Nature Trail Development on Small Acreages

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Nature Trail Development on Small Acreages

Introduction

Nature trails are popular for wildlife viewing, walking, hiking, horseback riding, bike riding and other outdoor activities. Land managers often design and maintain trails in expansive public use areas. There is increasing interest from homeowners, business owners, wildlife enterprise entrepreneurs, school teachers, boy scouts, hospital personnel, parks department staff and others to develop and maintain nature trails on smaller landholdings.

The purpose of this publication is to provide an introduction to trail design for those who intend to develop trails for nature walking, hiking, horseback riding or ATVs on less than 40 acres. Some technical aspects are presented for those planning to expend resources for constructing trails such as around schoolyards or community facilities or as part of a wildlife enterprise.

Many trail design and maintenance features are the same regardless of property size. With proper planning and construction, nature trails can be designed to minimize human disturbance and impacts on wildlife, plants, soils and waterways. A well-designed trail can aid in land management, such as through simplifying timber evaluations or creating fire breaks. Properly built trails also provide opportunities to teach youngsters about wildlife, forestry and natural resources.

Construction costs can be reduced if you are willing to build it yourself (Figure 1). The equipment needed to construct a trail depends on the purpose of the trail and the type of trail use. Hand tools can be used to create a low-impact, natural-looking path with minimal disturbance to vegetation. Those wanting a larger trail bed for horses, ATVs or other uses may need a rubber-tracked back-hoe, mini skid steer or a light dozer. Additional information about equipment is available in Appendix A.

Several firms specialize in trail building around the region and country. The Professional Trail Builders Association (PTBA) (http://www.trailbuilders.org/) offers a list of trail builders for hire by region and by expertise. American Trails (www.americantrails.org) is another good resource for locating trail builders as well as materials and supplies.

FIGURE 1. Hand tools such as a Pulaski (right) and McLeod fire tool (left) can be used to construct and maintain trails. ***Photo by Ted Toth, National Park Service volunteer.***

CONTOUR TRAILS:
The Sustainable Solution

- Outsloped tread
- Sustainable grades
- Frequent grade reversals
- Erosion resistance
- Path that traverses along the sideslope
- Provision for sheet flow of runoff
- Positive user experiences
- Low maintenance

FIGURE 2. An example of a sustainable trail. ***Photo courtesy of the U.S. Forest Service.***

Trail Planning

Designed with sustainability in mind, a nature trail can provide years of enjoyment. A well-designed trail will save time and money over the long term and minimize future trail maintenance. A trail that just "happens" is almost always too steep or narrow, doesn't follow the contour and has erosion problems. Sustainable trails require minimal maintenance because their design and materials hold up to recreational use and severe weather conditions. Sustainable trails won't be eroded by water and use, won't affect water quality or the natural ecosystem, meet the needs of the trail user and do no harm to the natural environment (Figure 2).

A trail that just "happens" is almost always too steep or narrow, doesn't follow the contour and has erosion problems.

The primary key to developing a sustainable trail is keeping water off the trail. A trail built on top of a ridge, straight up and down the side of a hill (Figure 3) or in a bottom will hold water and erode. An ideal trail is built on the side of the ridge, slightly slanted outward, and kept clear of rocks, branches or other debris several yards on both side of the trail. Such obstructions can cause water to pool or create an erosive rut on the trail.

FIGURE 3. This cup-shaped trail forces water down its center and is not sustainable. Rocks, side logs and other debris that funnel water onto the trail should be removed periodically. ***Photo by Becky McPeake, UA Division of Agriculture, Cooperative Extension Service.***

An incredible amount of work is necessary for scouting, design, layout, construction and maintenance of a trail. Good planning includes understanding the lay of the land. Design the trail with the trail user in mind and the desired difficulty level of the trail. A trail designed for strollers, wheelchairs or tricycles would be different than one for backwoods hikers.

Solid planning is essential. If you've ever encountered a trail disaster, chances are it resulted from poor planning. Some glaring examples are:

- Building out-of-rhythm sections (abrupt turns). *Why did this happen? The trail's rhythm and flow weren't checked before cutting it in.*
- Water funneling down and eroding the tread. *Why did this happen? The trail grade was designed too steep.*
- Multiple trails or rogue trails. *Why did this happen? The trail wasn't laid out in the best place to begin with.*

The best trail developers and maintainers are those with *trail eye*, the ability to anticipate threats to trail integrity and to head off problems. Seek local experts who have experience in planning and constructing trails. Contact the U.S. Forest Service, Arkansas State Parks, city parks department or others in your area. Discuss your trail plan with them.

Wildlife and Plant Impacts

Wildlife and wildflowers add interest to a trail hike. Yet trails can adversely affect plants and wildlife. Plant sustainability is affected by soil erosion, wildflower picking or harvesting of plants and repeated trampling off trail. Wildlife are affected in different ways depending on the type of species and flushing distance, type and intensity of human activity and time of year or day.

Research has documented behavioral responses of wildlife to trail users. **Flight initiation distance** is the distance at which an animal starts to move away from an approaching threat such as a trail user. Flight initiation distance has been recorded for a variety of species (Table 1). These distances are based on being approached by a single person on foot. Flight initiation distance serves as a general guideline for establishing buffers from critical wildlife areas. Since flight initiation distance measures the starting distance at which the animal begins to evade a threat, wider buffers may be need to minimize wildlife disturbance. If groups of people will be using a trail, wider buffers may be desired. Adding 130 to 170 feet of buffer is recommended for reducing wildlife disturbance, if space allows. However, many other factors influence flight initiation distance. Flight initiation may diminish over time as wildlife become habituated to human activity.

To reduce impacts of trails and trail users on wildlife and plants, best trail practices are:

- Align trails along or near existing human-created edges or natural edges rather than bisecting undisturbed areas.
- Keep a trail and its zone of influence away from specific areas of known sensitive species.
- Avoid or limit access to critical habitat patches.
- Provide diverse trail experiences so that trail users are less inclined to create trails of their own.
- Use spur trails or dead-end trails to provide access to sensitive areas because these trails have less volume.
- Generally, concentrate activity along trails rather than disperse it.
- Keep trail construction impact as narrow as possible.
- Concentrate weed control at road and trail crossings, trailheads and riparian areas.

TABLE 1. Flight initiation distance of selected Arkansas wildlife species.[1]

Flight Initiation Distance		Flight Initiation Distance	
Species	**Flight Distance (feet)**	**Species**	**Flight Distance (feet)**
Elk	280 to 660	Groundhog	26 to 82
Bald Eagle	165 to 2900	Meadowlark	100
Gray Squirrel	9 to 17	American Robin	30 to 46
Great Blue Heron	660	White-Tailed Deer	328
Great Egret	330		

[1] Flight distances are reported from research publications. Anecdotally, the authors have observed flight initiation at smaller distances for Great Blue Heron and White-Tailed Deer that have become habituated to people.

Tread and Soil Impacts

Tread is the actual travel surface of the trail. This is where the rubber (or hoof) meets the trail. Tread is constructed and maintained to support the designed use for your trail. For dirt trails, the tread should be mineral soil with little to no vegetation. Forces such as soil type, annual precipitation and other factors may influence how long the tread remains stable before maintenance is needed.

The tread surface should match the intended use. Easier trails should have a smooth tread surface. Backcountry trails can be rougher and more challenging. Leaving some obstacles in the trail helps slow down users.

Surface water should flow in thin sheets across the trail instead of down the trail. To do so, locate the trail on the contour. Diversion should be used only if efforts fail to eliminate pooling or streaming. Running water erodes tread and can even lead to the loss of the trail itself. It is more important to understand how the forces of water and gravity combine to move dirt than it is to actually dig dirt.

Follow the contour to keep water from running down the trail. Tread, whenever elevated, should have a slight outslope of 4 to 6 percent of the tread width (nominally 1.5 to 3 inches from high side to low side) to drain better (Figure 4). Other design elements are a rolling contour trail, building the trail on the sideslope, maintaining sustainable grades and

FIGURE 4. A sustainable trail with soil tread having a 4- to 6-percent outslope (1.5 to 3 inches from high side to low side). ***Photo by Glen Moody, National Park Service, Buffalo National River.***

It is more important to understand how the forces of water and gravity combine to move dirt than it is to actually dig dirt.

outsloped tread. These trail designs let water continue to sheet across the trail where it will do little damage.

Soil type and texture have a major influence on soil drainage and durability. Texture refers to the size of individual soil particles (Table 2). Clay and silt are the soil components with the smallest particles. Small particles tend to be muddy when wet and dusty when dry. Clay and silt don't provide good drainage. Sand is made of large particles that don't bind together at all and is very unstable. The best soil type for a trail is a mixture of clay, silt and sand.

Knowing soil types along a planned trail will help with developing a solid, stable tread. Soil maps and accompanying data tables describe the suitability of soil types for roads, structures, farming, forestry, etc. Soil maps are available from your local soil and water conservation district, USDA Natural Resources Conservation Service, county Extension office or the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/ (Figure 5).

Reduce soil erosion by locating trails on soils with low erodibility (e.g., coarse-textured, low organic matter, low soil moisture, minimal slopes). Design trails to follow the contour. Use rolling grades and other measures to route runoff away from the trail. Build a boardwalk across wet soils and avoid steep slopes. Avoid developing trails in potentially erosive or sensitive areas. If necessary to build in these areas, use trail surface materials like crushed gravel to reduce erosion.

Trails along waterways or riparian corridors are critical areas for many ecological functions which can be negatively impacted by poorly designed and managed nature trails. To minimize impacts and maintenance issues, locate the primary trail to the outside of the riparian corridor and then provide access to the waterway at strategic points.

Key considerations for trails along riparian corridors are:

- Locate primary trail outside of the riparian corridor.
- Leave some riparian areas as refuges without trails.
- Provide access to stream at strategic locations.
- Minimize the number of times a trail crosses a stream.
- Avoid crossings at confluences where two or more streams meet.

The best time to analyze a trail is during or immediately after a hard rain. You might try walking your trail in the rain during construction and watch what the water is doing and how your drains and structures are holding up. Think about soil type, slope, distance of flow and water volume before deciding your course of action.

TABLE 2. Soil Ribbon Test.

To conduct a soil ribbon test, roll a handful of moist soil back and forth between both hands into a tube shape. Squeeze it between your thumb and forefinger to form the longest and thinnest ribbon possible. Match how it feels and the texture properties with the attributes below.

Texture	Feel	Ribbon	Best Trail Soil[1]
Sand	Grainy	Can't form a ribbon	Add clay and silt
Loam	Soft with some graininess	Thick and very short	
Silt	Floury	Makes flakes rather than a ribbon	Add sand and clay
Sandy Clay	Substantial graininess	Thin, fairly long – 50 to 76 mm (2 to 3 inches) – holds its own weight	Add silt
Clay	Smooth	Very thin and very long – 76 mm (3 inches)	Add sand and silt

[1]Adding soil to improve trails is realistic only for short stretches where ground is most vulnerable.

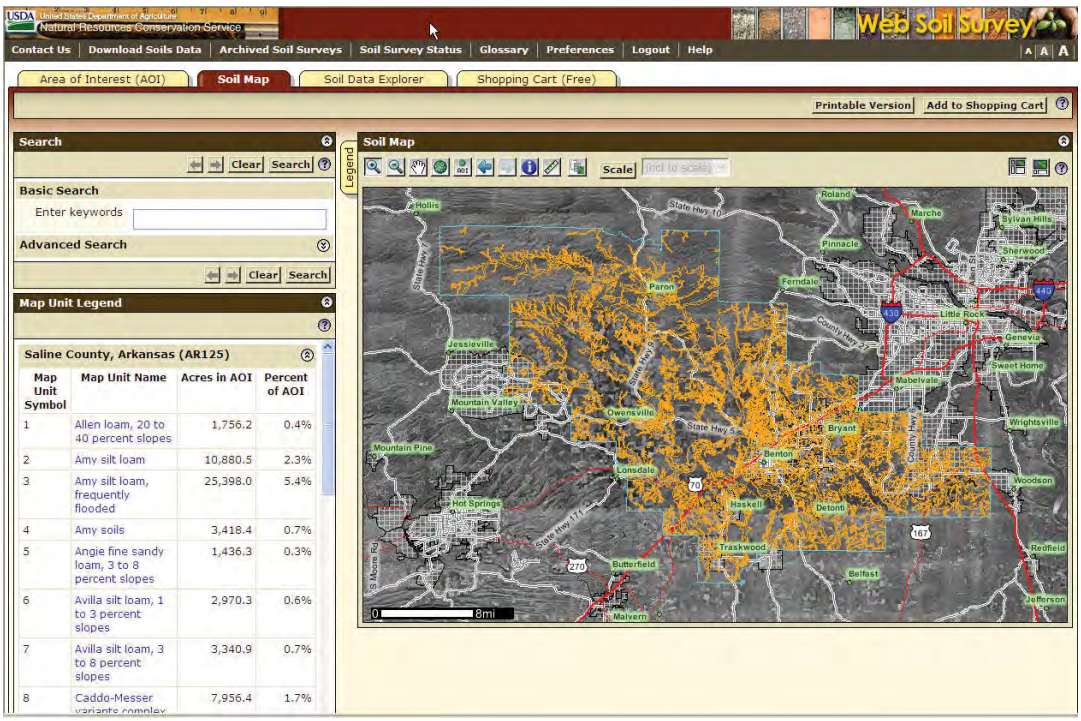


FIGURE 5. Information about soil types on your property is available online from the Web Soil Survey or at your local Natural Resources Conservation Service office. ***Saline County, Arkansas.***

Visual Appeal

Many people, regardless of background, prefer similar visual elements in the landscape. Some of these include:

- Waterscapes (e.g., lakes, meandering streams)
- Manicured landscapes
- Savanna or park-like landscapes
- Trees in scale with surrounding features
- Absence of dead or downed wood
- Clean waterways with no or limited woody debris
- Large mature trees and trees with broad canopies
- Spaces defined by edges (e.g., pasture bordered by woods)

Many of these visual elements are not desirable for achieving goals for water quality, soil protection and wildlife habitat. Naturalistic landscapes providing valuable ecological functions are often viewed as untidy and undesirable, while manicured landscapes with limited ecological functions are perceived as demonstrating stewardship and are visually desirable.

