# Developing The "Blueprint" for Sustainable Trails

**Ralph Protano, Trails Development Manager**
**Jim Rodstrom, Director of Construction**

Cleveland Metroparks

# CLEVELAND METROPARKS TRAIL INVENTORY

All Purpose Trails-100+ Miles

Hiking Trails-100+ Miles

Bridle Trails-100+ Miles

Non-Sanctioned Trails-100+ Miles


# CLEVELAND METROPARKS

## 2011 COMMUNITY SURVEY

**6,000 Households, 1,246 Respondents**

**71% List Hiking/Walking on Trails as Primary Activity**

**Ways to Improve Experience in Parks:**

***Trail Connections-68%***

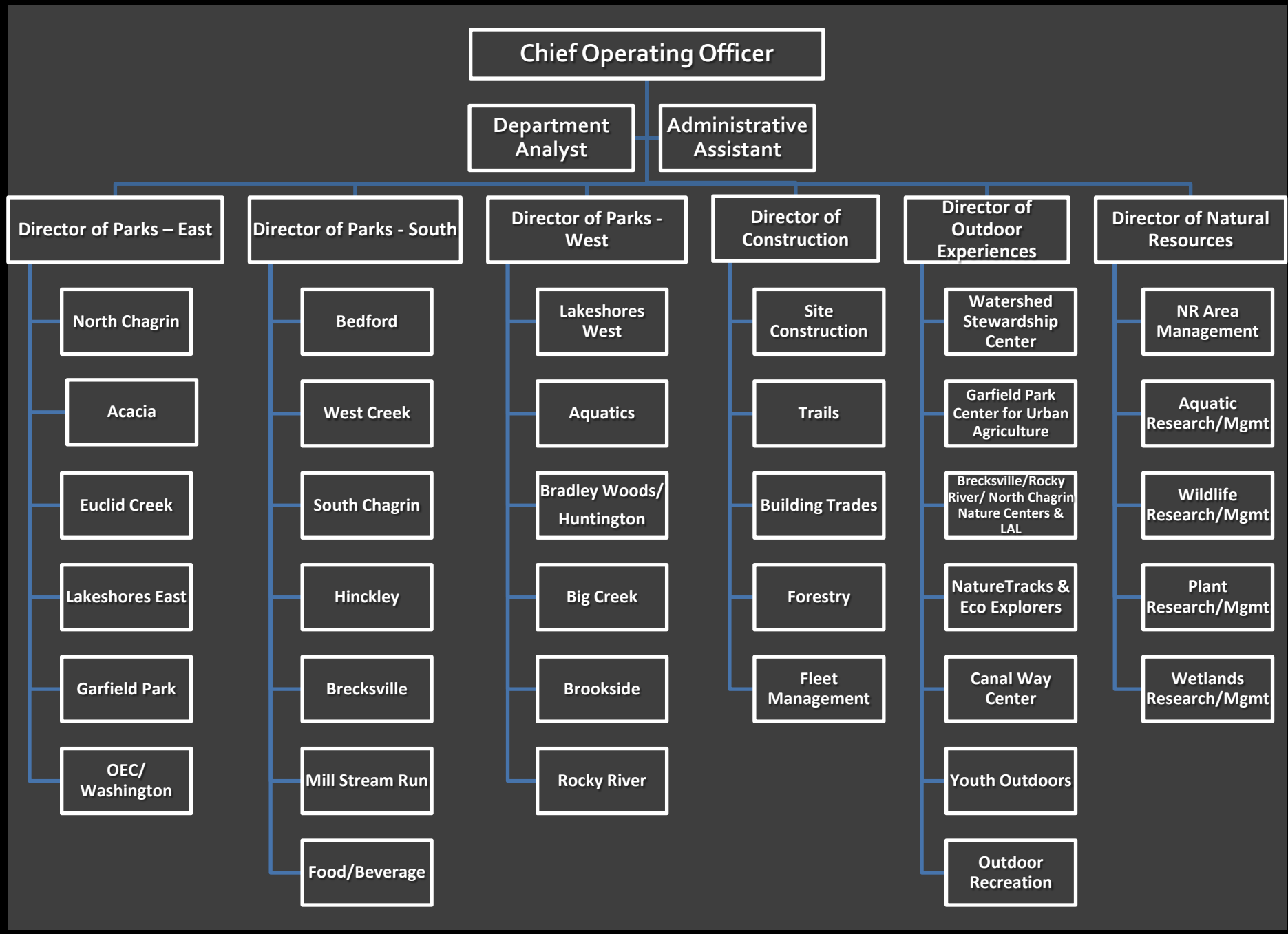
***Increase Number of Hiking/Biking Trails-59%***

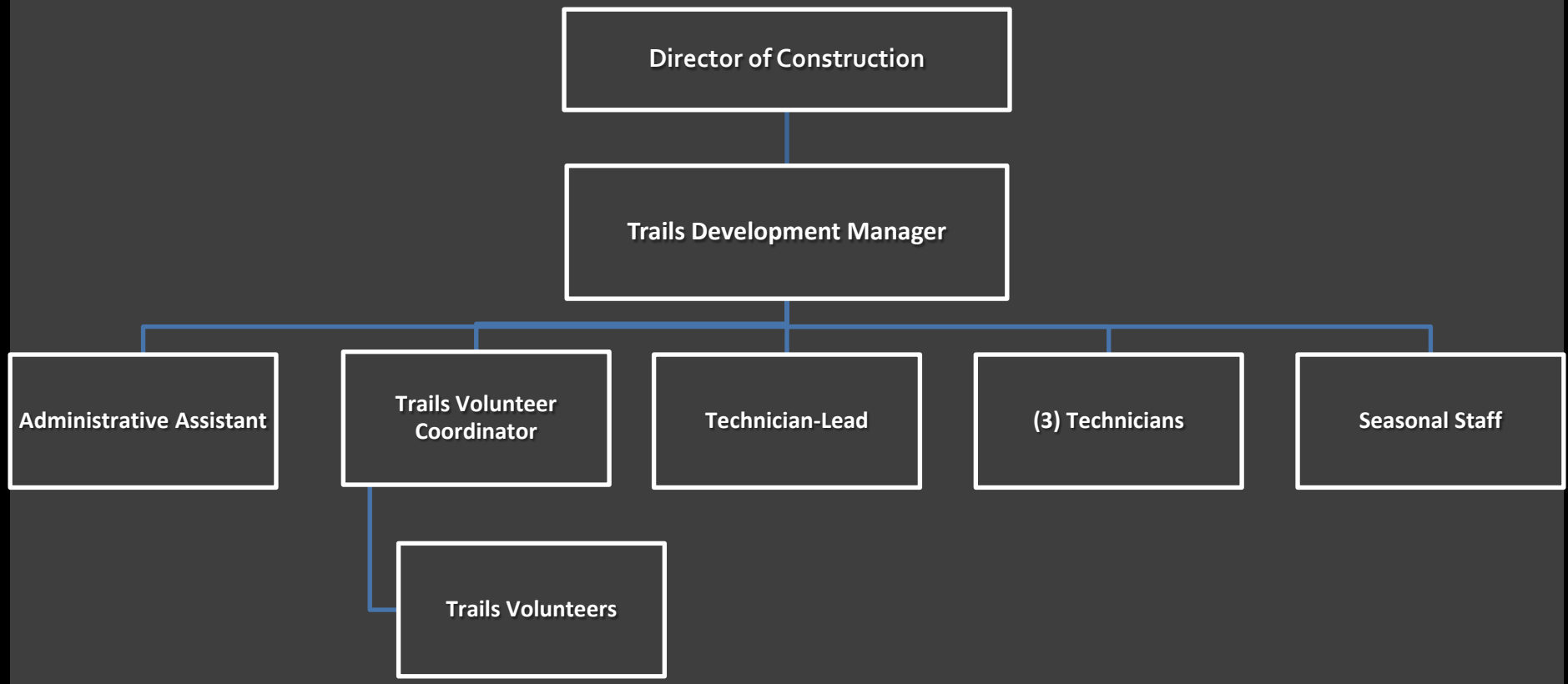
# Royalview Trail

10+ Mile Bike/Hike Trail Project

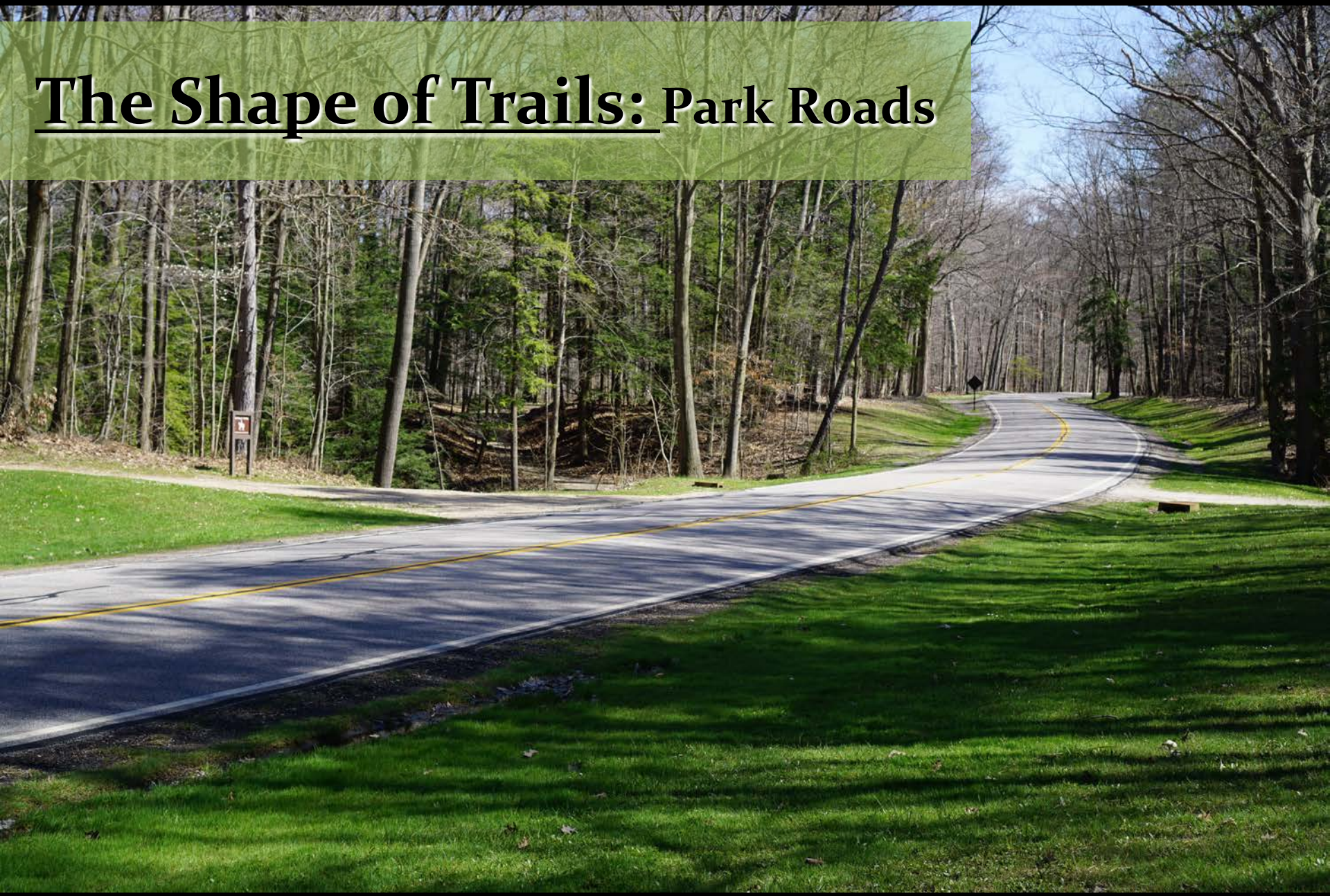
Student Conservation Association

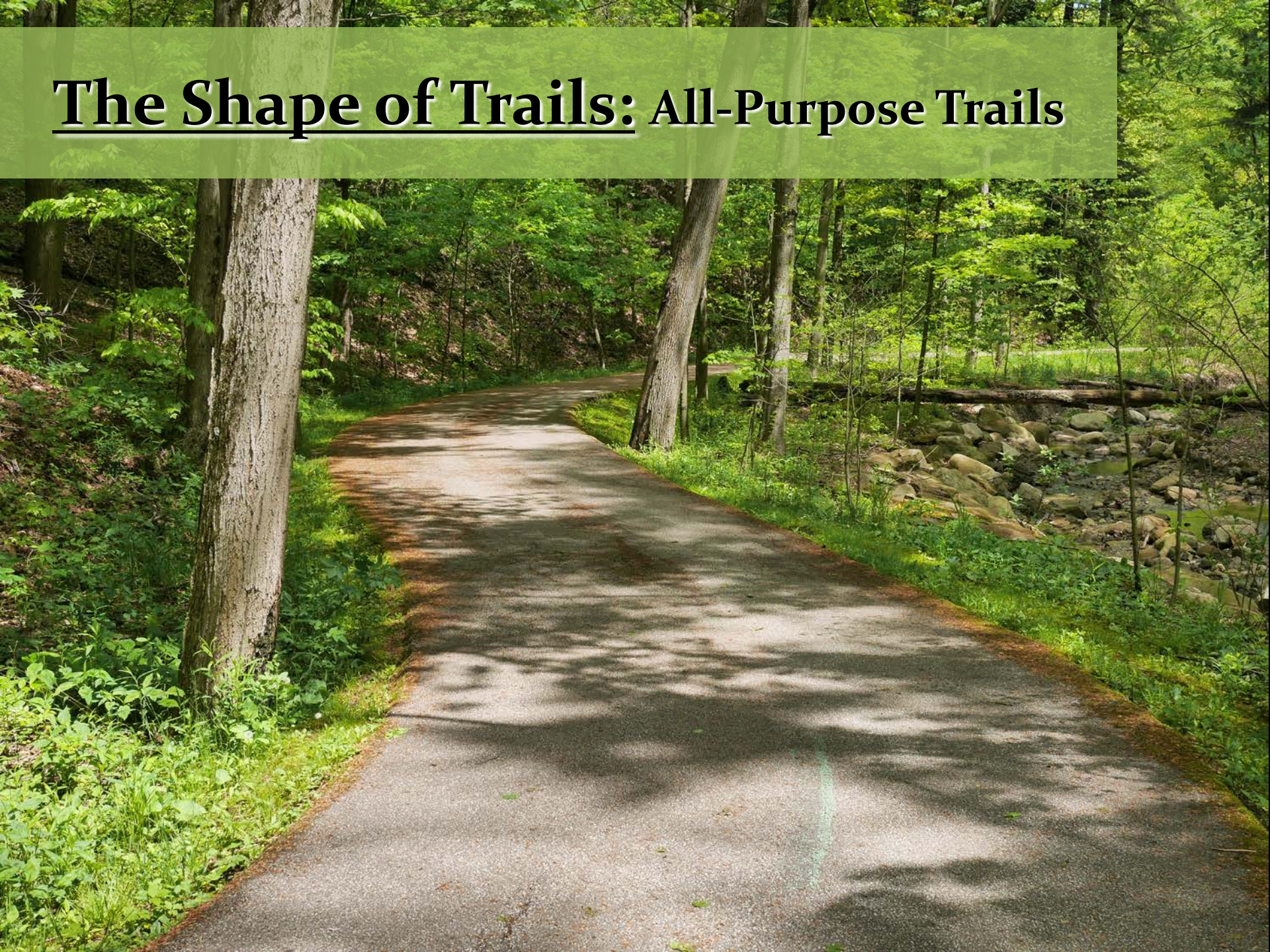
Cleveland Metroparks Maintenance Staff


Chief Operating Officer
Department Analyst
Administrative Assistant
Director of Parks – East
North Chagrin
Acacia
Euclid Creek
Lakeshores East
Garfield Park
OEC/ Washington
Director of Parks - South
Bedford
West Creek
South Chagrin
Hinckley
Brecksville
Mill Stream Run
Food/Beverage
Director of Parks - West
Lakeshores West
Aquatics
Bradley Woods/ Huntington
Big Creek
Brookside
Rocky River
Director of Construction
Site Construction
Trails
Building Trades
Forestry
Fleet Management
Director of Outdoor Experiences
Watershed Stewardship Center
Garfield Park Center for Urban Agriculture
Brecksville/Rocky River/ North Chagrin Nature Centers & LAL
NatureTracks & Eco Explorers
Canal Way Center
Youth Outdoors
Outdoor Recreation
Director of Natural Resources
NR Area Management
Aquatic Research/Mgmt
Wildlife Research/Mgmt
Plant Research/Mgmt
Wetlands Research/Mgmt


