Trail Design and Maintenance

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Stewardship Handbook
for Natural Lands in Southeastern Pennsylvania

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TRAIL DESIGN AND MAINTENANCE

General Guidelines

In general, three types of guidelines should be followed in constructing new trails and maintaining existing trails: ***recreation enhancement***, ***environmental protection***, and ***public use and safety***. If followed during trail layout, they will result in trail alignments that offer a more aesthetically pleasing and varied recreational experience, a more stable trail that can be maintained with less expense, and a safer and more enjoyable outdoor experience for users. The more time and thought that is put into the trail planning phase, the better the trail is likely to be. Well-designed trails take advantage of natural features, are low maintenance, and meet the needs of the user. The trail should meander around trees and rocks, follow the shape of the land, and otherwise take advantage of natural land features. The best trails show little evidence of the work that goes into them. A little extra effort spent widely scattering cut vegetation, blending slope cuts, or raking leaves back over fillslopes pays off in a more natural-looking trail.

Recreation Enhancement

- Trails should be varied so as to enhance the user's enjoyment and visual experience.
- Trails should provide scenic views and incorporate points of interest such as historic structures or sites, wetlands, ponds, or rock outcrops. Main trails should bypass these resources where possible, with only secondary trails providing access to them.

- Trails should be buffered from the sight, sound, and hazards associated with man-made features, including roadways, buildings, and urban or suburban land uses.
- The trail designer should make creative use of vegetation to enhance the hiking experience.
- The trail designer should route trails through varied types of plant cover, avoiding alignments through continuous stands of similar vegetation.
- Trails should not have long straight sections that are unbroken by vegetation or topography. Short trail sections with many broad turns are desirable.
- Sudden changes in direction or too much meandering should be avoided, except where switchbacks are needed to negotiate a long steep slope.
- Planting showy native plants and butterfly or hummingbird-attracting plants in a naturalistic style in key areas along trails can greatly improve user enjoyment.
- Locating resting areas (benches or access to large, flat-topped boulders) near features such as streams and ponds will allow users opportunities to pause and enjoy the sights and sounds of the resources on the property.

Environmental Protection

- Every attempt should be made to position trails outside of environmentally sensitive areas, but, with careful planning, a trail may incorporate special features of the landscape into its design with minimal environmental impact.
- When locating a trail, primary emphasis should be placed upon characteristics of soils and topography that control trail stability.
- Trails should follow the contour of the landscape.
- Trails should not go straight up steep grades.
- Areas having slopes in excess of 20% should be avoided, unless those areas are to be paved or otherwise stabilized (e.g., steps).
- Soils that are deep, well drained, resistant to erosion, and do not have high seasonal water tables are most suitable for trail development.
- Where trails follow steep grades, sidehilling—cutting a notch and sometimes filling to form a narrow bench—should be used to reduce erosion and improve surface drainage.
- Switchbacks should be used when going up steep gradients where sidehilling cannot gain elevation fast enough.
- Switchback segments should not be visible from one another.
- Wide turns should be used in switchbacks to limit shortcutting, particularly where the trail is in an open hardwood forest where users can see ahead. Visual anchors should be used to encourage users to follow the trail.
- Trail layout should minimize impact on sensitive resources, such as wetlands. If highlighting these areas, special precautions should be taken to reduce the impact of hikers through the use of bridges and elevated walkways.
- Side trails leading to fragile resource areas should generally be longer and more difficult to discourage the majority of main trail users from using them.

