PART ONE

The Building Blocks of Great Trails

Riding off-highway vehicles is a great way that families explore the great outdoors together.

Chapter One
Principles of Successful OHV Management

The 4Es: Engineering, Education, Enforcement, Evaluation

The process of creating great OHV trails starts with an understanding of the fundamental principles of OHV management. These principles need to be carried through planning, design, implementation, maintenance, and program management and they apply to existing trails and new trails.

The Need for Management

The first underlying principle is that OHV recreation needs to be managed. The use is not going to go away and it cannot be ignored. The days of having a block of land where they go and ignoring what is really going on there are no longer possible. The ostrich approach to management is prone to failure. Unmanaged OHV recreation can lead to user-created trails, unacceptable resource impacts, poor recreation experiences, conflict with other stakeholders or other recreationists, antagonistic community and media relations, and litigation. The target of most of this negativity is usually the group of riders who really just want their share of the recreational resource, a place to ride responsibly, and to be left alone. Too often, the eventual result is closure and a reduction of riding opportunities.

When OHV use is managed, trails are designed to provide high-quality recreation experiences, resources are protected, past impacts are rehabilitated, there is a positive working relationship with stakeholders and other recreationists, there is community and media acceptance, if not support, and the riders are seen as partners rather than the enemy. Ultimately this leads to continued or increased riding opportunities.

A motivation for and a benefit from recreation is an escape and a release. Endorphins and adrenalin are released. All of this is beneficial, but needs to occur in a managed setting, not an unmanaged setting. Certainly, two questions that arise are: "Can an unmanaged setting be transformed into a managed one?" and "How do I accomplish that?" The simplistic answer to the first question is: "In most cases, yes." This book gives the answer to the second question.

Management includes parking, signing, kiosk, maps, barriers to control and direct use, and a clean toilet for customer service

A Case in Point…

In 2007, the Bear Creek OHV area in Kelowna, British Columbia, was on the verge of closure. Unmanaged OHV use had been occurring there for 35 years; there was a maze of user-created trails, hillclimbs, significant resource impacts, angry stakeholders, and upset residents. The community and media were up in arms. The local club, the Okanagan Trail Riders Association, saw the writing on the wall and started taking action by seeking advice from experts. Not long after, Recreation Sites & Trails BC declared the area a Recreation Site and began active management. At 35,000 hectares (110,000 acres), it is the largest recreation site in the province. There was a lot at stake.

By 2012, the accomplishments included: 224 km (139 miles) of sustainable, well-designed trails; a trail ranger program; a camp host program; a massive closure and rehabilitation effort was completed; riders were compliant with sound and spark arrester requirements; a new trail pass was being overwhelmingly accepted; a sensitive grassland ecosystem had been protected; and the stakeholders, media, and residents were appeased.

Bear Creek is the first designated, managed OHV trail system in BC and it is now being used as an OHV model for the province.

Bear Creek Before Management…

Bear Creek Today...

The Three Key Elements for Success

The creation of any successful trail, trail system, or OHV park involves the successful application of three key elements: provide for the riders' needs; design for sustainability; and develop an effective operations and maintenance (O&M) program. These three elements form the basis for the Great Trail Continuum.

1. Provide for the Riders' Needs. What does this mean? If the riders want hillclimbs or other potentially high-impact activities, does a manager give it to them? Not necessarily. It means that the manager evaluates the site to determine what experiences can be reasonably and sustainably provided. Then the manager can ensure that whatever experiences can be provided are delivered as high-quality, high-fun factor opportunities. A key point here that cannot be overemphasized is that if riders get the experience they want ON the trail, they will not look for it OFF the trail. From an OHV management standpoint, this is huge. There are those who are skeptical, including some riders, but this theory has been validated in project after project.

Tip, Trick or Trap?