Director of Construction
Trails Development Manager
Administrative Assistant
Trails Volunteer Coordinator
Technician-Lead
(3) Technicians
Seasonal Staff
Trails Volunteers

# The Shape of Trails in Northeast Ohio


The Shape of Trails: Park Roads


The Shape of Trails: All-Purpose Trails

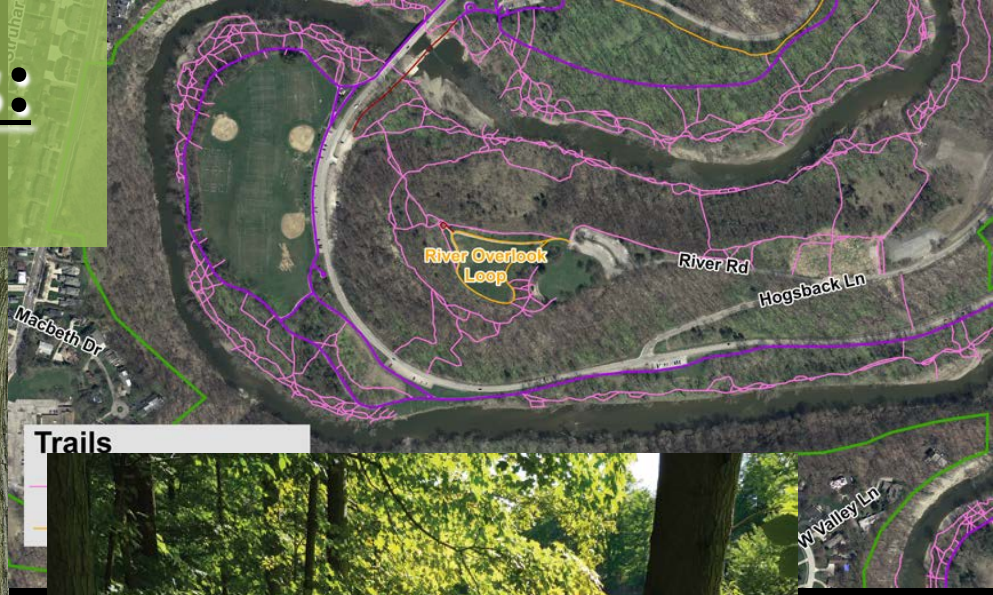
# The Shape of Trails: Equestrian Trails

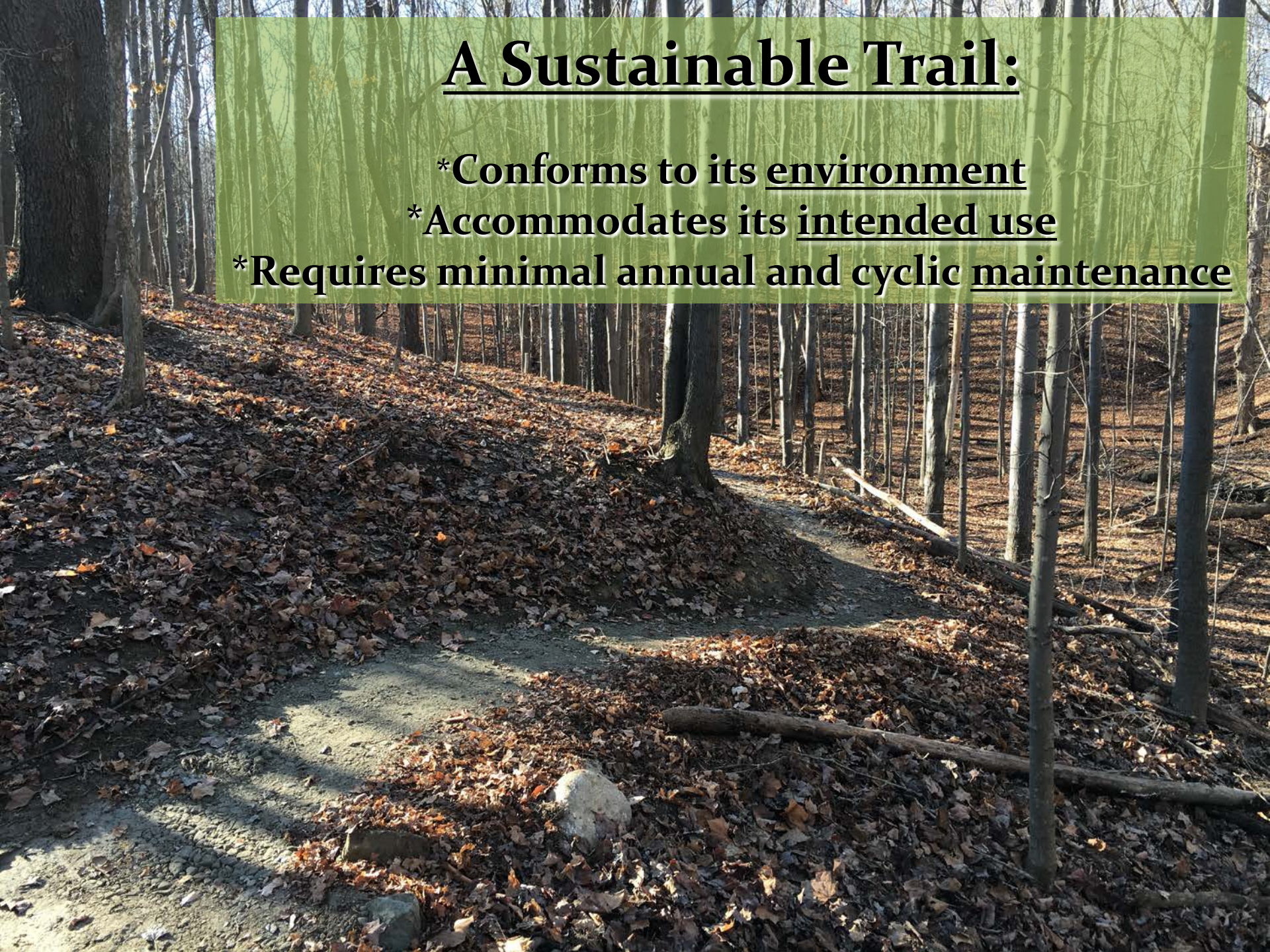
# The Shape of Trails: Hiking Trails


# The Same Shape at Every Scale


# The Shape of Trails:

## Bootleg Trails



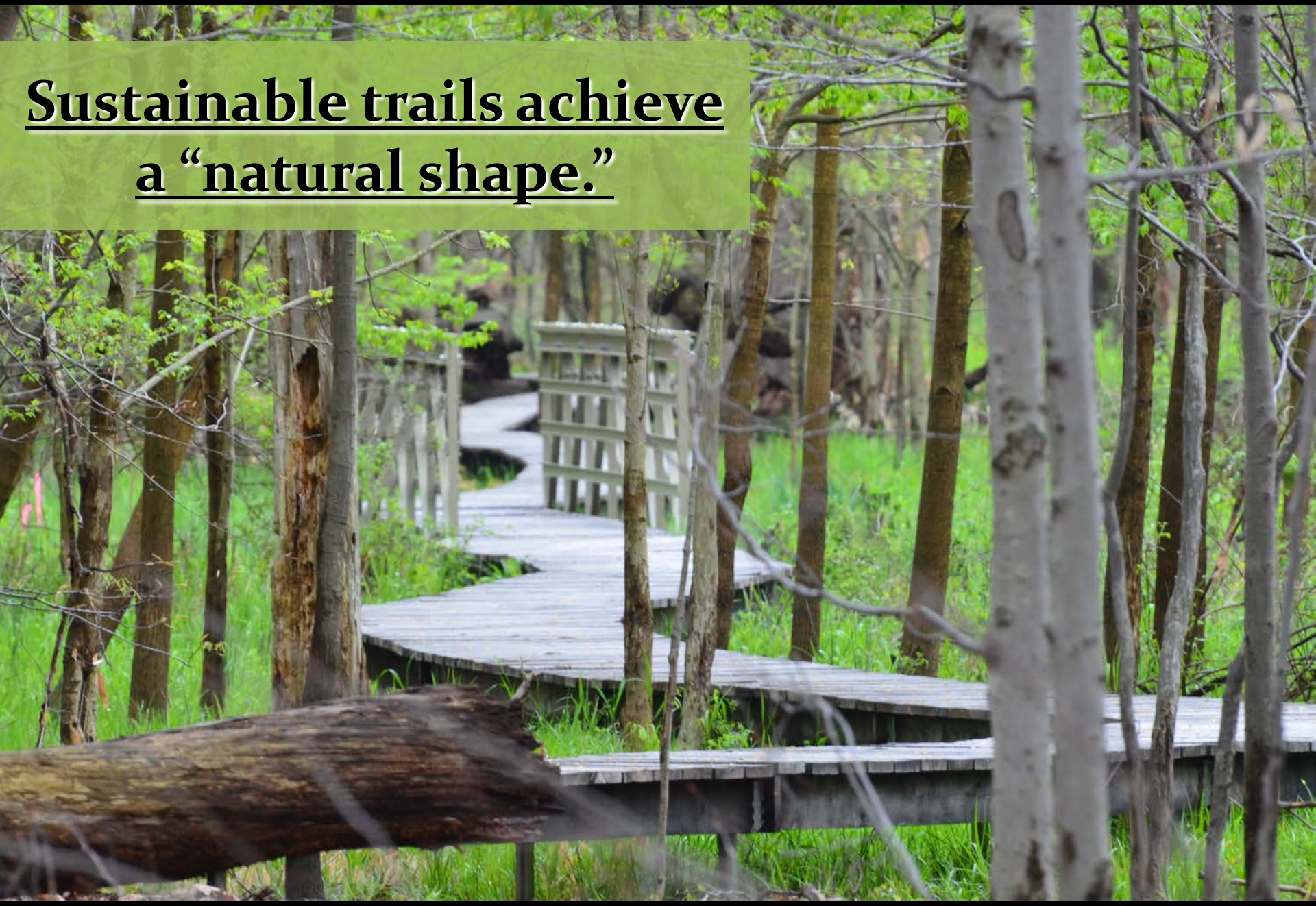



# A Sustainable Trail:

*Conforms to its environment
*Accommodates its intended use
*Requires minimal annual and cyclic maintenance

# Sustainable Trailbuilding

*Reacts to the site and works with the terrain.
*It is a land management technique


Sustainable trails achieve
a “natural shape.”