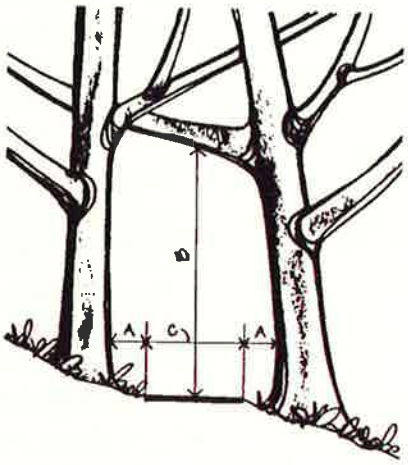
Public Use and Safety

- Where there are road crossings, the hiker's exposure should be minimized by crossing in the shortest practical manner, usually at right angles, with adequate sight distances.
- Trails should not parallel road rights-of-way.
- Trails should avoid areas of streams and ponds with steep banks, deep water, or other potential hazards to children.
- Where trails are in the vicinity of urban or suburban land uses, they should have a buffer as wide as possible and sight lines as long as possible to keep potential conflicts with adjacent landowners to a minimum.

TRAIL CLEARING DIMENSIONS

Hiking
A = 1′
B = 6′–8′
C = 1½′–2′

Equestrian
A = 2½′
B = 10′
C = 3′



PA DER, *Bureau of State Parks, Division of Outdoor Recreation, The Pennsylvania Trails Program, 1980.*

Trail Construction

Constructing good, easily maintained trails and their associated structures is somewhat complicated. The basic concepts are described below, but please refer to **Additional Information Sources**, *page 217*, for detailed reference manuals on the subject.

Trail Clearing

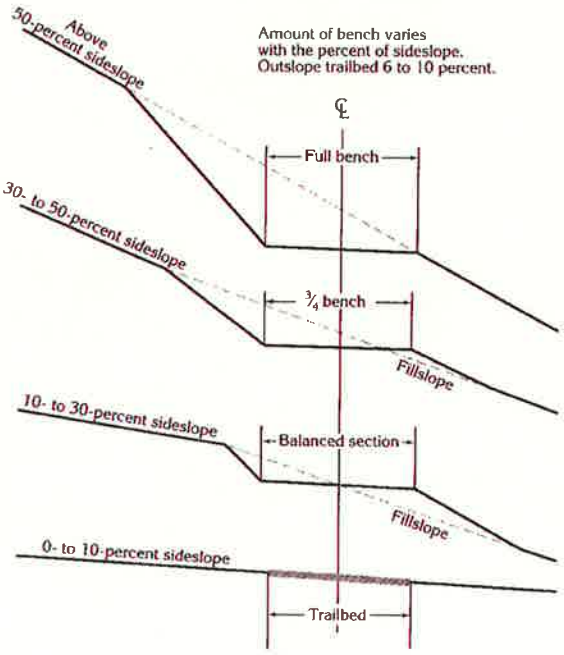
When rerouting an old trail or establishing a new trail, the general alignment should be walked and flagged to determine exactly how the treadway should wind and dip, which rocks should be removed, and which trees might need to be cut. This is a critical step in the trail building process, as slight shifts in the alignment can significantly affect drainage and treadway durability.

After the precise location of the trail is determined, the treadway should be cleared. For hiking trails, an 18–24-inch wide treadway should be cleared with all projecting limbs cut back an additional 1 foot. For equestrian trails, a 3-foot-wide treadway should be cleared with all projecting limbs cut back an additional 2½ feet for a total horizontal width of 8 feet. The trail should be cleared to a vertical height of 6–8 feet for a hiking trail and 10 feet for an equestrian trail.

In clearing trails all shrubs, vines, low-hanging branches, blowdowns, small trees, and fallen logs should be removed. Logs and rocks can be used along the trail edges and as anchors and points of interest. Shrubs and small trees should be cut flush with the ground surface. Care should be taken not to disturb the ground surface or to pull plants out by the roots as this will lead to erosion of the treadway. Large trees fallen across the trail should be left in place by making two cuts and removing a 4-foot-wide section from the trunk across the trail. If motorbikes or mountain bikes are a potential problem, the logs can be notched to provide a flat surface for hikers, yet prohibit the passage of wheeled vehicles.

