

# Designing Sustainable Trails for Different Primary Uses

Understanding trail user motivations-
providing the desired trail experience

Trail Wisdom
SMARTER Trails

# For smarter trails- get to know your user

- Understanding the users of any given trail is as important as understanding the landscape
- Users come in many different travel modalities, and have a wide range of motivations as to why they are on the trail
- Each user group has sub groups:
- Pedestrians- walkers, hikers, backpackers, dog walkers, runners
- Mountain bikers: exercise riders, family riders, racers, riders looking for high challenge trails

# User specific design:
# Trail efficiency vs distance

# Physical Sciences involved in trails:

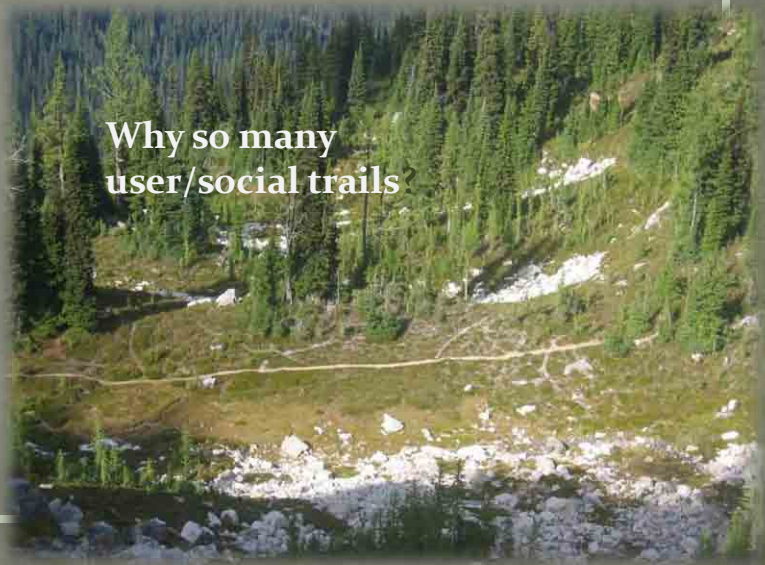
- **Geography**
- **Topography**
- **GIS**
- **Geology**
- **Biology (wildlife, botany)**
- **Forestry**
- **Hydrology**
- **Soil Science**
- **Meteorology**
- **Physics**
- **Geometry (for trail structures)**
- **Landscape Architecture**
- **Ecology**
- **Erosion Control BMPs**

Trails are not easy, in fact there are very complicated with many different things to consider in the planning/design phase

# Human Sciences: The Art of Trails

- Psychology
- Sociology
- Study of Human Emotions
- Ergonomics
- Aesthetics
- Politics