Tip: Three Key Elements for Success
- Provide for the riders' needs
- Design for sustainability
- Develop an effective O&M program

High Quality Opportunities + Varied Opportunities = Success

When riders have a high-quality recreation experience, they are smiling at the end of the day. What does that mean to the OHV manager? The riders recognize they have something good. This means they become proud of it and want to protect it. Compliance with the rules and regulations increases. Peer pressure to make others compliant goes up. Volunteerism increases. Vandalism goes down. The need for enforcement goes down. There is an increased willingness to accept trail fees. And management spends less time and money dealing with problems on the "have to" list and more time working on the "want to" list.

Tip, Trick or Trap?

Tip: When riders find what they want ON the trail, they will not look for it OFF the trail

Happy Riders = Happy Managers

How do managers provide for the riders' needs? First of all, they need to know who the riders are and understand the various vehicle types and the experiences those riders are looking for. This book covers a wide range of vehicles and a wide range of riders, but fortunately, they all have similar recreation needs and desires.

Riders' needs and desires:
- Fun, fun, and more fun. People recreate to have fun.
- Connect with nature. Find our roots and a simpler existence.
- Escape from society
- Relieve stress
- Physical exertion and exercise
- Challenge for their vehicles and themselves
- A variety of experiences and difficulty levels
- Build camaraderie with friends and family engaged in the same activity
- A sense of belonging to a group
- A legal place to ride and feel welcome
- Enjoy quality facilities: kiosks, toilets, camping, etc.
- Enjoy quality trails, signing, and mapping
- Access to water features, scenic viewpoints, and unique features
- The opportunity to view wildlife

A skilled OHV specialist understands these desired experiences. Many planning teams however, do not have an OHV specialist or an OHV representative, and the planning team members are not expected to become OHV enthusiasts. If at all possible, put at least one OHV club, area, or state association representative on the planning and design team. Also, attend some club meetings and take the team out on a club ride. It is a great way to learn about the activity, what draws people to that activity, and the very social nature of that activity. Most important of all is go out to the project area on the weekends when the riders are there and talk to them. It will be easy to discover that they are real people and they like to talk about their activity. It is also a very effective relationship builder.

Tip, Trick or Trap?

Tip: Size Does Matter
When the demand for trails exceeds the supply, managers have lost control of the use

A word of caution when soliciting input on what riders would like to see in the project area - many times riders will say "I like it the way it is." Their answer will reflect what they've experienced. If all they know is poor quality, then there is no bar to measure it against. It is a place to ride and it's their place to ride, so it's good. It is important to recognize this so that the trail system planning and design is not swayed in the wrong direction by inaccurate input. Many riders have never ridden a designated, well-designed, or managed trail system.

There is another potential trap. If there is an unmanaged project area today, chances are that the customers are locals who have ridden there forever. It can be a mistake to base planning on that rider group and their current riding activities. Once a designated, managed trail system has been implemented, the rider base and demographics will change. As soon as a map is produced, or a website is developed (recommended), or someone puts videos on YouTube, suddenly the whole world knows about this trail system and riders will come from all over the area, state, or region to experience it. What was maybe once an all-male group of locals with a single focus, can now be a mix of singles, families, and extended families with multiple vehicle types. Where perhaps there were fifteen riders on a weekend day, there may now be 150 or more. These are changes that managers need to recognize and assimilate into the planning process.

Tip, Trick or Trap?

Trap: User-created trails meet the users' needs

Another common mistake managers make is to stop treating riders as people. Don't exclude a facility or interpretation because the area is an OHV riding area. And don't exclude trails or activities because the riders might already have enough. People will want and enjoy whatever the developers can reasonably provide: parking, camping, concession area, a wide variety of trails and difficulty, motocross (MX) tracks, youth training area, safety training area, mudding area, sand pit, 4WD trails, rock crawl, endurocross, hillclimbs, open riding areas, etc. The only limitations to amenities provided should be the size of the site, physical characteristics of the site, dollars for construction, dollars and infrastructure for O&M; and social, political, resource, and legal constraints.

