PCTA Trail Skills College Curriculum

Instructor Planning Guide

Course 205. Tread Re-Construction

This course goes beyond a triage approach covered in Course 203 Waterbars and Checks because reconstruction indicates a more thorough restoration of damaged tread to ideal specifications. Review hillside hydrology and how trails should work. Practice systematic slough & berm removal, re-cutting sidehill tread. Learn to reconstruct tread after gullying, tread creep, nasty roots, and uprooted trees. Pre-requisites: 201 and 203, or equivalent experience.

STUDENT SKILL OUTCOMES:

- Clear review of hillside hydrology, ideal trail design, and remedying cupped tread and restoring it to appropriate outslope by removing slough and berm.
- Understanding of the difference between of gullied trail on a sidehill, and gullied trail up the fall line (where only checks can remedy).
- Understanding of Tread Creep, Nasty Roots, Uprooted Trees and how to remedy.

KEY TERMS:

Review: Hillside hydrology, sheet flow, outslope, erosion, tread, slough & berm, outslope, cupped tread, grade dip, grade reversal, gullied tread, check dam. New: tread reconstruction, fall line, tread creep, re-cut tread, guide features, washout.

TOOLS NEEDED PER 8 STUDENTS:

2 fire shovels, 4 McLeods, 3 adze hoes, 3 Pulaskis, 2 pick mattocks, 1 small rock bar, 1 rheinhard, and/or any other tools used commonly for drainage work in your area. Tennis ball or orange.

WORK SITE REQUIREMENTS:

A section of trail near a trailhead that needs a variety of work, from brushing and log out to drainage structures and perhaps a special project (rock wall, stump removal, poor stream crossing)

TRAIL MAXIMS:

“Get the water out of the trail or the trail out of the water.” “Think like water.”

WORK SITE REQUIREMENTS:

One half mile section of trail, ideally near a trailhead, in need of tread reconstruction. Most importantly, it should contain a section where total slough and berm removal, plus restoration of outslope, could replace the need for waterbars or dips. Ideally it would need a variety of work including remedies for tread creep, gullying, nasty roots, and/or tree wells.

KEY CONCEPTS:

1) Safety Document and Concerns:
   - Personal Protective Equipment (PPE), Job Hazard Analysis (JHA), Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
2) Trail Crew Leave No Trace: Have a positive impact on the land through trail work and be sensitive to off trail and camping impacts.
3) Proper/ Improper Tool Care and Use:
   - Fire shovel, McLeod, adze hoe, Pulaski, pick mattock, rock bar, Rheinhard
4) Hillside Hydrology/ How Trails Work:
   - Effects of water in diverse soil types
   - Basic trail design and maintenance
5) Develop “Trail Eyes”:
   - Suggest hiking in rain to better understand water on trails
   - Have students observe various user types to see how they impact trails
6) Re-cutting Tread:
   - Layout and flag re-cutting work like with new tread construction
   - Remove all slough and berm, eliminate cupping
   - Restore 2-3 ft wide bench, shape backslope to 45 degrees
   - Make outslope 8–16% so it ages to hold 5–10%
7) Tread Reconstruction:
   - Cupped vs. Gullied Tread:

– Cupped tread is minor, remove slough and berm, restore outslope
– Gullied tread is severe, consider installing checks
  ▪ If on sidehill, may be able to pull berm into tread
  ▪ If on fall line, install checks, fill with tamped rock and soil
  ▪ Use rip rap rocks to narrow overly wide gullied tread
- Tread Creep:
  – Remove what's uphill pushing users to outer edge
  – Add guide features, re-cut tread if needed
- Nasty Roots:
  – Restore outslope: build retaining wall and backfill to cover roots, or
  – remove roots, being careful not to kill tree
  – If just a few roots, remove ones with daylight under them, leave rest
- Uprooted trees:
  – If unstable remove, if stable can be used in solution
  – Reestablish solid tread and 8' wide trail corridor

8) Report Work Promptly

BACKGROUND

Hillside Hydrology and How Trails Work (& Fail)

Water from rain, melting snow and seeps is a major threat to trails. In a perfect trail world, when water ***sheet flows*** down a hillside and encounters a trail with good ***outslope***, it gently crosses the trail and continues down the hillside without causing any ***erosion*** of the trail ***tread***. In the worst case, hillside sheet flow is interrupted and water follows the trail instead. As the water gains volume and speed on steep ***grades***, it erodes a trail into a deep gully filled with rocks and roots left behind after the soil has been carried away.

This can happen all at once in a major storm event, or slowly over years due to a lack of trail maintenance. Regardless, the outcome is the same: a trail difficult to use and sediment carried downhill, often into streams causing habitat damage. Such a trail needs major reconstruction or to be decommissioned. But it doesn't need to come to this, if trail workers work to prevent it; and that is the objective of this class.

In a more typical world of trails, diverse circumstances cause tread erosion in varying amounts. Trails in soft soils, and especially on steep grades, are at most risk of erosion. In such conditions, trail users (hikers & horses on the PCT) loosen tread soil as they walk the trail. When water comes along (and to a lesser extent wind), the loosened soil is carried away leaving a concave or ***cupped tread***. Simple compaction of soft soils exacerbates cupping.

Some of the loosened soil is moved to the downhill side of the tread, where combined with leaves, needles, and sprouting plants, it forms a raised ***berm***. Berm by itself, or combined with cupped tread, disrupts the outslope of ideal tread and prevents water from leaving the trail. Thus water runs along the trail eroding the tread.

