

## Trail layout and design terms and best practices

### The Trail Design Process:

1. Concept Stage: Define the intent and purpose of the trail, gather support and initial conceptual approval, and set design parameters
2. Survey Stage: Identify Control Points (on paper and in the field)
3. **Layout Stage:** Connect the points (map, walk, and flag), Bring it all together (the balancing act). If possible analyze existing local trails to see what works and doesn't
4. Approval Stage
5. Final Layout and Construction Planning Stage: Pin flag final line and create construction plan
6. Begin Construction, Adjust Layout and Plan as revealed conditions warrant.

Your own experiences will be your best teacher. Others' experiences produced these **Best Practices:**

1. Understand the trail user base and recreational aesthetic- who will use the trail, what kind of experiences they expect or desire. A trail must ultimately integrate into the site and users. Determined on a site by site basis.
2. Minimize tread grades
3. Design drainage into the trail alignment/layout rather than construct them post facto
4. Build on a slope (a "resistant alignment" across slopes, not down them)
5. Avoid Flat Areas and Fall Lines (and switchbacks if possible)
6. \*Understand trail building techniques, required construction skillsets, and required labor
7. Identify potential construction resources (local or imported)
8. Avoid ridge tops (primary transportation corridors for wildlife; often used by Native Americans; noise from ridge-top trails is broadcast over a wider area)
9. Create loops and avoid dead end trails for a sense of purpose
10. Avoid crossing water (however, streams/rivers can be natural sound barriers)
11. Put trails through thick vegetation to conceal the trail, reduce noise, and keep users on the trail
12. Put intersections at rises with open sight lines (to reduce collisions)

### Terminology and Other Concepts

1. **Bench cut** or **side hilled** trail- a trail bed cut into a side slope
2. Braiding- new social trails or shortcuts next to the intended path (due to inefficient layout)
3. Compaction- the compression or consolidation of the trail bed (can increase durability and/or runoff)
4. Creep/downhill creep/soil creep- the movement of a side slope down a hill (curved trees, cracking, slumping...)
5. Cross slope or out slope- the grade or slope of the tread perpendicular to the direction of travel (intended to shed water off the trail, typically 5%, but may vary with running grade)
6. Displacement- (user based) movement of trail soil or rocks from the trail bed

7. **Efficiency**- an efficient means of getting from A to B, whether A to B is 10 miles or 10 feet apart. Will users cut corners, shortcut, or create a new social trail?
8. Erosion's externalities:
  - a. Increased turbidity: decreased sunlight/photosynthesis (vegetation, and diatoms); decreased oxygen
  - b. Increased Sediment: smoother water bottoms; reduced turbulence/oxygen; possible phosphorus boost
  - c. Increased Organic Matter: from turbidity killing plant life; from direct organic matter input; both feed anaerobes, reducing oxygen
9. **Erosion Potential** = Water Volume + Speed (sheet flow becomes rills, becomes gullies, becomes channels)
  - a. Depends on multiple factors:
    - i. Area and steepness of the (tread) watershed or "catchment"
    - ii. Length, grade, and width of trail within watershed
    - iii. Tread compaction and "Soil" (Horizon) composition
10. **Fall line**- the line water or a ball would travel down a slope
11. **Flow**- how the trail unfolds in front of users
  - a. Horizontal/lateral flow- left to right
  - b. Vertical flow- ups and downs (grade reversals)
12. Frost heave- soil swelling due to ice crystal lens growth (susceptible: silty, loamy; less so: dense clays, gravel, sand). Low wet areas are more susceptible as they provide water for the growing lenses.
13. **Grade reversal**- a running grade change from descending to ascending, or vice versa
  - a. Aligned Crests and Dips or troughs- layout or alignment includes "Grade Reversals" in design
  - b. Constructed Crest/Dip or trough- Post construction additions due to poor layout or user dynamics
    - i. Drainage Dips, Knicks, Rolling grade dips, water bars
    - ii. Earthen Constructed Reversals: 0 to 20% grades
    - iii. Water bar or Steps leading to Dip: 20% to 30% grades
    - iv. Water bar followed by Stone Steps: 30% or greater
14. **Grade/slope/running grade**- the inclination of a trail surface compared to a horizontal plane
  - a. **A percentage**- rise/run x 100 or  $100 \times \tan(\text{slope degrees})$
  - b. A ratio- of rise to run (1:10, 10:100, 1/10, 10/100)
  - c. An angle- (rise/run)  $\tan^{-1}$  or  $\tan^{-1}(\text{slope\%/100})$
  - d. 10% is often considered the max sustainable *prevailing or overall* grade for trails
    - i. applies to most soils (rocky or durable, to mixed loamy)
    - ii. steeper trails often cause displacement by traffic (not as noticeable in low use situations)
    - iii. unless the tread watershed provides a large volume of water to the trail, water will not gain enough speed at 10% or less (assuming it is adequately out sloped)
    - iv. a 10% grade in sandy or fragile soils may erode