OHV recreation is a family activity, so plan to provide opportunities for a variety of vehicle types, ages and skill levels

2. Design for Sustainability. Sustainability is one of those terms that many use and few really understand. In reality, there are four key aspects to sustainability: resource, experience, political, and managerial. Most people just think of resource sustainability so let's delve into that first.

There are many definitions of resource sustainability. It is one of those terms that makes a trail or project feel warm, fuzzy, and good; and the hope is that it will make the antagonists feel good also. Managers and developers say to the trail consultants: "I don't know what it is, but that's what I want."

A sustainable trail:
- Flows and harmonizes with the landscape
- Lays lightly on the ground and maintains natural drainage patterns to minimize impact and reduce erosion
- Provides resource protection over the long term when properly managed and maintained
- Provides a high-quality recreation experience now and in the long term
- Can be managed and maintained efficiently and cost-effectively
- Minimizes conflicts between stakeholders and other recreationists
- Minimizes political and media controversy by having the right activity in the right place

A sustainable trail does not mean that:
- It is the cheapest trail to construct or the least costly means to upgrade an existing trail to achieve durability
- The trail will not require maintenance since every trail requires some degree of maintenance every year
- The trail will not require adaptive management
- The trail will continue to be sustainable if use patterns or use types change

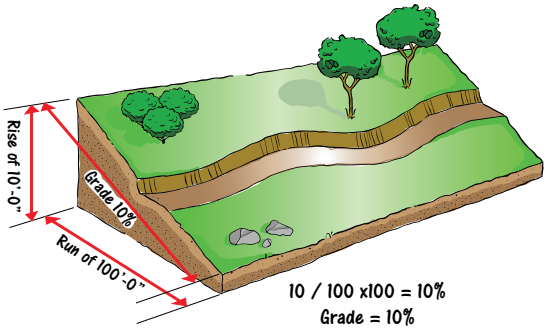
A sustainable trail has constant flow and roll. Tangents are minimized and grade reversals force water off the trail at regular intervals. Flow is the rhythm of the trail, which is usually created by a very curvilinear horizontal alignment. Roll is the vertical rise and fall of the trail grade. Roll also contributes to the rhythm of the trail, but its key role is providing natural drainage points through grade reversals, which significantly reduce the potential for soil movement. Trail hardening is used where needed and a multitude of trail design and engineering structures are incorporated where applicable. The tread is durable and the trail offers a high quality recreation experience within the intended difficulty level without the difficulty changing over time due to unintended degradation.

Horizontal Flow + Vertical Roll = Increased Sustainability

Let's take one more step in this discussion. Listed under *Providing for the Riders' Needs* are hillclimbs, mudding areas, and open areas. How sustainable are these? They may not be, but every trail section or challenge area does not have to be sustainable. The value of the recreation experience may outweigh any potential impacts or the value of the resource may not warrant any special mitigations. The key is that management understands that a trail or area may not be sustainable and makes a conscious decision to manage it that way. There are some steep, gnarly, rutted trails that are going to run water when it rains. Often these are the trails that provide the WOW and are highly valued by the riders. If that runoff does not have direct connectivity to a stream or if that connectivity can be mitigated with something like a sediment basin, management can decide to accept the tread impacts and more frequent maintenance costs, and keep the trail for its recreation value.

This ATV trail rolls and flows with the landscape.

Calculating grade or sideslope



Grade is the vertical rise and fall of the trail. Rolling the grade means frequent transitions from positive (up) grades to negative (down) grades. We also talk about the steepness of the ground referred to as slope or sideslope. Both grade and sideslope are calculated the same way.

3. Develop an Effective Operations and Maintenance (O&M) Program. As stated previously, OHV recreation needs to be managed and this means ongoing management. The trail or trail system needs to be maintained and evaluated on a regular basis, and adaptive management applied in a timely manner to keep indicators from becoming problems (i.e., effective application of the 4Es described later in this chapter). This takes personnel, materials, the proper equipment, and funding. Too often, project planners and developers focus on the design and construction and overlook the critical elements of management and maintenance.

Having shop and storage space, the proper equipment, and skilled personnel are key to an effective O&M program.