The same process that forms berm happens on the uphill side of the tread, often exacerbated by additional material falling

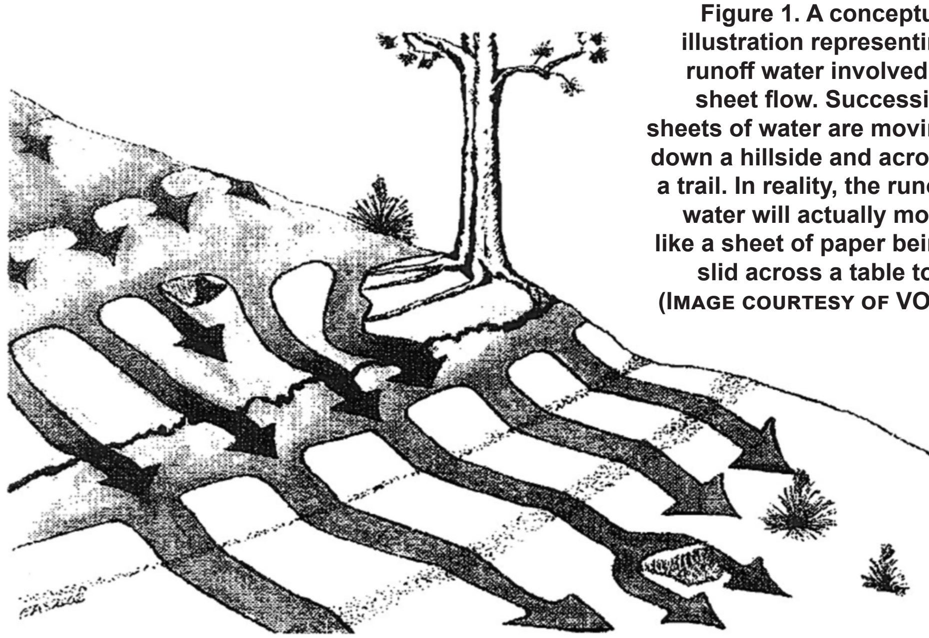
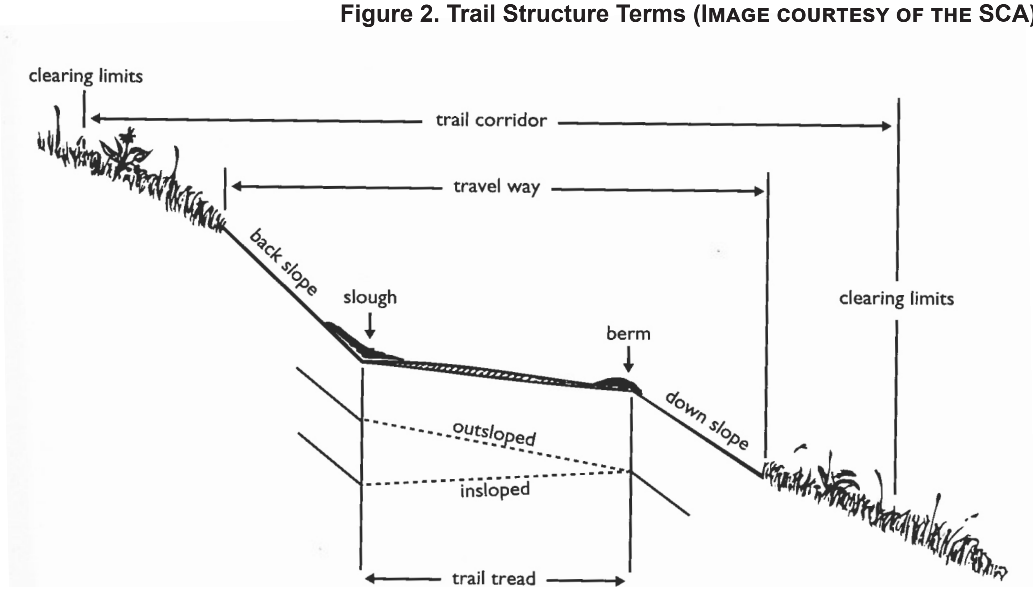


Figure 1. A conceptual illustration representing runoff water involved in sheet flow. Successive sheets of water are moving down a hillside and across a trail. In reality, the runoff water will actually move like a sheet of paper being slid across a table top. (Image courtesy of VOC)

onto the trail from the ***backslope***, creating what is called ***slough***.

Figure 2. Trail Structure Terms (Image courtesy of the SCA)



Water moves faster on steeper trail grades, giving it more force and thus eroding more soil. Greater water volume also increases the amount of soil that can be moved. To protect a trail from erosion one or more of three things need to happen: 1) reduce the amount of water running down a trail; 2) reduce the speed of the water moving down a trail; and 3) reduce the erosive force of users' feet loosening the soil.

The best way to achieve these objectives is by good ***trail design*** and construction, whereby a new trail is built with modest grades (less than 15%), passing only through durable soils, and includes ***grade reversals*** at regular intervals that naturally shed water (http://www.imba.com/resources/trail_building/up_down.html). In addition, such an ideal trail is well constructed to precise standards with generous outslope on a well-compacted full ***bench*** (http://www.imba.com/resources/trail_building/contour.html).