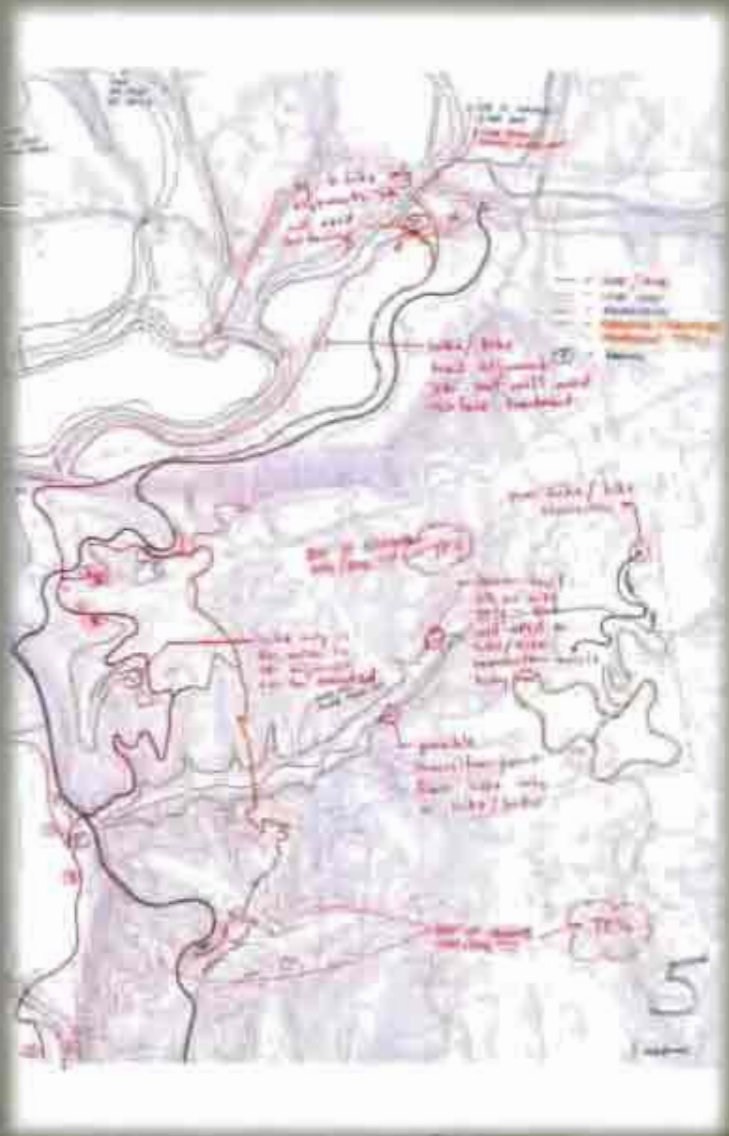




## The planning process:
## (a combination of some or all of the following)

- Stakeholders meetings
- Design team meetings
- Asking and answering a wide range of questions related to desired trail experiences
- Map and other paper resources study
- Fieldwork and study of the landscape (determining control points for trail)
- Development of trail specifications

# Great trails start with good planning



# Trail planning: Who, What, Where, Why

- Who will this trail serve?
- Why? Why are we building this trail?
- What types of different users will be on this trail?
- If multi use, which group is the predominate user?
- What kind of experience will this new trail provide?
- What level of difficulty will this trail be rated?

- Is your existing system failing to meet the needs of your current or future users?
- Is there a trail user group whose needs aren't being met?
- Do you need a new trail, or can you modify/improve your existing trail to meet current needs?

# Public process: stakeholder meetings

Goals:

-Understand users needs and desires

-Develop project support and nurture partners

-Present early ideas and get feedback

# What do users want in a new trail?

# Public process: Site visits/field work

# Host a trail education day


Help users better understand sustainable trail design, but also let them learn how complicated trail design can be.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# Other methods for gathering info- understanding the user

- User exist trail surveys
- Online surveys
- Observation of users
- Bring the meeting (and opportunity for impute) to the people

*There are many reasons why people use and enjoy trails: understanding their needs/desires is critical*

- Sight seeing
- Scenery
- Solitude or serenity
- Fun and excitement
- Discovery and exploration
- Adventure and challenge
- Pushing and testing one's limits
- Exhilaration
- Exercise- physical fitness
- Exercise for pets
- Stress reduction- mental health
- Re-fresh one's spirit, re-creation
- Education
- Socialization
- Nature Study- birding, wildlife study, wildflowers
- To marvel at creation
- Re-Connecting with the natural world
- Transportation

# Destination motivations vs. Journey motivations

## We must understand this to design the right trail for the user's motivations

- Destination users seek direct routes taking them to the desired destination in an efficient route

Casual users are the most difficult group to manage

- Journey motivated users are there for the trail experience, not any destination. How the trail "feels" and interest along the trail are important here.

Trail runners, mountain bikers and serious hikers came to travel on the trail, they want to be there

# What are the planned uses of this trail?

- Walkers?
- Dog walkers?
- Hikers?
- Trail runners?
- Mountain bikers (what level of difficulty)?
- Horses?
- What can we do to encourage kids on trails?
- Are we considering the needs of persons with mobility challenges?

- **Different uses (or combos of uses) will drive the design process and specifications**

# Design Team work:
# Study the maps, learn the land

Feasibility: What will the land base support?

