PCTA Trail Skills College Curriculum

Field Reference

Course 200. Basic Trail Design

For curious trail workers who want to understand why so many trails are in bad shape because of how they were made. Learn how better design and layout makes trails more sustainable and less prone to erosion. Introduction to different trail design standards appropriate for different kinds of trails. This class is for anybody interested in these topics, but students with some trail building and maintenance experience will benefit the most.

STUDENT SKILL OUTCOMES:

- Appreciation of well planned trails versus trails that "just happen."
- A basic understanding of hillside hydrology and how trails should work.
- Some knowledge of basic trail design and layout principles.
- Developing "trail eyes" for control points, causes of erosion, and factors influencing sustainable trail grades.

KEY TERMS:

Control Points: specific locations on a landscape that a newly designed trail must pass through (positive control points) or avoid (negative control points). Examples of positive control points include low mountain passes, the best trailhead location, and ideal bridge locations. Negative control points include areas of highly erodable soils, avalanche chutes, and boulder fields, among others.

Curvilinear Alignment: The opposite of ***Fall Line*** alignment, curvilinear means the trail basically follows the contour lines of the topographical map. This alignment helps runoff to sheet across the trail without accumulating or diverting.

Fall Line: the shortest and steepest way down a hill, indicated by a clinometer or a rolling ball. Trails that follow the fall line are likely to erode badly and are impossible to drain. Ideally they should be relocated to follow the side slope at a grade less than 10% or have check dams installed to slow further erosion.

Grade: the angle or slope of any surface, though here most concerned with the grade trails climb, as well as that of tread out-slope, back-slope, and also of the natural hillside fall line or side slope. In trail work, grade is expressed as a percentage (%), determined by dividing rise (vertical) over run (horizontal). Most commonly in trail work grades are measured with an instrument called a clinometer. Note that clinometers have both a percent scale (usually on the right) and degree scale, which are not the same.

Hillside hydrology: generally describes how water from rain, melting snow, and seeps travels down natural slopes. Here we are especially concerned with how such water interacts with trails. Troy Parker uses the additional term, "tread watersheds", to describe the subsections of a hillside that shed water to a particular piece of trail between two drainage structures.

Maximum Sustainable Grade: Each trail's tendency to erode will be influenced by many factors, including Use type and level; Season of use; Precipitation volume and intensity; Soil type and durability. The more prone to erosion the tread is, the more gentle its maximum grade should be.

NEPA: A trail that is to be built or significantly relocated on any Federal land must follow guidelines of the National Environmental Policy Act to be sure that trail construction and use do minimal damage to fragile ecological, historical, or archeological resources. This involves the analysis by a variety of specialists, including botanists, wildlife and fisheries biologists, and archeologists.

Renegade Trail: (aka illegal trail) a trail built by individuals and groups without the permission or guidance of professional land managers. Such trails often are poorly designed, constructed, and maintained, leading to erosion and damage to wildlife, plant, and archeological resources.

Sheet Flow: the passage of rainwater and snow melt down a hillside as a thin layer, causing minimal erosion until it reaches a drainage. Such sheet flow, when it reaches a uniformly outsloped trail, simply crosses the trail and continues down the hillside. If it is interrupted by a flat, cupped, or insloped tread, the water is diverted down the trail and erodes the tread.

Trail Class: A rating indicating the level of development of a given trail. It is based on many factors including the land through which it passes, the intended users for whom it is designed and built, the resulting design parameters and its likely level of maintenance. Forest Service Trail Classes are 1 to 5 with 1 being most primitive, such as a faint wilderness trail, and 5 most developed, such as a paved trail. (See www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm especially pages 6-10.) A trail class is closely related to its difficulty level.

Topographic Turn: Better than a switchback or climbing turn, because they utilize a feature in the topography to wrap the trail around. Unlike "stacked" switchbacks, they are less detectable, and therefore less prone to cutting and erosion.

User Trail: (aka ***social trail, bootleg trail***) a trail created by the feet of users without proper design, construction, or maintenance. Some present few problems, while others are prone to erosion and damage habitat. A common problem is the development of a net of many such trails in an area, leading to user confusion and excessive impact on plants. See also, renegade trail.