Re-cutting Tread

Alas, because many trails had unskilled designers and poor construction and/or poor maintenance, today trail volunteers often must work on trails with erosion problems. Where existing trail grades are modest, the most thorough remedy to typical erosion patterns is to have a crew take the time to systematically ***re-cut tread***. This means removal of every inch of slough and berm, eliminating cupped tread, and cutting deeper where necessary to get a 2-3' wide, outsloped, full bench. Carefully lay out the work to be done with pin flags or wooden stakes, and be sure to mark grade reversals or grade dips. Shape the backslope to an even 45 degree angle. Finally, be sure that you restore adequate outslope when complete, preferably 8-16% outslope (1-2" of drop per 12" of tread width) so that they will age to hold 5-10%. Less durable soils require greater outslope.

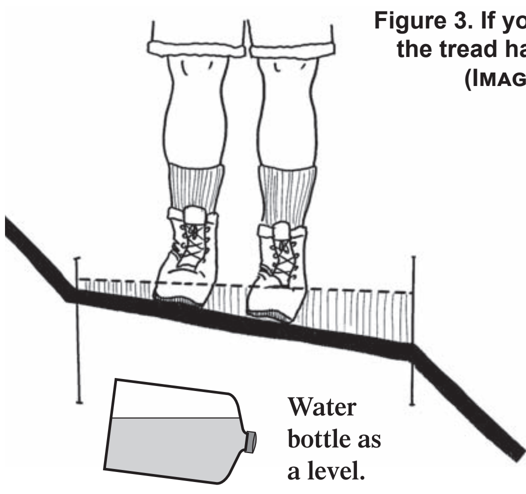


Figure 3. If your ankles start to roll, the tread has too much outslope. (Image courtesy of USFS)

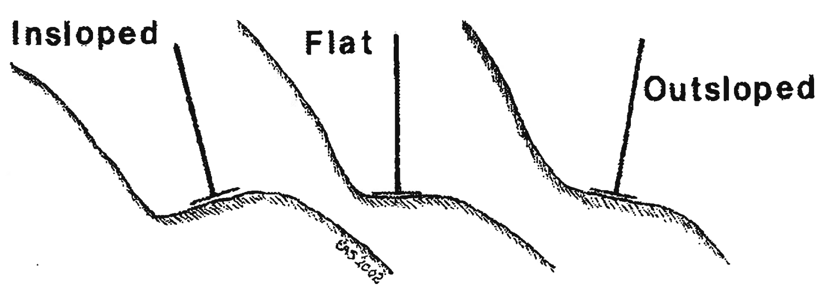
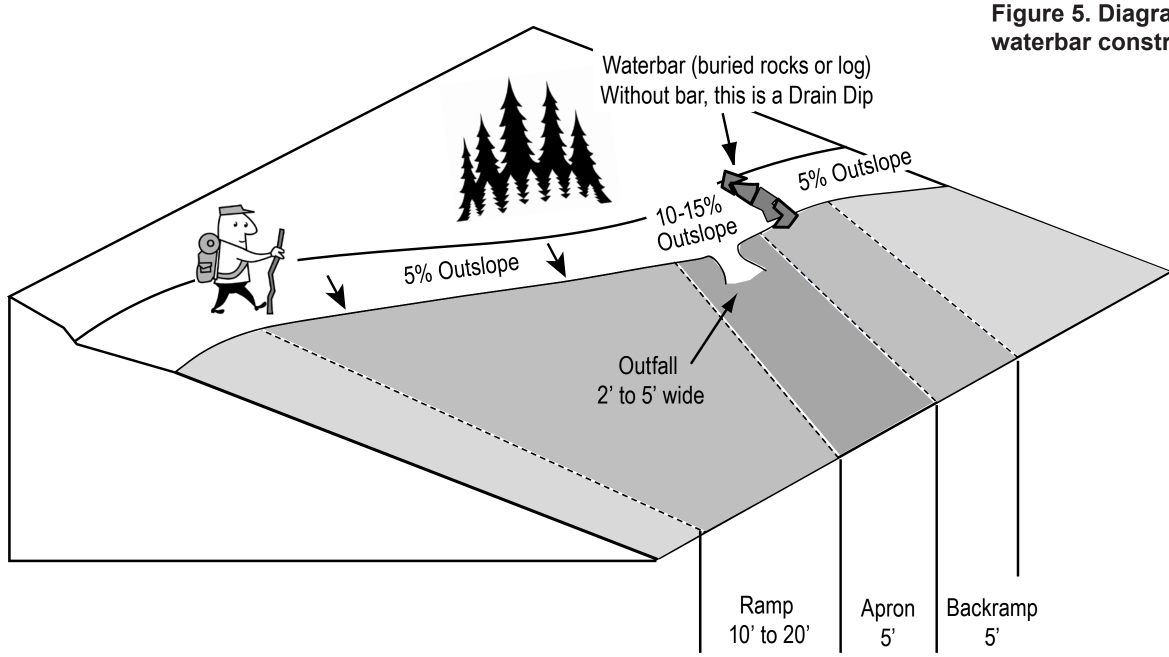


Figure 4. A McLeod used as an outslope gauge. (Image courtesy of VOC)

The goal of such ***tread reconstruction*** is to restore the tread to ideal specifications, as though the trail were newly constructed. Like new trail construction, re-cutting is best done when soils are moist and can be compacted. This can be achieved with a motorized vibrating plate compactor, or crews can do the work in late fall, just before deep snows (greater than 5') will do the compacting for you. If trail workers are then able to keep up with touch-up slough and berm removal as part of regular annual maintenance, systematic re-cutting shouldn't become necessary again.