# 2 primary influencers of trail experience

- Alignment: Relationship of the trail to the landscape
- Specifications: relationship of the trail to the users

# Develop trail specifications:

- Trail specs will influence the construction phase of the project, and thus need to be considered up front during the design phase
- Trail difficulty will affect trail design
- Trail specs will/should influence long term management of any given trail

- Tread width, average grade, max sustained gradient, max tread grade, corridor width and height, user types, max height for mandatory obstacle, tread rugosity- all of these need to be considered in design phase

# Trail Type Matrix-Definitions

- **Trail Type Name:** Name of trail for trail inventory to be included in management plan
- **Difficulty Rating:** Information to be shared with users on how difficult the trail experience will be
- **Difficulty Symbol:** Symbol of trail difficulty as shown on maps, kiosk, website and any other method of information conveyance
- **Typical Tread Width:** Typical range (narrowest to widest) of trail tread width for this type of trail
- **Typical Corridor Width:** General description of width between trees and other vegetative matter close to the trail

# Trail Type Matrix-Definitions

- **Tread Rugosity:** Smoothness or roughness of trail tread including roots or rocks protruding above main tread surface
- **Protrusions:** Minor irregularities above trail tread surface
- **Obstacles:** Major irregularities that are full tread width and generally un-avoidable
- **Average Gradient:** How steep is the average grade of the trail as measured in percent (vertical distance vs. linear distance)
- **Maximum Sustained Grade:** Steepest grade on trail for a sustained distance (50+ feet)
- **Maximum Grade:** Steepest overall section of trail (short distance)
- **Typical Tread Materials:** What does the tread surface of the trail consist of?

# Trail Type Matrix-Definitions

- **Steepness of Side-slope (exposure factor):** How steep is the prevailing side-slope of the landscape the trail is running through (how serious would a fall be off trail)?
- **Turn Radius:** Tightness of turns and switchbacks found on the trail and general flow or rhythm of trail experience (open and flowing vs. tight and twisty)
- **Formality of Trail and Structures:** Trail rating helps to determine how formal the trail experience will be
- **Typical Drainage and Waterway Crossings:** Typical way the trail tread would interact and/or cross waterways (streams, creeks, drainages)
- **Duty of Care:** Sliding scale, refers to potential liability exposure of trail and structures
- **User Profile**: General description of experience level, fitness level, motivations, etc. of a typical user on any given trail type