The challenge is to design trails that minimize impact on desired ecological functions while providing visual appeal and instilling long-term commitment to practices that benefit soil, water and wildlife. Though not visually appealing to some, grassy or shrubby buffers near streambanks reduce soil erosion, improve water quality and provide habitat for a number of wildlife species. Building trails on a streambank is not advisable (Figure 6).

Strategies for enhancing the visual preference of buffers are:

- Design the part of the buffer viewable by the public to be visually pleasing while the interior can be designed to achieve the desired ecological functions.
- Use selective mowing to indicate stewardship without greatly reducing the ecological functions.
- Provide visual frames to contain and provide order around the buffer (e.g., wooden fence).
- Use interpretive signs and education programs to increase awareness and preference.

FIGURE 6. This trail was built too close to the stream. Buffers reduce soil erosion, improve water quality and provide habitat for wildlife. ***Photo by John Pennington, UA Division of Agriculture, Cooperative Extension Service.***

The challenge is to design trails that minimize impact on desired ecological functions while providing visual appeal and instilling long-term commitment to practices that benefit soil, water and wildlife.

- Enhance visual interest and diversity by increasing seasonal color and by varying plant heights, textures and forms.
- Provide simple habitat improvement such as nesting boxes and feeders. Wildlife usually increase visual preference.

Determine Trail Uses

When planning a trail, it is important to understand how the trail will be used, how much it will be used and what quality of user experience you want to offer.

Multi-Use or Single-Use?

Multi-use trails work if:

- There are many primary users but only a few secondary users.
- The trail is used in different seasons by different users.
- The trail is designed and maintained to accommodate all users.
- Clear rules are posted about how to behave (pass, regulate speed, etc.) when encountering other types of trail users.

Consider a single-use trail if:

- Different types of users have different levels of tolerance for noise, effort in using the trail, speed of travel or influence on the tread.
- You want to offer a high-quality trail experience for one type of user.

How Much Use?

How much will the trail be used at any one time, day, season or year? As trail use increases:

- Increase tread and clearing width.
- Create a more durable tread.

What Quality of Experience?

Design your trail to fit the user experience that you want to offer. Consider:

- Physical ability of trail users. For example, reduce trail grade if you want to accommodate people with a range of physical abilities.
- Exposure to personal risk (e.g., injury, getting lost).
- Duration of the experience. Is it 30 minutes or 3 hours?
- Purpose for the trail. If the trail simply leads to a destination, choose the shortest and easiest sustainable route. If the trail itself is the destination, choose the most interesting route.

Preference studies have identified attributes that trail users find desirable in trails. These attributes can be used to enhance the recreational experience and increase trail usage. Key design considerations are:

- Trails passing through several types of plant communities are generally more preferred.
- Incorporate waterscapes and historical or cultural elements as anchor points where possible (e.g., old stone walls, streams).
- Trails passing through open areas with few trees or distinct features are less preferred. A mixture of open and enclosed areas is desirable.
- Create a sense of mystery through a curvilinear path alignment.
- Provide trails that are connected, accessible to users and that encourage multiple uses.
- Design trails to reduce exposure to noise and air pollution.
- Create vantage points where users can view wildlife, other trail users or interesting features.
- Trails for small acreages should be loops that bring users back to the starting point.
- Trail maps, trail head marker and/or bulletin boards are useful for conveying information to visitors about your trail.

Establish Design Standards

Before scouting the trail corridor, set your design standards. Keeping users on the trail and water off the trail is the primary goal for all trail designs. Base the design standards on trail uses (Table 3), the quality of experience (including the level of risk) and construction resources, budget and expertise. Modify the design standards to fit your needs.

Consider these aspects of the trail design: trail configuration, trail length, tread surface, tread width, clearing width, clearing height, grade, turning radius, sight distance, water crossings and special requirements.

TABLE 3. Recommended trail design standards for hiking, horses, biking, ATVs and off-highway motorcycles.

Trail Use	Configuration	Length	Tread Surface	Tread Width	Clearing Width	Clearing Height	Grade	Turn Radius	Sight Distance	Water Crossing	Other Uses	Unique Facilities
Hiking	Loop or multiple loops for day hikes; variety in landscape; frequent curves and grade changes; spur trails to points of interest	5-15 miles	Mineral soil, embedded rocks, bed-rock, asphalt or concrete	2-3 feet light use or 1-way 4-6 feet heavy use or 2-way	4-6 feet light use or 1-way 6-10 feet heavy use or 2-way	8 feet	1-7 percent preferred, 10 percent maximum sustained, 40 percent for short distances	Not critical, but 6 feet preferred	Not critical, but 50 feet recommended, especially at road crossings	Stepping stones or ford if water less than 2 feet deep; culvert or boardwalk 3-4 feet wide for light use, 5-6 feet for heavy use; at least on handrail if boardwalk is high-use, more than 12 feet long, or more than 4 feet over water	Low-use horseback riding	Resting benches
Horse	Loop or multiple loops with variety of scenery and terrain, and open parade area; 1-way traffic; avoid water and road crossings; avoid wet areas and steep slopes where it is difficult to maintain tread	5-25 miles	Mineral soil; crushed, compacted gravel	2-4 feet light use or 1-way 6-8 feet heavy use or 2-way	8 feet light use or 1-way 12 feet heavy use or 2-way	10 feet minimum 12 feet preferred	1-10 percent preferred, 10 percent maximum sustained, 20 percent for short distances	6 feet	50 feet minimum 100 feet preferred and at road crossings	Ford slow-moving water less than 3 feet deep – select site with stable sand or gravel base; soil-covered culvert is better than bridge; bridge only if water is deep and swift, must be well-designed	Hiking	Parking with trailer space, tether line; or campsites with tether lines or corrals, water, manure dump
Touring Bike	Loops and linear trails; 1-way traffic	5-50 miles	Limestone fines; other crushed stone 3/8 inch or less; 2 inch asphalt over 3-4 inch base of compacted gravel	3-6 feet light use or 1-way 8-10 feet heavy use or 2-way	8 feet light use or 1-way 10-14 feet heavy use or 2-way	8-10 feet	1-3 percent preferred, 5-10 percent maximum sustained, 15 percent for short distances	Radius in feet = (1.25 x velocity in MPH) + 1.5	50 feet minimum 100 feet at road and water crossings and on 2-way trails	Culvert or boardwalk with handrails; orient deck boards 45°-90° to direction of travel; width 4-8 feet for light use or 1-way, 10 feet for heavy use or 2-way	Hiking	Bike rack
Mountain Bike		5-20 miles	Mineral soil, bedrock	2-3 feet	6-8 feet			4 feet minimum 8 feet preferred				
All-Terrain Vehicle (ATV)	Trail system with loops of varying difficulty, easy trails provide access to difficult trails; 2-way trails; occasional obstacles	5-20 miles	Mineral soil, bedrock, loose rocks less than 6 inches in diameter	5-7 feet light use or 1-way 8-12 feet heavy use or 2-way	6-10 feet	8 feet	0-25 percent preferred, 25 percent maximum sustained, 45 percent for <100 yards	10 feet minimum 25 feet maximum	50 feet minimum 100 feet preferred	Culvert with handrails, or boardwalk with curbs; orient deck boards 45°-90° to direction of travel; width 4-8 feet for light use or 1-way, 10 feet for heavy use or 2-way	Mountain bike, OHM	Parking with trailer space, warm-up loop; rest stops or shelters after 15 miles
Off-Highway Motorcycles		5-50 miles	Mineral soil, bedrock, rocks firmly embedded in tread surface	1.5 - 2 feet light use or 1-way 3-6 feet heavy use or 2-way	6-8 feet	8 feet	0-30 percent preferred, 25 percent maximum sustained, 50 percent for <100 yards	4 feet minimum 10 feet maximum	50 feet minimum 100 feet preferred	Culvert with handrails, or boardwalk with curbs; orient deck boards 90° to direction of travel; width 4-6 feet for light use or 1-way, 10 feet for heavy use or 2-way	Mountain bike, ATV	Parking with trailer space, warm-up loop; rest stops or shelters after 15 miles

Keeping users on the trail and water off the trail is the primary goal for all trail designs.

Trail configuration is the overall shape of the trail.

- Linear trails are appropriate for long distance travel (several miles) or where the land ownership (right-of-way) is too narrow to permit development of a loop trail.
- Spur trails are short linear trails that take users to points of interest or connect different loop trails.
- Loop trails permit the user to begin and end at the same location without repeating any part of the trail.
- Stacked loop trails (a series of interconnected loops) permit users options for different distances, routes or destinations.

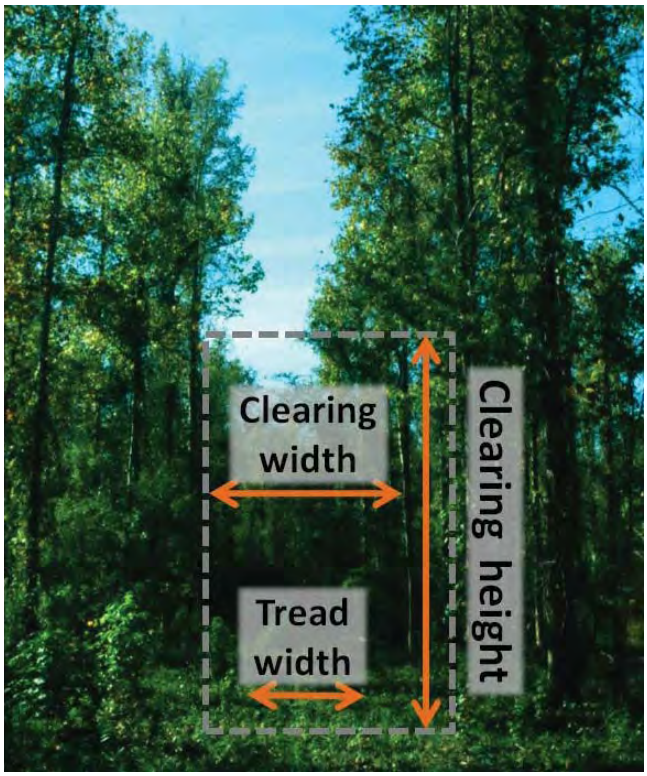


FIGURE 7. Tread width, clearing width and clearing height. ***Text by the authors, photo by Brian Lockhart, USDA Forest Service, Bugwood.org.***

Tread surface refers to the type of surface material (e.g., soil, gravel, rock) and its condition (e.g., smooth, rolling, rough). High-use trails require more durable materials and smoother surfaces than light-use trails.

Tread width (Figure 7) is the width of the useable trail surface. In general, the tread width that is suitable for light-use or one-way travel should be doubled for heavy-use or two-way travel. For example, common trail widths are 18 inches, 24 inches and 42 inches, depending on user type.

Clearing width (Figure 7) is the total width to which rocks, trees, tree limbs and other obstacles should be removed. As a general rule, clear at least 2 feet on each side of the tread. Where a trail passes through dense vegetation, vary the clearing width to avoid an unnatural tunnel effect. In general, maintain clearing width from the ground up to the clearing height, except you may leave vegetation, rocks and other objects less than 2 feet tall near the tread edge.