# A Language for Trails:

Human Perception

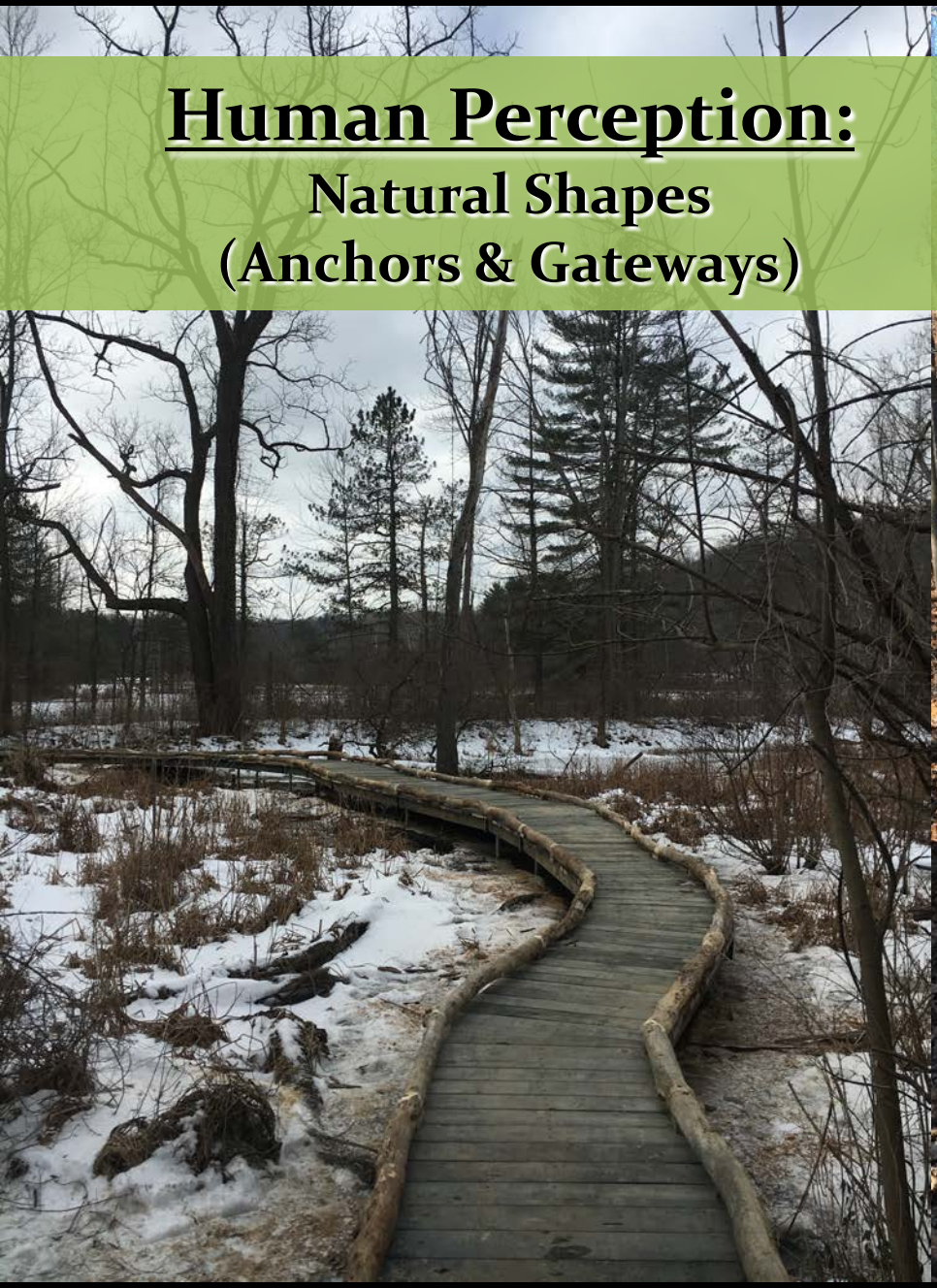
Terrain Dynamics

Physical Forces


Human Perception

# Human Perception:

## Natural Shapes
## (Anchors & Gateways)

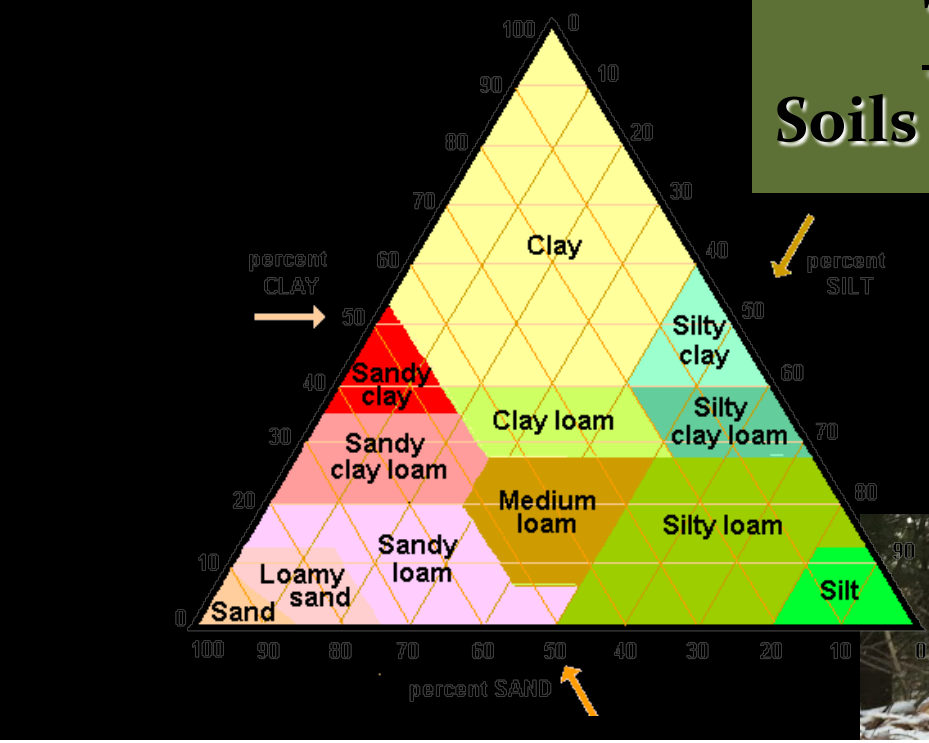


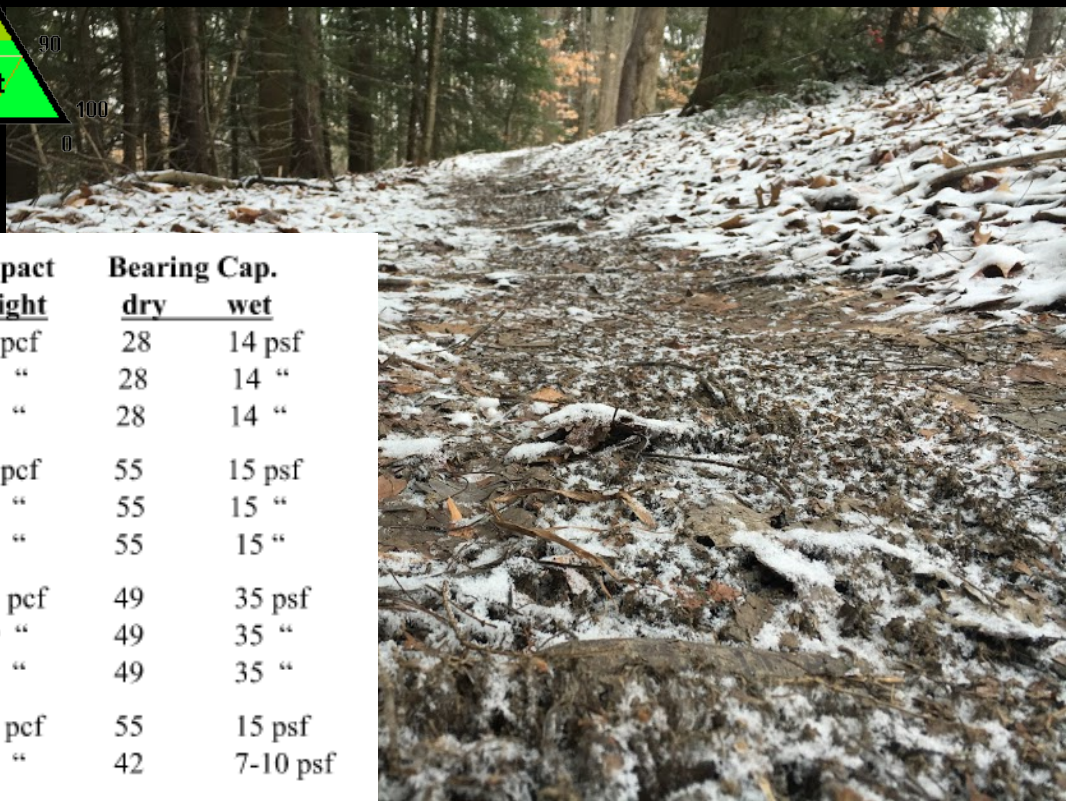
# Human Perception:
# Desired Experience
## (Safety, Efficiency & Playfulness)

# Terrain Dynamics

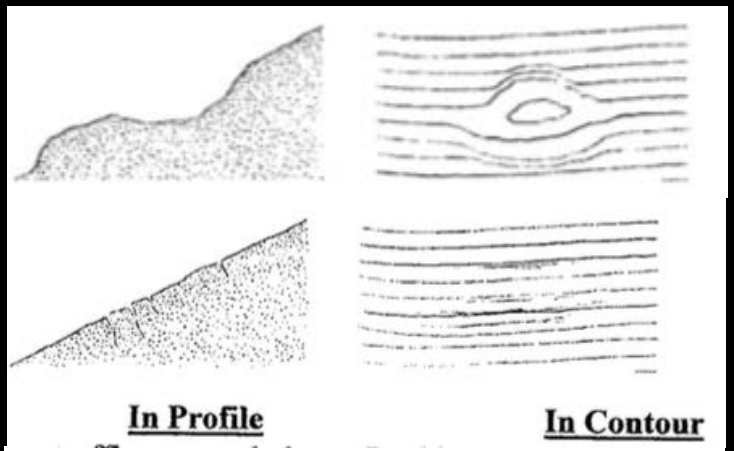
# Terrain Dynamics:

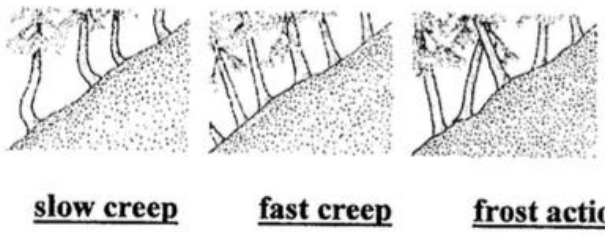
## Soils as Dynamic Structural Materials

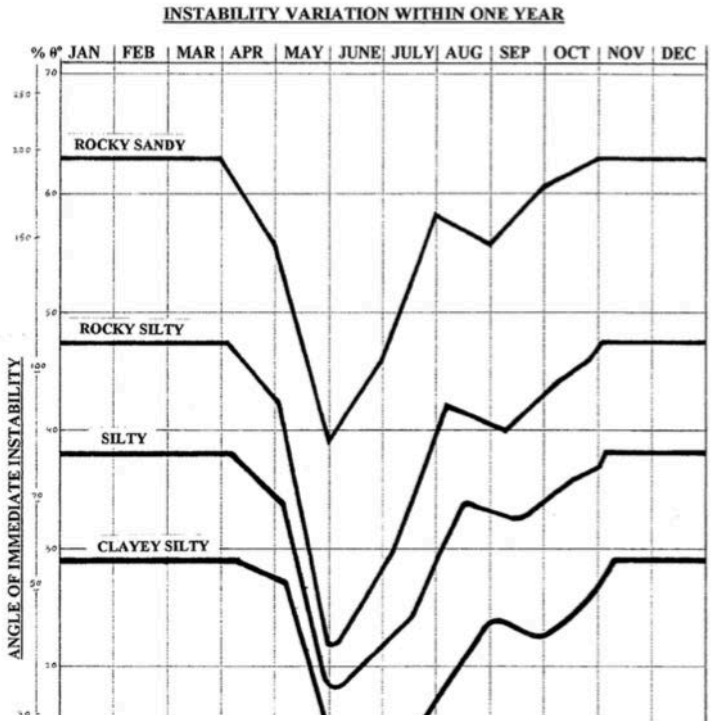


| Type | Rock & Gravel | Sand | Silt | Clay | compact weight | Bearing Cap. dry | wet |
|---|---|---|---|---|---|---|---|
| Rocky Silt Loam | 25% | 20% | 40% | 15% | 89 pcf | 28 | 14 psf |
| Gravelly Silt Loam | 25% | 20% | 40% | 15% | 93 " | 28 | 14 " |
| Silt Loam | | 20% | 60% | 20% | 83 " | 28 | 14 " |
| Rocky Clay Loam | 25% | 15% | 30% | 30% | 90 pcf | 55 | 15 psf |
| Silty Clay Loam | | 15% | 55% | 30% | 83 " | 55 | 15 " |
| Clay Loam | | 28% | 37% | 35% | 87 " | 55 | 15 " |
| Rocky Sandy Loam | 25% | 40% | 25% | 10% | 95 pcf | 49 | 35 psf |
| Gravelly Sandy Loam | 25% | 40% | 25% | 10% | 99 " | 49 | 35 " |
| Sandy Loam | | 65% | 25% | 10% | 96 " | 49 | 35 " |
| Sandy Clay | | 45% | 15% | 40% | 92 pcf | 55 | 15 psf |
| Silty Clay | | 20% | 40% | 40% | 85 " | 42 | 7-10 psf |



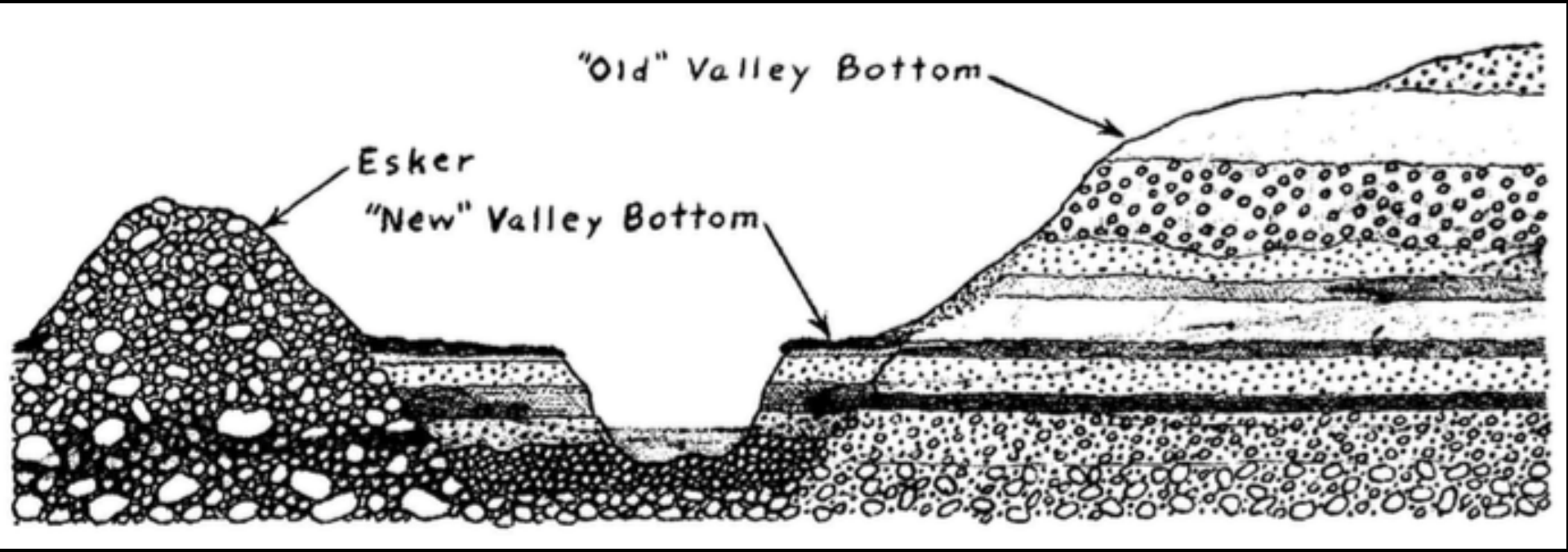

| Soil Type | nom. Angle of Repose | | Angle of Instability @ Field Cap. | | @ 75% Sat. | | @ 100% Sat. | |
|---|---|---|---|---|---|---|---|---|
| Sandy Loam | 34° | 67% | 40° | 84% | 29° | 55% | 24° | 45% |
| Silt Loam | 32° | 62% | 31° | 60% | 18° | 32% | 10° | 18% |
| Clay Loam | 20° | 36% | 16° | 28% | 6° | 11% | 5° | 8% |
| 25% Rocky Sandy Loam | 36° | 73% | 43° | 92% | 36° | 72% | 32° | 62% |
| 25% Rocky Silt Loam | 35° | 70% | 40° | 83% | 27° | 51% | 20° | 36% |
| 25% Rocky Clay Loam | 26° | 49% | 27° | 51% | 17° | 30% | 15° | 27% |
| 10% Rocky Sandy Loam | 35° | 70% | 42° | | | | | |
| 10% Rocky Silt Loam | 33° | 65% | 35° | 70% | | | | 24% |
| 10% Rocky Clay Loam | 22° | 40% | 20° | 36% | 10° | 18% | 8° | 15% |

# Terrain Dynamics:

## Slope Stability

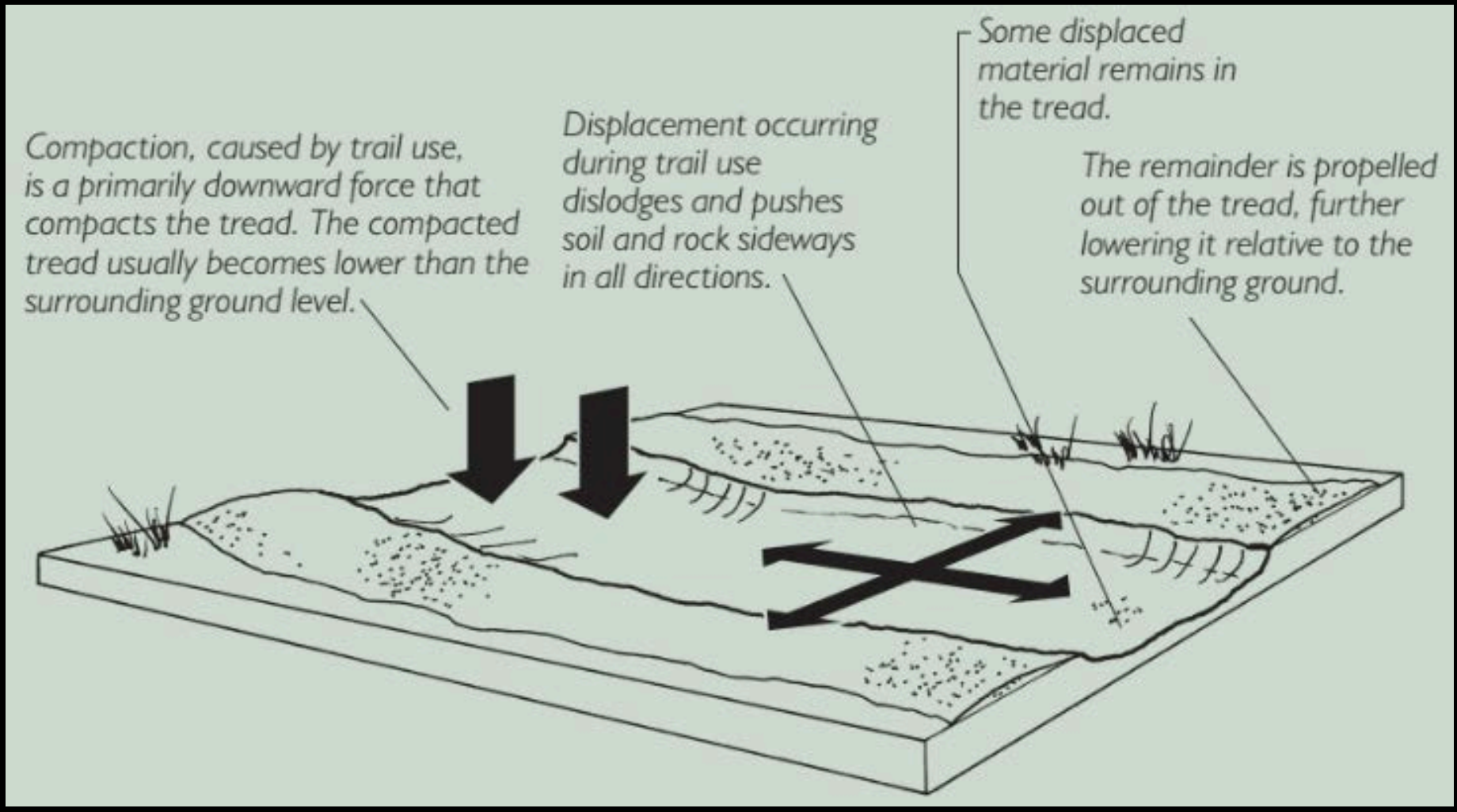
# Terrain Dynamics:

## Characteristics of Depositional Terrains



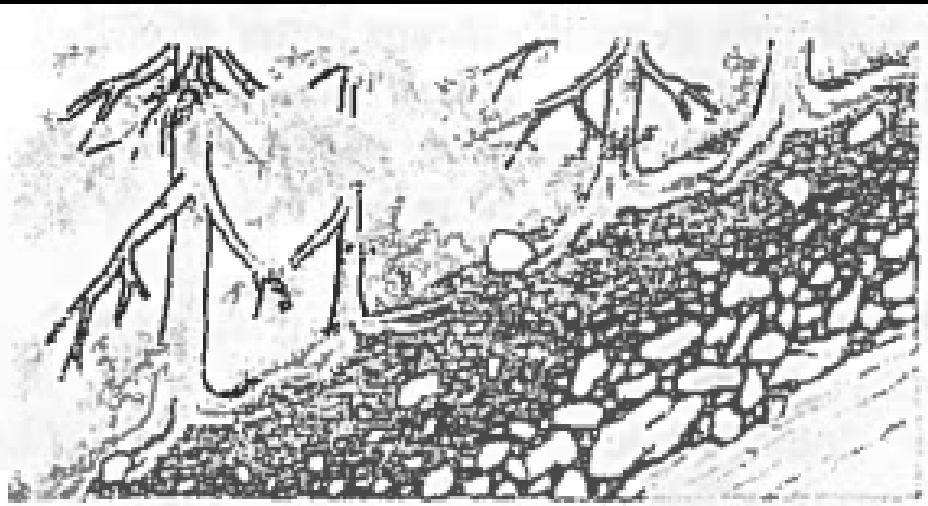
# Physical Forces

# Physical Forces:
## Compaction, Displacement & Erosion

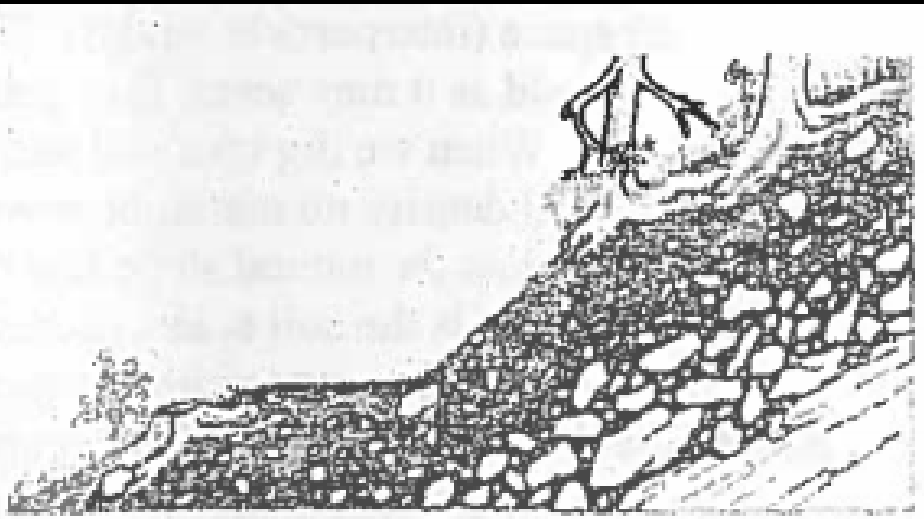



**Source:** ***Trail Planning, Design, and Development Guidelines,*** **by Minnesota Natural Resources, 2007**

# Physical Forces:
## The Ground as a Structure



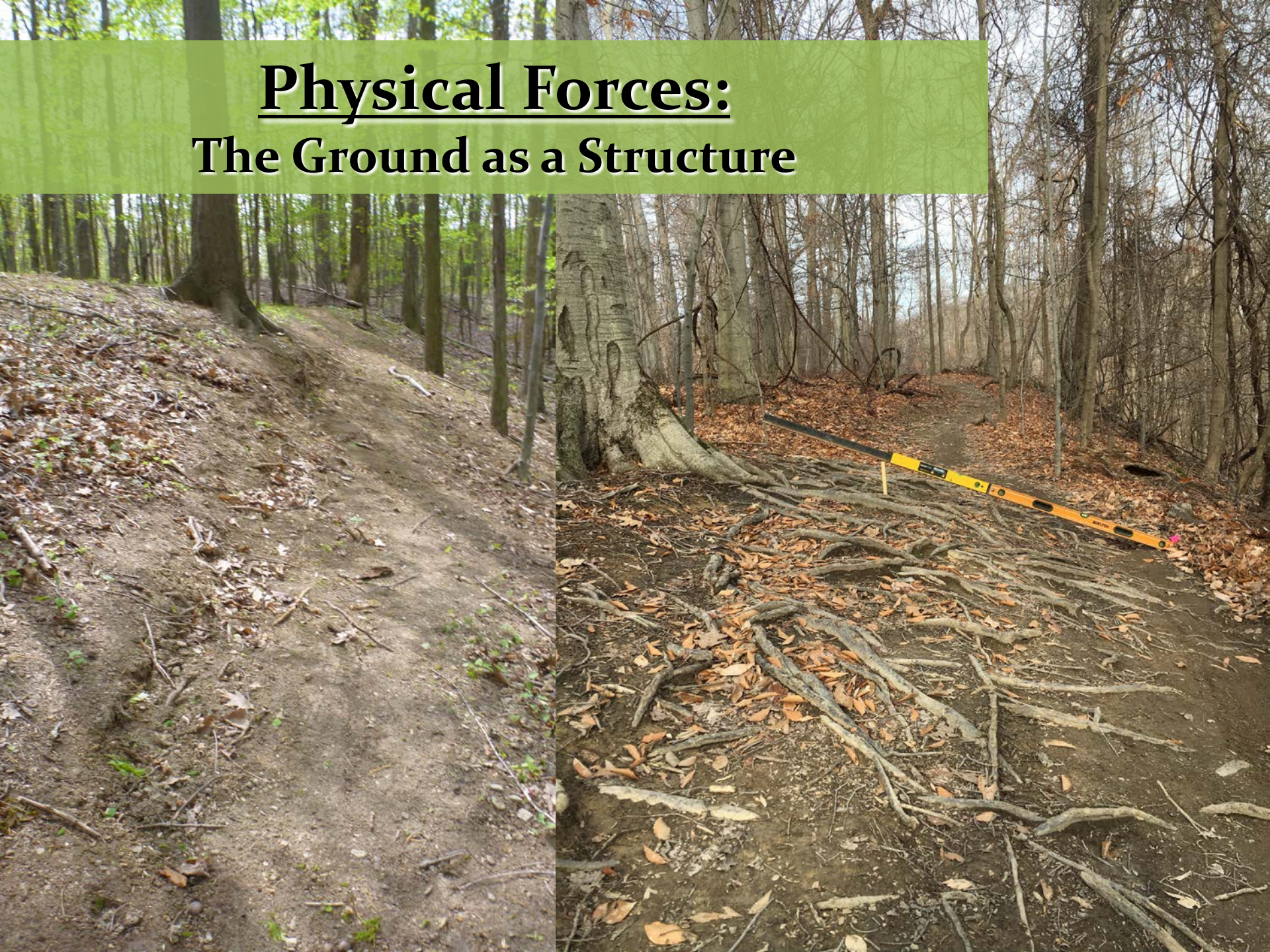
Ground Structure



with Trail Structure

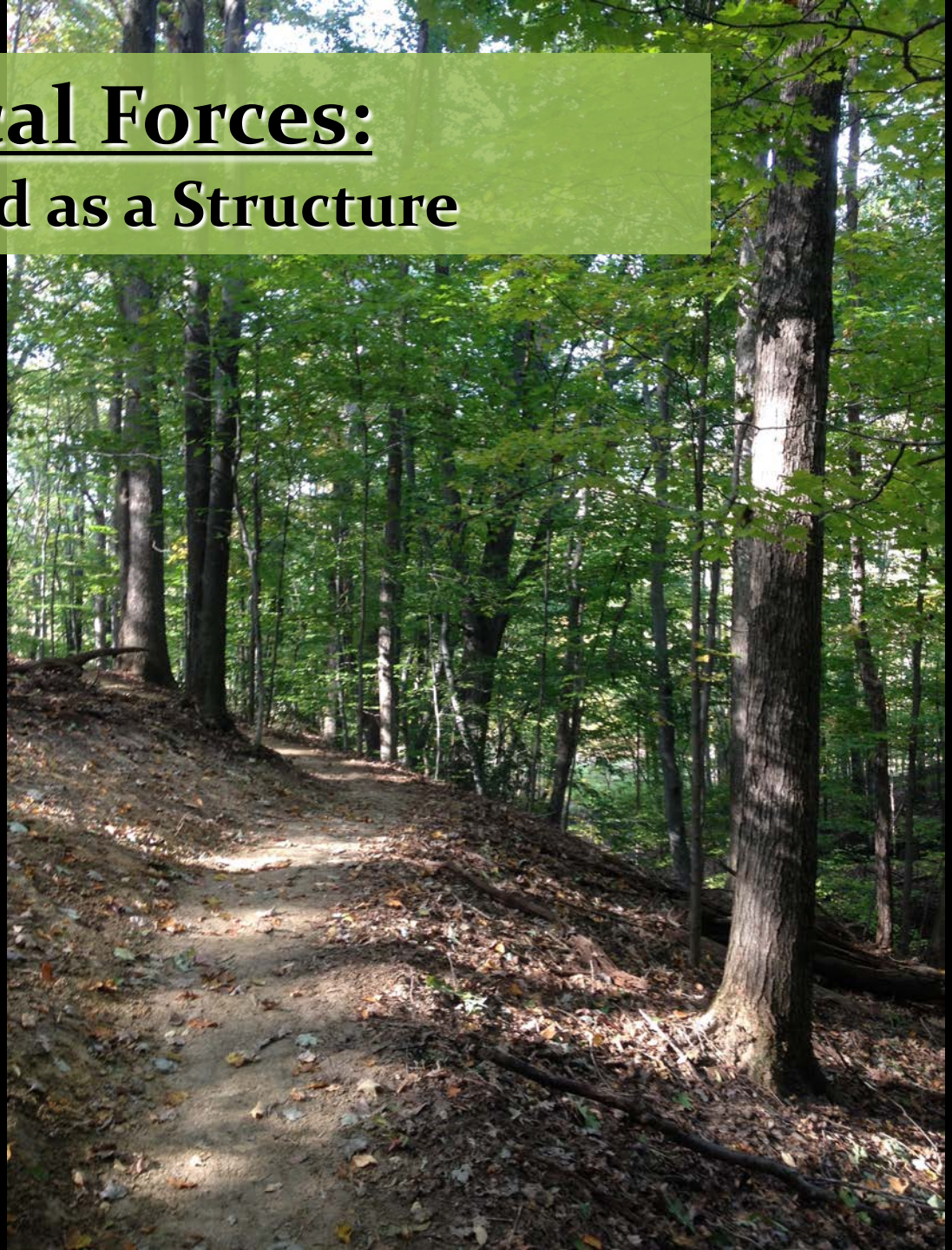
# Physical Forces:

## The Ground as a Structure



# Physical Forces:

## The Ground as a Structure



# Trail Language Summary

## Human Perception

- Natural Shape
- Desired Experience

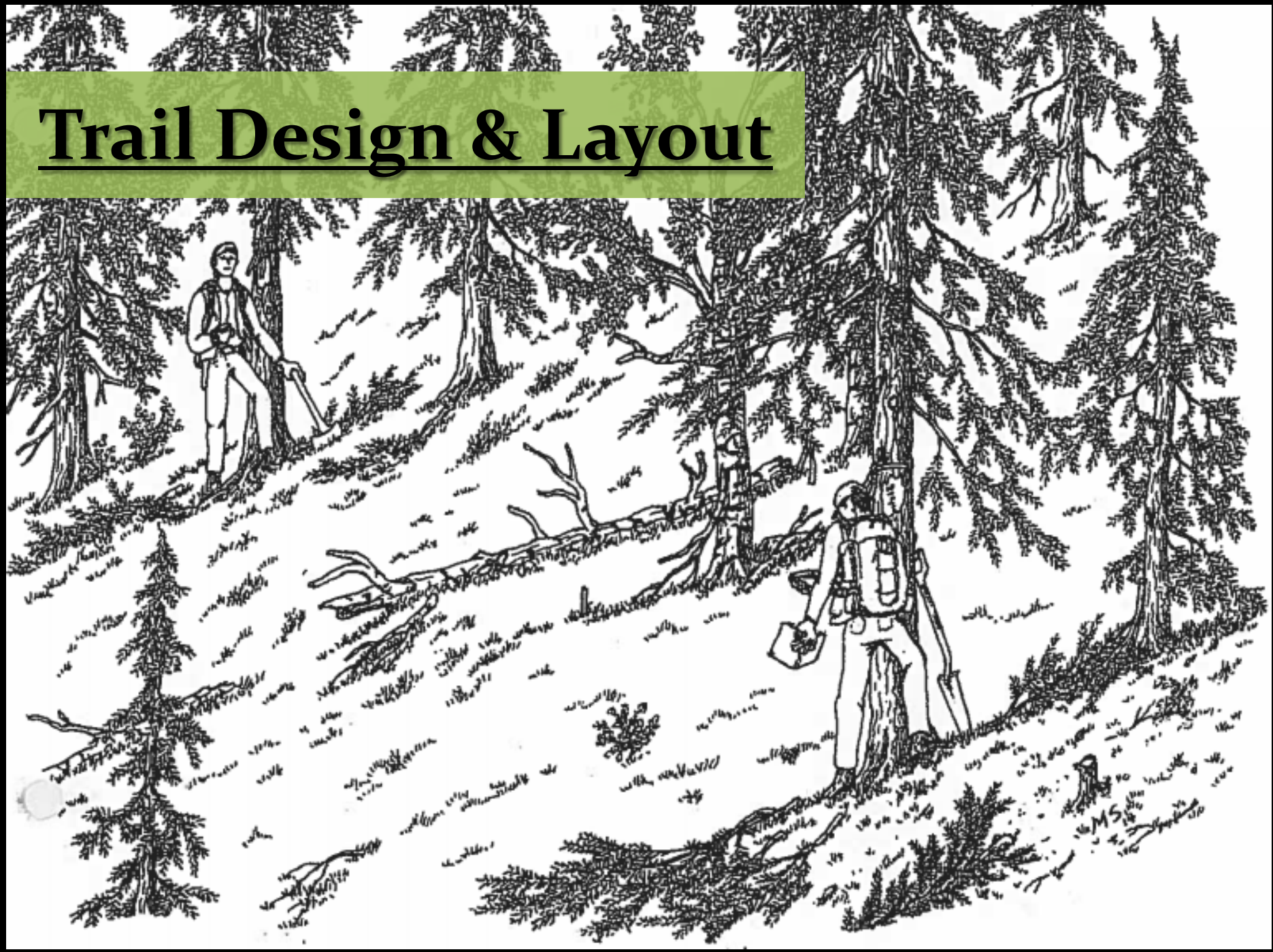
## Terrain Dynamics

- Soil Strength
- Slope Stability
- Hydrology

## Physical Forces

- Compaction, Displacement, Erosion
- The Ground as a Structure

# Trail Design & Layout



# The Design Process

## Trail Use Questions
## Sustainable Elements
## Terrain & Human Elements

## TRAIL DESIGN WORKSHEET

**Trail Name** _____ **est. Length** _____ miles **Date** _____
**Proposed Location**(general)_____

**PURPOSE:** /_/ Recreational /_/ Utilitarian /_/ Interpretive /_/ Historic /_/ Other_____

**USE: Designed for** _____ **ADA** /_/ No /_/ Yes – (attach description)
**Allowed** _____
**Prohibited** _____
**Design for Traffic Flow:** /_/ One-Way /_/ Two-Way /_/ One-Way w/ passing pullouts
**Use Season:** /_/ Summer /_/ Winter /_/ Both /_/ Other (describe) _____
**NOTES:** _____
_____

### SUSTAINABLE ELEMENTS

**ALIGNMENT:** /_/ Contoured /_/ Other (describe) _____
**CONSTRUCTION:** /_/ Full-Bench /_/ Other [1] (describe) _____
**Allowed Turns:** /_/ Sweep Turn /_/ Switchback /_/ Banked Turn
**DRAINAGE:** /_/ Grade Reversals // spacing ____ (see attached spacing vs grade sheet)
**CONTROL** /_/ Tread Outslope at ___% /_/ Tread Crown at ___%
/_/ Other (describe) _____
**GRADE:** Average for Trail Length ____% Average for Climbing Leg ____%
Grade Reversals at ____% for ____ feet minimum. Average Map Grade ____%
Maximum ____% for _____ feet and ____% of trail length.
In-Turn ____% for Sweep Turns, __5_% for Switchbacks.
**TREAD:** /_/ Mineral Soil (describe in general) _____
Structural Section ____ inches thick, roots & rocks over ___ inches removed.
/_/ Hardened (describe) _____

### OTHER ELEMENTS

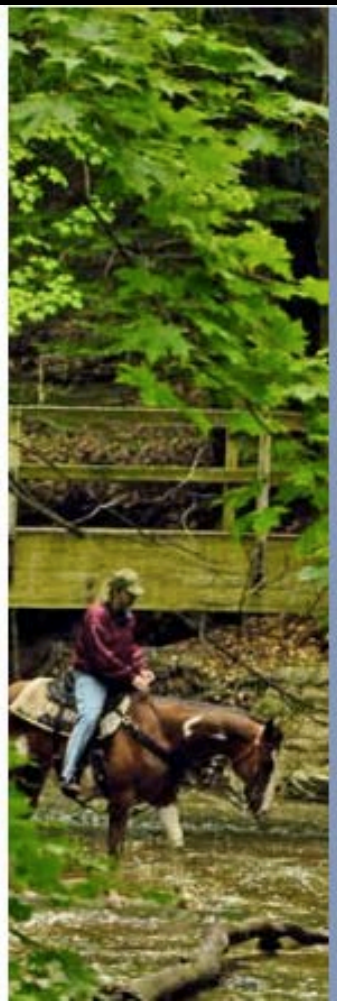
**TREAD WIDTH:**minimum ___ inches; maximum ___ inches; in passing pullouts ___ inches
**TURN RADIUS:** minimum ___ feet; optimum ___ feet; Banked Turn Inslope ___ %
**BACKSLOPE ANGLE:** _____ Fill Slope Angle: _2:1_
**CLEARING:** Width ____ feet beyond Tread Margin Height ____ feet above Tread Level
**STRUCTURES:** List any Prohibited in –
Tread _____
Slopes _____
Drainage _____
Stream Crossings _____
**PROHIBITED:** Construction Methods _____
Maintenance Methods _____
**MAINTENANCE CAPACITY:** Attach description of staff, equipment, tools, etc., available for maintenance of area trails totaling _____ miles (include proposed trail).