# Trail Development Plan

**Difficulty Rating:** *Moderate*

**Difficulty Symbol**: *Blue Square*

**Typical Tread Width:** *24"-40"*

**Typical Corridor Width:** *Vertical chokepoints at tread width limits*

**Tread Rugosity:** *Moderate, some irregularity*

**Average Gradient:** *10% or less*

**Maximum Sustained Grade:** *13%*

**Maximum Grade:** *18% for short distances*

**Typical Tread Materials:** *Mostly lightly surfaced tread (2" of DGA) with some natural surface in places*

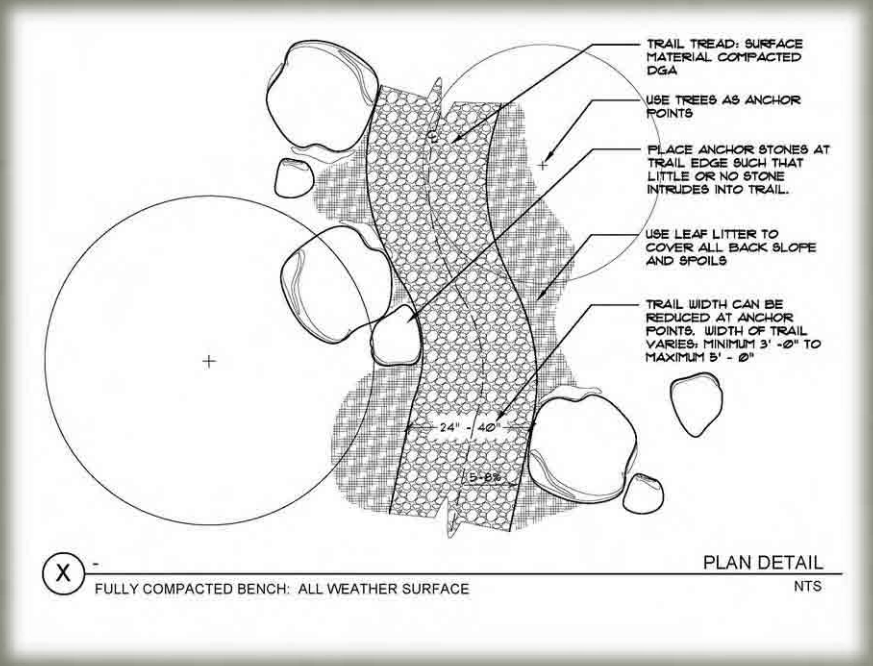
***Trail Type Name: H/B ST-2***

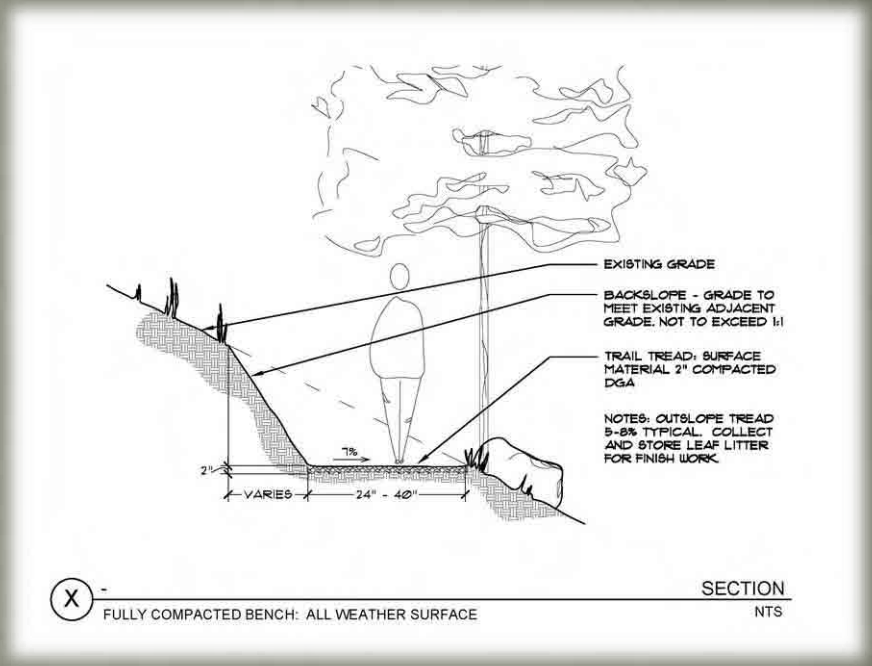
***Hike/Bike All-Weather***

***Single Track***

***Moderate***

# Trail Development Plan




***Trail Type Name: H/B ST-2 Hike/Bike All-Weather Single Track- Moderate***

# USFS-Trail Management

- Trail Class 1: Minimally Developed
- Trail Class 2: Moderately Developed
- Trail Class 3: Developed
- Trail Class 4: Highly Developed
- Trail Class 5: Fully Developed

# USFS Trail Design Parameters

## Design Parameters

Design Parameters are technical guidelines for the survey, design, construction, maintenance, and assessment of National Forest System trails, based on their Designed Use and Trail Class and consistent with their management intent[1]. Local deviations from any Design Parameter may be established based on trail-specific conditions, topography, or other factors, provided that the deviations are consistent with the general intent of the applicable Trail Class.

| Designed Use: BICYCLE | | Trail Class 1 | Trail Class 2 | Trail Class 3 | Trail Class 4 | Trail Class 5 |
|---|---|---|---|---|---|---|
| Design Tread Width | Single Lane | 6" – 12" | 12" – 24" | 18" – 36" | 24" – 48" | 36" – 60" |
| | Double Lane | 36" – 48" | 60" – 80" | 48" – 84" | 60" – 84" | 72" – 120" |
| | Structures (Minimum Width) | 18" | 18" | 30" | 48" | 60" |
| Design Surface[2] | Type | Native, ungraded<br>May be continuously rough<br>Sections of soft or unstable tread on grades > 5% may be common and continuous | Native, dirted, grading<br>May be continuously rough<br>Sections of soft or unstable tread on grades > 5% may be common | Native with some onsite borrow or imported material where needed for stabilization, occasional grading<br>Intermittently rough<br>Sections of soft or unstable tread on grades > 5% may be present, but not common | Native, routine grading with improved sections of borrow or imported material<br>Stable with minor roughness | Likely imported material, routine grading<br>Uniform, firm, and stable |
| | Protrusions | ≤ 24"<br>Likely common and continuous | ≤ 24"<br>May be common and continuous | ≤ 3"<br>May be common and continuous | ≤ 3"<br>Uncommon and continuous | No protrusions |
| | Obstacles (Maximum Height) | 24" | 12" | 6" | 6" | No obstacles |
| Design Grade[2] | Target Grade | 5% – 20% | 5% – 12% | 3% – 10% | 3% – 8% | 2% – 5% |
| | Max (Pitch Maximum | 30%<br>20% on downhill-only segments | 25%<br>15% on downhill-only segments | 15% | 10% | 8% |
| | Maximum Pitch Density | 20% – 30% of trail | 15% – 20% of trail | 10% – 20% of trail | 5% – 10% of trail | 0% – 5% of trail |