For someone new to OHV O&M, it is hard to envision that ATVs, ROVs, or motorcycles will be needed just to access the trails and haul tools and materials where needed. All of these usually require trailers and tow-vehicles to move them around.

The team will also need much of the same equipment and materials needed for non-motorized trails. They will need hand tools and power tools plus signing, fencing, culvert, and barrier materials. They may need a small backhoe, mini-excavator, trail dozer, tracked dumpers, and other equipment. They will need stockpiles of dirt and various gradations of rock, silt fence, filter cloth, and a place to store all of this. Vehicles and equipment always have something broken, so a place for repairs with hoists and tools is also needed. Then, of course, there is the need for personnel trained and qualified to perform the work and operate the equipment. Much of this can be acquired over time while renting, contracting, or using volunteer resources until the O&M program is fully implemented.

Elements of a successful O&M program:
- Multi-year maintenance plan
- Comprehensive management plan
- Dedicated and knowledgeable personnel
- Management commitment at all levels
- Dependable funding
- Positive attitudes
- Pro-active management
- Strong volunteer program
- Adaptive management techniques

Effective Application of the 4Es

The 4Es are the most basic and most essential principles in the successful implementation of an OHV project, or any project for that matter. They are inter-related, co-dependent, and all must be considered and applied to ensure success. They are:
- Engineering
- Education
- Enforcement
- Evaluation

These well engineered signs provide clear, simple and effective education messages

Success will be achieved by utilizing the 4Es in conjunction with commitment, persistence, firm resolution, and hands-on management. It isn't enough to put up a sign and walk away. Signs make good targets or garage wall decorations. It is important to stay in the ring for all 10 rounds. Persistence leads to success. The message will get through.

Engineering happens on the ground. It is applied during trail and facility location, design, and construction. It is using structures for resource protection or mitigation. Engineering is using effective signing, fencing and barriers to control and direct use. It is having proper tools and equipment for operation and maintenance.

Education happens in the mind. It is used to welcome the public, set expectations, inform visitors of the rules and regulations, inform riders of open trails and areas and the allowable vehicle types, and inform the rationale for closed or restricted trails. These messages are conveyed through effective signing, quality mapping, websites, kiosks, conducting complimentary tech checks, and face-to-face communications with the riders. It can be done by managing agency personnel, volunteer trail patrollers, or campsite hosts.

Signing and mapping are the primary media by which management communicates with their customers. Both must be clear, concise, effective, and agree with each other. Properly engineered signs significantly increase rider compliance and reduce the need for the third E: Enforcement. The overwhelming majority of riders want to ride legally. When they get lost or confused due to poor signing or mapping, management has lost control of the use and must live with the consequences.

Effective education results in:
- Improved compliance
- Improved quality of the rider experience
- Reduced conflicts
- Reduced resource impacts

Enforcement happens in the wallet. But it is not just about writing tickets and assessing fines. Effective enforcement uses a variety of tools such as face-to-face communication, warnings, and just being seen. Of course there are those people who only respond to citations and fines. But the majority of the riders feel more secure in areas with visible enforcement and may feel the agency cares about the area. Riders have seen too many riding areas closed due to a few irresponsible people and understand the agency is working to keep these trails open.

Effective enforcement results in:
- Increased compliance
- Increased agency and management visibility
- Less vandalism
- Increased visitor security
- Support for field personnel or volunteers

The area with the least resources is always enforcement. However, by doing a thorough job of engineering and education, the need for enforcement can be vastly diminished, although it can never go away.