KEY CONCEPTS:

1) Trail Origins:
   - Early Progression of Trails
   - Establishment of Federal Land Reserves
   - Renegade/ User Trails
2) Trail Planning and Design Process:
   - Establish User Type and Standards
   - Research: Topo maps, Land Management Plans
   - Identify Major Control Points
     – Areas the trail corridor needs to go to (positive) or miss (negative)
     – Major controls are identified before reconnaissance
   - Establish Broad Corridor Alignment
   - Minimize trail impacts on the environment if possible by avoiding meadows, prime habitat areas, and known nesting sites.
   - Get Big Picture Overview
   - Field Check by Reconnaissance
     – Establish minor control points
     – Assess land capabilities
     – Take advantage of inherent aesthetics
   - Plot Control Points and Trail Corridor
   - Bring In Resource Specialists
3) Trail Layout Process:
   - Hydrologic Influences of Trail Alignments
     – When trails divert sheet flow
     – Fall line trails cannot be drained
     – Arbitrary drainages/waterbars are not ideal
     – Better: curvilinear alignment, good outslope, full bench, grade reversals in natural drainages
   - Determine Maximum Sustainable Linear Grade
     – Use type, level; Precipitation volume, intensity; Soil type, durability
     – Rise over Run
   - Determine Grades Between Control Points
     – If too steep, add run with well-placed turns
   - Common Design Mistakes
     – Inadequate planning
     – Alignment too steep/on Fall line, Ridge tops, Flat/soggy land, Meadows
     – Lack of restoration
   - Flag the Trail Alignment
     – Clinometer use: Zeroing on a partner, Shooting grades across terrain
     – Flag between control points
     – Include grade reversals, especially in natural drainages
     – Loose flagging and tight flagging
4) Safety Documents and Concerns (for field exercise):
   - Personal Protective Equipment (PPE), Job Hazard Analysis (JHA)/ Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
5) Develop "Trail Eyes":
   - Notice trail grade, soil type, erosion concerns, control points

Figure 1. Control Points
(Image courtesy of the SCA)

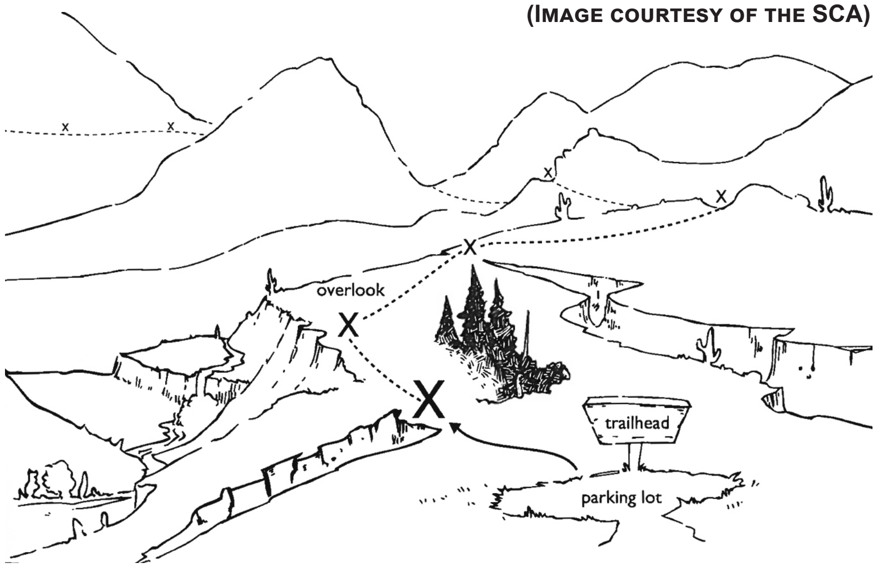
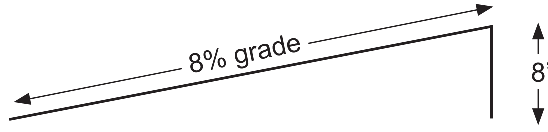


Figure 2. Frequency of Grade Reversals or Cross Drains
Source: Forest Service Trails Handbook 2309.18, Chapter 3,
Trail Pre-construction & Construction

	Grade (percent)						
Material Type	**2**	**4**	**6**	**8**	**10**	**12**	**15**
Loam	350’	150’	100’	75’	50’	*	*
Clay-Sand	500’	350’	200’	150’	100’	50’	*
Clay or Clay-Gravel	-	500’	300’	200’	150’	100’	75’
Gravel (rounded rock)	-	-	750’	500’	350’	250’	150’
Shale or Angular Rock	-	-	800’	600’	400’	300’	250’
Sand	Varies with local amounts of fine clay and silt. Drainage diversions generally are not required in “pure” sand because of the fast rate of water absorption. For sand with appreciable amounts of fine binder material, use “clay-sand” distances as shown above.						
* Grades not recommended in this material. - Generally no diversion required for soil stability.							

Figure 3. Calculating Percent of Grade



$$\text{Percent of grade} = \frac{\text{8 feet (rise)}}{\text{100 feet (run)}}$$