy, you should stop working and call it a day. You will not be able to build proper trail in these conditions. During the summer, thunderstorms are common, if you are on the trail and a thunderstorm with heavy rain and lightning approaches, you should be looking for shelter or walking out to your vehicles. In warm or hot weather, wear loose comfortable clothing. Clothing such as shorts and open toed shoes should not be worn! Plan your day so that you begin early in the morning and be off the trail by the hottest part of the day. Take frequent breaks and DRINK WATER! to avoid dehydration.

Tool Use

Proper tool use and handling will make the work easier, more productive and can help prevent injuries.

Hand Tools – Maintain control of tools when carrying them to the work site and when they are in use. Carry tools so that all sharp points are away from you. If you are walking across steep terrain, carry your tool so that you can toss it away from your body if you begin to slip or fall. NEVER CARRY A TOOL OVER THE SHOULDER! Give yourself plenty of room when using tools, so that each trail worker maintains a “zone of safety” to not injure the other people working around you.

Power Tools & Equipment – Know the proper use and field maintenance of all power tools and mechanical equipment. Beware of the conditions in which you are working. Never work alone when using power tools. Chain saws and other gas-powered equipment should only be used by Agency staff or by workers who have been trained and certified. Always wear the proper personal protective equipment for this type of trail construction.

Rock Work – Rockwork to some people is the best part of trail work. With enough practice and skill you can use rock for steps and build retaining walls. Be aware of the potential hazards:

- Use the proper tools for moving rocks.
- Wear gloves when moving rocks so that if your fingers get caught in a pinch there will be some protection. You can easily pull your hands out of the gloves if caught.
- When working in a group to move rock, communicate your moves and work together.
- Roll rocks to move them, do not attempt to pick a rock if it is too large and heavy. Use your legs or pry bars to lift rocks. Make sure the area below where you are working is clear so a rock rolling down the hill will not cause an injury.
- Rocks may not go where you intend them to go, so have an exit path away from the rock. Know what is below where you are working and have a plan to warn others if the rock rolls out of control.

Environment Hazards

Poison Ivy – Many people have a negative reaction when they come into contact with poison ivy. If you are one of these people, know how to identify the plant and avoid it when possible. If you do make contact, wash the exposed areas with cool water and soap as soon as you can. Hot water opens the pores and may cause further irritation. Use lotion if skin begins to breakout and over the counter topical medications to relieve the itching. Go seek medical attention if the rash area is large or spreads.

Snakes – You may have the opportunity to see a snake in the woods. Since most trail work is noisy, they usually leave the work area. If you do see a snake, do not disturb it. Snakebites are very rare, but if you get bit, stay calm, walk out slowly with a partner or group and go to the nearest hospital. Do not try to cut and suck the poison or use a tourniquet to stop the spread of venom.

Yellow Jackets and Bees – Yellow jackets, bees, wasp, or spiders are common encounters on the trail especially in the late summer. If you know that you are allergic, bring your medication, know how to use it and tell the work group leader at the start of the work trip what needs to be done in case of an allergic reaction. If you are bitten/stung and you begin to feel weak or the area begins to swell, ask someone to walk out with you and get to the nearest medical facility. Some people can use an over the counter medicines to reduce the affects of allergic reactions.

Allergies – If you have allergies, bring your medications on the work trip and tell the work group leader at the start of the work trip what needs to be done in case of an allergic reaction.

Summer Heat – Drink water and take breaks. Know your physical limits, since the heat will drain your energy.

Cold weather – Dress in layers and remove a layer when you start to sweat. Take periodic breaks to cool down and drink water. You can still get dehydrated in fall and winter.

B. Trail Construction Equipment: Clearing vegetation to create a winding path through the forest or fields can provide an interesting and attractive trail environment for the trail user. Safety is of primary concern when using trail construction tools. The use of Personal Protective Equipment is essential to prevent accidents and injuries. First aid kits with adequate supplies to treat cuts; lacerations and abrasions must be taken out with the trail construction crew. The primary trail building tools to accomplish this task are listed below:

1. **Lopping shears or clippers** – use to prune limbs off trees or cut small saplings up to 1 inch in diameter. Small saplings should be cut 2 feet tall so the root systems can be dug out with a Pulaski or mattock. Other pruning tools such as an extending pole pruner may be needed for equestrian trails or used to open up views at overlooks.
2. **Pruning saw** – used to prune limbs from trees and cut small saplings greater than 1 inch in diameter. Use caution with pruning saws to avoid being cut by the saw teeth. Place the saw in the protective cover when not in use. Route the trail around trees larger than 3 inches in diameter route unless in a secondary succession thicket.
3. **Pulaski or forester’s axe** – used for removing roots, small stumps, small rocks and for digging trail tread along graded sections of trail. Has a full ax face and smaller grubbing cutter.
4. **Mattock** – used for digging large rocks from the trail tread and for digging trail tread along graded sections of trail. Has a smaller cutting head and larger grubbing cutter. May need a pick mattock when working in rocky areas.
5. **Fire rakes** – These rakes have 4 triangular shaped teeth and are used to remove vegetation down to the soil layer. Also used for digging trail tread along graded sections of trail especially finishing the 2nd cut to create a 45 to 60 degree back slope above the trail tread.

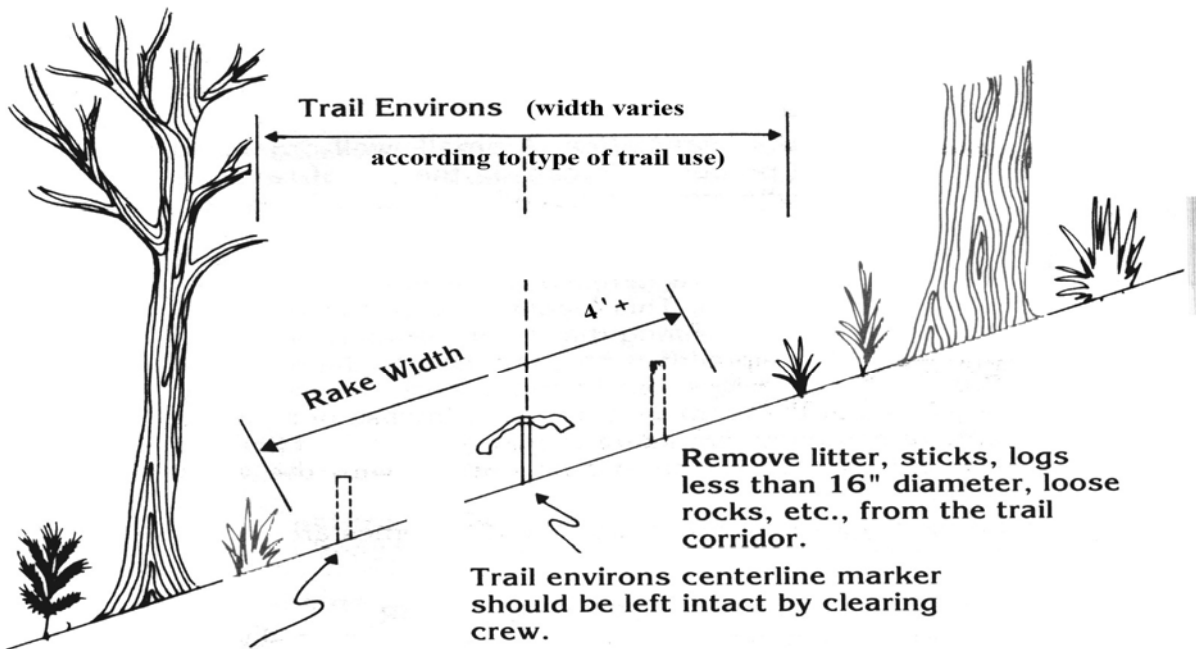
It is very important to keep the tools sharp and to use caution when carrying tools to the work site. Remove any dirt and debris from the tools with a wire brush before storing them and spray the tools with a rust inhibitor to help keep them clean, sharp and free of rust.

C. Trail Corridor construction: The trail corridor, which must be cleared, should be thought of as a rectangular box or “tunnel” sized to fit the type of trail use. Once the trail route has been finalized and flagged, remove branches, twigs and small trees less than 2” in diameter growing

in this tunnel. This is applicable for any type of trail construction no matter how wide. The trail user should have enough room to pass through the area free of obstructions and have a clear passage. However, some obstacles (fallen logs, large rocks, etc.) are desirable to add a degree of challenge or to discourage use of the trail by motorized vehicles. **Figure 3** shows how the trail corridor (trail environs) fits into the landscape.