Clearing height (Figure 7) is the height above the tread surface to which overhanging rocks, tree limbs and other obstructions must be removed. As a general rule, clear 8 feet for hikers and bikers and 10 feet for horse riders. Keep in mind that leaves will bend deciduous tree branches 1 to 2 feet lower in summer than in winter and ice or snow will bend evergreen tree branches and raise the tread surface.

Turning radius is the radius of an arc drawn through the centerline of the tread where the trail curves. As travel speed increases, particularly on bike trails, consider lengthening the turning radius, widening the trail or clearing a runout zone.

Sight distance is the distance that a user can see down the trail from any point on the trail. Adhere to the recommended minimum sight distance, but vary sight distances to add interest. For bike trails, lengthen sight distance to allow faster travel and reduce sight distance to slow travel.

Water crossings refer to the type of structures recommended for crossing bodies of water. A ford, stepping stones, culvert or boardwalk may be appropriate. Your choices will be affected by the type of user, type of trail experience offered, type of water body, length of crossing, legal status of the water body, your ingenuity and your budget.

Select the Corridor

Perhaps the most enjoyable step in trail design is exploring the corridor to determine where to place the trail. A trail corridor is a wide swath through the landscape that encompasses the trail. Analyze the entire area, refining the trail location as you gather more information.

Keep in mind that the rolling contour trail is sustainable and requires low maintenance. When establishing design standards and selecting the trail corridor, remember the design features for a rolling contour trail are:

- Locating a new section of trail on a sideslope.
- Keeping the trail grade less than half of the grade of the hillside.
- Building with a full bench cut to create a solid, durable tread.
- Constructing plenty of grade reversals.
- Outsloping the tread.
- Compacting the entire trail tread.

Maps help you identify land uses on your property and neighboring properties (e.g., cropland, pasture, forest, river, lake), roads, trails, buildings and utility rights-of-way. Aerial photographs of your property (Figure 8) are available at no charge from the Natural Resources Conservation Service or the Farm Service Agency office in each county (http://offices.sc.egov.usda.gov/locator/app). Aerial photos are also available on the internet through the Spatial Analysis Laboratory at the University of Arkansas at Monticello (http://sal.uamont.edu/), Geostor (http://www.geostor.arkansas.gov) or private companies such as Google Earth (http://earth.google.com/). Look for photos in a scale of at least 4 inches to 1 mile, but preferably 8 inches to 1 mile.

Topographic maps (1:24,000 scale) are very helpful in all terrain, especially if your trail covers a large geographic area (Figure 9). They show elevation changes, forest and open areas, rivers, lakes, wetlands, buildings, roads, trails, cemeteries and other features. Topographic maps are available from the U.S. Geological Survey, the Arkansas Geological Survey, commercial CDs and DVDs, map dealers and recreational outfitters.

When evaluating large sites, other maps or geographic information systems may provide information on water resources, rights-of-way, utilities, land uses, roads, land ownership, vegetation cover types, wildlife habitat, flood zones, etc. Possible sources include the Arkansas Game and Fish Commission, Arkansas Natural Heritage Commission, The Nature Conservancy of Arkansas, local planning and zoning authority, and universities.

FIGURE 8. An aerial photograph helps identify land uses and with trail planning. C.A. Vines 4-H Center, Ferndale.

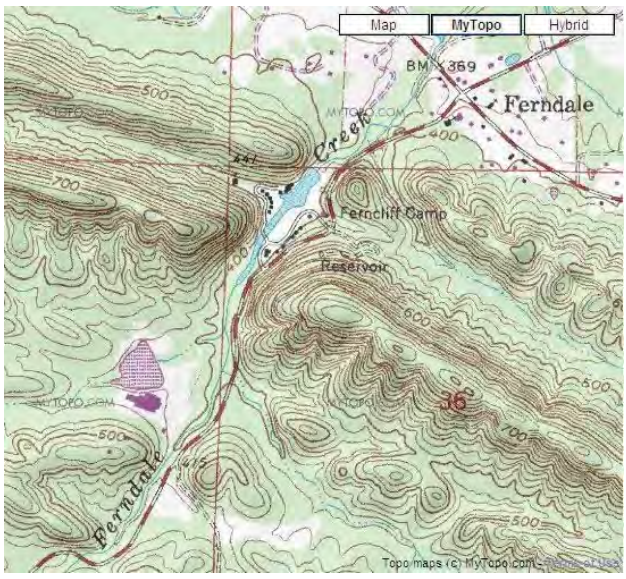


FIGURE 9. A topographic map shows elevation. The more closely spaced the lines, the steeper the slope. Ferndale, Arkansas. *Source: MyTopo.com.*

Scout the Trail Corridor

Use topographic maps or aerial photos to map the potential route. Use these maps or sketch a map to identify control points (i.e., places where the trail has to go) because of:

- Destination
- Water crossings
- Rock outcrops
- Desired features

To clearly see landscape details, scout when deciduous trees have lost their leaves. Look for natural pathways that require little clearing or construction (e.g., hillside bench or river bank terrace).

If possible, scout in all seasons to reveal attractive features and hazards that may affect location, construction or maintenance. Look for:

- Spring: high water, ephemeral (temporary or seasonal) ponds, flowers
- Summer: dense foliage, normal water level
- Fall: foliage color
- Winter: icicles, snow scenes, frozen water

Note existing trails and roads, control points, obstacles, points of interest and anchor points. Take notes and mark locations on a map and record GPS coordinates. These GPS coordinates can be provided to trail builders and users for navigation.

Existing trails and pathways. Existing trails and roads may be good links to new trails. Scout the corridor in both directions. However, existing trails or old roadways typically were not designed properly and show evidence of erosion, pooling or other features that warrant their abandonment.

On existing trails, place a priority on:

- Correcting truly unsafe situations. As an example, repair impassable washouts along a cliff or reroute the trail.
- Correcting problems that cause significant trail damage, such as erosion.
- Restoring the trail to the planned design standard.

Maintain the trail when the need is first noticed to prevent more severe and costly damage later. Some trails may need to be abandoned and reconstructed elsewhere to avoid these problems.

Control points. Control points are physical or legal constraints on a trail's location. Ownership or management unit boundaries, a steep slope forcing a trail through a narrow section of hillside, a cliff that forces a trail around one end, a wetland forcing the trail along a narrow upland ridge or a stream that can be crossed easily in only a few places are examples of control points.

Maintain the trail when the need is first noticed to prevent more severe and costly damage later.

A special point of interest may also serve as a control point. Run your trail past significant points of interest, e.g., unusual landforms (sink hole, hill, valley, gorge); different forest types or ages; forest opening; grassland; farmland, especially if it attracts feeding wildlife; scenic vista; boulders; rock outcrop; wetland; ephemeral (temporary or seasonal) pond; lake; river; creek; waterfall; historic site (may also be an obstacle); archeological site (may also be an obstacle); wildlife habitats (den trees, rock piles, dense thickets, layers of forest vegetation, water sources, sand banks, cliffs, caves, crevices); and an old homestead. Attract wildlife to the trail corridor with nesting boxes, breeding sites, food plots, feeding stations, roost poles, watering devices and other constructed habitats.

Obstacles. Obstacles can include a steep slope, rocky soil, boulder field, rock slide, cliff, rock ledge, eroding bank, steep-sided gully, gorge subject to flash floods, water body, wetland, habitat for rare species, historic and cultural sites, fence, highway, sources of objectionable sound and objectionable views. Some obstacles may require expensive crossing structures.

Anchor points. At frequent intervals, take the trail past subtle anchor points (e.g., large or unusual tree, rock, patch of shrubs) that add interest and draw attention to landscape features.

Grading Your Map

After roughing out your route, go back again and pay attention to the finer details on your map. Include *positive* control points – features such as a scenic overlook, a waterfall or pond. Avoid *negative* control points – areas that have noxious weeds, critical wildlife habitat or undesirable soil conditions.

Grade is the slope angle along the trail's centerline. Grade can be expressed as a percent or an angle. Percent is easier to understand. **Percent grade** is the rise (elevation change) divided by the run (horizontal distance) multiplied by 100. For example: (rise of 10 feet) / (run of 100 feet) x 100 = 10 percent. You can measure the grade with a commercial or homemade clinometer (Figure 10).

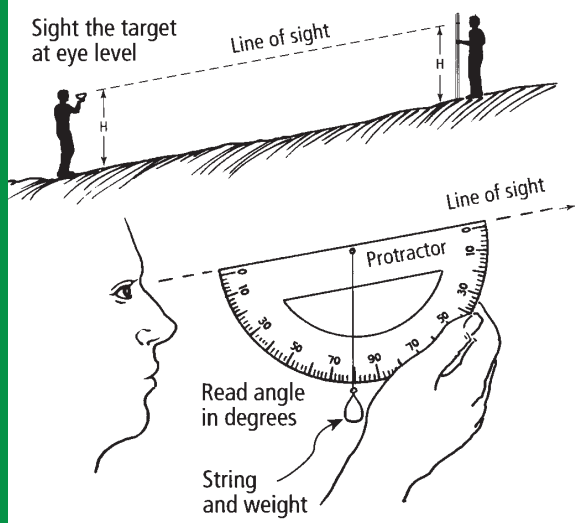
It is easy for trail users to travel long distances on low grades. High grades require more work and should extend for shorter distances. Follow the **10-Percent Guideline**. When plotting the trail on a map, connect the control points following contour lines. Keep the grade of each uphill and downhill section less than 10 percent for distances no more than 100 feet. A 3-percent grade is the maximum for disabled access.

Plotting your trail with 10-percent grades on a topographic map will help keep the route at a sustainable grade. When marking your new trail outdoors, you'll have more flexibility for tweaking the grades and the actual trail route. Note that elevation change, up or down, is always a positive number.

Plotting your trail with 10-percent grades on a topographic map will help keep the route at a sustainable grade.

FIGURE 10. A clinometer is a useful tool for evaluating trail grade. ***Photo by Becky McPeake, UA Division of Agriculture, Cooperative Extension Service.***

How to make and use a clinometer.



Drawing courtesy of Baughman and Serres (2006).

Make a clinometer with a protractor, short string and small weight.

To measure grade:

1. Sight along the protractor's flat edge and read the degree aligned with the string.
2. Determine the slope angle:

   90° – (angle read on protractor) = slope angle in degrees

   Example: 90° – 80° = 10° slope

To convert degrees of slope to percent slope:

1. Look up the tangent of the slope angle in degrees on a scientific calculator or in a tangent table in a book.
2. Determine the percent of slope:

   Tangent (of slope angle in degrees) x 100% = % slope

   Example: Tangent (10°) x 100% = 0.176 x 100% = 17.6 or 18% slope

Additional Points to Consider

- Avoid placing your trail in areas with threatened or endangered flora, fauna, geology and natural plant communities. Ask the Arkansas Department of Natural Heritage (501-324-9619, www.naturalheritage.org) or the Arkansas Game and Fish Commission (800-364-4263, www.agfc.com) about whether these resources are likely to be found on or near the trail location.
- Protect cultural resources such as historic structures (buildings, dams, bridges, fire towers, etc.), archaeological sites (above and below ground) and cemeteries (including unplatted historic cemeteries, burial mounds and other ancient burial sites). Cultural resources can be damaged by soil disturbance, soil compaction, rutting, change in public access and change in vegetation and other features. Whenever a government permit, license or funding is needed for a project, a cultural resources management review may be required. To learn about locations of cultural sites, contact the Arkansas Historic Preservation Program (501-324-9880, http://www.arkansaspreservation.org).
- Discuss your trail project with neighbors to learn about the impact on their properties and potential linkages to other trail systems.
- Consider your budget for land and right-of-way acquisition, construction and maintenance. This will put a reality check on your design plans.
- If building trails for public use, trail preferences and layout need to be considered further. See Appendix B.

Mark Trail Location

Tie surveyor's plastic flagging (comes on a roll like tape) in trees and brush or use construction flag markers to give a rough idea about where the trail will go. As you mark the trail, keep your design standards in mind.

Mark the lower side of the trail using one of these materials:

- Rolls of plastic flagging (tie strips to branches).
- Wire flags (stiff wire, 2 feet or longer, with plastic flag).
- Wooden stakes (12-18 inches or longer) topped with brightly colored flagging or paint.

Marking the lower side of the trail improves the visibility of the length and depth of the bench cut. Plus the marker is not in the way when swinging the Pulaski or other trail-cutting tool as it would be if the marker were placed in the center of the trail.

Space the markers approximately 20 feet apart in dense vegetation and up to 100 yards in open fields. Write cumulative distances on markers every 100 feet to make it easy to match markers with trail maps and notes.

Map the route. Use a global positioning device or a compass and distance measurements to develop a trail map.

- Mark structures and special instructions on the map.
- Make special note of places that require deviations from trail standards.
- Photograph sites where trail structures are needed to assist in planning materials and equipment or to show potential contractors what these sites look like.