**Form Completed by** _____, _____
Name Title

(1) These are NOT Sustainable.

# Trail Use Questions:

**Purpose**
**Design Use**
**Allowed Use**
**Prohibited Use**
**Possible Unintended Use**
**Season(s) of Use**
**Intensity of Use**
**Realistic Use Control Methods**

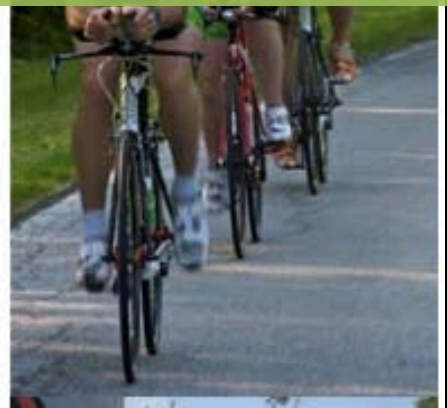


## Greenway and Trail Network

Greenway and trail networks are core physical assets of the Cleveland Metroparks and a primary vehicle for fulfilling the organization's three-part mission. Trails provide opportunities for recreation and education while immersing participants in the out-of-doors. They provide a venue for a wide range of hands-on activities and programs. Beyond these functions, trails supplement the region's transportation network by providing safe routes for walking and biking. Greenways are conservation areas intended to protect ecologically significant land and water features as well as provide valuable environmental services.

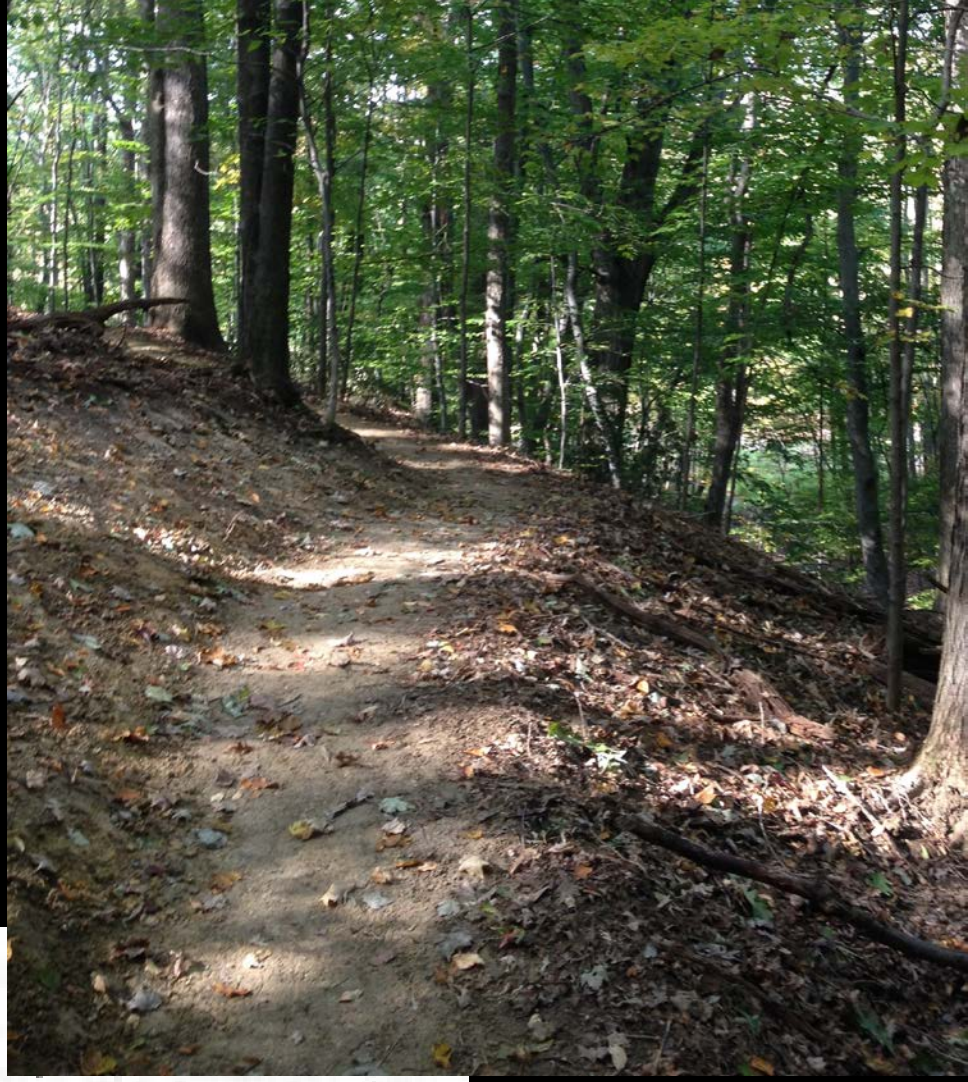
### Goal

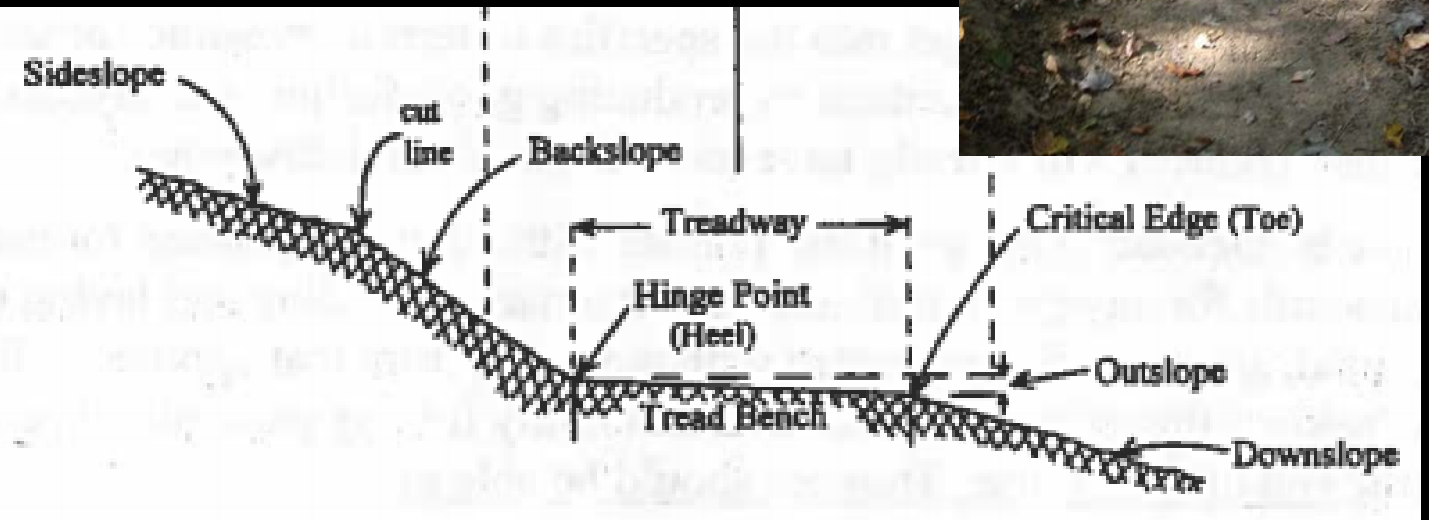
Provide environmental, economic, and community benefits for the people of Northeast Ohio through an accessible, regional greenway and trail network structured around the "Emerald Necklace" and other greenway corridors.



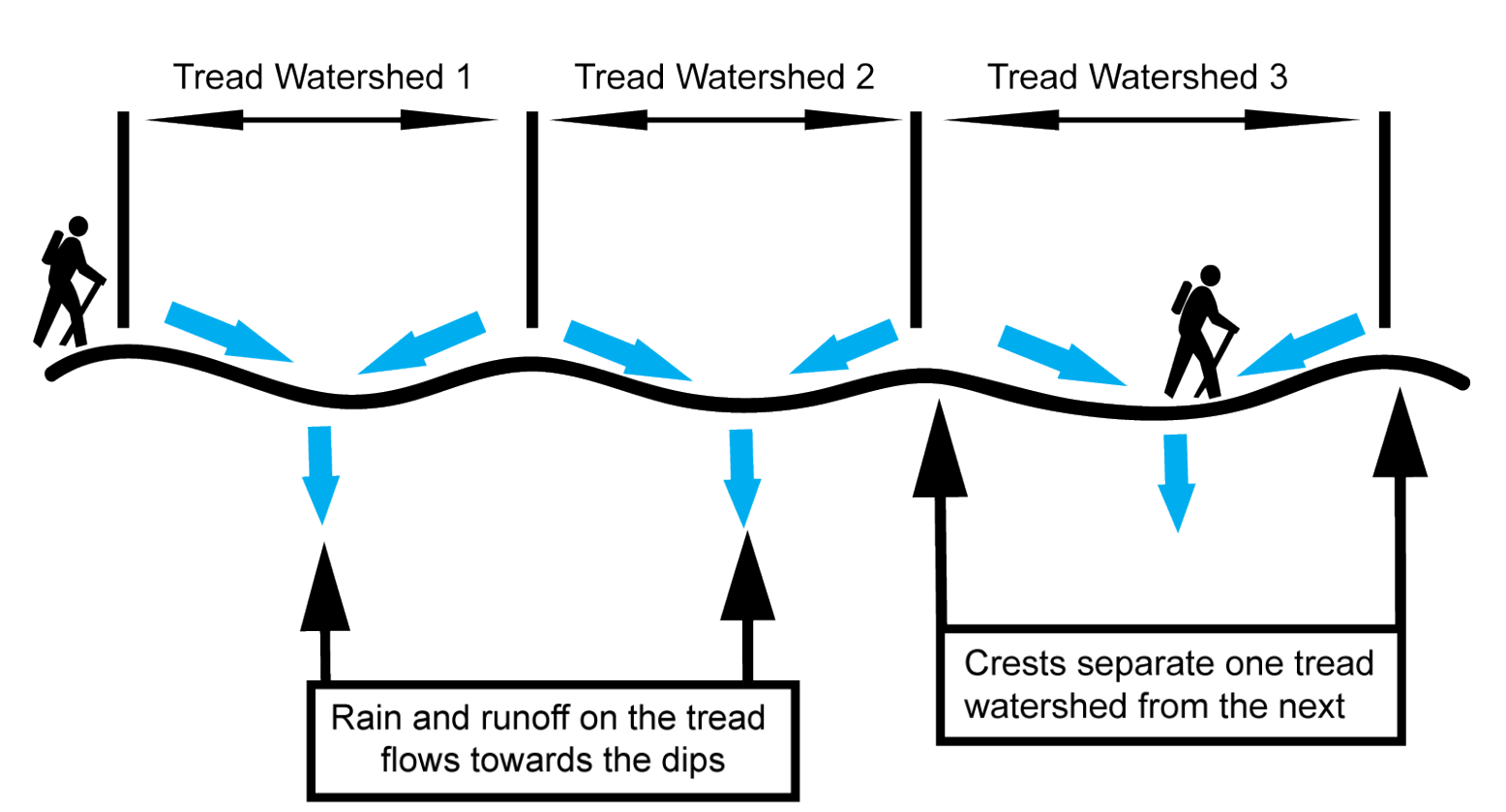
# Sustainable Design Elements

# Sustainable Design Elements:
## Full Bench Construction



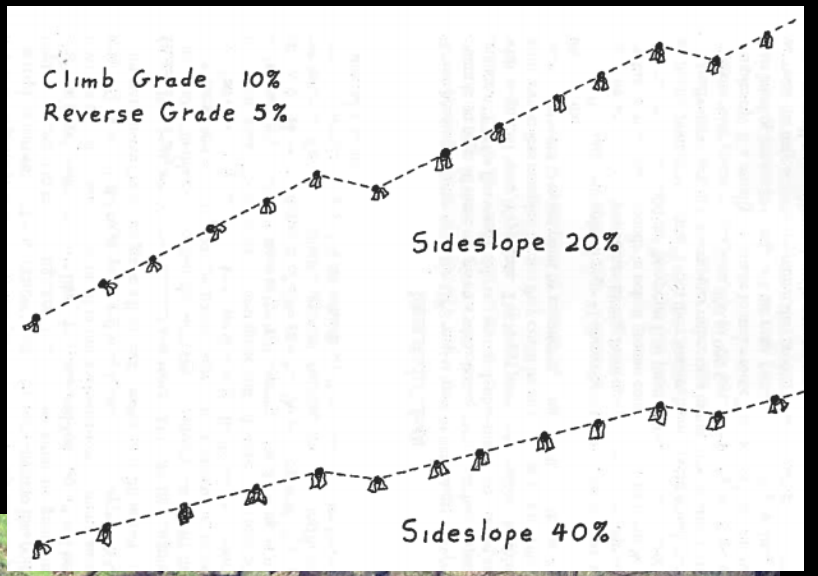


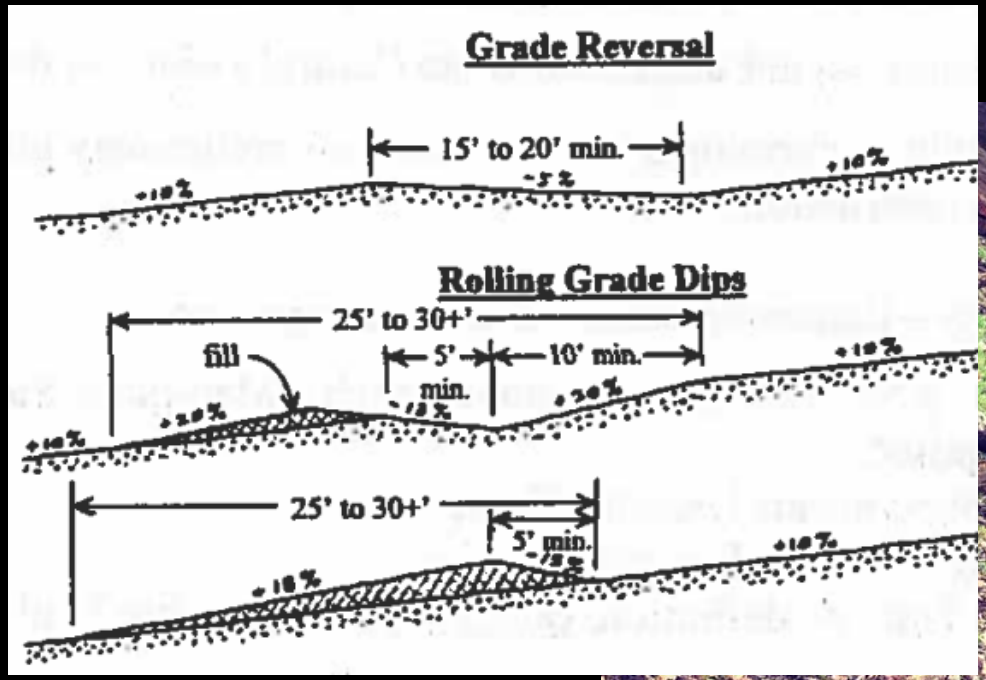
# Sustainable Design Elements:
## Integrated Drainage Control