Figure 3

Procedure for Construction of Trail Corridor



Saplings should be cut off at least one foot high or higher, depending on their size. If the clearing crew is also doing stump removal, they can be removed at this time.

Modifications of the height and width in the trail corridor zone may become necessary for the following reasons:

- Cutting branches 2 feet higher than the standard may be necessary when the trail passes through rhododendron thickets or areas with older evergreens. This will allow room for the trail user to pass by even if branches might drop down due to snow or water accumulation.
- Clearing the trail wider along trail sections to be built on steep hillsides will provide room for the trail tread grading construction. Trimming branches back to the tree trunk is healthy for the tree and will minimize the need for future trail corridor clearing.

Clearing techniques:

1. Branches, twigs and vines can be removed with lopping shears. Branches larger than 1 inch in diameter should be removed with a pruning saw. Cut branches adjacent to the branch collar to promote faster healing by the tree and to prevent injury to trail users from leaving stubs. Pruned branches and other debris should be dispersed along the downhill side of the trail or concealed behind large trees or boulders.
2. Saplings and small trees up to 2 inches in diameter to be removed should be treated in different ways according to the species. Needle-leaved evergreen saplings up to 1 inch and hardwoods less than ½ inch in diameter may be cut with lopping shears slightly below ground level.

However, to prevent stump sprouting, deciduous hardwoods and broadleaf evergreens such as holly and rhododendron, must be dug from the trail tread. Such saplings, up to 3 inches in diameter, should be cut off 3 feet above ground level, which will leave a “handle” to facilitate removal. Use a pulaski or mattock to dig out the stump and roots completely from the trail tread starting 12” away from the trunk.

- D. Trail Tread Grade construction:** This phase of trail construction follows clearing the trail corridor and is the most time consuming and labor intensive part of trail construction. It may be accomplished concurrent with trail clearing or delayed depending upon the availability of labor and funds. Tread construction tools include pulaski’s, mattocks and fire rakes:

Trail construction techniques:

1. Level Terrain - Building tread on deep, well-drained soil in level or gently sloping terrain (5% or less) where no side hill construction is necessary. This is the simplest and most common situation over much of Tennessee. It includes bottomlands, plateau areas and ridgelines.

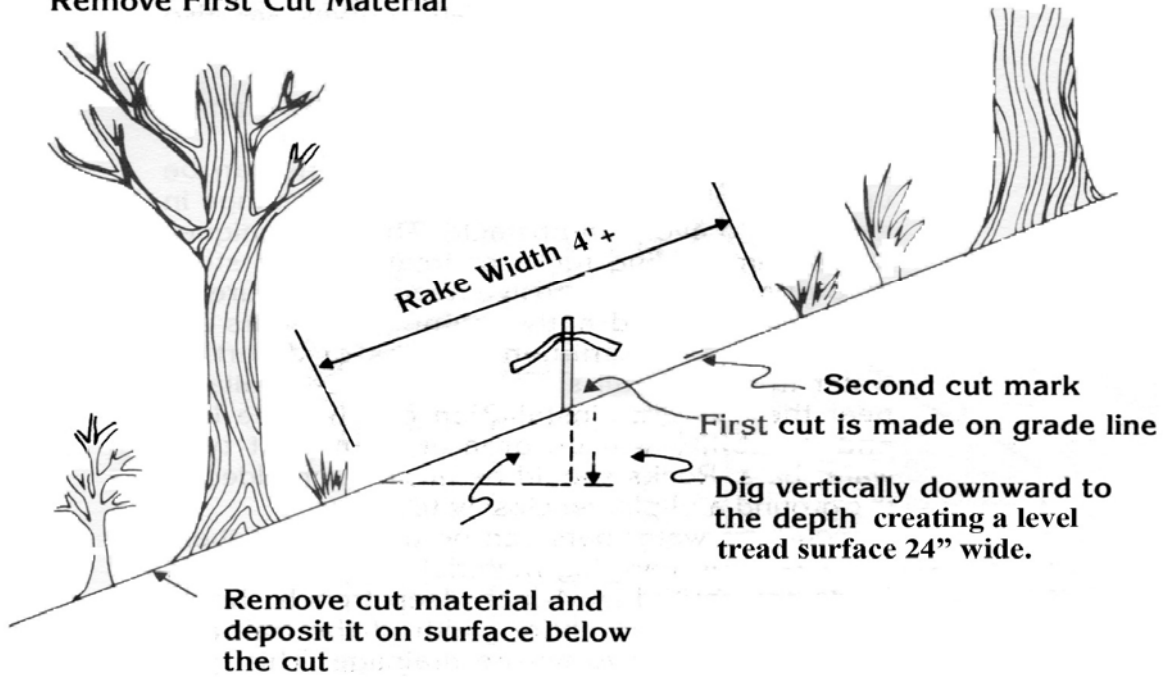
- Rake to remove the leaf litter and other loose material from the tread surface for a width of 2 feet for single-track trails for backpacking and mountain bikes.
- Chop or dig out vines, weeds and stumps left in the tread area.
- Remove any embedded rocks from the tread surface.
- Rake tread smooth and fill in and level any low spots.
- Trail should outslope 2-5% for water to drain across and off the trail.