When clearing is completed, cuttings should in general be scattered in areas adjacent to the trail and left to decompose. It may be necessary to collect

TYPICAL TRAIL CROSS SECTIONS



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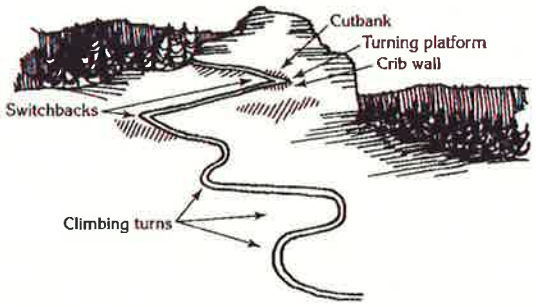
SWITCHBACKS AND CLIMBING TURNS



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Climbing turns can be built on gentler slopes, usually not more than 15–20%. Switchbacks are needed on steeper slopes.

the cuttings and remove them from the immediate trail area where the trail runs through more formally landscaped areas such as along public roads and through suburban developments.

In the first year of a trail's use, repeated clearing is required to deter continued vegetation growth. In subsequent years, clearing will probably be necessary only two or three times a year. An exception would be in open fields and grassy areas where mowing is required to maintain a clearly visible treadway.

Treadway Stabilization

The type of tread surface on trails will ultimately be determined by the rate of use, the terrain through which the trails pass, and the underlying soils. Initially, once a trail has been cleared, it should be surveyed to ascertain where special measures should be taken to stabilize the treadway, mainly treadway hardening and erosion control measures. Most problems are likely to occur where a trail traverses steep slopes or wet areas, or where surface water drainage flows across the trail during storms.

In most areas there will be no need for actual trail construction, as careful trail design should have selected stabilized areas. In existing stable areas with slopes of less than 10%, the exact alignment of the treadway can be delineated by sweeping herbaceous and trailing plants and leaf litter off the path. If, with time and use, initially stable areas begin to show signs of erosion, then some stabilizing type of material, such as crushed stone, should be integrated into the soil of the treadway.

Trails on Slopes

Where a trail cuts across a slope greater than 10% (1 foot rise for every 10 feet of run), a slightly outsloped or sidehill

treadway should be excavated to prevent trail widening and erosion *(top far left)*. Depending on the slope, the amount of excavation and the use of the excavated material varies. On steeper slopes, excavated soil is not used at all in the fillslope. This soft material is likely to erode away quickly, creating dangerous soft spots on the downhill edge of the trail. As the slope decreases, it becomes more feasible to use fill material as part of the treadway.

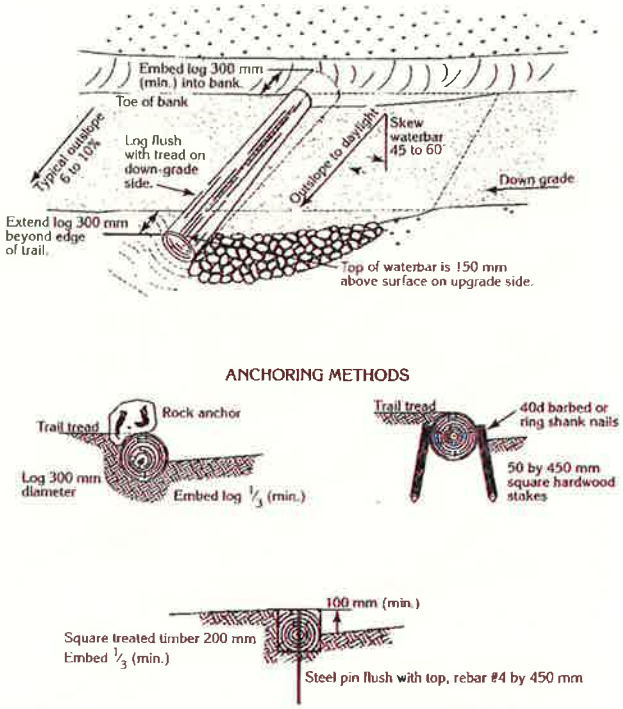
Switchbacks and climbing turns are used on steep slopes where sidehill trails alone cannot provide the needed rise in elevation in a limited distance. A climbing turn is a reversal in direction that maintains the existing grade going through the turn without a constructed landing. A switchback is also a reversal in direction, but has a relatively level constructed landing *(bottom far left)*. Switchbacks usually involve special treatment of the approaches, barriers, and drainages. Long sections of trail between these turns are usually better than short ones; fewer will need to be built and there will be less of a temptation to shortcut them. Both switchbacks and climbing turns take skill to locate and are relatively expensive to construct and maintain, therefore, every effort should be made to minimize their use when designing a trail.