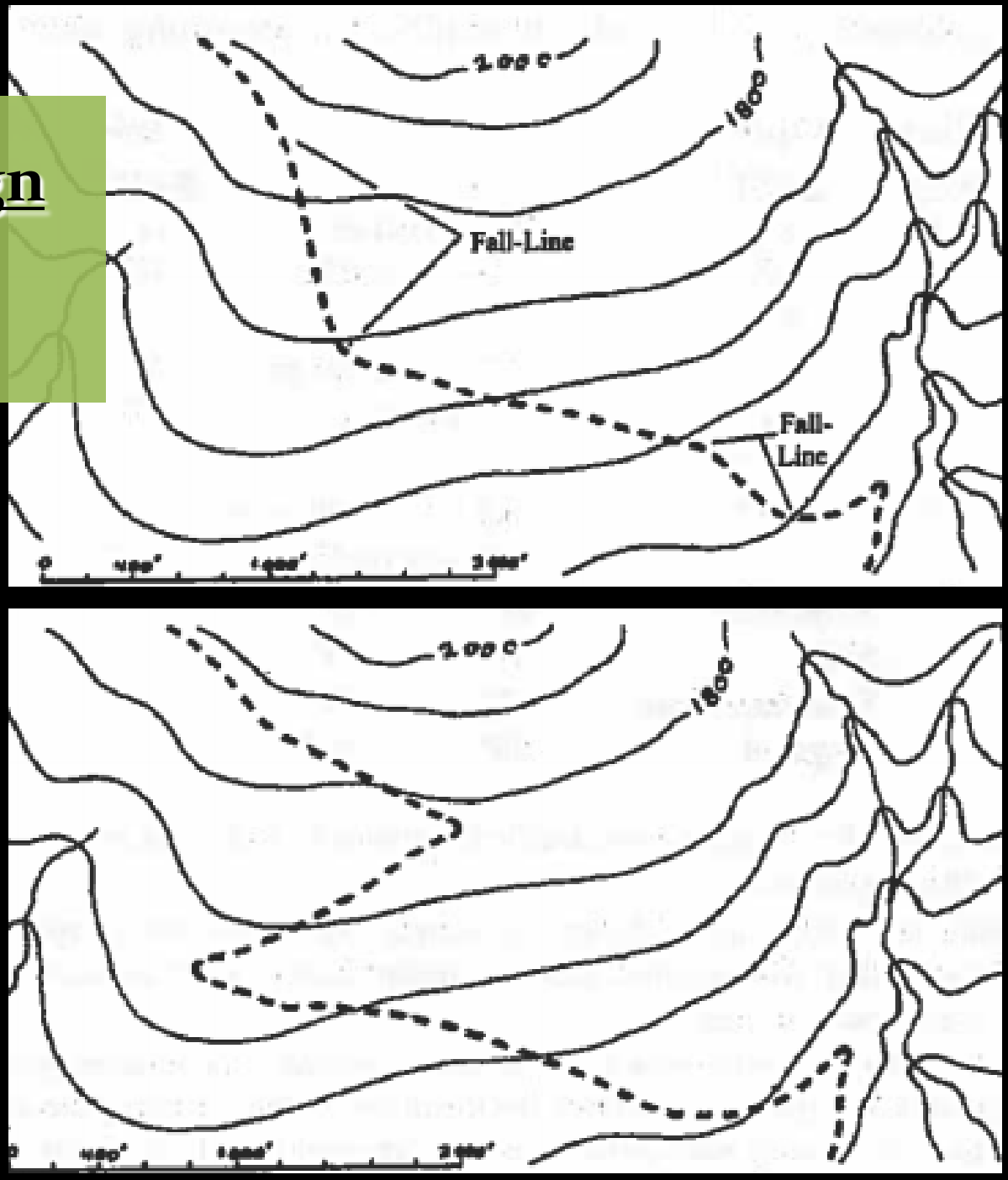

Source for Diagram: *Trail Planning, Design, and Development Guidelines*, by Minnesota Natural Resources, 2007

# Sustainable Design Elements:
## Integrated Drainage Control

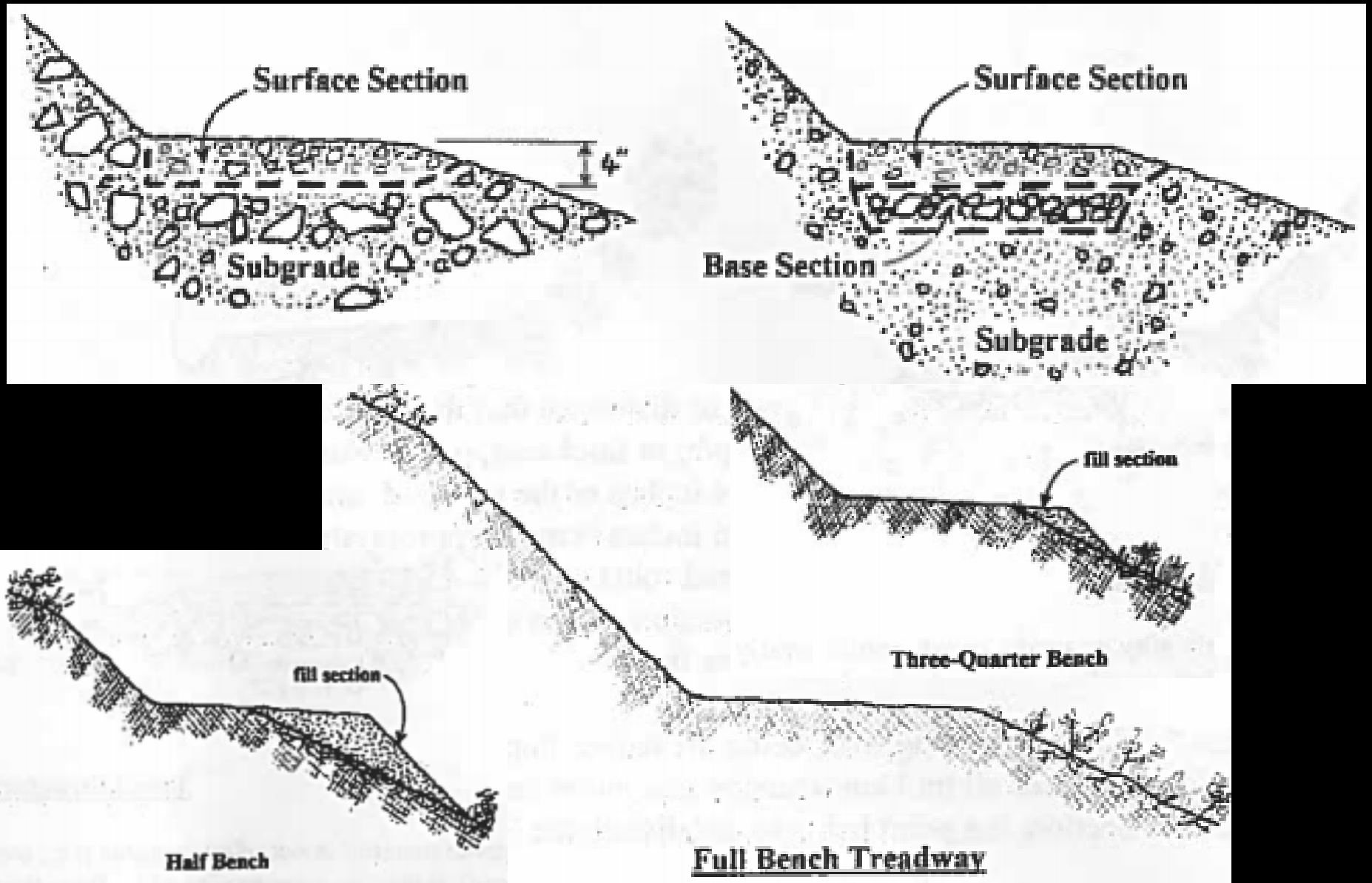



# Sustainable Design Elements:
## Controlled Grade



# Sustainable Design Elements: Tread Materials



# Sustainable Design Elements:

## Prohibited Construction/Maintenance Methods

# Sustainable Design Elements:

## Maintenance Capacity

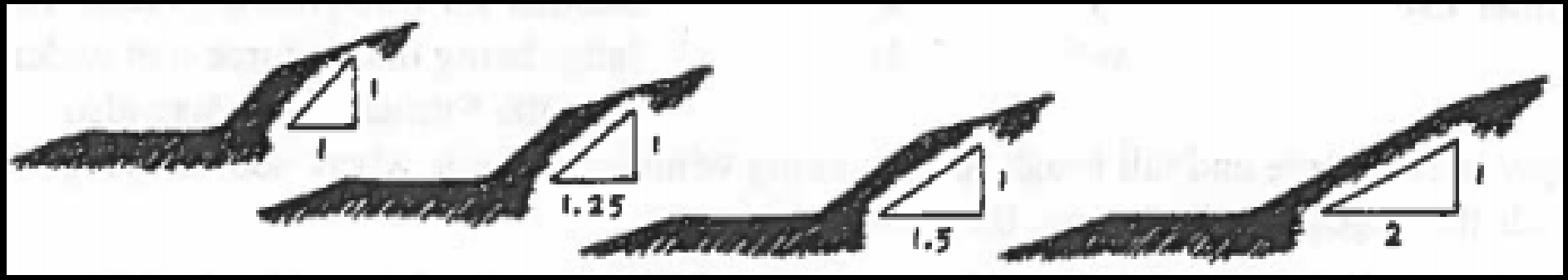
| | Low Maint. | Mod. Maint. | High Maint. |
|---|---|---|---|
| **ground slope** | 10%-50% | 5%-10%, 50%-80% | <5%, >80% |
| **ground stability** | good | moderate | poor |
| **alignment** | contoured | mostly contoured | cuts across contours |
| **tread material** | durable | hardened | not durable |
| **tread width** | <3' | 3'-5' | >5' |
| **drainage** | integral | adequate | inadequate |
| **climb grade** | Avg <10% | Avg 10%-15% | Avg >15% |
| **structures (per mile)** | few, simple | several or complex | many and complex |
| **traffic volume** | low | moderate | high |
| **traffic intensity** | low | moderate | high |

# Terrain Elements:
## Backslope & Fillslope Angles

**Backslope Angle**

| Soil: | granular, erodable | | rocky, stable | |
|---|---|---|---|---|
| Moisture: | moist, stable | dry/wet, unstable | moist, stable | dry/wet unstable |
| Cut: 2'- | 1:1 | 1:1.5 | 1:1 | 1:1.25 |
| >2' | 1:1.5 | 1:2 | 1:1.5 | 1:1.75 |

1:1 = 45° = 100%
1:1.25 = 39° = 80%
1:1.5 = 34° = 67%
1:1.75 = 30° = 57%
1:2 = 27° = 50%



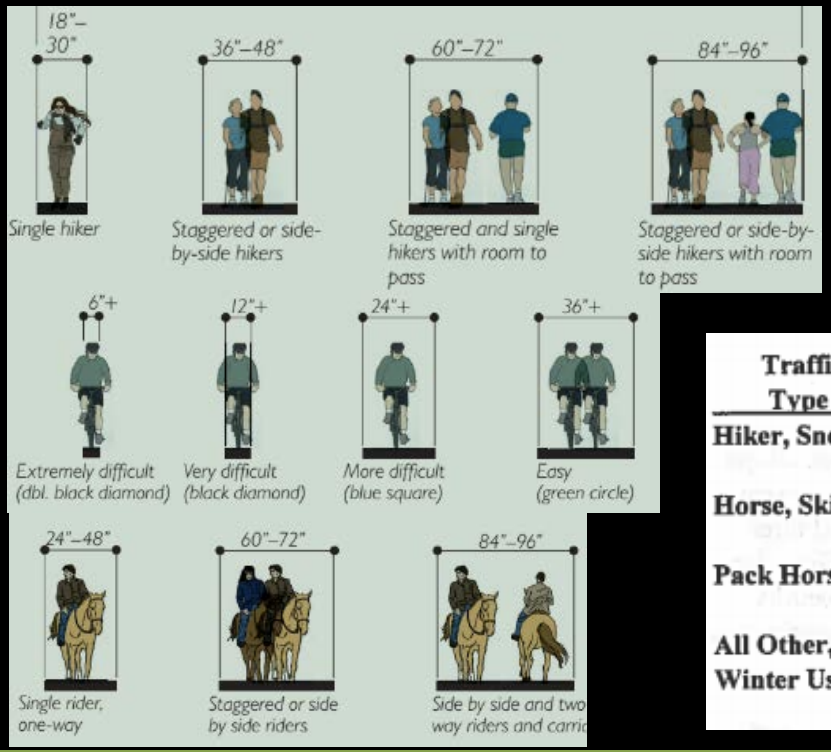
# User Elements:

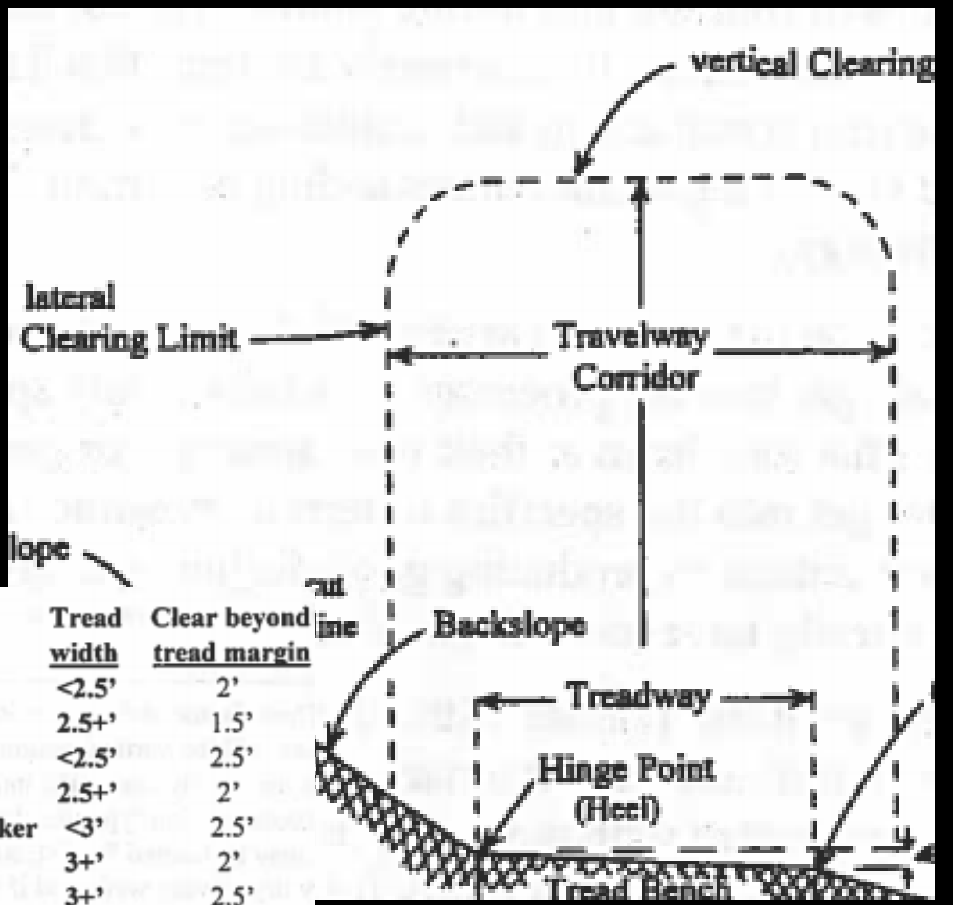
## Tread Width
## Turn Radius
## Clearing Margin