| Designed Use: BICYCLE | | Trail Class 1 | Trail Class 2 | Trail Class 3 | Trail Class 4 | Trail Class 5 |
|---|---|---|---|---|---|---|
| Design Cross Slope | Target Cross Slope | 5% – 20% | 5% – 8% | 3% – 5% | 3% – 5% | 2% – 3% |
| | Maximum Cross Slope | 20% | 10% | 5% | 5% | 5% |
| Design Clearing | Height | 8' | 8' – 8' | 8' | 8' – 8' | 8' – 8' |
| | Width | 24" – 36"<br>Some vegetation may encroach into clearing area | 36" – 48"<br>Some right vegetation may encroach into clearing area | 48" – 72" | 72" – 96" | 72" – 96" |
| | Shoulder Clearance | 6" – 12" | 6" – 12" | 6" – 12" | 6" – 12" | 12" – 18" |
| Design Turn | Radius | 2' – 3' | 3' – 6' | 4' – 8' | 8' – 10' | 8' – 12' |

[1] For definitions of Design Parameter attributes (e.g., Design Tread Width and Short Pitch Maximum) see FSH 2309.18, section 86.

[2] The determination of trail-specific design grades, design surface, and other Design Parameters should be based upon soils, hydrological conditions, use levels, erosion potential, and other factors contributing to surface stability and overall sustainability of the trail.

# Develop concept alignments:


# Concept planning yields a paper map design, but not a real trail design (that happens in the field)

LOUISVILLE LOOP
PARK ROAD
HIKE/BIKE TRAIL
HIKING TRAIL - SOFT SURFACE
HIKING TRAIL - EXCURSION
HIKING TRAIL - SIGNATURE
EQUESTRIAN TRAIL
EQUESTRIAN TRAIL - PRIVATE
SIDEWALKS & PATHS
P PARKING AREA
TH TRAILHEAD
CP COMMUNITY PARK
EQ EQUESTRIAN TRAILHEAD

# Applying trail planning process to on the ground design: Let the flagging begin

# GPS tracking a pin flagged design

Trail specifications certainly affected this trail design process:

Rocky Knob Park- Boone NC

# Understanding User Impacts:

- Trail users come in an variety of shapes, sizes and methods of travel
- Trail users go downhill and uphill (unlike water)
- Trail users can and often do change directions
- Trail users will travel trails in a range of  various trail conditions (wet vs. dry, covered with snow and ice etc.)
- Trail users travel at various speeds and for each trail user type the speed is not a constant (acceleration/deceleration)
- Different trail users effect tread surfaces and soils differently

# Factors that determine user impacts on trail tread:

- Average combined weight of trail user (horse with rider, mountain bike with rider, hiker with loaded backpack) Amount of surface area of user in contact with the trail tread (PSI).
- Hardness of the contact area of trail user in relation with trail tread surface (shod hoof, hiking boots, running shoes, tires)
- Alternating contact or consistent contact between user and trail surface
- Relative speed of travel modality and consistency of speeds traveled (acceleration/deceleration, speed carried into turns, momentum forces)
- Distances traveled
- Relative amount of users in any given user group
- Duration of stay
- Physics of propulsion ( how do the different users propel themselves forward on flats and uphill and how do they resist gravity on downhill)

# Compaction vs. displacement forces

# Maximum Trail grades.

**Maximum allowable trail tread grade is very site specific and varies based on a number of factors. The variables to considered include:**