Surface Water Control

Diverting surface water off the trail is one of the first priorities in designing and maintaining trails. Running water erodes the treadway and support structures and can even lead to loss of the trail itself. The first choice to address surface water is to enhance the natural drainage by outsloping the treadway and creating grade dips such as Coweeta dips, bleeders, or drainage dips. The aim is to take advantage of the natural topography wherever possible, making sure the water won't return to the treadway. A Coweeta dip uses a reversal in grade on sidehill trails to shed water continuously all along the trail segment. A bleeder is a shallow graded depression across the treadway. A drainage dip, appropriate only on grades less than 8%, is a channel reinforced with earthen mounds running diagonally across the treadway.

Waterbars are the second most common drainage structure after outsloping. They are diagonal rock or log barriers that divert water off the treadway *(above)*. Even though waterbars have been standard practice in the past, they should be avoided where it is feasible to use some form of a grade dip. By design, water hits the

LOG OR TREATED TIMBER WATERBAR AND ANCHORS



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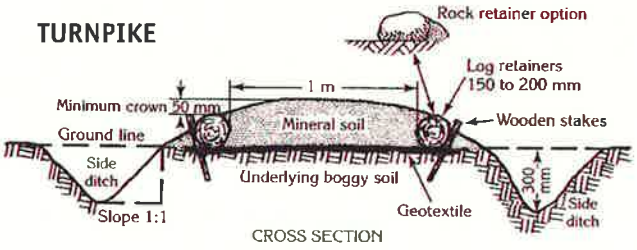
waterbar and is turned. The water slows down and sediment drops in the drain. The number one cause of waterbar failure is sediment filling the drain until the water tops the bar and continues down the trail, rendering the waterbar useless. A good grade dip can be built more quickly, works better, requires less maintenance, and is less obtrusive on the landscape.

Waterbars are useful on trails where there isn't much soil to work with, in areas that experience torrential downpours, and where a tripping hazard is acceptable. They may also be necessary when repairing older trails where no provision was made during design or construction for proper drainage.

Correctly installed, a waterbar must be constructed of rock or a rot-resistant type of wood. Logs should be a minimum diameter of 6–8 inches at the small end—greater if water flow is heavy—and all bark must be removed. It should be placed at a 30°–45° angle and extend at least 1 foot past the outside edge of the treadway on both sides. If the natural topography would allow water to return to the trail, it is essential that the situation be remedied by extending an outlet trench beyond the end of the rocks or log. Where water flow is heavy or the bar directs water down a steep slope, runoff may erode the soil adjacent to the treadway. Where this is a problem, rocks should be placed in the channel to slow the water and make it drop its sediment.

Drainage ditches are trenches along the side of a trail to collect water seeping from a hillside or runoff entering a trail that can't be immediately removed with a grade dip. The water can then be diverted across the treadway at appropriate points with a dip or water bar.



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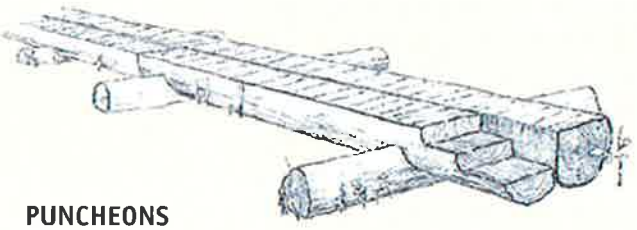
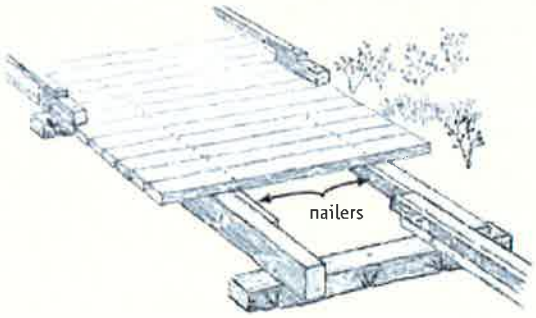