Instead of clearing large trees, consider passing on the upper side to avoid damaging roots with the digging. Plus this will save you some work as tree roots are difficult to dig through.

Obtain permits for crossing streams, wetlands, railroads, highways, rights-of-way, etc.

Begin constructing the trail soon after flagging, before markers are moved or damaged.

Clear the Trail

Clear the trail in these stages:

1. Remove small trees, shrubs and limbs from large trees.
2. Rake debris from the trail.
3. Cut large trees.
4. Remove stumps and boulders.
5. Move soil to level the tread.

The extent of clearing needed depends on the clearing height and width of the trail, the quality of the user experience (e.g., a rough, challenging trail or a smooth, easy trail) and the primary season of use (e.g., ice or snow may cover some obstacles in winter).

Construct the Tread

Create a tread surface that is smooth, properly outsloped and durable enough for intended users. Save effort by placing the trail on soils that withstand trail use.

For most soils, trail construction and compaction are best when soil is neither wet nor bone dry. Some soils may work better a few days after a rain when soil conditions are favorable.

Select Tread Materials

Consider how tread materials will react to compaction, displacement and erosion.

Compact the tread as much as possible during initial construction, paying close attention to maintaining an outslope. Compaction comes from the downward force from feet, hooves, wheels, etc. When a tread is fully compacted, it holds its shape and resists displacement and erosion. Some materials have better compaction properties than others. Tread materials that do not compact (e.g., sand, organic soil, water-saturated soil) or that compact too much (e.g., peat) will not retain a desired shape. Excessive compaction tends to lower the tread and encourages water to collect in depressions.

Displacement is sideways force that moves tread material off the trail, raising trail edges over time. Displacement also lowers the tread, enabling water to collect in depressions. Water and wind erosion remove tread material, destroying the tread. The potential for erosion from running water increases as the slope and/or volume of water increases. If possible, use materials for the tread from the immediate surroundings. Natural materials are inexpensive and blend well with the landscape.

Consider hardening the tread with rock, pavers or other materials as a last resort when the tread cannot be rerouted to fix the problem. Circumstances which may require tread additions are when:

- Drainage is poor and mud is a problem.
- Flowing water causes unacceptable erosion.
- Tread material compacts or displaces too much to retain the desired tread shape over the long term.
- Tread must be narrow and clearly delineated to protect the surrounding area.

The potential for erosion from running water increases as the slope and/or volume of water increases.

Types of Tread Materials

Typically the tread material that is most sustainable and lowest maintenance is mineral soil. However, depending on the situation, other tread materials may be suitable. Following are strengths and weaknesses of different tread materials.

Soil. Mineral soil is composed primarily of sand (0.05 to 2.0 mm – coarse texture), silt (0.002 to 0.05 mm – medium texture) and clay (0.002 mm – fine texture). Soil with a high percentage of silt, moderate percentage of sand and small percentage of clay makes a very durable tread. Such a soil resists excessive compaction and erosion while allowing internal drainage.

Soil composed mainly of sand will not erode with water or become muddy, but because sand does not compact, it is subject to displacement and wind erosion. Soil with a high clay and silt content is subject to water erosion and mud. Soil composed mainly of clay retains water and can be muddy and slippery when wet, and unless it is highly compacted, it is also subject to water erosion.

Typically the tread material that is most sustainable and lowest maintenance is mineral soil.

Organic soil (humus) is composed of decomposing plant materials. Soil composed mainly of decomposed organic material will compact and erode and can become water saturated and muddy. Soil composed mainly of undecomposed organic material compacts too much to be suitable as tread material.

Bedrock. If a feature of the site, smooth bedrock makes a very durable tread. It can be slippery for horses, especially on slopes.

Vegetation. Vegetation survives best on a lightly used, wide trail in full sunlight (Figure 11). Typically little sunlight reaches the ground in forested environments, particularly where tread width is kept to a minimum.

FIGURE 11. A grass tread is appropriate for lightly-used trails in full sunlight. Heavy equipment or a bush hog may be needed for maintaining this type of trail. ***Photo by Chris Stuhlinger, University of Arkansas at Monticello.***

In Arkansas natural vegetation should be discouraged along trails to reduce tick habitat and transfer of tick-borne diseases. Contact your local county Extension agent for advice about appropriate herbicides to use along your trail.

Duff is un-decomposed organic matter (e.g., leaves, twigs, moss, pieces of bark and wood) that litters a forest floor. Duff does not compact well and is easily displaced. Duff should not be on the tread. For shaping during construction, remove duff from the tread to expose the mineral soil.

Wood Chips. Maintaining wood chips on a trail can be a maintenance issue. However, wood chips can be used to define the tread on newly constructed foot trails, to suppress vegetation growth, and to raise the tread in muddy areas. Apply a 3- to 4-inch layer of large wood chips that do not contain leaves or small diameter twigs which decay rapidly. Hauling and spreading wood chips requires extensive labor, and wood chips need to be replaced every three years as they decay or are displaced. In most situations, wood chips should be a temporary tread material.

Rock. Rocky material includes gravel (from sand to 3 inches diameter), cobbles (3 to 10 inches), stones (10 to 24 inches) or boulders (greater than 24 inches). Rocks are useful on trails that receive heavy use, especially by horses or where a very firm, smooth tread is needed such as for touring bicycles or ATVs (Figure 12). Rocky material resists excessive compaction and displacement and provides a very strong tread. If protruding rocks are hazardous or too bumpy for your quality standards, excavate rocks or chip off the protruding piece. If the tread is really rocky, horses will require quality shoes. If the tread is sandy or soft, horses may not need shoes and hooves can be maintained using "natural hoof care."

Crushed rocks compact and resist displacement better than rounded rocks (e.g., from beaches, river beds and glacial till). Crushed rock made from hard rock is more durable than from soft rock. A tread composed entirely of rounded cobbles is prone to displacement, but when embedded in clay, cobbles add durability to the tread. If used in a mixture of sizes including plenty of small particles to fill voids, rocks interlock well. To achieve a smooth, firm surface, mix small gravel with rock dust from a commercial-scale rock crusher. For small jobs, haul a portable rock crusher to the work site. To produce a small quantity of gravel for chinking crevices, crush rocks with a sledgehammer or the rounded end of a steel pry bar.

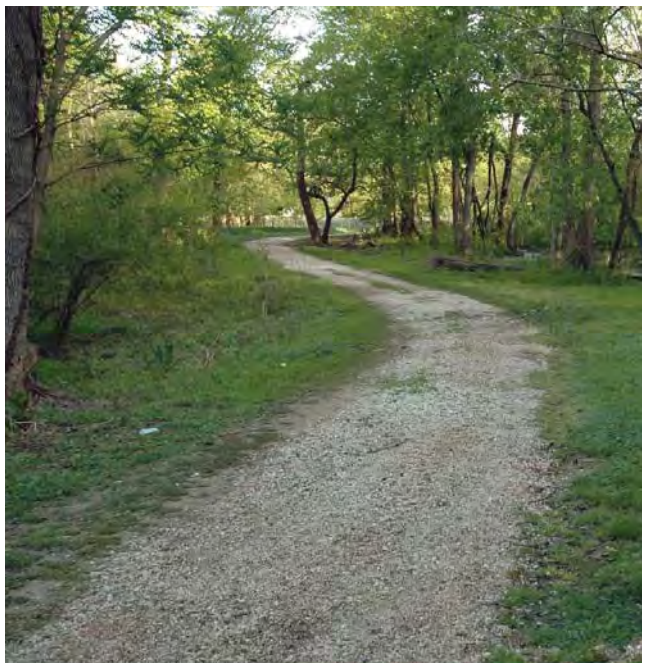


FIGURE 12. Gravel can be an effective tread particularly for ATVs but expensive for privately owned trails on small acreages. ***Photo courtesy of the National Park Service.***

Paving Stones/Bricks. Concrete paving stones and bricks are available in many sizes and shapes. Interlocking pavers may be most useful. These manufactured materials are uniform in size, easy to handle and easy to acquire. However, pavers are heavy to transport and expensive, and their uniform geometric shapes and colors may not match native materials.

Porous Pavement Grids. Sectional grids made from plastic or steel are laid directly on the ground to provide traction while protecting underlying soil from erosion. Vegetation can grow through the grid. Consider grids for nature trails on moderately steep slopes that are prone to erosion.

Solid Pavement Panels. Easy-to-install plastic panels (approximately 4 feet long x 4 feet wide x 2 inches thick) that lock end-to-end can provide a firm walkway over sand or gravel.

Asphalt. Asphalt is a good choice where a hard surface is needed, such as for wheelchairs, touring bicycles, in-line skaters or heavy hiking use. Asphalt is expensive compared to natural surfaces and crushed rock, and the site must be accessible to the equipment needed to apply and roll it. Tree roots may uplift and fracture asphalt laid on shallow soil over bedrock. Asphalt applied with heavy equipment is most durable, but tread width is limited by the equipment, typically 8 feet or wider. Where a narrow tread is desired, lay asphalt by hand, but it will be less durable. Use a hot mix for new construction or large repairs. Use a cold mix for small repairs, less than 1 cubic yard. Asphalt can be colored to some extent by the gravel used in the mix.

Concrete. Use concrete in the same situations mentioned under asphalt. Concrete is more durable than asphalt but also more expensive. Haul large quantities to the site by truck; mix small quantities on-site. You can color concrete with additives to blend with the surrounding site. For better traction on steep slopes, broom the surface, trowel grooves across the tread or leave the surface unfinished.

Avoid Tread Edging

Edging a trail with rocks, logs, timbers or other material should be avoided (Figure 13). Tread edging on the lower side of a trail (i.e., that is higher than the tread) is almost always a wrong choice. This creates a berm or dam that holds water on the trail causing erosion and other trail maintenance issues.

If tread edging is intended to hold tread fill material in place (e.g., sand, gravel, asphalt), install hard, continuous edging (e.g., preservative treated 2 x 4-inch lumber, 4- to 8-inch diameter round logs or sawn timbers) along the lower side of the tread. Where the trail curves, cut shorter pieces or use edging material that can be bent. The tread must be lower than the outslope and not catch water or debris coming off the trail. Otherwise, tread edging will create a maintenance nightmare.

Edging a trail with rocks, logs, timbers or other material is almost always a wrong choice.

FIGURE 13. Do not edge your trail with logs or rocks as these funnel water down your trail causing erosion. Leaves are poor tread because they do not compact well, can become slick and are easily displaced. ***Photo by Jamie Schuler, University of Arkansas at Monticello.***

Install Structures

The structures you need to cross obstacles on a trail depend upon the conditions you encounter, the type of user experience you want to offer, the amount of use, accessibility and your budget.

Crossing Flat Land

Flat land may seem like an easy place to build a trail, but if the soil is mainly clay or silt or the water table is high, poor drainage may lead to mud puddles. Generally it is best to avoid building a natural surface trail on flat land. Solutions include relocating the trail where there is side-hill drainage or raising the tread above the surrounding flat ground.

Crossing a Hillside

A hillside trail must quickly drain surface water off the tread while maintaining its shape and a grade that is comfortable for trail users. Options for crossing a hillside include full-bench and cut-and-fill trails, retaining walls, diverting water across the tread and, if all else fails, diverting water flowing down the tread.

Full-Bench and Cut-and-Fill Trails (Figure 14). A flat outslope trail bed cut from a hillside provides a safe and comfortable crossing for users. In a full-bench trail, the full width of the tread is cut from the hillside. A full-bench trail usually has a well-compacted base because the underlying material has been in place for a long time.

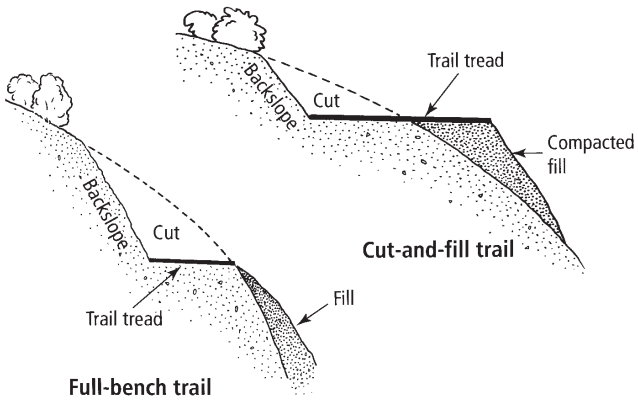


FIGURE 14. Full-bench and cut-and-fill trails provide safe travel across steep slopes. ***Drawing courtesy of Baughman and Serres (2006).***

If part of the tread is built upon fill material that was cut from the hillside, it is a cut-and-fill trail (e.g., half-bench or quarter-bench trail). Fill material may be difficult to compact, especially with hand tools. If fill material is not well compacted, horses and vehicles may destroy the tread. If fill material must be used for part of the trail bed, use large rocks to form the trail bed and serve as edging, then cover them with tightly compacted soil. Backslope is the area above a trail where material has been cut from a hillside in the process of leveling the tread. The backslope grade necessary to prevent soil erosion depends on the material. A backslope of 3:2 (horizontal run: vertical rise) is adequate for stable materials whereas a backslope of 4:1 may be needed on erodible materials. Never create a vertical backslope.