It is important for students to understand that the natural aging process of trails necessitates vigilant maintenance. If neglected, erosion problems will only grow worse and require major reconstruction or decommissioning the trail. PCT volunteers need to identify the portions of their trail section that need the most drainage work and regularly give them special attention.

Figure 5. Diagram of modern waterbar construction



Other Tread Reconstruction Techniques

In some cases, thorough re-cutting of the tread not feasible, or is insufficient because of steeper grades. As discussed in Courses 201 and 203, the two most common triage solutions are to target the areas of worst erosion and construct either earthen ***drain dips*** (aka rolling grade dips) (http://www.imba.com/resources/trail_building/gradedips_2.html) or modern style ***waterbars*** with rocks or log.

Gullied Tread: Checks can be effective triage for gullied tread. Waterbars and dips can't divert water from the trail if the trail follows the fall line. In such cases, checks are simply a means to harden or armor the tread and slow further erosion. Checks also help retain fill (rocks and dirt) brought in to restore the gully.

Sometimes checks are used to armor the tread when it's not gullied, but simply unstable, or steep.

Also known as rock riser steps, or check steps, these are rocks (or logs) set perpendicular to a gullied trail, each step rising no more than 6-8". If several checks are constructed on a horse trail, they should be about 6', 12', 18', or 24' apart to approximately match the gait of a horse. Users don't generally like steps, so it is important to make them comfortable. It is also helpful to install rip rap (scree) or guide rocks on the flanks of the steps, to narrow wide gullies and keep users from going around steps.

For more about building checks, see Course 203 Waterbars and Checks.

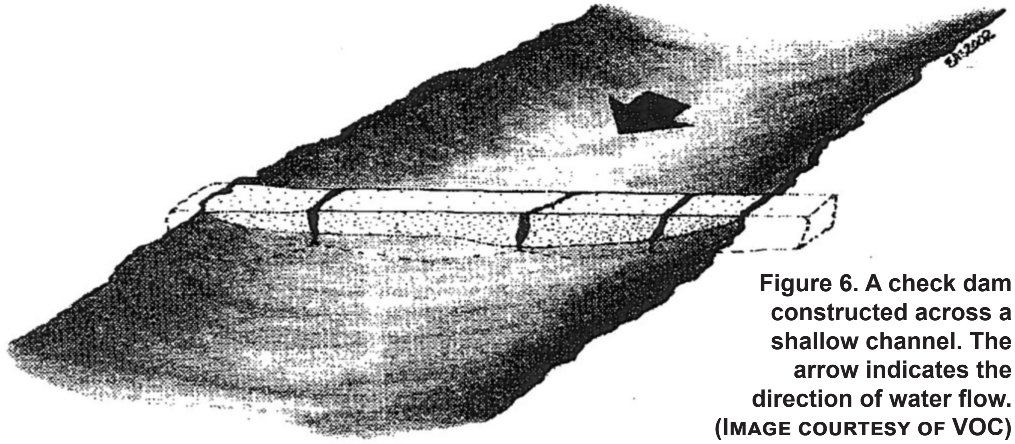
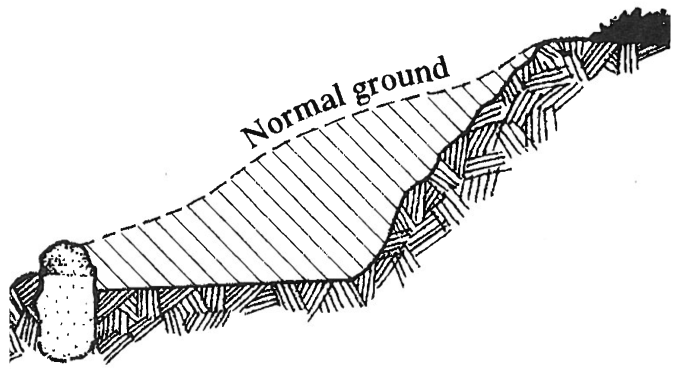


Figure 6. A check dam constructed across a shallow channel. The arrow indicates the direction of water flow. (Image courtesy of VOC)

Figure 7. Stabilizing Tread Creep. Guide rock properly installed to help prevent tread creep. Do not create a continuous barrier that impedes water drainage. (Image courtesy of USFS)



Tread Creep: Also known as slipped tread, trails sometimes migrate gradually down slope for a variety of reasons. Many users, especially horses, have a tendency to walk on the outside of the trail, but a variety of factors can exacerbate that tendency, "pushing" users physically or psychologically to the outside, where they break down the trail edge. These factors include: 1) brush growing encroaching from the uphill side of the trail corridor; 2) excessively steep uphill sideslope; and 3) exposed rocks or roots on the uphill side of the tread.

To prevent tread creep from happening, it is necessary to remove the three factors listed above. If it is impossible to eliminate all three, install ***guide features*** at irregular intervals along the down hill edge of the trail to encourage users to move to the middle of the trail. Guide features can be well-embedded large rocks (solid so they won't be rolled out) or logs moved in perpendicular to the trail (NOT parallel, which blocks drainage).

To remedy advanced tread creep, it is necessary to re-cut tread and backslope, yielding a compacted outsloped tread.