PUNCHEONS



US Department of Transportation, Federal Highway Administration

Trails in Wet Areas

Trails should be designed to avoid wet areas. Equestrian trails in particular should avoid small streams and wetlands if at all possible to prevent water degradation from erosion and excrement. Where this is impossible or an existing trail has developed a drainage problem, several options exist. Because nearly every technique for fixing trails in wet areas is expensive and needs to be repeated periodically, relocating the problem section of trail should be considered first.

Using stepping stones is a simple and relatively inexpensive technique for crossing small drainage swales and muddy

areas. The stones should be large, fairly flat on top, and buried such that they rise above standing water, but don't rock. Space the stones for the average stride, remembering that trails are for children, too.

Turnpikes are used to elevate the trail above wet ground. The technique uses fill material from parallel side ditches and from off-site, if necessary, to build up the treadway higher than the surrounding water table *(top far left)*. The most important consideration is to lower the water level below the treadway base and carry the water under and away from the trail at frequent intervals. Turnpike construction is used to provide a stable trail base in areas of high water table and fair to well drained soils. They are practical up to 10% grades.

A puncheon, or bog bridge, is a wooden walkway used to cross muddy areas *(bottom far left)*. It can be used where lack of tread material makes turnpike construction impractical or firm mineral soil cannot be easily reached; puncheons can be supported on muddy surfaces better than turnpikes, which require good drainage. They consist of decking made from flat-topped logs, called stringers, notched into base logs, or mud sills, set into firm ground. If firm footing is not available, use rock and fill to solidify the bottom of the trench they're set in, increase the length of the sill to give it better flotation, or use more sills for the needed flotation.

Crossing Drainage Swales, Streams, and Wetlands

For minor crossings of small streams and drainage swales, there is no need for construction of elaborate bridges. Natural stream crossings using stepping stones are ideal where the stream flow is generally low and there are not significant fluctuations, except following major storm events. The stepping stones should be large and flat-topped. They should be placed approximately 2 feet apart across the stream. Ideally, the bottom on which the stones are laid should be stone in order to prevent movement.

As an alternative to stepping stones, a simple bridge could be constructed of a single or double stringer with two base logs similar to the puncheon described above. The base logs should be placed on each bank above the flood level on a flat stone or ledge, secured with pins if possible. The stringer(s) should be secured to the base log on each end using 10-inch or 12-inch spikes or large bolts. Both the base logs and the stringers should be of rot-resistant wood, such as black locust, eastern red-cedar, or white oak, from which all the bark has been removed. To facilitate construction, crossing sites for bridges should be selected where the banks are the same height and midway between turns. A handrail is needed for safety only if the top of the stringer is more than 3 feet above the stream. The stringer surface should be randomly scored to provide safer footing when wet.

Any new stream crossing that involves a structure requires a permit from the Pennsylvania Department of Environmental Protection, Bureau of Dam Safety, Obstruction, and Stormwater Management.

Boardwalks are elevated post and decking structures that provide access to marsh and wetland ecosystems with minimal negative impacts. Boardwalks are usually constructed of wood and the foundation is usually a pier or wood post. If touching the ground or submerged in water, the posts most often are chemically treated with an oil- or water-based

wood preservative such as creosote, pentachlorophenol, chromated copper arsenate, or zinc chloride. These wood preservatives are toxic to the natural environment and can be harmful to human health. They do, however, add longevity and structural safety. Two alternatives are posts made from recycled plastics that do not release harmful chemicals into the ground or water and galvanized steel helical piers and anchors. The recycled plastic post is either mechanically driven to the depth of firm soil or bedrock or secured in a concrete footing set in an excavated hole. The helical piers and anchors screw into the ground quickly, much the same as a wood screw goes into a piece of wood. Railings are an optional consideration for boardwalks that meander through wetland habitat. When the height of the decking above the ground exceeds 30 inches, rails are recommended.