**Turn Radius**

| | Sweep Turns | | Switchbacks | | Banked Turns | |
|---|---|---|---|---|---|---|
| | min. | opt. | min. | opt. | min. | opt. |
| Hikers | 8' | 10' | 6' | 8' | na | na |
| Runners/Joggers | 10' | 12' | 8' | 10' | 10' | 12' |
| Horses | 10' | 12' | 8' | 10' | na | na |
| Pack-Strings | 12' | 14' | 10' | 12' | na | na |
| Mtn. Bikes | 10' | 12' | 10' | 12' | 10' | 12' |
| Motorbikes | 15' | 20' | 15' | 20' | 15' | 18' |
| ATVs | 15' | 20' | 15' | 20' | 15' | 18' |
| ATVs w/ trailers | 25' | 30' | 25' | 30' | 22' | 28' |
| Snowshoers | 8' | 10' | 6' | 8' | na | na |
| Skiers | 15' | 20' | 15' | 20' | na | na |
| Snowmachines | 20' | 25' | 20' | 25' | na | na |

Typical Trail Width by User Type & Traffic Volume




| Traffic Type | Tread width | Clear beyond tread margin |
|---|---|---|
| Hiker, Snowshoer | <2.5' | 2' |
| | 2.5+' | 1.5' |
| Horse, Skier | <2.5' | 2.5' |
| | 2.5+' | 2' |
| Pack Horse, Mtn. Biker | <3' | 2.5' |
| | 3+' | 2' |
| All Other, Summer | 3+' | 2.5' |
| Winter Use | <3' | 4' |
| | 3+' | 3' |

**Source for Clearing Width:** ***Trail Planning, Design, and Development Guidelines,*** **by Minnesota Natural Resources, 2007**

# Trail Design Summary

## Trail Use Questions

•Purpose, Design Use, Allowed Use, Prohibited Use, Possible Unintended Use, Seasons, Intensity of Use

## Sustainable Design Elements

•Full-Bench Construction
•Integrated Drainage Control
•Controlled Grade
•Tread Materials
•Maintenance Capacity/Restraints

## Terrain Elements

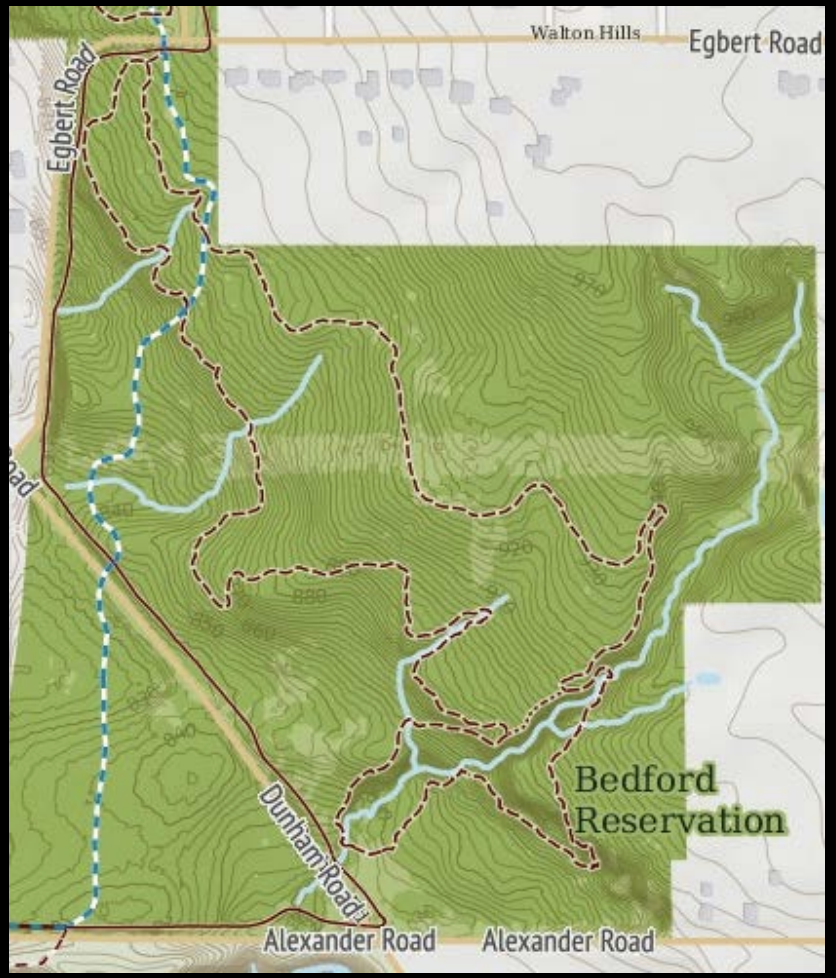
•Slope Angles

## User Elements

•Tread Width
•Turn Radius
•Clearing Margin

# Trail Layout Process

# Preliminary Layout: Study the Map



# Preliminary Layout: Map Control Points

## Possible Control Points

(T = terrain-related  U = use-related  A = administrative)

- T Very Flat Ground (<5% slope) (1)
- T Very Steep Ground (>80% slope) (1)
- T Cliffs
- T Sloping Bedrock (2)
- T Wetlands (muskeg, swamp, wet tundra)
- T Stream Crossing Locations (3)
- T Stream Confluences (4)
- T Active Floodplains (4)
- T Dense Brush Fields/Doghair Thickets (5)
- T Fragile Meadows/Subalpine Tundras (5)
- T Seepage Zones/Pocket Bogs
- T Active Landslides
- T Major Avalanche Tracks (5)
- T Talus/Scree Slopes (6)
- T Weak or Unstable Soils
- T Ice-rich/Frost-active Soils
- T "Turn Points" (slopes acceptable for sweep turns or switchbacks) (7)
- T "Anchor Points" (eg., stable-ground terminus points for wetland crossing) (8)
- TU Passes
- TU Ridgecrests, Saddles
- TU Trailheads
- TU Trail Junctions
- TU Camp Areas
- TU Stock Holding Sites (9)
- U Natural View Points/Interest Features
- AU Archeological/Historic Sites
- A Critical Habitats
- A Land Ownership Boundaries
- AU Route Easements/Rights-of-Way

This is *not* an all-inclusive listing. Every route has its own characteristics and peculiarities, which may add one or more items to the list (eg., tidal estuaries in a coastal setting).

**Notes:**

(1) Normal "good" range is 20% to 60%; for motorized is 15% to 40% due to turn radii, bench widths.
(2) Not always "bad" -- possible tread benching equals very high durability.
(3) Requires good stream reconnaissance.
(4) Active areas, avoid if possible.
(5) May be constructable, but maintenance frequency/intensity will be high.
(6) Avoid Scree, but Talus can be very stable and durable.
(7) Sweep Turns 10% to 25% sideslope; Switchbacks 20% to 40+% sideslope, but are not motorized friendly.
(9) Need water, and often need grass.

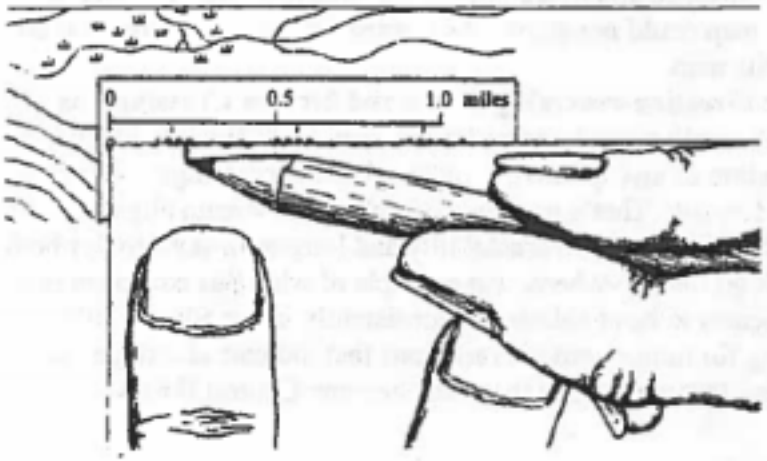
(8)

# Preliminary Map Layout: Map Routing

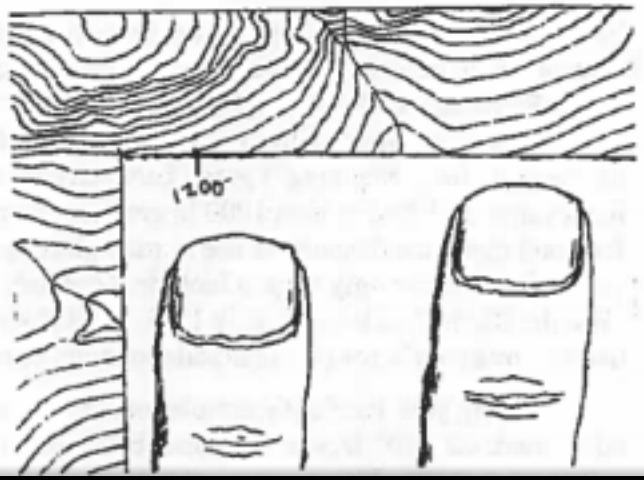
**Mapping Grade**

**Nominal vs Actual Grade**

| | granular soils | | | | rocky soils | | | |
|---|---|---|---|---|---|---|---|---|
| | non-motor'd | | motorized | | non-motor'd | | motorized | |
| % nom. | % act. | length for 50' vert. | % act. | length for 50' vert. | % act. | length for 50' vert. | % act. | length for 50' vert. |
| +/-2 | 0 | na | 0 | na | 0 | na | 0 | na |
| 5 | 4.0 | 1250 | 3.6 | 1389 | 4.3 | 1163 | 4.1 | 1220 |
| 8 | 5.8 | 862 | 5.0 | 1000 | 6.5 | 769 | 6.0 | 833 |
| **10** | **7.4** | **676** | **6.5** | **769** | **8.3** | **602** | **7.7** | **649** |
| 12 | 8.1 | 617 | 6.8 | 735 | 9.5 | 526 | 8.6 | 581 |
| 15 | 10.4 | 481 | 8.9 | 562 | 12.0 | 417 | 11.0 | 455 |
| 17 | 11.0 | 455 | 9.0 | 556 | 12.9 | 388 | 11.5 | 435 |
| 20 | 13.2 | 379 | 10.9 | 459 | 15.3 | 327 | 13.8 | 362 |
| 22 | 13.9 | 360 | 11.2 | 446 | 16.2 | 309 | 14.3 | 350 |
| 25 | 16.0 | 313 | 13.0 | 385 | 18.6 | 269 | 16.4 | 305 |
| 30 | 16.9 | 296 | 12.5 | 400 | 21.9 | 228 | 19.2 | 260 |




Marking the paper

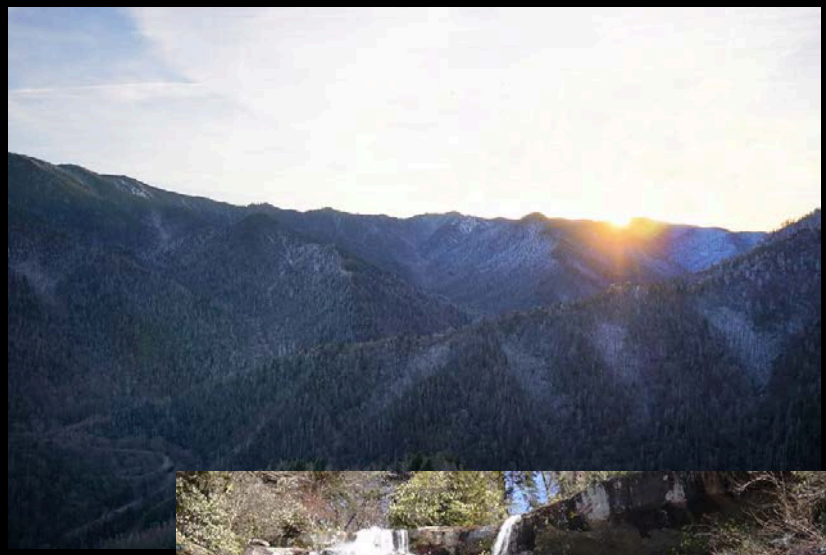


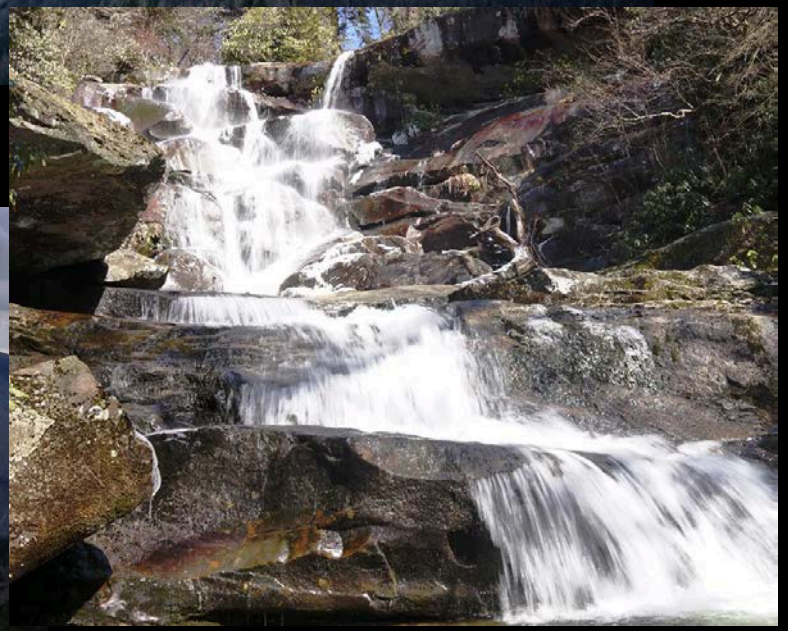

Plotting the distance between contours

# Initial Ground Investigation

**Some Example Waypoints**

| Use for | Symbol | Name | Description |
|---|---|---|---|
| Control Points assumed | ○ | 01, 02, etc. | wet, pfrost, psoil, allfan, seep, brush, slide, avtrak, etc. |
| confirmed | ⊗ | | |
| Route Points proposed | □ | 01, 02, etc. | station number*, or sturn, sback, trlhead, trljct, grdrev, gully, etc. |
| established | ■ | | |
| stream crossings | ≈ | 01, 02, etc. | ford, bridge, flog, culv, etc. |
| pass, saddle, wetland crossing | ⌒ | 01, 02, etc. | pass, sadl, wland, etc. |
| campsites | ▲ | 01, 02, etc. | camp, cabin, etc. |
| user point | 📷 | 01, 02, etc. | ovrlook, hist, arch, fish, etc. |
| danger area | ◇ | 01, 02, etc. | cliff, gorge, slide, qksand, etc. |