2. Gentle Slopes – Building tread on deep, well-drained soil on terrain (5-20% side slopes) where minor side hill construction is necessary. This is a common situation in middle

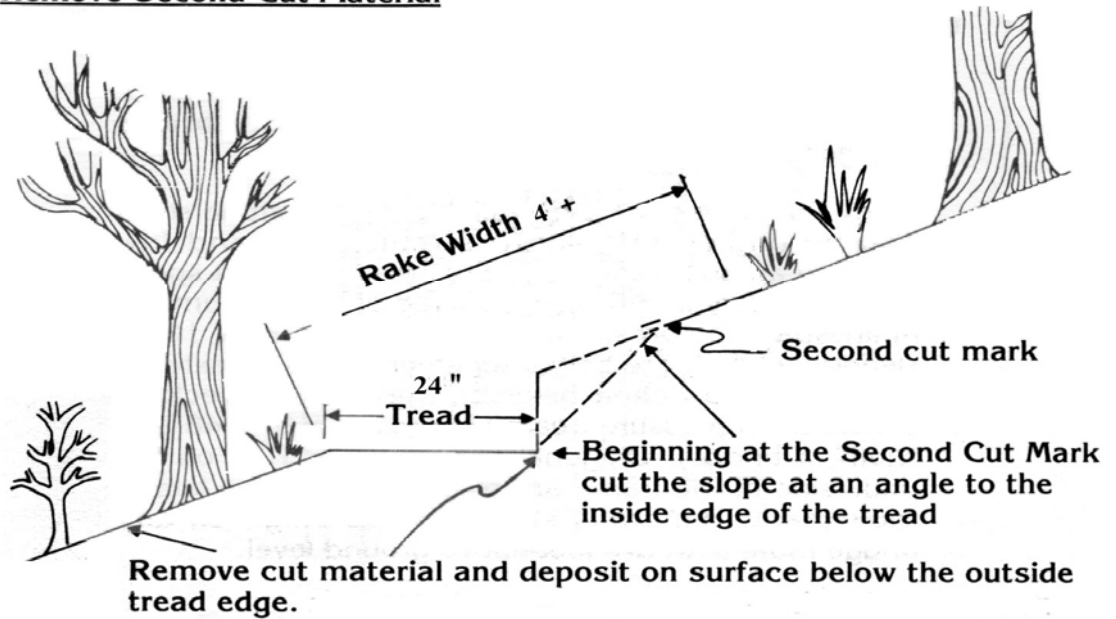
and east Tennessee. It includes the base of hills along the Highland Rim, the Cumberland Plateau and the ridges and valleys of east Tennessee. **Figure 4** shows the first and second cuts of hillside trail construction.

Figure 4

**Hillside Tread Construction
Remove First Cut Material**



Remove Second Cut Material



- Rake to remove the leaf litter and other loose material from the tread surface for a width of 4 feet.
- Chop or dig out vines, weeds and stumps left in the tread area.
- Remove any embedded rocks from the tread surface.
- Out slope the trail 2-5 % to insure water will run off the trail tread.
- Make 1st cut 3-4 inches deep and 2nd cut the back slope to a 60 degree angle
- Rake tread smooth and fill in and level any low spots.