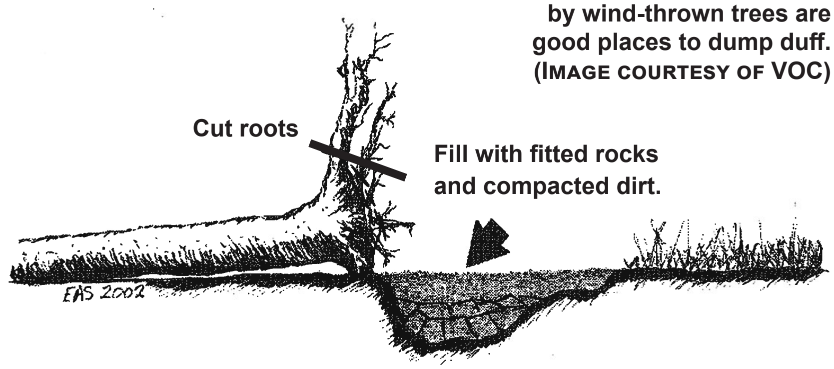
Nasty Roots: For reasons not entirely clear to this author, in some settings, dense mats of roots grow, apparently in association with slipped tread. I speculate that certain species of trees prefer their roots close to the surface and thus grow toward open trails. Some root mats probably result from user trails that were never excavated and feet simply exposed roots that were always there.

To remedy such situations, there seem to be only two choices: either 1) build a low retaining wall on the outside edge of the trail and then cover the roots with imported soil to create a compacted outsloping tread, or 2) cut most of the roots out to then cut outsloped tread. Try not to use the latter approach when it may kill adjacent trees.

If there are just a few roots in otherwise reasonable tread, the rule of thumb is to only cut out roots that show daylight under them (and thus could trip a hiker or horse). Scattered roots running across the tread that are well embedded should stay to help hold the soil in place. Roots running parallel with the tread do not serve such a purpose, and can be removed as time allows.

Uprooted Trees: Trees adjacent to the downhill side of a trail that blow over, often leave gaping

Figure 8. The root holes left by wind-thrown trees are good places to dump duff. (Image courtesy of VOC)



holes in the tread that need to be repaired. If a tree and root wad are stable, they can be incorporated into a solution. If they are unstable and will continue to undermine the trail, they need to be removed before reestablishing the tread. The solution to each situation will vary, but two things need to be insured: 1) an 8' wide trail corridor is reestablished; and 2) the restored tread must be solid, usually be a combination of filling the hole with fitted rocks, and then layers of well compacted soil. The trail corridor can be reestablished by either cutting away enough of the roots, or slightly relocating the tread up hill. When realigning the tread up hill, make sure to blend the new section in with the existing trail grade as smoothly as possible. An abrupt climb up and over a tree well is typically unstable, and won't meet the trail's specifications.

The following causes of tread reconstruction are beyond the scope of this course, but worth knowing about.

Wash Outs also known as blow outs, occur when a flash flood on a small or intermittent stream washes away a section of trail. Solutions will vary with the specific situation, though rock retaining walls and compacted fill are likely needed. Be sure that the reconstructed tread includes a grade dip through the stream draw of sufficient size to keep future water from washing out the trail again.

Landslides and moving talus slopes are cause for either major tread reconstruction or trail relocation. Either approach is likely a major undertaking. Reconstruction after a landslide likely involves construction of rock or log crib structures to support the reconstructed tread. If a landslide is likely to recur, relocation is a prudent choice.

Also beyond the scope of this class is tread armoring, a labor intensive but long-term solution for tread problems (http://www.imba.com/resources/trail_building/rock_armoring.html).

Trail Crew Leave No Trace: Students may protest, 'Our job is to leave a trace.' It's true that trail work has an impact on the land… but the work that is completed is meant to reduce overall impacts on the land. There are ways to bring Leave No Trace ethics into all the work completed on the trail, including how we go about completing projects, where we choose to camp and take breaks, and how the crew behaves in relation to other visitors and wildlife. It is important that we foster a Leave No Trace ethic since we are a model for other public land users and are in the position to influence other's behavior.

- Be respectful of other visitors: minimize visual impacts, hide brush whenever possible, store tools and take breaks off the trail, and never leave stubs (a.k.a. staubs, pungy sticks) when brushing.
- Travel and take breaks on durable surfaces: keep off trail disturbance to a minimum
- Dispose of waste properly: pack out garbage you find or create, and dispose human & pet waste properly.

TEACHING TIPS & TECHNIQUES

Visual Aids: Use diagrams in conjunction with real-life examples as visual aids when discussing concepts.

Work Safe: For all tasks, demonstrate the proper stance and technique for each of the tools to minimize body strain. To reduce back strain bend the knees, have a powerful core, keep legs well apart, and use a rocking motion that uses the whole body.

Try All Tools: Encourage each student to try all the tools and then decide which two they would choose, if they were to carry only two tools for a day of tread and drainage work. They should see that everyone has their own preferred tools depending on body type and other factors.

Emphasize Compaction: Loose dry soils that do not cohere well, it is impossible to durably restore tread. Such work must be done when there is good moisture in the soil so that it can be well compacted with a McLeod and boots, or if available a motorized vibrating plate compactor. The ideal time is just prior to winter when fall rains have moistened the ground and winter snow will further compact the work. Ideally, material is compacted so that a thumb pressed into the dirt will not penetrate more than a quarter inch--this takes persistence.

Re-cutting Tread: It is important to focus this type of intensive labor upon trail sections identified as critical for drainage, because it may be impractical to keep an old trail completely free of slough and berm. It is important to do so in areas where significant tread cupping has started, though let them know that if water running on the trail is the problem, a new drainage structure is likely needed uphill to prevent further cupping.