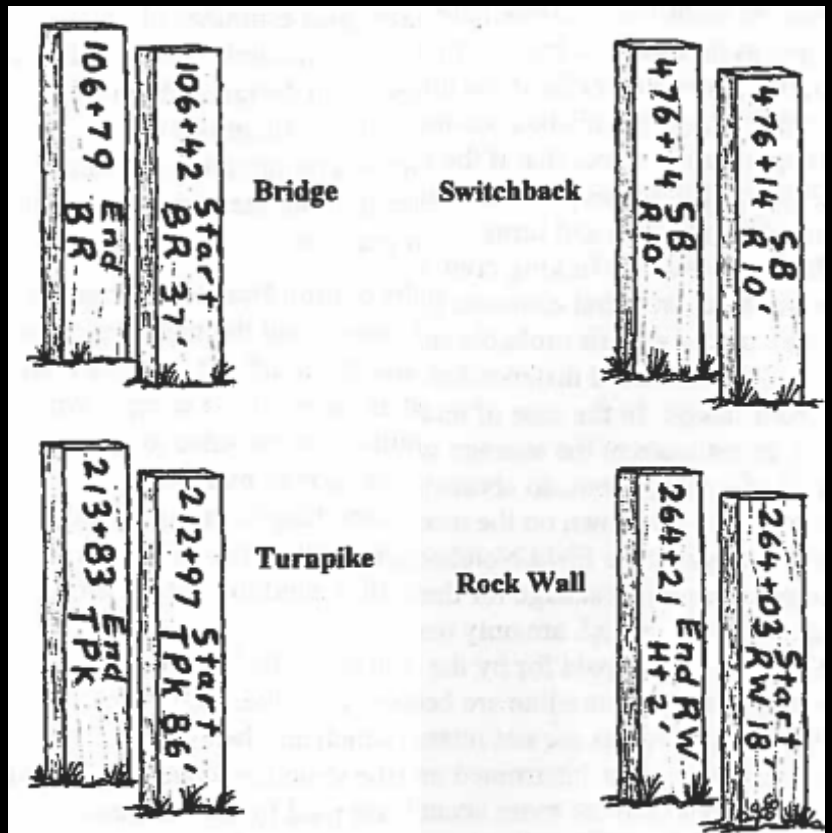
# Preliminary Flagline Routing

# Final Construction Layout

| Dist | STA | Grade | SS | blaze | CPS |
|---|---|---|---|---|---|
| 52 | 103+54 | -2/+5 | 10+ | ℄ | |
| 41 | 104+25 | +9 | 10-15+ | ℄ | 26 |
| 20 | 104+45 | -5 | 7-20 | ℄ | |
| 49 | 104+94 | +11 | 20-25 | ℄ | |
| 87 | 105+81 | 7-3 | 20-25 | ℄ | |
| 46 | 106+27 | +10 | 25 | ℄ | |
| 50 | 106+77 | +9 | 25-30 | ℄ | |
| 16 | 106+93 | -4 | 25 | | |
| 14 | 107+07 | +6 | 20 | ℄ | |
| 45 | 107+52 | +10 | 20 | ℄ | 27 |
| 16 | 107+68 | +10 | 20 | ℄ | |
| 15 | 107+83 | -5 | 20 | | |
| 59 | 108+42 | +6 | 20 | ℄ | |
| 63 | 109+05 | +7 | 30 | ℄ | |
| 18 | 109+23 | -5 | 30 | | |
| 58 | 109+81 | +5 | 25-20 | ℄ | |
| 55 | 110+36 | +8 | 20-15 | ℄ | |
| 26 | 110+62 | -4 | 15 | ℄ | |
| 37 | 110+99 | +9 | 20 | ℄ | |
| 45 | 111+44 | +10 | 20 | ℄ | 28 |
| 16 | 111+60 | +10 | 20 | ℄ | |
| 37 | 111+97 | +10 | 20-25 | ℄ | |
| 20 | 112+17 | -4 | 25-30 | | |
| 78 | 112+95 | +11 | 30 | ℄ | |

Notes

incorporate swale drain to W
start Reverse
end Reverse
thick moss
traverse thick moss, possible frost
" " " "
" " " "
start Reverse
end Reverse
start Sweep Turn, 15' R
end Sweep Turn
end Runout (shot at 0), start Reverse
end Reverse
rock stands in so.l
start Reverse " " " "
end Reverse " " " "
" " " "
start Reverse, incorporate swale
end Reverse
start Sweep Turn, 15'R
end Sweep Turn
end Runout (shot at 0)
start Reverse bedrock knob 20' uphill from trail
end Reverse
start Reverse



# Trail Layout Summary

## Preliminary Layout

- Map Reading
- Mark Control Points
- Map Routing

## Initial Ground Investigation

## Preliminary Flagline Routing

## Final Construction Layout

# Full-Bench Construction Method

# Full-Bench Construction Method

# *Flagline Communication*

# Full-Bench Construction: Site Preparation

# Full-Bench Construction: Trail Rough-Cut

# Full-Bench Construction: Trail Rough-Cut

# Full-Bench Construction:

## Disperse Excavated Materials

# Full-Bench Construction:

## Backslope Rough-Cut & Material Dispersed

# Full-Bench Construction:

## Finishing Work

# Full-Bench Construction:

## Restoration and Finishing Work

# Full-Bench Construction:

## Pack-out and Leave-No-Trace


Full-Bench Construction:
Break-In Maintenance

# Full-Bench Construction Summary

- Site Preparation
- Trail Rough-Cut
- Backslope Rough-Cut
- Finishing Work
- Site Restoration
- Break-In Maintenance
- Annual/Cyclic Maintenance

# Context-Appropriate Reactions

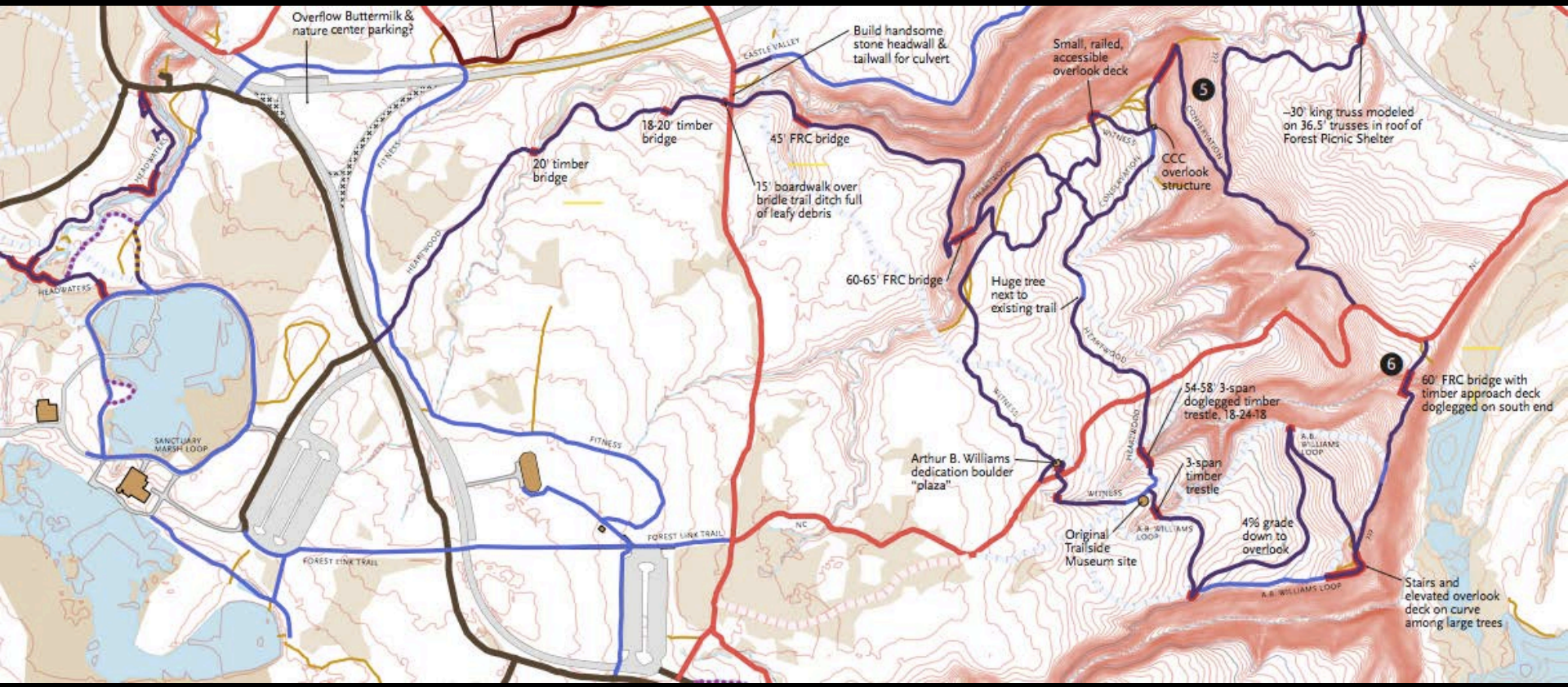

# Forbes Woods:
# A new kind of neighborhood connection

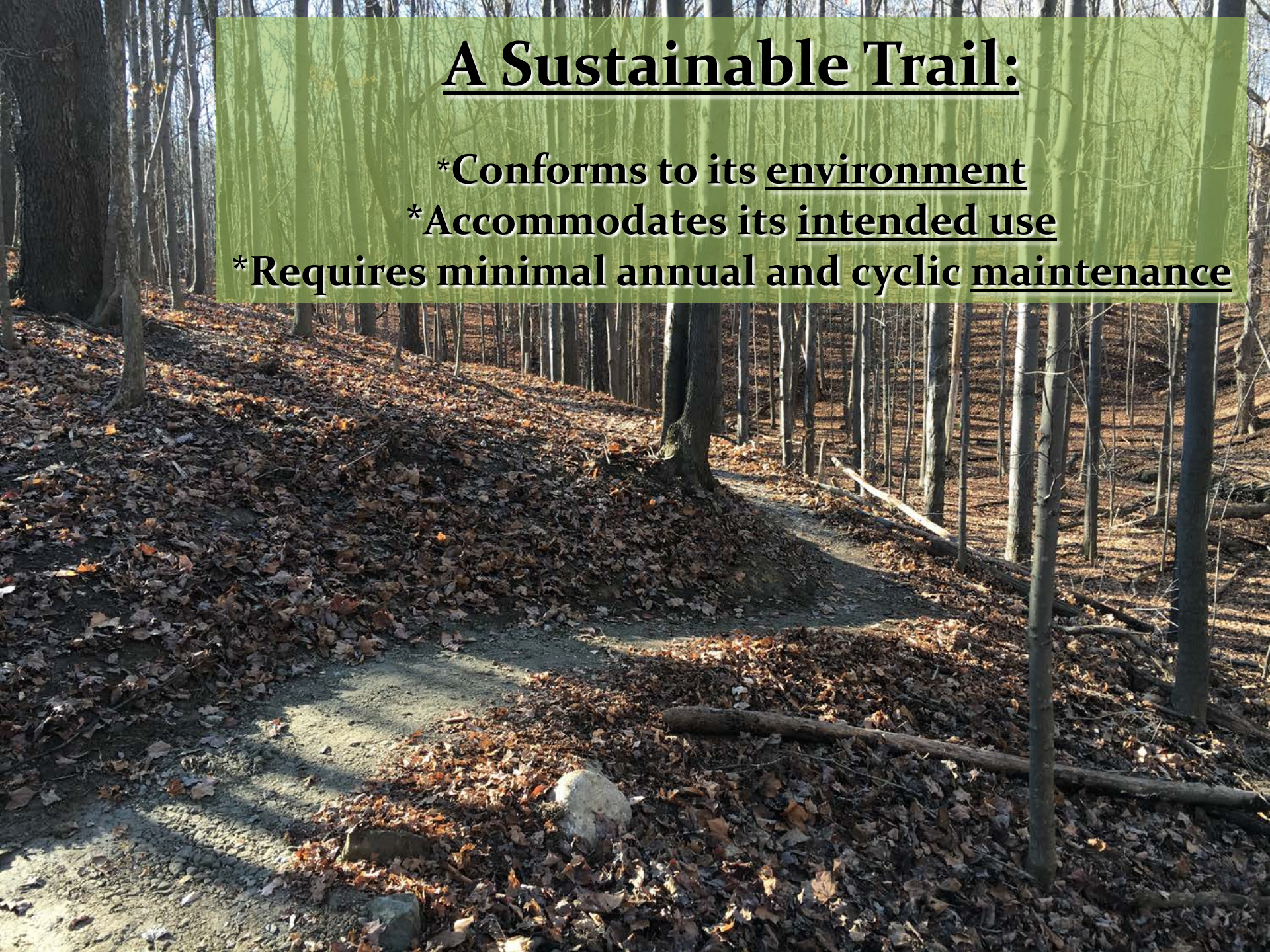
# Program Goals

*Crotched Mountain, New Hampshire*

# Working Steps

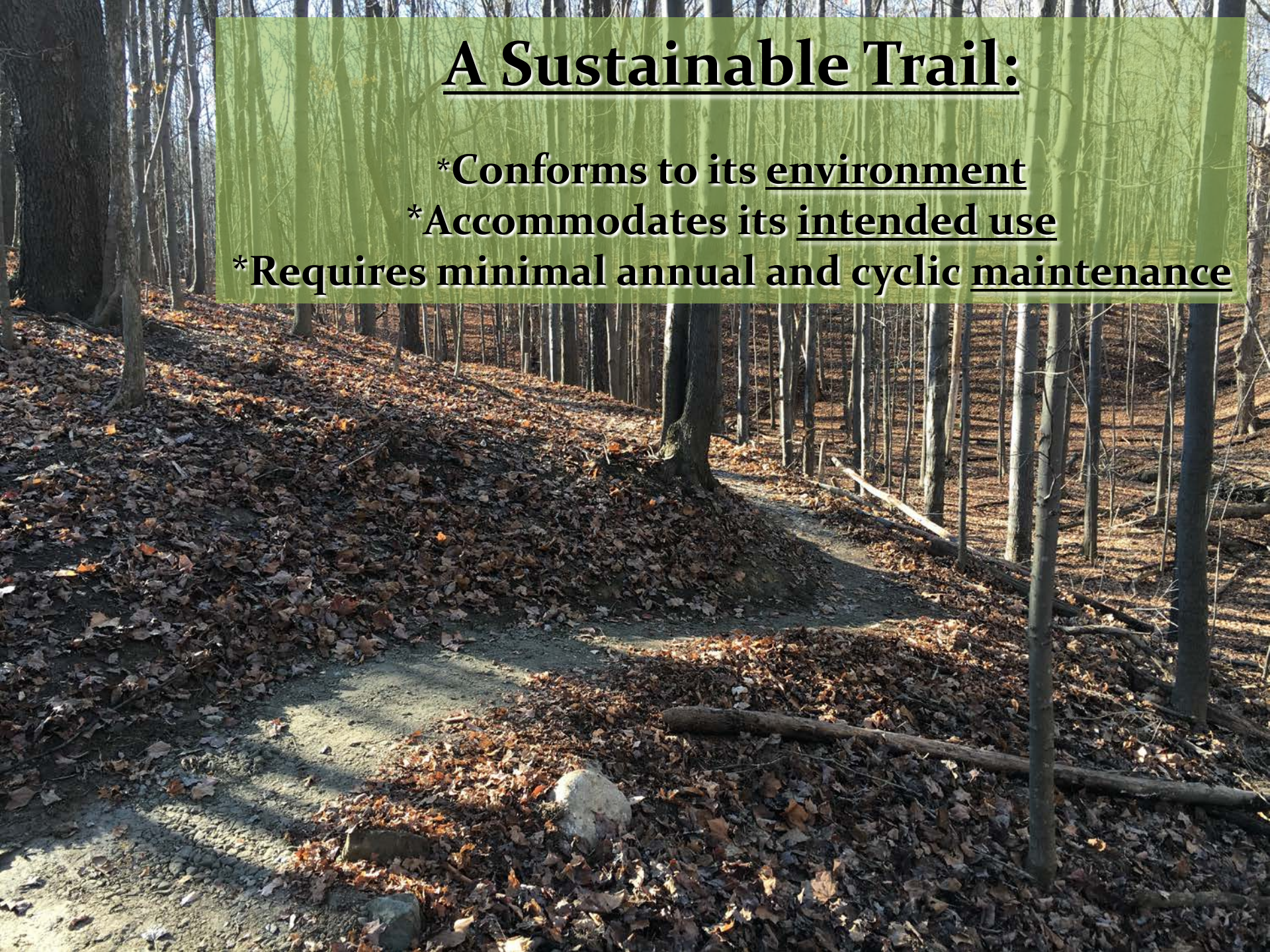
## Trail Design/Layout Study in North Chagrin with a Universal Acesss Trail System





# A Sustainable Trail:

*Conforms to its environment
*Accommodates its intended use
*Requires minimal annual and cyclic maintenance



# A Sustainable Trail:

*Conforms to its environment
*Accommodates its intended use
*Requires minimal annual and cyclic maintenance

# Questions and Comments?

**Thank you and happy trails! –Ralph & Jim**