A Case in Point…

At the Bear Creek Recreation Site in Kelowna, British Columbia, a major effort was launched to change rider behavior and ethics from go anywhere/do anything to designated routes only and to convert from no rules to spark arresters and 96dbA sound limit required. A trail ranger group was formed by the club and they diligently educated and patrolled every weekend for two years. After that period, the riders who would conform did and the riders who refused to conform knew that the trail rangers had no enforcement teeth. Those riders showed up weekend after weekend and flaunted the rules in the trail rangers' faces. The trail rangers needed enforcement to back them up, but the enforcement was in a different Ministry and protocols had not been established for OHV enforcement. The trail rangers became discouraged and participation waned. The education program was at a critical point and without all of the 4Es, failure loomed on the horizon. Too much had been invested and too much had been gained to risk failure. Riders had sustainable trails, resources were protected, past impacts had been stabilized and rehabilitated, and stakeholders were gaining acceptance. All of this hard work and positive results were about to be negated by the lack of the ability to implement all of the 4Es.

Evaluation tells us what is happening. It tells us how well the managers have achieved the other Es. Monitoring is the component that ties all of the Es together. How is the manager doing? What is working and what isn't? Are the closure and rehab efforts successful? Is the signing effective, fading, shot up, or still in place? Are riders compliant with the rules and regulations? Is there a high level of customer satisfaction? What feedback is coming back from the riders, law enforcement, stakeholders, or general public? Are the erosion control measures in place and effective? Are the trail structures in place, sound, and effective? Is the trail starting to degrade from poor design, lack of maintenance, or increased use?

Tip, Trick or Trap?

Trap: To think an issue, such as enforcement, is one department's issue. If it's a management problem, it's everyone's problem. All 4Es and all personnel must work together.

For the best results, have everyone perform the evaluation. Yes, everyone. Anyone involved in the project site should be involved in the monitoring of the site. This includes the riders, all field personnel, law enforcement, trail patrollers, management, etc.

How often does evaluation occur? At some level, it occurs daily. It is a team effort and everyone should have their eyes and ears open whenever they are on site.

The 4Es are a process of adaptive management. Implement, observe, and then make any necessary corrections in a timely manner. With experience in OHV management and behavior, the observers will be able to predict what will or could occur before a problem or issue even starts. Management then has the unique opportunity to make pro-active adjustments. It's also a process of recognizing reality and understanding human nature. Managers will always be more effective if they can work with human nature rather than against it.

Design and Management Strategies for the 4Es

Here are a few strategies for using all of the 4Es.

- Conduct education prior to any rule changes, closures, or restrictions.
- If there is a trail through an area to be restricted, never close it before an alternative route around the area is open.
- Never just put a fence across a trail to close it.
- Never just put a sign on a trail or off to the side of the trail to close it.
- Don't invest in expensive rehab and native seeding until rider behavior has changed.
- If a sign gets stolen, replace it. If it gets stolen again, replace it again. Persistence and resolution will eventually prevail.

- When tracks appear where they shouldn't be, go back to the 4Es and ask why. Is it errant rider behavior, or is there a problem with trail alignment, signing, or mapping; is the trail not meeting the riders' needs?
- If a closure gets breached, fix it. If it gets breached again, fix it and install more barriers or signs.

Effective Application of the 4Es = Successful Project Implementation = Successful OHV Management

The 3Ds: Dispersal, Dispersal, Dispersal

Dispersing the riders is a key to successful OHV management because it spreads the riders out over a larger area. Why is this a benefit? By providing dispersal, there are fewer riders on any given section of trail. While this can reduce trail maintenance costs and potential wildlife disturbances, it primarily reduces the number of encounters with other riders and enhances the quality of the recreation experience. Like any other trail recreationist, OHV riders value stopping and enjoying the natural environment. OHV recreation is a very social activity, but just because the riders enjoy being with their group doesn't mean that the riders enjoy being with all of the other groups on the trail system.

Having a large acreage to work with and a high-mileage trail system is certainly an advantage in providing the opportunity for dispersal, but dispersal is actually achieved by providing multiple loops or trail junctions. Each trail junction serves as a decision point, a rider can go left or right. The more decision points there are the more effective the dispersal. From a trail planning and design standpoint, the more decision points that can be provided in the proximity of the trailhead or staging area, the more quickly the riders can be dispersed. Even on small trail systems or OHV parks, though the trails may be more concentrated and the available mileage reduced, some level of dispersal can still be achieved by providing more trail junctions. As a general rule, as the opportunity for dispersal goes down, the need for site hardening goes up to increase durability.