Test Your Work: Roll a tennis ball or orange to test efficacy of the final work--it should easily leave the trail.

"Trail Eyes": A great way to understand tread issues is to observe several different busy sections of trail, watching from a discrete location to see how horses, hikers, and other users use the trail. Be sure to watch a piece of side-hill trail, and even better if it is on a steep grade. Observe whether users walk along the outside of the tread. Observe if their feet loosen the soil in any significant way. Watch how they interact with drainage structures.

To understand drainage issues walk trails on a rainy day, the rainier the better. Encourage students to get a pair of rubber boots and an umbrella, in addition to rain gear, so they can be comfortable examining how water interfaces with trails. Ask them to notice how water sheets off hillsides, accumulates in small rivulets and then crosses an outsloped tread, or follows one with berm, carrying loose sediment to drainage structures. The ultimate goal is to gain the ability to "think like water" and possibly "see water running down the trail, even on sunny days."

See discussion in curriculum overview for ideas how to help students develop their Trail Eyes. Make sure they notice all drainage structures needing to be cleaned. Nearly full drain dips are the most easily missed.

TRAIL FUN

For a fun wrap-up do a fast-paced "Jeopardy"-style quiz based on the KEY CONCEPTS.

A drainage treasure hunt at the end of the day would be a good final exam.

REFERENCES

Crew Leader Manual. 2002. Especially Chapter 9, "Basic Trail". *Outdoor Stewardship Institute, a program of Volunteers for Outdoor Colorado. See also* www.osionline.org/resources.html click on "Crew Leadership for Trails" under Resources.

Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails by Troy Scott Parker. 2004. www.Natureshape.com

Trail Construction and Maintenance Notebook. 2007. Woody Hesselbarth. USDA Forest Service. The chapter on Tread is especially useful www.fhwa.dot.gov/environment/fspubs/07232806/page09.htm. A free copy can be ordered at: www.fhwa.dot.gov/environment/rectrails/trailpub.htm

Trail Solutions: IMBA's Guide to Building Sweet Singletrack. 2004. Pages 197-209 covers trail problems and how to solve them. International Mountain Biking Association has many online resources. Link to all of them at www.imba.com/resources/trail_building/index.html

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STUDENT SKILL OUTCOMES:

- Clear review of hillside hydrology, ideal trail design, and remedying cupped tread and restoring it to appropriate outslope by removing slough and berm.
- Understanding of the difference between of gullied trail on a sidehill, and gullied trail up the fall line (where only checks can remedy).
- Understanding of Tread Creep, Nasty Roots, Uprooted Trees and how to remedy.

KEY TERMS:

Berm: the mound of soil that develops at the outside of tread. Berm disrupts tread out-slope and prevents water from leaving the tread to the down-slope.

Checks: (aka check step, check dam) a log or row of rocks perpendicular to a gullied ***fall line*** trail, embedded in both banks, to slow the rate of water erosion. If several are constructed on a horse trail, they should be 6', 12, 18', or 24' apart to approximately match the gait of a horse.

Cupped Tread: trail tread that is dished out by users feet loosening the soil and then water (and/or wind) carrying the soil away. Such tread holds water on the trail leading to cupping erosion on grades above a few percent.

Erosion: the transport of soil by water, wind, or gravity, usually in a manner that degrades the preexisting soil condition.

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 ***checks*** installed to slow further erosion.

Grade Reversal: regular ups and downs designed into a trail alignment is the best way to shed water from a new trail. Such ups and downs can be added to an existing trail with great labor by constructing water bars and drain dips (aka rolling grade dip).

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.

Out-Sloped Tread: a trail surface that tilts to the downhill side of the trail to shed any water that arrives from above. Trails should be constructed and restored with 8-16% outslope (1-2" of drop per 12" of tread width) so that they will age to hold 5-10%. Less durable soils require greater outslope. On rare occasions tread is in-sloped, shedding water to an ***inside ditch*** just uphill of the trail, later crossing the trail through a culvert or other drainage structure.

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.

Slough: the debris deposited on the inside of tread at the base of the back-slope, primarily delivered by gravity from the back-slope above. Its accumulation causes the tread to narrow, forcing users to the out side of the tread, which can lead to collapse or tread slip.

Tread: the surface of a trail, on which users walk or ride.

Trail Reconstruction: the process of revamping a badly eroded or slipped section of trail using all appropriate means such as tread reconstruction, construction of drainage structures, and minor relocations.

KEY CONCEPTS:

1) Safety Document and Concerns:
   - Personal Protective Equipment (PPE), Job Hazard Analysis (JHA), Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
2) Trail Crew Leave No Trace: Have a positive impact on the land through trail work and be sensitive to off trail and camping impacts.
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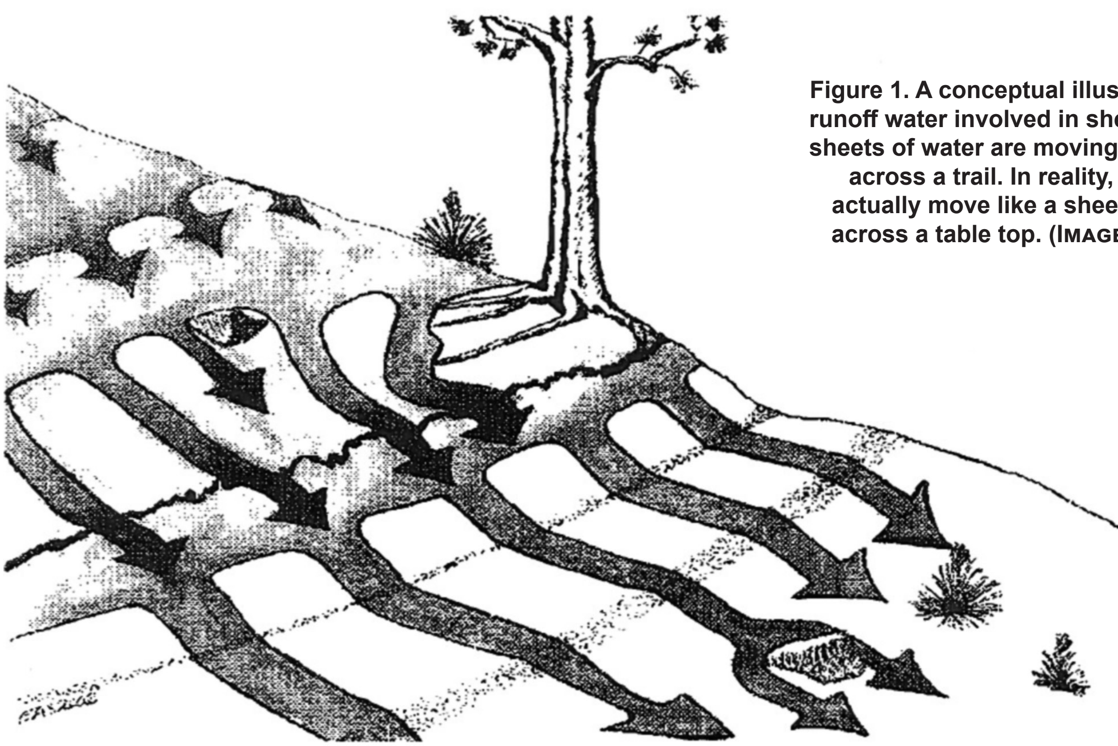

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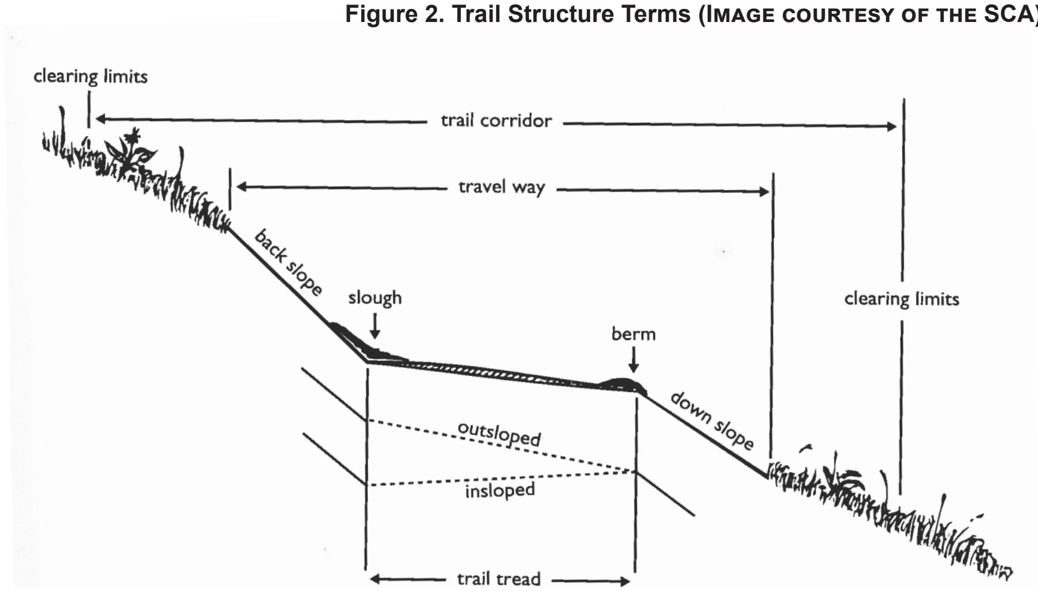

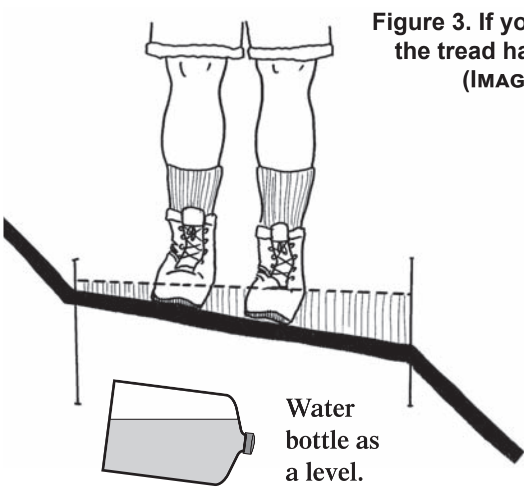

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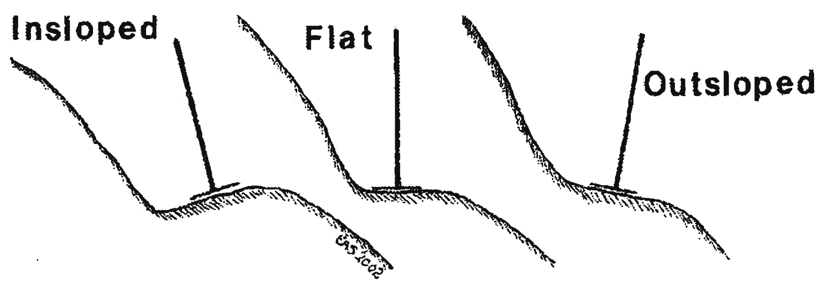