3. Steep Slopes – Building tread on deep, well-drained soil on terrain with (20-60% side slopes) where major side hill construction is necessary. This is a common situation in middle and east Tennessee. It includes base of hills along the Highland Rim, the Cumberland Plateau and the ridges and valleys of east Tennessee. **See Figure 4. Note:** the tendency of new trail builders is to dig a hole or to dig parallel to the hillside slope angle. An experienced trail crew supervisor will closely monitor side hill construction and offer encouragement and constructive criticism when needed.

- Rake to remove the leaf litter and other loose material from the tread surface for a width of 4 feet or more depending on the type of trail.
- Chop or dig out vines, weeds and stumps left in the tread area.
- Remove any embedded rocks from the tread surface.
- Out slope the trail 2-5 % to insure water will run off the trail tread.
- Make first cut 6-12 inches deep and 2nd cut the back slope to a 60 degree angle
- Rake tread smooth and fill in and level any low spots.
- Trail should outslope 2-5% for water to drain across and off the trail.

CONSTRUCTION TECHNIQUE TIPS:

When building graded trail, start on the down slope edge and work back into the slope. This will help keep the tread construction level. Think, I'm building a miniature interstate highway. The beginning trail builder either will dig a hole or will dig parallel to the slope of the hillside. Experienced trail builders should work side by side with beginners to show them proper trail construction methods.

Use pulaskis and mattocks to do the heavy digging and then finish the trail tread using a fire rake to remove the cut materials depositing them on the downhill side of the trail and cut any small roots exposed. Rake the cut area smooth and DO NOT use any of the cut material as fill to build the trail tread. Rake the fill below the trail tread so that water can run across the trail instead of down the trail.

See the picture on the next page to view a section of newly graded trail.



Cutting the back slope on a graded section of trail

C. TRAIL SUPPORT FACILITIES

1. TRAILHEADS

Trailhead facilities include parking areas, toilets, water if available and a trailhead kiosk sign. The kiosk is a place trail users can pick up literature and find the rules and regulations for the area.



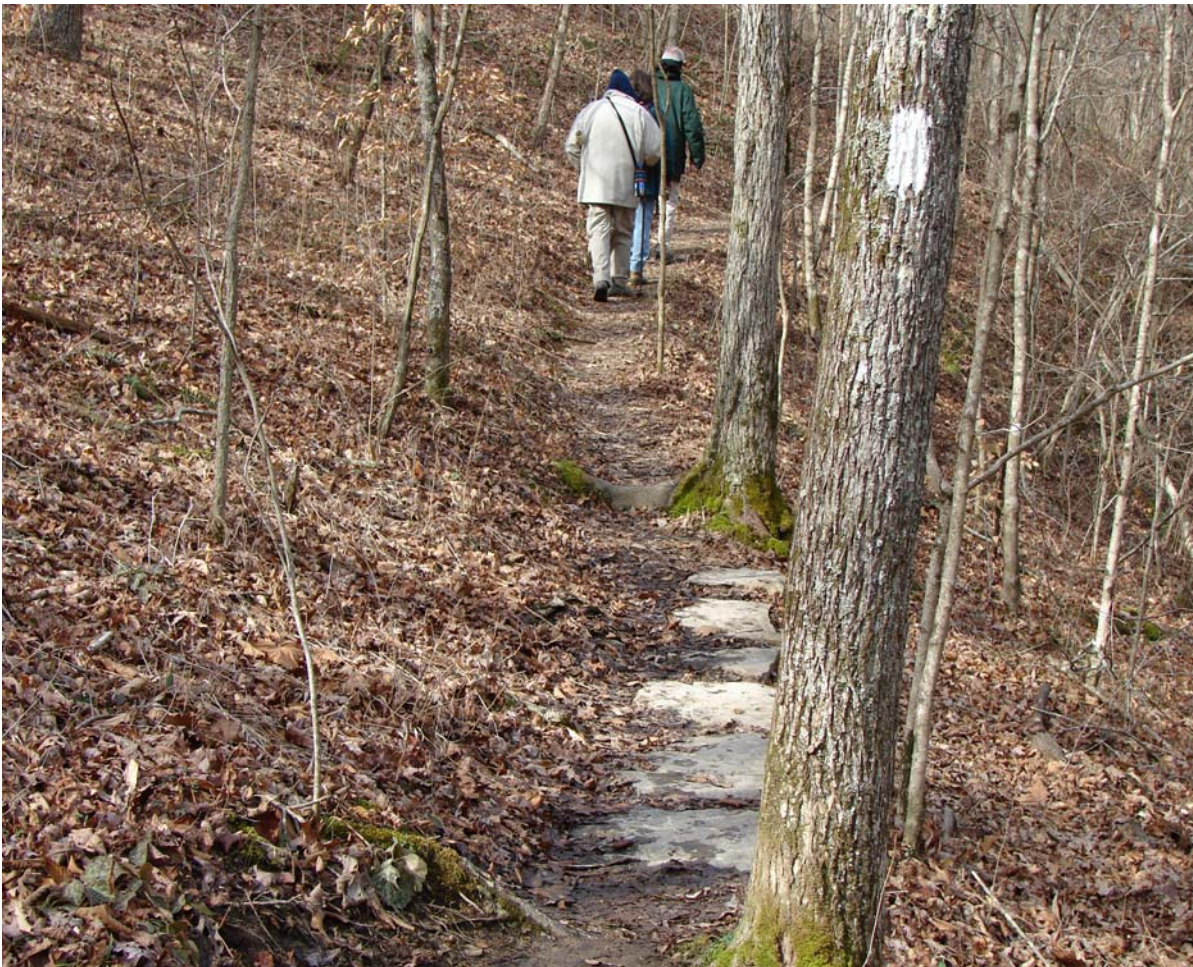
**Trailhead Kiosk with map of
Park boundaries and trails**