Outslopes. Where a trail crosses a hillside with medium- to coarse-textured soil, outslope the tread to quickly drain off surface water (Figure 15). A 2- to 5-percent outslope is quite common and suitable for most trail users.

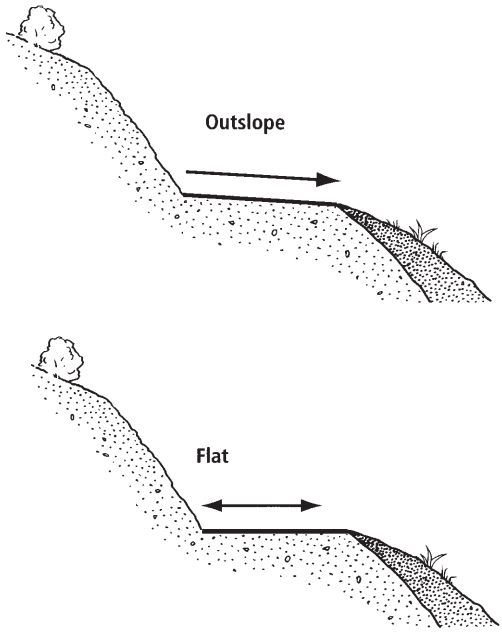


FIGURE 15. Outslope and flat. ***Drawing courtesy of Baughman and Serres (2006).***

Some trail designers recommend no outslope on **horse trails**. Horses tend to walk on the outside edge of a tread and will crumble the edge over time. A flat tread is safer for horses that may slip when the surface is wet. If you build a flat-cross-section trail, divert water from the tread using a rolling grade.

Retaining Walls. Where a trail cuts across a slope and vegetation does not stabilize exposed soil above or below the tread, a retaining wall will prevent soil erosion. A retaining wall below the tread may be more

durable than one along the backslope. Building a retaining wall to support the tread may negate the need for cutting into the backslope, thus preserving natural vegetation that holds the soil. Tie walls into the embankment with a deadman (e.g., geotextile fabric, logs or large rocks embedded into both the embankment and the wall). Build walls without mortar or install drain pipes to allow water to seep through the wall.

Divert Water Flowing Down the Tread. Where the tread has a relatively flat or concave cross-section, some water will run down the length of the trail. To prevent soil erosion, divert water off the tread with a rolling grade check or, as a last resort, using waterbars.

- **Rolling Grade.** A rolling grade divides the trail into narrow watersheds with undulating crests and dips like a gentle roller coaster (Figure 16). Water drains off at the dips. Ideally, no part of the tread is completely level. Outslope the bottom of each dip and make the outlet wide enough (about 15 feet) to drain off water without clogging.

  Place tread dips at natural drainage ways and at other locations as needed. Rolling grade is most appropriate when traversing hill slopes (fall lines) of 20 to 70 percent. On hill slopes less than 20 percent, water does not drain well at the dips.

  Drainage dips can deposit sediment into waterways. To reduce sedimentation, consider these alternatives: maintain a low tread grade on the approach to the drainage; design a small tread watershed with a short slope toward the waterway; harden the tread; or maintain a nearly level tread and install a boardwalk or culvert over the waterway.

  Also use rolling grade to ascend/descend hillsides. In those situations, rolling grade is most effective when the tread grade is less than ¼ to ⅓ of the hill slope. For example, if the hill slope is 45 percent, the tread grade should not exceed 15 percent, and 10 percent is preferred. As the trail climbs, periodically reverse the grade downhill for a few steps to create a dip that allows water to drain off.

  Even when a trail is outsloped, insloped or center-crowned, a rolling grade is desirable. These cross-sectional shapes are difficult to sustain over long periods without substantial maintenance.

  Adjust the size of each tread watershed depending on these factors:

  – When the watershed above the tread is large, increasing the potential for runoff, make tread watersheds small.

  – If the water infiltration rate of the upslope soil is slow, resulting in more potential runoff, make tread watersheds small.

  – If the potential for erosion is high, make tread watersheds small. Hardening the tread, placing the trail beneath a tree canopy that will intercept precipitation and reduce splash erosion or reducing tread width to minimize exposed soil will also reduce risk of erosion.

  – Where trail grade is steep, make tread watersheds small or reduce the trail grade by lengthening the trail or adding switchbacks or turns. Tread erosion risk is relatively low when tread grade is less than 5 percent,

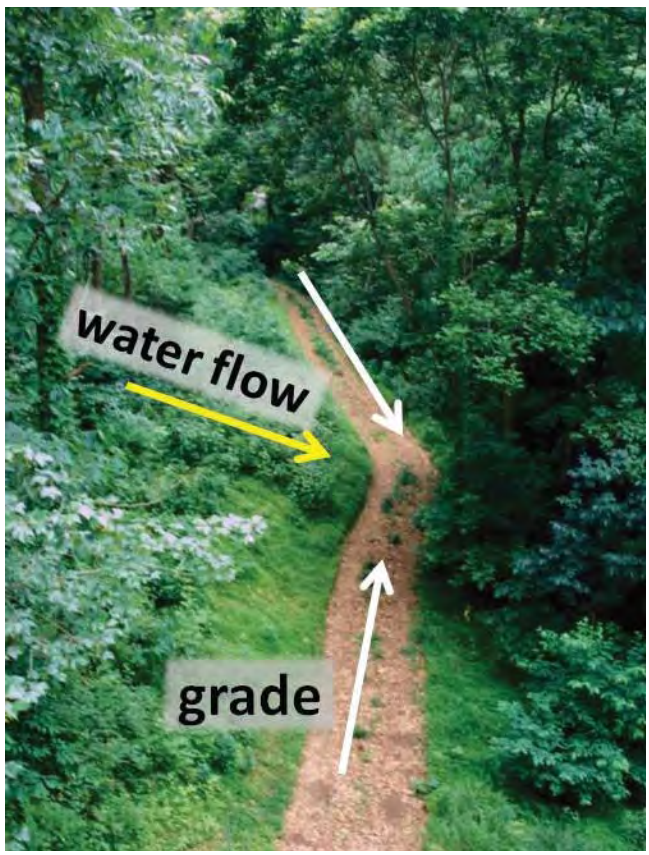


FIGURE 16. A rolling grade uses undulating crests and dips to divert water off the tread. ***Photo by John M. Randall, The Nature Conservancy, bugwood.org.***

moderate when tread grade is 5 to 10 percent and higher when tread grade is greater than 10 percent.

  - When hill grade is steep, make tread watersheds small. Tread dips drain best when there is a substantial difference between the tread grade and hill grade.

- **Waterbars.** Waterbars are usually used only as a last resort when other water diversions fail and the trail cannot be rerouted. A waterbar is an obstruction placed across a trail tread to divert surface water off the tread (Figure 17). Waterbars may be needed on a sloping trail with a flat cross-section (no outslope) or where rolling grade is not adequate to divert water at tread dips. However, given a choice, trail design experts prefer rolling grades over waterbars. Waterbars commonly fail when sediment fills the drain requiring frequent maintenance to keep any level of effectiveness. Water tops the waterbar and continues down the tread. A rolling grade is quicker to install than a waterbar, plus it typically works better.

Because most waterbars create a significant bump in the trail, they are not desirable on trails used for bicycling or ATVs. A rubber waterbar can be used for bicycle trails. When waterbars are placed on horse trails, horses tend to compact the soil immediately above and below the waterbar leading to depressions that collect water and mud. Horses also can damage waterbars because of their weight and strength. When used on horse trails, anchor waterbars well. Other options are open-topped culverts, usually made of wood, that direct water off the road surface while minimizing impedance to most users.

If a rolling grade or rerouting the trail is not possible, place waterbars at a 30° to 45° angle across a trail. Where heavy runoff is expected, place stones at the outflow to disperse water without causing soil erosion. The tread must be outsloped above the waterbar and ideally water never reaches the waterbar. If a waterbar diverts water into a ditch, make sure the bar does not protrude into the ditch where it might catch debris and block the ditch.

FIGURE 17. Trail before and after waterbars were installed to divert water off the tread. Waterbars should be installed only as a last resort. ***Photo courtesy of Maine Department of Environmental Protection, Bureau of Land and Water Quality.***

Use judgment and experimentation in spacing waterbars. Closer spacing is needed where the trail grade is steep, the soil is erodible or you want a high-quality tread without the expense of hardening materials. Refer to the Best Management Practices of the Arkansas Forestry Commission (www.forestry.state.ar.us, 501-296-1940) for details.

Climbing and Descending Steep Slopes and Cliffs

A climbing turn is a sustainable and effective trail design for most Arkansas hills and mountains. Occasionally other designs such as switchbacks, fixed ropes, climbing causeways or steps may be required.

Climbing Turns. Well-constructed climbing turns require little maintenance. However, next to waterbars, climbing turns are the trail structure most often constructed inappropriately. The tread is outsloped so that water runs perpendicular across the trail without impedance from rocks, branches or other debris either beside or on the trail. A climbing turn continues to change grade through the turn. It is built on the slope surface, and where it turns, it climbs at the same rate as the slope itself. If the slope is 15 percent, the turn forces travelers to climb at 15 percent. It becomes increasingly difficult to travel if the slope is steeper than 20 percent.

The advantages of climbing turns in appropriate terrain is that a larger radius turn (13 to 20 feet) is relatively easy to construct. Trails that serve off-highway-vehicle traffic often use insloped, or banked, climbing turns so that riders can keep up enough speed for control. Climbing turns are also easier than switchbacks for horses to negotiate.

Well-constructed climbing turns require little maintenance. However, they are the trail structure most often constructed inappropriately.

Switchbacks. A switchback reduces trail grade by lengthening the trail in a zigzag pattern (Figure 18). Design each trail segment to conform to the desired grade as much as possible. Place a switchback where the trail reaches an impassable obstacle or begins to run too far in the wrong direction. Avoid closely spaced switchbacks to discourage trail users from taking shortcuts, leading to erosion.

FIGURE 18. Switchbacks help the user traverse a steep slope at a comfortable pace. ***Photo by Ken Cheetham.***

To further reduce shortcuts, locate switchbacks at interesting focal points (e.g., conspicuous tree, boulder or rock outcrop) and place barriers (e.g., boulders, logs, thorny bushes) in the cutoff zone. Build the switchback platform with a 2- to 5-percent grade. On a very steep slope install a retaining wall to support the platform or install steps. If the main trail has a substantially steeper grade than the platform, create a transition grade as the trail approaches the switchback platform. Divert surface water off the trail above the switchback by means of inslope to a ditch. Design the switchback with the correct turning radius for the intended users. Switchbacks may not be practical for ATVs because of the long turning radius they require.

Fixed Ropes. On a lightly used foot trail with a steep slope and soil that becomes slippery when wet, a rope can help hikers climb or descend the hill. Tie a rope (½ inch or larger diameter) to a firm object at the top of the slope and lay the rope along the tread or tie it to trees along the trail as a handrail.

Climbing Causeways. When a slope has an uneven surface or is constructed of erodible materials, a climbing causeway builds up the tread in short sections. A climbing causeway (Figure 19) is useful on hiking and sometimes horse trails, but hazardous for bicyclists, motorcyclists and ATVs. Use 6- to 10-inch diameter logs or sawtimber as crossbars at 4-foot or longer intervals to prevent fill material from migrating downhill. Using the same material, place logs along each side of the tread to hold fill material in place. Fill the spaces between logs with soil or gravel, varying the fill depth to create long steps that provide the desired grade. A climbing causeway is most useful on grades of 10 to 20 percent. For steeper grades, consider installing steps.

FIGURE 19. A climbing causeway gradually builds the tread grade in sections. ***Photo by Ted Toth, National Park Service volunteer.***

Steps. Where trail grade exceeds 20 percent, steps help prevent erosion while aiding hikers and horses. Make step height (rise) 5 to 9 inches (7½ inches is ideal) and step depth (run) at least 10 inches. You can vary step depth up to several feet to fit the hill slope (Figure 20).

Make simple steps by anchoring logs, sawn timbers or large stones across the tread and backfilling with soil. Make more durable steps from 6- to 8-inch diameter logs or sawn timbers positioned into a three-sided box fastened with steel rods and backfilled with soil or gravel.