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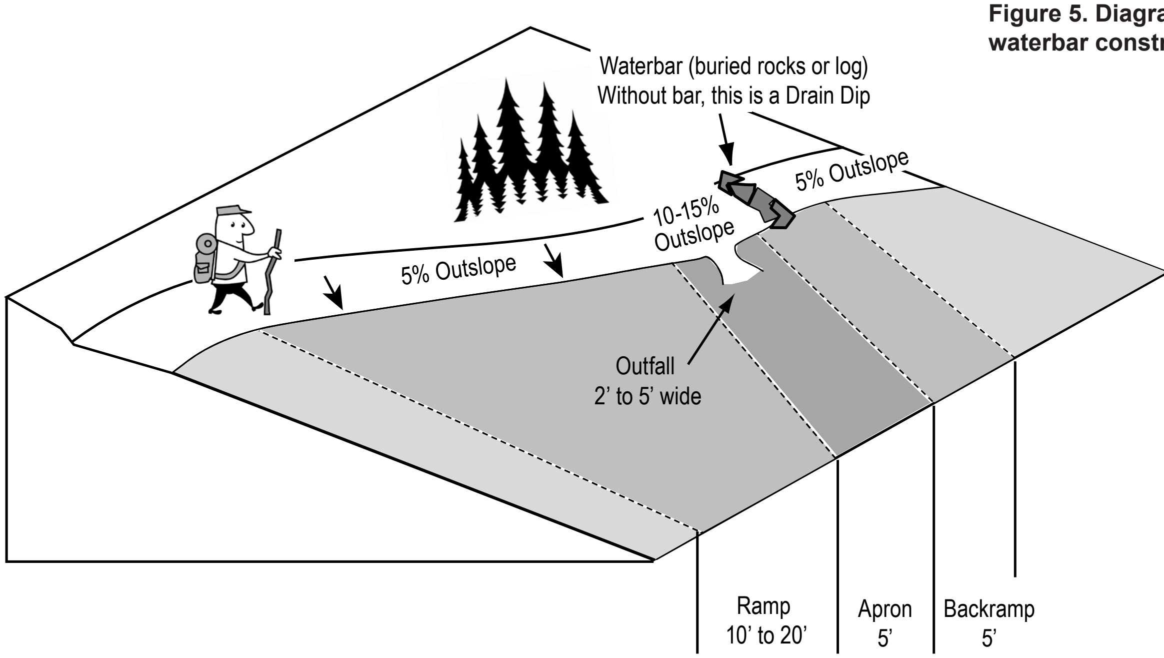

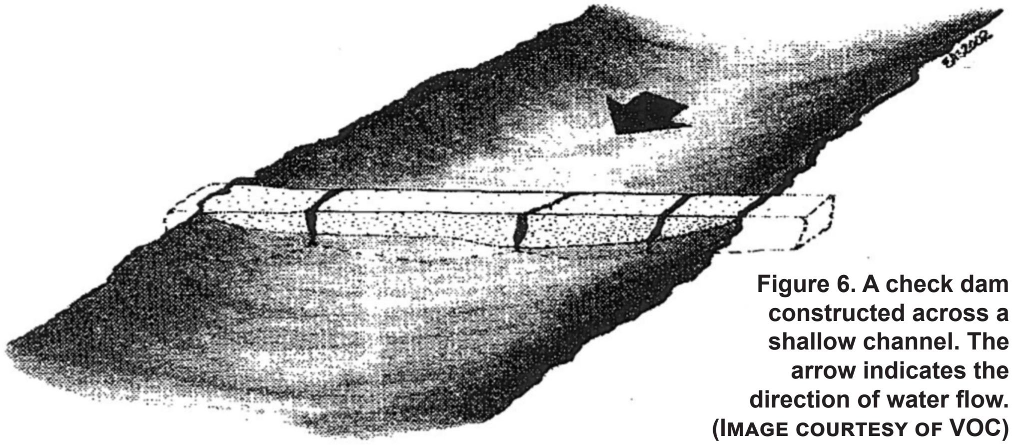

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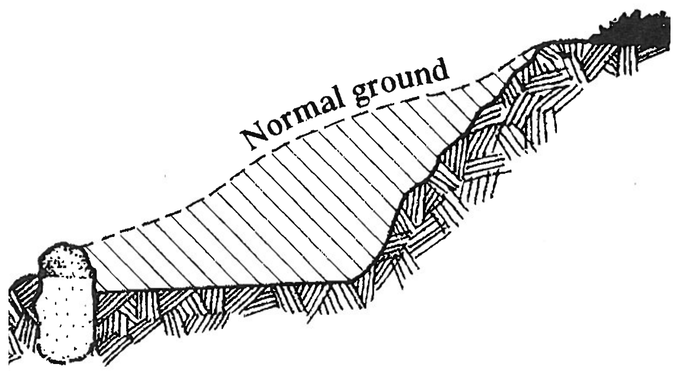

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