2. TRAIL MARKING

Paint Blazes - The standard trail blaze is a vertical rectangle 2” wide by 6” tall. White exterior latex paint is used to mark the main trail. Other colors can be used to mark side trails to other points of interest such as overlooks or campsites. If there are a number of trails in one area, a different color can be used to mark each trail.

Paint blazes should be made 200 to 300 yards apart and should be a reassurance that the user is still on the trail. If the trail is well defined, fewer paint blazes should be needed. The paint blazes should be placed on prominent trees adjacent to the trail with a diameter larger than 4”. The trees should be within 1-2 feet of the trail tread and the blazes should be 5 feet high from ground level. Loose bark should be scraped from the tree making sure NOT to damage the cambium layer before applying the paint. Paint blazes should be checked annually and repainted every 3-4 years.

Trail junctions (side or intersecting trails) should be marked with a double blaze. This is one blaze over the first separated by a 3-inch space. These double blazes should start 100 yards from the junction point in all directions.



Beaman Park trail blaze

3. TRAIL SIGNS

Trail signs provide direction, mileage or education information. The trail should be measured with a rolotape in order to determine the length of the trail and any side trails. Distances should be rounded to the next tenths of a mile.

Standard highway signage identifying the trailhead must conform to the **MUTCD**. Trail user groups need to work with the managing government agency for approval of federal or state highway signage. The **TDOT** must approve any signage that would be erected on a state highway right-of-way.

Trail signs found in the backcountry providing location, direction and mileage should have 1.0-inch tall letters and numbers. Trail junction signs should have 1.5 to 2 inch tall letters. These signs are generally made of treated wood or decay resistant western red cedar or redwood. Letters and numbers are routed into the boards and the board stained or painted. Names, mileage and directional arrows can be painted white or color-coded to match the paint blazes found on a particular trail. Boards are generally 2" x 6" (2 lines) or 2" x 8" (3 lines) wide and 4' – 6' long.



Trail Junction Sign at Beaman Park

4. TRAIL BRIDGES

Trail crossings of streams involve a wide variety of opportunities. From placing large rocks in wet areas to building elaborate boardwalks, streams provide opportunities for the trail builder to be creative. However, any bridge that is built must be structural sound and able to hold the weight of the bridges materials as well as the trail users crossing the bridges. Most trail bridges are build of pressure treated lumber but others have been built of steel and there is now a trend using prefabricated fiberglass bridges that can be carried to the bridge site and the pieces bolted together.

Trail builders must work with the land managing agency and follow their regulations and specifications for bridges.



20' trail bridge at Beaman Park

Internet Resources

The following list of Internet resources are places where the trail user can find new trails to try out and also places to volunteer to do trail construction or maintenance. The Internet is a great resource for trail building information and trail user clubs. Some of these resources are listed below.