Permits may be required for a boardwalk. The US Army Corps of Engineers (for the Delaware River watershed: Philadelphia District, 215-656-6729; for the Susquehanna River watershed: Baltimore District, 410-962-3670) requires a permit for any discharge of fill within wetlands.

Abandoning Trails

When it becomes necessary to abandon a trail, it should be done effectively and with sensitivity. Restoring abandoned trails to a natural state requires as much attention and planning as constructing new trails. The goal is to reduce the continuing impact abandoned trails have on the landscape. Simple restoration may consist of blocking new shortcuts and allowing the vegetation to recover. "Planting" old tree stumps and placing rocks naturalistically within the old treadway helps give the trail immediate closure. Complex restoration projects include obliterating the trail, recontouring, and revegetating the treadway with appropriate plant species (*see* **Native Plant Materials**, *pages 172–200*). Careful monitoring and follow-up are necessary to ensure that eventually almost all evidence of the trail is gone.

Each abandoned trail should be closed. If the trail is not blocked to prevent further use, the trail may persist indefinitely. Closure is particularly important if stabilization and revegetation are being attempted. The abandoned treadway should be blocked to all traffic, recontoured, and disguised to prevent users from being tempted to take it. This work should be accomplished for all segments visible from trails that remain open.

If the section of trail to be abandoned is short, it is simplest to just pile brush along its entire length. If it is long, brush should be placed far enough along from its intersections with trails in current use to obscure the path. Extending the brush a few feet on either side of the entrance will help deter users from going around the blockage. If there are any areas of active erosion, these should be stabilized to restore the natural contour and drainage patterns. Revegetation can be accomplished passively or actively. Passive revegetation allows surrounding vegetation to colonize the abandoned trail. This works when erosion has been stopped, adequate precipitation occurs, and adjacent vegetation consists of desirable (native) species that spread and grow rapidly. Active revegetation ranges from transplanting onsite vegetation to planting seeds or propagated plants of appropriate native species (*see* **Native Plant Materials**, *pages 172–200*). Successful revegetation almost never is complete within a single season.

Trailheads and Parking Facilities

Determine where trailhead and parking should be located, taking into consideration safe vehicular access, site conditions suitable for construction of a parking area, proximity of neighbors, and ease of policing. Try to avoid locating parking facilities and trailheads in areas where the trail would deteriorate under heavy use. Before you finalize the site location, you should contact Pennsylvania One Call (1-800-242-1776) to determine if there are any underground utility lines near the site.

The most critical element in the design process is accurately projecting the number of parking spaces that should be constructed at a trailhead. Parking should be provided for the average high day of trail use. This would be a typical weekend day in the spring or fall. Do not attempt to design for a peak day.

The second most important step in the design process is the development of standard construction specifications for trailheads and parking areas. Functional, aesthetic, and maintenance considerations are important to establishing these specifications. The trailhead areas should be simple, well built to minimize maintenance needs, and attractive, blending in with the natural setting as much as possible, with a minimum of grading and vegetation disturbance. The entrance drive and parking areas should be properly constructed with crushed stone laid over a base suitable for soil and drainage conditions on the site. Asphalt paving should not be used except to stabilize high-traffic entrance and parking areas. Along the perimeter of the parking areas and where there has been clearing for construction, native plant species should be planted to restore the area after construction. Place a signboard or kiosk to provide users with rules and regulations, management information, maps, and other important information (see below).

Trail Signage

Trail signage is used to guide trail use and to provide information about features along the trail. Trailhead signage and kiosks provide basic information (e.g., name of property, property map), orient visitors to trail rules and regulations, such as the uses allowed on the trails and the times when the trails are open or closed, and present information about the property and the organization that owns and manages it. The trailhead is also an excellent location for distributing trail maps.