15. **Half Rule**- keep trail grades at less than half the fall line; %grade < fall line%/2
16. Negative control point- a point resource managers do NOT want users (sensitive habitat, unsafe areas...)
17. **Positive Control Point**- a point of interest where resource managers want people to go (destinations/end points, a peak, valley, natural feature, vista...not the only components of a good trail)
18. Safety- A trail that feels dangerous will lead to an unpleasant experience, while one that is too protective will feel tame and incomplete. Safety is often relative to the user group(s). Determining the degree of safety is ultimately a factor of who the majority of users will be and the type of experience being created.
19. **Side slope**- the hill or mountain's slope, steepest down the fall line
20. Slope Stability- how stable is the slope that a trail traverses?
  - a. Friction angle- angle of repose at which a soil is on the verge of slumping/sliding or failing
  - b. Check local road cuts for "potential" safe angles (or slopes) to traverse (but they may have plates piles)
  - c. Sample friction angles:
    - i. Clay (dry lump) 25–40° or 46-84%; Clay (wet excavated) 15° or 26%
    - ii. Gravel (loose dry) 30–45° or 57-100%; Gravel (natural w/ sand) 25–30° or 46-57%
    - iii. Sand (dry) 34° or 67%; Sand (water filled) 15–30° or 26-57%; Sand (wet) 45° or 100%
21. **Sustainability**- "to endure." For trails this means:
  - a. low environmental impact
  - b. low maintenance requirements (minimal construction, reconstruction, and maintenance)
  - c. high user satisfaction and efficiency (safe, and exciting, with minimal user conflict)
22. **Tread**- the trail surface
23. **Tread watershed** or **catchment**- the watershed above a trail (that could potentially erode the trail)
24. **Visual guides**: lead, draw, or ground users along the trail to keep them on the trail
  - a. **anchors**- a focal point or ornament (a large rock, an isolated tree...)
  - b. **Gateway**- a passage or hallway between items (slots, 2 rocks, 2 trees, rock and tree...)
  - c. **Edges**- provide contrast between spaces while adding drama to the experience (cliffs, a water body, a rock garden, vegetation changes...)
25. Quick and dirty on soil

Texture	Feel	Ribbon
Sand	Grainy	Can't form a ribbon
Loam	Soft with some graininess	Thick and very short
Silt	Floury	Makes flakes rather than a ribbon
Sandy Clay	Substantial graininess	Thin, fairly long—50 to 76 mm (2 to 3 inches)—holds its own weight

Clay	Smooth	Very thin and very long—76 mm (3 inches)
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Trail design and building have come a long way since the first primitive foot worn paths and more contemporary hiking club blaze wars began. This isn't to say there were no trail layouts in times past that built with soil retention and user experiences in mind.

Some designs will last a lifetime, others will "live fast and die young." Like all things on earth trails age. Some age like wine, others vinegar, and almost all trails gain a character or body shaped by users, and weather. Good trail design attempts to ensure a long life ahead, and a character that many users will come to love.

Trail building and layout is partly science, and partly art. Designing and building involve a synergy of objective and subjective evaluations that attempt to create a lasting end product. Psychology also comes into play as designers and builders need to consider user (group) dynamics and behaviors to tie traffic management and efficiency into some degree of flow and durability. In addition, they attempt to marry a trail to the landscape. The art and psychological guesswork in layout means the end result could vary tremendously from one designer or builder to another. Even the science can push people in different directions, but it's the science that will ensure they design and build in a similar (sustainable) frame.

"Sustainable" trails are *scientific* because trail builders and designers use *empirical* data, or experiences, to find out what works and doesn't. They also use tools to *repeat* successful design elements and techniques. By "tools" I don't mean digging implements, but tools that *measure* like levels, tape measures, clinometers, and trustworthy math and physics equations. For me, trail science is about an awe and fascination with nature, and learning from the successes and failures we experience...to create something beautiful, and smart.

Most trail builders would argue that there are three 'smart' things to attain in this day and age: 1) low environmental impact; 2) low maintenance requirements; 3) high user satisfaction and efficiency (and perhaps a related fourth: minimal user conflict). Science certainly plays into all three of these: 1. ecology 2. engineering 3. engineering and biology. In a word, "sustainability"—sustainability for other species, the trail itself, and perhaps our own species if you consider the physical and mental health benefits of trails.

I don't know how much farther trail science will go from what it is now, but at a minimum I suspect like most things in life it will evolve. I think most trail builders and maintainers try their best to learn and carry on best practices and traditions, because I think most people want to create something beautiful and lasting, something smart. I hope to help everyone get a step closer to doing this in the layout and design workshop.