Regional Trails Information

Appalachian Trail Conservancy – www.appalachiantrail.org
Bays Mountain (Kingsport) Trails – www.baysmountain.com
Buffalo Mountain (Johnson City) Trails - www.etsu.edu/biology/friendsofnature/BMP/trail_map.htm
Cherokee National Forest – www.fs.fed.us/r8/cherokee/recreation/trails
Jefferson National Forest Trails - www.fs.fed.us/r8/gwj/recreation/index.shtml
Johnson County Trails Association - www.johnsoncountytrails.org
Kingsport Greenbelt – www.kingsportgreenbelt.com
Mendota Trail - www.mendotatrail.org/
Mountain Bike Trail listing - www.singletracks.com
Steele Creek Nature Center Trails (Bristol, TN)- www.bristoltn.org/parks/Nature20%center.html
Tennessee Bicycle Routes - <http://www.tdot.state.tn.us/bikeped/routes.htm>
Tennessee State Parks – www.state.tn.us/environment/parks
Tennessee Equestrian Trails – www.picktnproducts.org/horses/trails.html
Tennessee Greenways & Trails Inventory – <http://environment-online.state.tn.us/greenways/TnMap.htm>
Tennessee Horseman – www.tnhorseman.com

Regional Organizations and Resources

Appalachian Resource Conservation & Development Council – www.appalachianrcd.org
Appalachian Trail Conservancy Land Trust - www.appalachiantrail.org/protect/tatl/
Black Diamond Resource Conservation & Development Council - www.blackdiamondrcd.org
Boone Watershed Partnership - www.geocities.com/RainForest/Vines/6411
Friends of Steele Creek - www.friendsofstelecreek.org
Greeneville Hiking Club – <http://greenevillehikers.xtn.net/>
Kingsport Parks & Recreation Department - www.Kingsportparksandrecreation.org
Kingsport Tomorrow - www.kingsporttomorrow.org
Land of Boone & Crockett Regional Land Trust – www.appalachianrcd.org
National Park Service – Overmountain Victory Trail - www.nps.gov/ovvi
Northeast Tennessee Mountain Bike Association - www.ntmba.org
Overmountain Victory Trail Association - www.ovta.org
Scott County (VA) Regional Horse Association – www.schorse.org
Shelby Farms Park Alliance – www.sfparkalliance.org
Southeastern Foot Trails Coalition - www.americanhiking.org/alliance/sai.html
Southern Appalachian Highlands Conservancy – www.appalachian.org
Southern Appalachian Man and the Biosphere Cooperative – www.samab.org
Tennessee Eastman Hiking & Canoe Club – www.tectn.org
Upper Tennessee River Roundtable - www.uppertnriver.org
Wolf River Conservancy – www.wolfriver.org

Tennessee Resources

Land Trust for Tennessee – www.landtrusttn.org
Tennessee Conservation League – www.conservetn.com
Tennessee Department of Environment & Conservation
Division of Natural Heritage – www.tdec.net/nh
Division of Water Pollution Control – www.tdec.net/wpc
Recreation Educational Services Division – www.tdec.net/recreation
Tennessee Department of Transportation – www.tdot.state.tn.us
Tennessee Division of Forestry – www.state.tn.us/agriculture/forestry
Tennessee Greenways & Trails Program – www.state.tn.us/environment/recreation
Tennessee Horse Council – www.tnhorsecouncil.com
Tennessee Parks & Greenways Foundation – www.tenngreen.org
Tennessee Rivers Assessment – www.state.tn.us/environment/wpc/publications/riv
Tennessee Scenic Rivers Association – www.paddletsr.org
Tennessee State Parks – www.state.tn.us/environment/parks
Tennessee State Recreation Plan – www.state.tn.us/environment/recreation/plan
Tennessee Trails Association – www.tennesseetrails.org
Tennessee Urban Forestry Council – www.state.tn.us/agriculture/forestry.tdfuf.html
Tennessee Wetlands Strategy – www.state.tn.us/environment/nh/wetlands/
Tennessee Wildlife Resources Agency – www.state.tn.us/twra/