Along the trail, signage can be used to highlight natural features (e.g., large tree, unique geology), historical uses (e.g., old stone walls) of the property, or to illustrate the complex interactions in natural ecosystems. They are also a good way to inform visitors of ongoing restoration activities—such as riparian buffer plantings—and how it will improve the conservation value of the property. Although there are endless amounts of information that can be communicated on any property, interpretive signage should be: (1) limited in number and (2) concise (if possible, include illustrations or photos to make the intended point more clearly).

Other appropriate types of signage for trails indicate the distance to other locations, points of interest, or improvements (e.g., office, shelters) and inform users where they are leaving the property.

Trail signage should be constructed of materials that are in harmony with the natural environment and are sufficiently rot-resistant. Options include wood (black locust, white oak for posts; cedar for the sign), recycled plastic, metal, fiberglass embedded, laminated, or for very short-term temporary signs, paper. Wood signs should be ¾–1½ inch in thickness with wording inscribed using a router or sandblaster. The sign can either be left unpainted or painted with one or two contrasting colors.

If possible, the signs should be installed on 4-inch x 4-inch posts with zinc-plated, galvanized, or stainless steel hardware. To make it easier to read the sign, the top end of the post should be cut at a 45° angle; to prevent it from being uprooted, attached a cross-piece (wood, rebar, spikes) to the bottom of the post before backfilling the hole. Locate the sign carefully, keeping it off the pathway, but close enough that visitors notice it. Signs located near roads (particularly those in the right-of-way) may require a permit or be subject to size limitations. Check with the municipality (if a township road) or PennDOT (if a state road) to determine any restrictions.

If a sign is destroyed or removed by vandals, temporary signs made of laminated paper or paperboard can be used where critical information needs to be conveyed. These types of signs are also appropriate in cases where there is a temporary hazard or obstacle soon to be remedied (e.g., fallen tree, landslide, gully).

Trail Marking

Trail markers include cut or painted blazes on trees; wood, plastic, or metal marker tags; and marker posts. These markers are used to help travelers identify the trail corridor when the treadway is indistinct, the ground is covered with snow, or when the path is confused by multiple trails or obscured by weather such as dense fog. They should be used only when the trail is not obvious, there is a sudden change in direction, and at trail junctions.

As with signage, standards should be developed for marking a trail system. This includes color, placement, frequency, and form of the markers. A common system is to use a primary color for each major trail and to have a standard color for all secondary trails. This enables users to know when they have diverged from a main trail whenever they see that color, regardless of which of the major trails they may be following. Colors considered most visible by experienced trail builders include blue, red, yellow, white, and orange. Keep in mind the use of the trail when selecting a color—white might not be a good choice for a trail used in the winter.

Markers should be placed carefully. They should be as close to the trail alignment as possible and plainly visible when walking the trail in all seasons, preferably without the need for routine clearing of foliage. Eye level is generally considered most effective, slightly higher if the trail is used in winter. Large trees

should be used in preference to smaller ones and never use a dead tree. If markers are light-colored, dark trees should be used, and vice-versa. Markers should not be placed on trees or features that are important elements of a view or setting; they should be visible but not mar the visual character of the trail.

The frequency of marker placement is a balance between reassuring, not confusing, the user and maintaining the natural character of the trail. If part of a trail has markers, all of it should be marked, but abrupt changes in spacing should be avoided, as they are confusing to users. Be conservative. It's better to improve tread visibility than to rely on markers.

The marking decisions should be based on traffic traveling in both directions. Where a trail has a clearly defined treadway, markers should be placed only at points of possible uncertainty. Markers should be clearly visible from any point where the trail could be lost. When a trail turns into or off another trail or road, a double mark should be placed, one directly above the other. Then, after the change in direction, another marker should be placed so that it can be clearly seen from the turning point. Markers should also be placed immediately after road crossings in a location where it will not be affected by street maintenance or snow clearing activities and where it is unlikely to be vulnerable to vandalism.