FIGURE 20. Box steps aid hikers with navigating steep slopes. ***Photo by Ted Toth, National Park Service volunteer.***

Crossing Wet Soil

Poorly drained soil on flat land may become muddy after rainfall or where groundwater seeps from a hillside and flows across the trail. Construct trails to avoid such sensitive areas which attract wildlife and harbor unique plant species. Trail development may adversely affect wildlife and plants using the seep or shallow water area. A well-designed trail can provide nature-viewing opportunities at a distance without harming wet areas. If disturbance is unavoidable, refer to an accredited publication such as *Wetland Trail Design and Construction* by the U.S. Department of Transportation, Federal Highway Administration, listed in the References section. Seek assistance from your local Natural Resources Conservation Service since disturbing wetlands may require a permit.

Crossing Waterways and Gullies

Stepping stones, ford or culverts help users cross open water in springs, streams and rivers.

Stepping Stones and Fords. On a primitive trail, hikers appreciate stepping stones that are firmly imbedded in the stream bottom. They might also wade across a slow-moving stream (less than 2 feet deep) through a ford. Horses can ford a slow-moving stream (less than 3 feet deep). Place a ford where the streambed has firm sand or gravel (Figure 21). On horse trails remove large rocks from the streambed to prevent tripping. If a small dam is installed to stabilize water depth and bottom structure, a government permit may be required.

FIGURE 21. Stream crossings for trails and ATVs should be perpendicular to the stream and located where erosion and streambed damage is minimized. ***Photo courtesy of the Adirondack Council.***

Culverts. Install a culvert to channel water across a trail, allowing trail users to cross a narrow stream (Figure 22). An open-top log or rock culvert is easy to clean when it becomes clogged, but it creates a hazard for some trail users. A pipe culvert covered with soil can be used by all trail users. Pipe culverts may be steel (durable, but heavy) or plastic (less durable, but lightweight for transporting into areas with difficult access). If the culvert is too small, high water will wash it out or flood land upstream from the culvert. Culverts located downstream from a forest require significant amounts of maintenance to keep debris from clogging the system. To permit fish movement on streams, a culvert should slope no more than 1 percent and its end must be flush with the stream bottom. Place rocks around the culvert's upstream end to armor the bank against erosion. Seek professional advice from a soil and water expert such as an Arkansas Stream Team Coordinator with the Arkansas Game and Fish Commission (800-364-4263) to gauge the appropriate diameter culvert to install.

FIGURE 22. Install a culvert pipe which can handle high water and is flush with the stream bottom with rocks around the upstream end to reduce erosion. ***Photo by Doug Rowley, National Park Service.***

Boardwalks. A boardwalk (Figure 23) enables trail users to cross over wetlands, fragile vegetation or unstable soil. On hiking trails, make the boardwalk deck (tread) from 2 x 6-inch lumber. Use thicker lumber on boardwalks intended for heavier users, such as ATVs or horses. Some boardwalk materials are made from recycled products. For more information about boardwalks, check publications in the References section of this guide.

FIGURE 23. Boardwalks allow users to cross over wet or ***sensitive landscapes. UA Garvan Woodland Gardens. Photo by Jerry W. Davis, U.S. Forest Service (retired).***

Bridges. Bridges are expensive to build and require a high level of expertise. First consider other alternatives, such as trail re-alignment, culverts, causeways or boardwalks. If bridge building is necessary, seek engineering assistance.

Trails That Cross or Utilize Roads

As a trail approaches a road crossing, add a tight turn, ridges and dips in the tread and/or narrow the clearing width to slow down users. On the final approach, the trail must be at a right (90°) angle to the road, nearly level and have a sight distance adequate for trail users to see the oncoming road in time to stop. Expand the clearing width 1½ to 2 times its normal width or thin forest trees to provide good visibility from the trail toward the road.

If the trail may be entered from a public road, install a barrier (e.g., posts, a gate, boulders, mound of dirt) to prohibit unauthorized entry. Install a sign visible from the road that indicates which trail uses are prohibited or permitted.

Crossing Fences and Gates

Fences may be necessary to restrain trail users from entering an area, to designate a property boundary or to contain livestock. Hikers can cross a fence at a stile or a gate. A gate is necessary for all other users. Trail users have a tendency to leave a gate open when it should be closed or closed when it should be left open. To keep a gate open, fasten it so that it cannot be closed. To keep a gate closed, place a spring or counterweight on the gate or tilt it to close automatically from its own weight. Install a latch that locks automatically when the gate closes, and place a sign on the gate, "Please Close Gate."

Gate width can help regulate the types of users. For example, a 2½-foot-wide gate will admit hikers and bicyclists but exclude horses and ATVs. A 6-foot-wide gate will admit all users except full-sized SUVs and pickup trucks.

Some gates are more visual barriers than physical barriers, such as a single horizontal bar (log or steel pipe), steel cable or several vertical posts spaced across the tread. This type of simple gate, along with a sign that defines what types of trail users may enter, will discourage some potential users, but some unauthorized trail users may go around or under the gate. If you are serious about keeping out certain types of users, your gate and adjoining fence must create a physical barrier. Other barriers also may be appropriate, such as an earthen berm, trench or large boulders. Install light reflectors on gates whether you expect people to use the trail at night or not! Reflectors are especially important safety features on gates that may be entered by motorized vehicles when gates are made from a single horizontal pole or cable that is not clearly visible at night.

Sign the Trail

If the trail is for personal use, signs are probably not necessary. Trails for visitors or guests need markings to keep them on the trail and prevent them from becoming lost. Four types of signs may be needed: trailhead sign, confidence markers, directional signs and warning signs.

Trailhead Sign. A sign placed at the beginning of the trail may include some or all of the following information:

- Map showing trail route, key features along the trail, a "you are here" mark, north arrow and map scale or distances along major trail segments.
- Name or number of trail, if there is more than one trail.
- Types of trail uses permitted (e.g., hiking) and uses specifically prohibited.
- How the trail is marked (e.g., paint marks, signs, rock cairns).
- Rules for trail use (e.g., stay on the trail, pets must be on a leash, hikers get off the trail to let horses pass).
- Warnings, including hazards along the trail (e.g., poisonous plants, venomous snakes, dangerous animals, steep cliffs, falling rocks, unsafe drinking water) and environmental features that must be protected (e.g., fragile vegetation, rare animals, natural spring).
- How to contact the landowner and emergency help (e.g., sheriff, fire, hospital).

Post trailhead information on a large rectangular board, sized to include all relevant information. To protect signs from weather, build a small roof over the sign board and/or enclose signs in a shallow box with a window.

Lay out the trailhead sign in components that can be changed without remaking the entire sign. Print signs in fade-resistant ink. (Photographs and some inks fade when exposed to sunlight.) Make letters at least 1 inch for headers and ¼ inch for body text.

FIGURE 24. These plastic blazes (confidence markers) for three color-coded trails were affixed with aluminum nails. Their angle indicates users need to veer left. ***Photo by Becky McPeake, UA Division of Agriculture, Cooperative Extension Service.***

Confidence Markers. Blazes or confidence markers placed strategically along the trail (Figure 24) reassure users that they are on the trail. Place them at least every ¼ mile in open country and much closer where the trail could be lost (e.g., at significant turns, where the trail crosses roads or other trails or where the tread is indistinct from the surrounding landscape).

- Paint marks on trees or rocks; use a template to create a geometric design, and change colors for different trails in the same area.
- Use aluminum nails to fasten 4- to 6-inch steel, aluminum or plastic markers to a tree, or preferably a post, so they are visible in both directions along the trail.
- Inscribe a board or order prefabricated markers with an emblem, trail number or name routed, painted or burned into it.

Directional Markers. A directional marker may be needed to direct trail users to the trailhead or at a sharp bend, fork or trail crossing. At trail intersections, place a sign that provides information about where each trail leads and how far away the next significant feature can be found. Rounded posts provide the most flexibility in positioning directional signs to point in the correct direction. Fasten a crossbar beneath the soil to prevent vandals from twisting the post.

Warning Signs. The trailhead sign should alert trail users about hazards along the trail or environmental resources that require protection. Place warning signs where trail users actually encounter hazardous situations or fragile environmental resources. A good warning sign will tell trail users what to do or not do, why and what the consequences are. Be friendly, but persuasive. Consider using humor through your words or drawings. Drawings are as good as words if their meaning is clear.

The following are poor warning signs because they give no reason for the required action:

- *Stay Out!*
- *Keep Off*

Here are better warning signs:

- Be polite; give a reason:
  Please stay on the trail. Protect the fragile glade!
- More forceful:
  Stay behind the fence, dangerous water, strong currents!
- It may help to give a warning and explain the consequences:
  $100 fine for walking on the endangered running buffalo clover.
- Trail users appreciate humor and still get the message:
  Please stay on the trail so you don't disturb the rattlesnakes. (The real purpose is to keep people from trampling vegetation.)

  Please stay on the trail so you don't trample the poison ivy. (This may be the reason, or it may be a way to keep trail users from short-cutting a switchback.)
- You also can provide a mixture of signs along a trail, some that are polite and others that are more forceful:
  Please stay on the trail to protect fragile wetland plants.

  Walking on the trail is free. Walking on wetland vegetation costs $100.

Trail Maintenance

Good trails require little maintenance other than periodic removal of fallen trees or other hazards and delimbing or pruning to maintain trail width. A well-designed trail will keep surface water from running down the trail and eroding the pathway and surrounding environment. The goal is to keep tread material on the trail and keep it well drained. Standing water results in soft, boggy tread or failure of the tread and support structures. If problems arise such as water damage to your trail, consider rerouting the problem sections. Some short sections of eroded trails may not be major problems and could eventually stabilize themselves. A short section of eroded trail may cause less environmental damage than construction of a longer rerouted section. Carefully weigh your options.

Good trails require little maintenance other than periodic removal of fallen trees or other hazards and delimbing or pruning to maintain trail width.

Removing Slough and Berm

On hillside trails, slough (pronounced "sluff") is soil, rock and debris that has moved downhill to the inside of the tread, narrowing it. Slough needs to be removed (Figure 25). Removing slough is hard work and is often not done adequately. Leaving slough is another reason trails "creep" downhill. Loosen compacted slough with a mattock or Pulaski, then remove the soil with a shovel or McLeod. Use excess soil to fill holes in the tread. Reshape the tread to restore its outslope. Avoid disturbing the entire cutbank unless absolutely necessary.

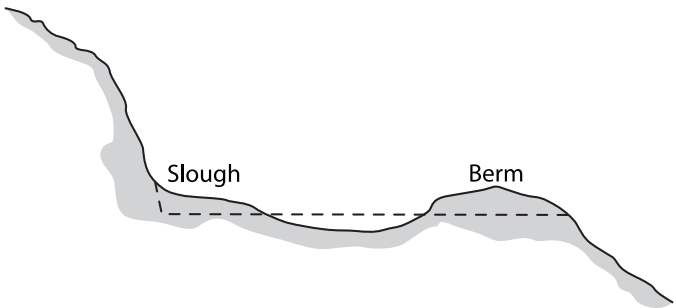


FIGURE 25. Remove the slough and berm, leaving the trail outsloped so water will run off. One fist's worth of drop for the length of a Pulaski is a good rule of thumb.

Berm is soil that has built up on the outside of the tread, forming a barrier that prevents water from running off the trail. Berms are a natural consequence of tread surface erosion and inadequate compaction during construction. Berms prevent water from flowing off the trail. Water runs down the tread itself, gathering volume and soil as it goes. Berm formation is the single largest contributor to erosion of the tread surface. Removing berms is almost always the best practice. Observe erosion on trails with and without berms. See what works best in your area.

Berms, especially when associated with tread creep, may form a false edge. A false edge has almost no ability to bear weight. This is probably the least stable trail feature on most trails and the major contributor to step-throughs and wrecks. Berms should not be constructed intentionally. Maintaining an outsloped tread will keep users on the center of the trail and water off of it.

Pull the lower edge berm back onto the tread surface and use it to restore the outslope. Use any slough material in the same fashion. Remove and widely scatter organic debris well beyond the clearing limits, preferably out of sight.

Tread Maintenance

Tread maintenance (Figure 26) aims for a solid, outsloped surface. Remove all the debris that has fallen on the tread, the sticks and stones and candy wrappers. Maintain tread at the designed width. This means filling ruts, holes and low spots. It includes

FIGURE 26. Trails may require periodic maintenance to fix problems with slough and berm. ***Photo courtesy of the National Park Service.***

removing obstacles such as protruding roots and rocks. It also means repairing any sections that have been damaged by landslides, uprooted trees, washouts or boggy conditions.

If puddling continues to occur on an existing trail, a knick (dip) may be constructed to move water off the trail. A knick is usually about 5 feet long and in a semicircle to remove water from a puddling area.