- **Difficulty rating of trail**
- **Amount of planned use**
- **Seasonality of trail use (how many months each year is the trail used)**
- **Type of trail users and predicted user impacts**
- **Soil compositions that make up trail tread**
- **Annual average precipitation and how it comes (snow, hard rains, mist)**
- **Steeper trails may require trail structures such as steps or armor to produce sustainability**

**As trail grades increase, so does the need for more frequent grade reversals (to effectively shed water).**

# Maximum trail grade guidelines

- An average overall  trail grade of 10% makes for a trail easy to travel in both directions (if desired).
- Hikers and mountain bikes have similar impacts and tread grades can run as high as 20% for short distances (in good soil conditions) for these 2 user groups. Don't forget frequent grade reversals for steeper trails.
- Horses have much higher impacts (soil displacement and sediment yield) and as such trail grades should be kept very conservative for sustainability(8-10%).

| Trail Grade | Remarks | Drainage Spacing |
|---|---|---|
| 0-2 | Avoid – difficult to drain, tread will need elevation to drain | Not possible unless tread is elevated |
| 3-10% | Ideal for general uses | 100-200 ft (dependent on yearly rainfall events) |
| 10-15% | OK in places if maintained | 100 ft |
| 15-20% | OK for short segments if well-maintained or in durable soils | 50 ft |
| >20% | Avoid unless steps are constructed or tread is armored | <50 -as frequent as possible |

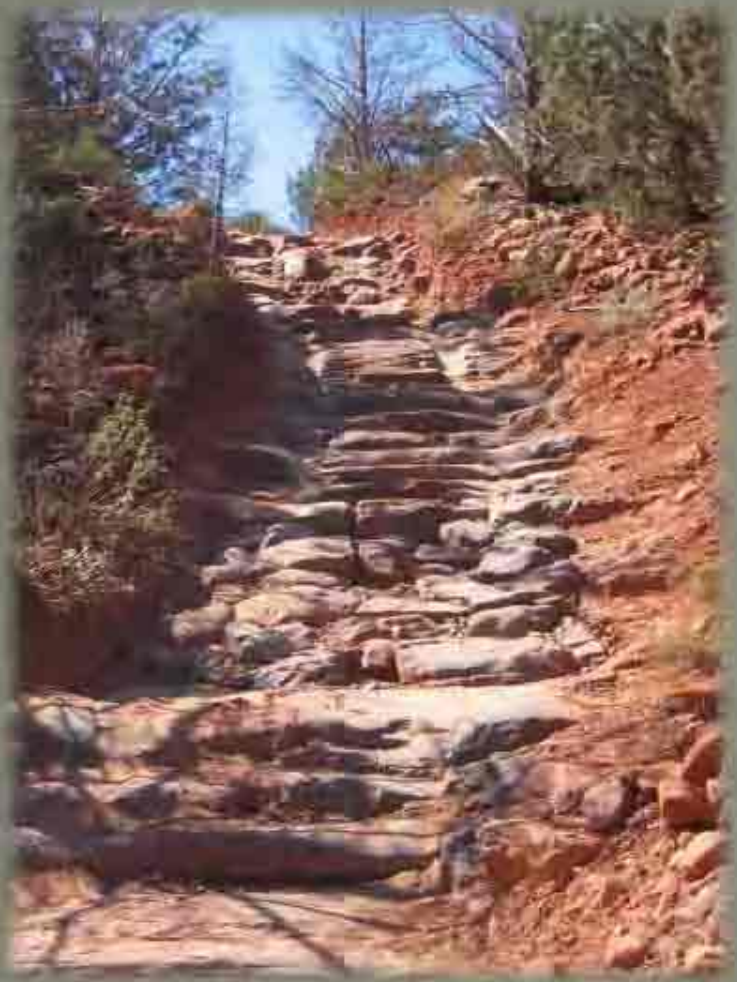
**Horse & Motorized Use Trails – Grades should not exceed 10% due to their higher potential for erosion. Gravel is also recommended unless soils are rocky or otherwise durable.**

# Tools for steeper trails- Foot Traffic Steps/stairs

# Tools for steeper trails-Mountain bikes

- Elevated wood structures
- Rock armoring
- Steps and step downs
- Natural rock for steep tread


# Tools for steeper ORV trails



# Tools for steeper horse trails?

# Questions?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