National Greenways & Trails Resources

American Canoe Association – www.acanet.org
American Farmland Trust – www.farmland.org
American Forests – City Green Program - www.americanforests.org/productsandpubs/citygreen/
American Hiking Society – www.americanhiking.org
American Horse Council – www.horsecouncil.org
American Rivers – www.amrivers.org
American Trails – www.americantrails.org
America Walks – www.americawalks.org
American Whitewater - www.americanwhitewater.org
AmeriCorps volunteers – www.americorps.org
Beneficial Designs (trail accessibility) – www.beneficialdesigns.com
Bicycle Federation of America – www.bikefed.org
Center for Watershed Protection - www.cwp.org
The Conservation Fund – American Greenways Program – www.conservationfund.org
Green Infrastructure - www.greeninfrastructure.net
International Mountain Bike Association (IMBA) – www.imba.com
Land Trust Alliance – www.lta.org
Leave No Trace – www.lnt.org
National Center for Bicycling & Walking – www.bikewalk.org
National Clearinghouse on Greenways & Trails – www.trailsandgreenways.org
National Recreation & Parks Association – www.nrpa.org
National Trail Training Partnership - www.nttp.net
National Trust for Historic Preservation – www.nationaltrust.org
The Nature Conservancy – <http://nature.org>
Path Foundation – www.pathfoundation.org
Pedestrian and Bicycle Information Center – www.walkinginfo.org

Rails-to-Trails Conservancy – www.railtrails.org
River Network – www.rivernetnetwork.org
Smart Growth America - www.smartgrowthamerica.org
Surface Transportation Policy Project – <http://transact.org>
Tread Lightly, Inc. – www.treadlightly.org
Trust for Public Land – www.tpl.org
Walkable Communities, Inc. – www.walkable.org

Federal Resources

Federal Highway Administration – www.fhwa.dot.gov
Federal Highway Administration’s Free Trail Publications Site -
www.fhwa.dot.gov/environment/rectrails/publications.htm
Federal Highway Administration’s Office of Safety – Safe Routes to School Initiative –
<http://safety.fhwa.dot.gov/saferoutes/>
National Highway Traffic Safety Administration – www.nhtsa.dot.gov/
National Register of Historic Places – www.cr.nps.gov/nr/
Scenic Byways Program – www.byways.org
Tennessee Valley Authority – www.tva.gov
U.S. Access Board (accessibility) – www.access-board.gov
U.S. Environmental Protection Agency – www.epa.gov
U.S. Fish & Wildlife Service – www.fws.gov
USDA Forest Service – www.fs.fed.us
Cherokee National Forest – www.fs.fed.us/r8/cherokee/recreation/trails
USDA Natural Resource Conservation Service – www.nrcs.usda.gov

Funding and Technical Assistance Sources

AmeriCorps – www.americorps.org
Federal Highway Administration – Transportation Enhancement Funds– www.fhwa.dot.gov/tea21/index.htm
Federal Preservation Grants – www.tennessee.gov/environment/hist/presgrnt.php
Forest Legacy Program - www.fs.fed.us/spf/coop/programs/loa/flp.shtml
IMBA Trail Care Crew – www.imba.org
Kodak American Greenways Grant Program – www.conservationfund.org
National Park Service’s Rivers, Trails & Conservation Assistance Program – www.nps.gov/rtca
Tennessee Department of Agriculture – 319 Nonpoint Source Program –
www.tennessee.gov/agriculture/nps.index.html

Tennessee Department of Environment & Conservation – Recreation Trail Program grants, Local
Park & Recreation Fund grants, Land & Water Conservation Fund grants –
www.state.tn.us/environment/recreation
Tennessee Department of Transportation – Enhancement Grants Program –
www.tdot.state.tn.us/local/grants.htm
Tennessee Parks and Greenways Foundation – www.tenngreen.org/stateparks.htm
Watershed Action Grants – www.conservationfund.org

Health Initiative Resources

Active Living by Design – www.activelivingbydesign.org
America on the Move – www.americaonthemove.org
America’s Walking – www.pbs.org/americaswalking
Centers for Disease Control and Prevention - www.cdc.gov/nccdphp/dnpa/physical/index.htm
National Coalition for Promoting Physical Activity – www.ncppa.org
National Association for Health & Fitness – www.physicalfitness.org
President’s Council on Physical Fitness and Sports – www.fitness.gov
Shape Up America – www.shapeup.org

SUMMARY

This manual is just the beginning point to learn about trail construction. IMBA, the U.S. Forest Service (USFS), the Appalachian Trail Conservancy (ATC), the Appalachian Mountain Club (AMC) and the Student Conservation Association (SCA) all have developed excellent resources on trail construction. *Trail Solutions*, *IMBA’s Guide to Building Sweet Singletrack* is an excellent trail building book.

Good luck and be safe!

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Back cover