Removing Roots and Stumps

Removing roots and stumps is hard work. Explosives and stump grinders are good alternatives for removing stumps, but chances are you'll have to do the work by hand. A sharpened pick mattock or Pulaski is most often used to chop roots. If you are relying on some type of winch system to help pull out the stump, be sure to leave the stump high enough to latch on for leverage.

Not all roots and stumps are problems. Before removing, consider whether a stump was left the last time around to help keep the trail from creeping downhill. If roots are perpendicular to the tread, fairly flush and not a tripping hazard, leave them. Remove roots that are parallel with the tread (Figure 27). They cause erosion and create slipping hazards. Look for the reason the roots were exposed and fix that problem.

Rock Removal

The secret to moving heavy rocks is to think first. For very large rocks, motorized equipment, drills and blasting may be required. Other solutions include ramping the trail over them or rerouting the trail around them.

FIGURE 27. Roots which run parallel to the tread create soil erosion and are a tripping hazard. ***Photo by Becky McPeake, UA Division of Agriculture, Cooperative Extension Service.***

Smaller rock-moving jobs require some of the same processes and tools used for removing larger rocks. Plan out where the rock should go and anticipate how it might roll. Be patient – moving rock in a hurry almost always results in the rock ending up in the wrong location.

Tools of the trade include:

- Lots of high-quality rockbars; don't settle for the cheap digging bars; you need something with high tensile strength.
- Pick mattock.
- Sledge hammer.
- Eye protection, gloves and hardhat; don't even think of swinging a tool at a rock without wearing these.
- Gravel box, rock bag, rucksack, rock litter; items useful for carrying rock of various sizes.
- Winch and cable systems; some rocks can be dragged or lifted into place.

When dealing with rocks, work smarter, not harder. Skidding rocks is easiest. Rolling them is sometimes necessary. Lifting rocks is the last resort.

The two most common injuries in rock work are pinched (or smashed) fingers and tweaked (or blown out) backs. Both sets of injuries are a direct result of using muscles first and brains last. High-quality rock work is almost always a methodical, even tedious, task. Safe work is ALWAYS faster than taking time out for a trip to the infirmary. Keep your fingers clear any time you deal with rocks. Twisting your upper body while holding a heavy rock usually isn't a good idea. When lifting rocks, keep your back straight and lift with the strong muscles of your legs.

Rockbars work great for moving medium and large rocks. Use the bars to pry rocks out of the ground and then to guide them around. When several people have two or three bars under various sides of a large rock, they can apply leverage to the stone and virtually float it to a new location with a rowing motion. Use small rocks or logs as a fulcrum for better leverage.

It may seem like fun at the time, but avoid the temptation to kick a large stone loose. When rocks careen down the hillside, they may knock down small trees, gouge bark, wipe out trail structures and start rockslides. Even worse is the possibility an out-of-control rock might cross a trail or road below you, hitting someone. If there is any possibility of people below, close the trail or road or post sentries in safe locations to warn travelers of the danger.

You might construct a barrier by laying logs against two trees to stop a rolling rock before it gains much momentum. Once a rock is loose, do not try to stop it.

To load a large rock into a wheelbarrow, lean the wheelbarrow back on its handles, roll the rock in gently over the handles (or rocks placed there) and tip the wheelbarrow forward onto its wheels.

To Learn More . . .

This handbook provides a basic introduction to trail development. Experts who have experience in planning and constructing trails include the U.S. Forest Service, Arkansas State Parks, city parks department or others in your area. Listed below are some statewide contacts about various aspects of trail construction. Additional written references are listed and provide more detailed descriptions of procedures for trail design and maintenance.

- **District Conservationist.** For rules affecting trails over streams and wetlands, contact the USDA Natural Resources Conservation Service – Arkansas at 501-301-3122 or visit a local service center (www.ar.nrcs.usda.gov).

- **City/County/State Roads and Highways.** Contact the governing road authority to learn about rules for trails that cross or follow roads.

- **Arkansas State Highway and Transportation Department.** Their Recreational Trails Program provides funding to local project sponsors (public and private/nonprofit agencies) for construction and maintenance of motorized and non-motorized recreational trails and trail support facilities (501-569-2209; http://www.arkansashighways.com/recreational_trails.aspx).

- **Arkansas Department of Parks and Tourism.** For information about building trails in Arkansas, call 501-682-7777 or visit a nearby state park and ask to speak with a trail construction expert.

- **University of Arkansas Cooperative Extension Agent.** County-based assistance with soil samples, plantings, herbicides, some wildlife and pond management. Contact the University of Arkansas Division of Agriculture Cooperative Extension Service, 501-671-2000, and ask for the Extension agriculture agent in your county, http://www.uaex.uada.edu/.

- **Watchable Wildlife Program.** Listings of trails and tips for watching wildlife in Arkansas. Contact the Arkansas Game and Fish Commission, 1-800-364-4263, and ask for the Watchable Wildlife Coordinator, or go online at http://www.agfc.com/species/Pages/SpeciesWatchableWildlife.aspx.

- **Arkansas Stream Teams.** Biologists provide assistance with streambank stabilization projects, constructing culverts and reducing soil erosion. Contact the Arkansas Game and Fish Commission, 1-800-364-4263, and ask for the Stream Team Coordinator in your area, or go online at http://www.agfc.com/fishing/Pages/FishingProgramsAST.aspx.

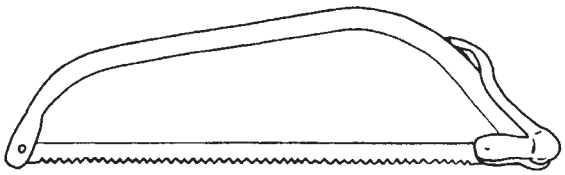
- **Arkansas Trails Council.** The Council can help locate trail groups in your area as well as trail events and training opportunities. Members are charged with building and maintaining the Arkansas Trails System List, which is comprised of some of the best trails in the state. The Council strives to provide the managers of the trails with some well-deserved recognition. Any trail is eligible, and anyone can apply to be on the list. Information including trail building resources is available at http://www.arkansastrailscouncil.com/.

Appendix A: Tools for Trail Building

Removing Small Trees, Shrubs and Limbs from Large Trees

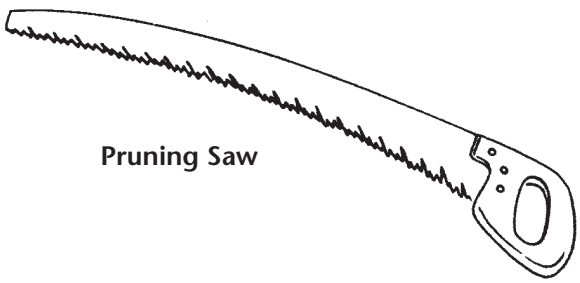
- **Lopping Shears.** Most lopping shears with scissor or anvil heads cut stems up to 1-inch in diameter; some models cut 3-inch stems. Overall length is 26 to 35 inches. Longer handles offer a greater reach and cut larger stems more easily. Ratchet heads offer powerful cutting with short handles.

- **Bow Saw.** Bow saws vary in length. A 24- to 30-inch blade will cut 6-inch diameter wood. It cuts horizontal logs more efficiently than standing trees. Some models fold for easy carrying.



Bow Saw

- **Pruning Saw.** A pruning saw's curved blade cuts on the pull stroke. Models with 6- to 10-inch blades and folding handles can be carried in your pocket and cut limbs up to 3 inches. Models 14 to 21 inches long with fixed handles cut limbs up to 6 inches.



Pruning Saw

- **Pole Saw.** A pole saw has a 14- to 17-inch curved blade attached to a 4-foot or longer handle. Use it to prune high limbs. An additional limb hook is useful for pulling down cut limbs that get hung up in a tree. Some models have a scissor- or anvil-type pruning head in addition to a saw.

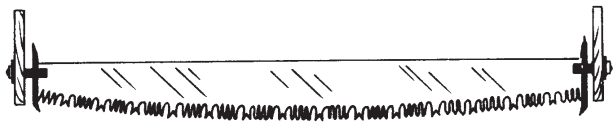
- **Pole Pruner.** A pole pruner with a scissor or anvil pruning head attached to a 10- to 12-foot long pole (often breaks down into two pieces for easier carrying) cuts high limbs up to 1¼-inch diameter. Use a pole pruner to cut flexible limbs, but use a pole saw to cleanly cut limbs close to the main tree stem.

Cutting Large Trees

Training is necessary before using any mechanical equipment and in particular these saws:

- **One-Person Crosscut Saw.** A one-person saw, from 3 to 4½ feet in length, will fell trees or cut logs from 6 to 16+ inches in diameter.

- **Two-Person Crosscut Saw.** Use a two-person crosscut saw to fell trees or cuts logs from 6 to 16+ inches in diameter.



Two-Person Crosscut Saw

- **Chain Saw.** A chain saw with a 16- to 24-inch bar cuts most trees and logs. Carry extra bar oil, fuel and chain file. Wear a hardhat with face shield, ear muffs, long-sleeved shirt, gloves, tear-resistant pants or chaps and sturdy boots.

- **Chain Saw-Powered Stump Grinder.** Cuts stumps, prunes and removes roots, clears brush, minor dirt work. Relatively small and portable.

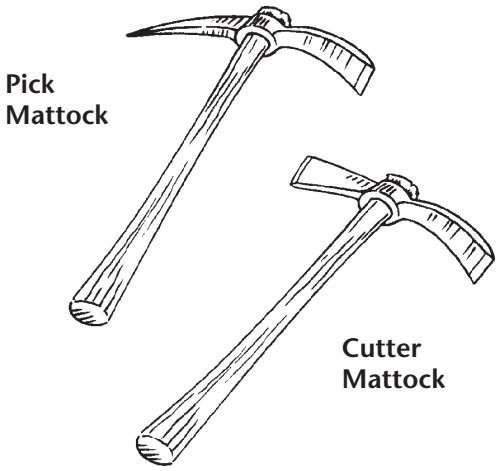
- **Pry Bar.** Use a tempered steel pry bar approximately 1 inch in diameter and 4 to 6 feet long to move logs and boulders. Or cut a tree about 4 inches in diameter and 10 feet long for prying.

- **Plastic Wedge.** When felling a tree, place plastic wedge(s) in the back cut to prevent the tree from leaning back and pinching the saw blade.

Removing Stumps and Boulders

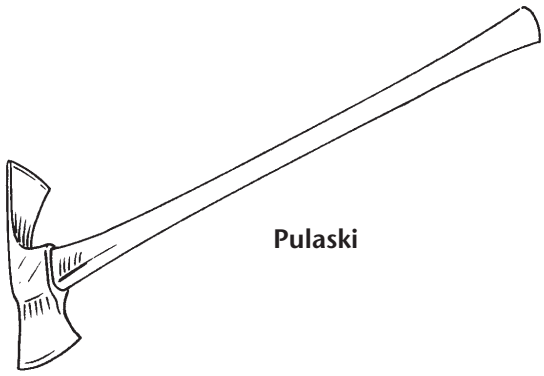
- **Shovel.** Select a shovel with a long handle, wide blade and pointed but curved tip. Never use a wooden-handled shovel as a pry bar.

- **Pick Mattock.** A pick mattock has a wooden handle about 3 feet long and a steel head with a 4-inch-wide strong hoe on one side and a long spike on the other side. Use it to dig up stumps, rocks and compacted soil.



- **Cutter Mattock.** A cutter mattock has a wooden handle about 3 feet long and a steel head with a 4-inch-wide strong hoe on one side and a long narrow (dull) ax on the other side. Use it to dig up stumps, rocks and compacted soil and cut tree roots.

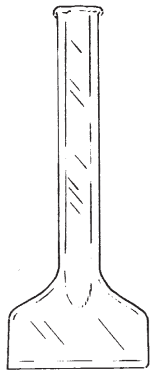
- **Pulaski.** A Pulaski has a wooden handle about 3 feet long and a steel head with an ax on one side and a lightweight mattock head (narrow hoe) on the other side. Use it to dig up tree stumps and cut roots.



- **Ax.** Look for a long-handled ax to cut tree roots, split wood or cut a felling notch into a large tree. When felling trees or cutting logs, use a saw for greater safety and efficiency. A single-bladed ax with a hammer head on one side can be used to pound stakes and wedges, but a sledge hammer is safer.

- **Steel Wedge.** Use a steel wedge with a sledge hammer to split wood.

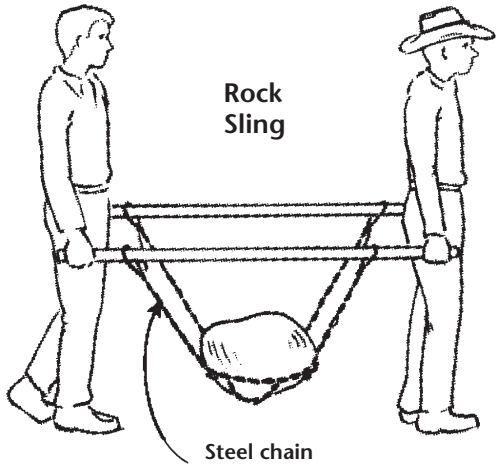
- **Rock Chisel.** Split or break rocks using an 8- to 12-inch-long chisel with a broad chisel tip and a 3- to 5-pound hammer.



- **Feather Wedges.** Use a hammer to drive this set of three wedges into a wide crack to split a boulder. These wedges will not become stuck in a boulder as will a single steel wedge or rock chisel.

- **Sledge Hammer.** Use sledge hammers in various weights to pound rock chisels, wood chisels and feather wedges. A sledge hammer is also used to break off large rocks protruding into the tread.

- **Rock Sling.** A rock sling is shaped like a litter/strecher. Two to four people use it to carry heavy rocks. Its two poles may be steel pipe or wooden poles about 6 feet long. The sling, fashioned from chain or strong rope, should sag close to the ground when a rock is rolled into the center.



- **Rock Bag.** Use this canvas bag with loop handles to carry rocks, soil or duff.

- **Winch.** A ratchet winch gives a 2:1 mechanical advantage; a Griphoist® offers a 30:1 advantage to move boulders and tree stumps.

- **Power Drill.** A gasoline-powered drill (jack hammer or rock drill) with a chisel tip breaks up large boulders or bores holes into rock for inserting explosives.

- **Explosives.** Explosives may be necessary to uproot stumps or break large boulders. You need a license to purchase and use explosives. A Boulder Buster™ is an alternative device that requires minimal certification and training but breaks boulders larger than 6 feet in diameter. It is a firing mechanism attached to a short pipe that fits into a rock crevice or hole, a steel plate that covers the hole and an explosive charge about the size and shape of a shotgun shell.

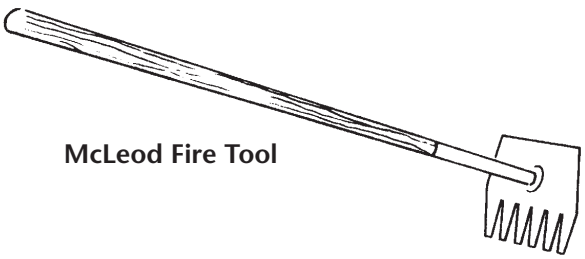
- **Bulldozer.** Use a small bulldozer with a roll bar and steel cage to clear rocks and trees and to excavate and level the tread. To uproot a large tree, cut off the stem leaving a 4-foot-high stump for the bulldozer blade to push against. Use the blade to undercut roots on each side of a big stump before lifting it.

- **Mini-Excavator.** Size varies, but the smallest mini-excavator has caterpillar treads that span only 4½ feet, a cab for the operator and a mechanical arm with a bucket at the end. Use it to excavate soil, rocks and tree stumps. On a steep slope it can excavate soil to form a flat trail bed ahead of its treads.

Moving Soil, Duff and Fill Material

- **Shovel.** Select a shovel with a long handle, wide blade and pointed but curved tip.

- **McLeod Fire Tool.** A McLeod fire tool has a 6-foot handle and steel head with a 10-inch-wide hoe on one side and a heavy-duty rake on the other side. Use it to clear small rocks, twigs and branches and to loosen soil to smooth a tread.



McLeod Fire Tool

- **Duff Blanket.** Rake or shovel duff from the trail bed onto a sheet of canvas or other heavy fabric, draw the four corners together, then carry the lightweight duff away and dump it.

- **Bucket.** Use 5-gallon plastic buckets with wire handles to haul fill material by hand.

- **Fill Boxes and Bags for Horses/Mules.** In remote areas, mules and horses can carry fill material in wooden boxes or heavy fabric bags attached to each side of a loading frame saddle.

- **Wagon.** Use a small wagon, especially one with a dump bed, to move fill material and supplies. Pull it with an ATV or other appropriate vehicle.

Safety Equipment

- **Hard Hat.** Wear a hard hat when felling trees, cutting branches over your head or whenever there is a possibility of being hit by flying or falling debris. When operating a chainwale, attach a face shield to the hard hat.

- **Safety Goggles/Glasses.** Wear safety goggles or glasses for all trail-clearing work, especially when working in a forest or brushland or when cutting or chopping wood and breaking rocks.

- **Ear Muffs.** Ear muffs for sound protection are essential when operating or working near noisy equipment.

- **Long-Sleeved Shirt and Pants.** They are nearly always appropriate to wear for protection from minor scrapes, cuts, punctures, irritating plants, biting insects and thorns, or when operating power tools.

- **Tear-Resistant Pants or Chaps.** Wear these when operating a chain saw or working in thorny brush.

- **Gloves.** Wear gloves to protect your hands from blisters, cuts and scratches, and when operating a chain saw.

- **Boots.** Sturdy boots provide ankle support and protection from saw blades, thorns, sharp rocks and other hazards.

Tool Storage and Maintenance

- **Storage.** Make rectangular wooden boxes to haul long-handled shovels, pry bars, axes, Pulaskis, McLeod tools, etc. Carry small tools in plastic buckets and boxes.

- **Maintenance.** Clean tools to remove soil and rust. Use wire brushes, steel wool, scrub brushes and water as needed. Thoroughly dry tools, coat steel surfaces with oil to resist rust, sharpen cutting tools and hang them for long-term storage.

Appendix B: Trail Planning for Public Access

Trail User Preferences

As a general guideline for local trails, the target population should be < 5 miles from the trail. For regional trails, people may be willing to travel 15 or more miles to use a greenway trail. Accommodate multiple modes of travel, but consider separating conflicting use (e.g., biking and horseback riding).

Human psychology also plays a role in trail planning. A useful trail must be easy to find, easy to travel and convenient to use. Trails exist simply because they are an easier way of getting someplace.

Greenway trails have documented low crime rates compared to other developed land uses. Vegetation can be managed to reduce the perception of fear or crime. Dense, naturalistic vegetation along one side of a trail is not perceived as unsafe as long as the other side is visually open. Provide 100 feet of both forward and rear visibility on trails where possible.

Trail Layout

A connected trail system offers a more pleasant, safe and continuous recreational experience than unconnected trails. Design trails to provide safe passage across potential barriers such as roads (e.g., through trail bridges and underpasses). Abandoned railroad lines may be converted to trails, often serving as an important regional trail in an area.

Requirements for trail planning vary, but they usually include an understanding of your soil, water and wildlife. They may also include construction skills such as building boardwalks or culverts and landscape design such as trail and bench placement. Communicating with persons skilled in documenting environmental and permitting requirements may also be required.

Align trails along or near existing human-created or natural edges rather than bisecting undisturbed areas. Riparian (streamside) corridors are critical areas for many ecological functions which can be negatively impacted by poorly designed and managed recreational trails. To minimize impacts and maintenance issues, locate the primary trail to the outside of the riparian corridor and then provide access to the riparian area at strategic points.

See the References section for additional resources about trails for public use.

Converting Pathways to Trails

Sometimes existing pathways such as abandoned railways or logging roads can also be used as trails. Or trails can be designed for future conversion to logging roads if a timber harvest is planned in future years.

Modifying Logging Roads. If a logging skid trail or haul road will be used both for logging and recreational use, design it to accommodate logging equipment. If the skid trail or road will not be used for 10 years for logging purposes, then design it more like a recreational trail. When the time comes to use it for logging, make temporary modifications (e.g., harden the tread, install temporary stream-crossing devices for heavy equipment, expand the clearing width and install more durable culverts or other drainage devices).

Converting Railroad Grades. Ballast stones make a poor tread. The stones are uniform in size and provide fast water drainage, but the surface is rough and the stones are subject to displacement. A thin layer of ballast stones makes a good base on which to place a more compacted surface of soil or small gravel. If the railroad bed is too narrow, remove some fill to achieve a wider bed. If land ownership permits it, divert the trail off the railroad bed from time to time to relieve boredom from long, straight sightlines. Save bridges, but modify decks and railings to create a tread surface and width suitable for trail users.

Appendix C: References and Additional Resources

Appalachian Trail Design, Construction and Maintenance by William Birchard, Jr., and Robert D. Proudman, 2000.

Baughman, Mel, and Terry Serres, Trail Design for Small Properties. 2006. St. Paul, MN: University of Minnesota Extension. 30 p. Copies available from Extension Store as Item #08425, http://shop.extension.umn.edu/PublicationDetail.aspx?ID=1817, or call 1-800-876-8636.

Bentrap, Gary. Conservation Buffers: Design Guidelines for Buffers, Corridors and Greenways. 2008. USDA Forest Service. http://www.unl.edu/nac/bufferguidelines/doc/conservation_buffers.pdf

Building Dry Stone Retaining Walls. National Center for Preservation Technology and Training, National Park Service – Cultural Resources, Department of the Interior. Web video 2002-06, March 2009. www.ncptt.nps.gov

The Complete Guide to Trail Building and Maintenance by Carl Demrow and David Salisbury, 1998.

Equestrian Design Guidebook for Trails, Trailheads and Campgrounds by USDA Forest Service. http://www.fhwa.dot.gov/environment/fspubs/07232816/index.htm

Equestrian Trail Guidelines for Construction and Maintenance by Missouri Department of Conservation. http://mdc4.mdc.mo.gov/documents /16131.pdf

Hesselbarth, Woody, Porian Vachowski and Mary Ann Davies. Trail Construction and Maintenance Notebook. U.S. Department of Transportation, Federal Highway Administration. 2007. http://www.fhwa.dot.gov/environment/fspubs/07232806/

Lightly on the Land: The SCAD Trail-Building and Maintenance Manual by Robert C. Birkby, 1996.

Low-Water Crossings: Geomorphic, Biological, and Engineering Design Considerations by Kim Clarkin, Gordon Keller, Terry Warhol and Suzan Hixson. USDA Forest Service publication with accompanying AutoCAD drawing CD. 2006. http://www.fs.fed.us/eng/pubs/pdf/LowWaterCrossings/Lo_pdf/1_Intro.pdf

National Off-Highway Vehicle Conservation Council's (NOHVCC) Trail Building Resources. Develops and provides a wide spectrum of programs, materials and information, or "tools," to individuals, clubs, associations and agencies in order to further a positive future for responsible off-highway vehicle recreation. http://nohvcc.org/education/

Recreational Horse Trails in Rural and Wildland Areas: Design, Construction and Maintenance by Gene W. Wood. http://www.Clemson.edu/for/book_form.htm

So You Want to Build a Trail – A Guide to Developing Urban Trails by Arkansas State Parks. To get a free copy, e-mail John Beneke, State Trails Coordinator, Arkansas State Parks, at john.beneke@arkansas.gov.

Trail Construction and Maintenance Handbook by U.S. Department of Transportation, Federal Highway Administration. www.fhwa.dot.gov/environment /fspubs/07232806/page02.htm

Trail Planning, Design and Development Guidelines (for trail building professionals) by Minnesota Department of Natural Resources, www.minnesotasbookstore.com, 651-297-3000.

Trail Solutions: IMBA's Guide to Building Sweet Singletrack by International Mountain Bicycling Association, 2004.

Trails Training DVD Series by the USDA Forest Service and the U.S. Department of Transportation. www.fhwa.dot.gov/environment/rectrails/trailpub.htm

U.S. Department of Transportation, Federal Highways Commission. Recreational Trails Program: Publications. http://www.fhwa.dot.gov/environment/rectrails /publications.htm

Wetland Trail Design and Construction by U.S. Department of Transportation, Federal Highway Administration. http://www.fhwa.dot.gov/environment/fspubs /01232833/toc.htm

Woodland Trails Layout, Building and Maintenance by Shad Baker, in *Kentucky Woodlands Magazine*, 4(1), April, 2009.

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> Baughman, M., and T. Serres, *Trail Design for Small Properties*. 2006. St. Paul, MN: University of Minnesota Extension. 30 p. Copies available from Extension Store as Item #08425, http://shop.extension.umn.edu/PublicationDetail.aspx?ID=1817, or call 1-800-876-8636.

We also appreciate Gary Bentrup for permission to use portions of *Conservation Buffers: Design Guidelines for Buffers, Corridors and Greenways*, USDA Forest Service, available online at http://www.unl.edu/nac/bufferguidelines/docs/conservation_buffers.pdf.

Another resource for this publication was *Trail Construction and Maintenance Notebook* by Woody Hesselbarth, Brian Vachowski and Mary Ann Davies of the U.S. Department of Transportation, Federal Highway Administration, which can be found online at http://www.fhwa.dot.gov/environment/fspubs/07232806/.

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