Tip, Trick or Trap?

Tip: Having several junctions in the vicinity of the trailhead will disperse riders more quickly

Trail Junctions = Decision Points = Dispersal

Seat Time and Recreation Activity Time

Recreation time is highly valued and often very limited. It is important to understand that OHV recreationists have come to a managed OHV park or trail system to ride. The sooner they can get onto their OHVs and the longer they can stay on their OHVs, the happier they will be (remember: Happy Riders = Happy Managers). Seat time, or riding time, is the primary component of the recreation activity time in which a rider participates or experiences in a given day.

The more seat time, the better the recreation experience. Why is seat time important to the OHV manager? If someone comes to an OHV park to spend 6 hours and they've done everything in 2 hours, what are they going to do for the rest of the time? The same applies to a trail system. Suppose there is a destination trail system with a campground. It will not be uncommon for an ATV group to come and camp for 2 to 5 days over a long weekend. If an ATV rider can ride 50 miles in a day on the trails and there are only 50 miles of trail, there is one day of riding provided. What will the rider do for the other days of their stay?

"Design it like a rifle and they will ride it like a bullet"
– Jim Schmid

More Recreation Activity Time = Higher Quality Recreation Experience

Remember the discussion on providing for the riders' needs. If riders find what they want ON the trail, they won't look for it OFF the trail. Having adequate mileage while still protecting resources is essential, but the other part of the equation in determining seat time is speed. If there are 20 miles of trail and it can be ridden at 20 miles per hour, one hour of seat time has been provided. If the designer is creative and makes the trails tighter, more serpentine, and reduces tread width so that the trails can now only be ridden at 10 miles per hour, the seat time has doubled. The advantages to the OHV manager are obvious. The challenge for the system planner and trail designer then is to maximize the mileage and reduce the speed.

Tip, Trick or Trap?

Tip: Speed causes issues

Reducing speed:
- Increases safety
- Increases seat time
- Reduces tread impacts and maintenance needs and costs
- Generally increases the fun factor and the recreation experience

Reducing the maximum possible speed does not eliminate the challenge or experience for the riders. They can still ride a trail at their fastest possible speed regardless of whether that speed is 2mph or 20mph.

Recreation Activity Time Includes...

- Seat time
- Spectating time
- Learning time (skills building, interpretaton, etc.)
- Viewing time (scenery, wildlife, etc.)
- Socializing time (trail rests, campfire gatherings, etc.)
- Eating time (including picnics)
- Other activities (fishing, group activities such as volleyball, swimming, etc.)

What if the size of the project area or OHV park does not allow for enough trail miles for one or more days? While seat time is important, spending quality time with friends and family in the outdoors also is an important aspect of recreation activity time.

Being able to ride to a desirable destination can extend and enhance the time on the ride. Viewpoints, interpretive sites, cultural or historical sites, ponds, streams, waterfalls, wildlife viewing opportunities, lunch at a lodge, photo opportunities, etc., can all extend and enhance the length of time the riders have with their group. The objective for the OHV manager is to provide sufficient recreation activities for the time the average visitor will spend at the site. OHV parks can do this nicely because they can offer many diverse activities, including trails, a variety of tracks, mudding areas, training and kiddie areas, rock crawl, endurocross and other technical features, play areas or open riding areas, concessions, fishing, and camping.

Tip, Trick or Trap?

Trap: One-way trails increase safety

One-Way Trails

This is a topic that always generates a lively discussion. Riders will often request trails be made one-way. Their argument is safety by reducing the risk of a head-on collision. In theory this may sound reasonable, but the fact is that as soon as riders are on a one-way trail, their speed will go up and their position in the trail will change because they don't have to worry about encountering any oncoming riders. Because riders will change their riding behavior if there is a possibility of another vehicle coming from the opposite direction, a two-way trail can be safer than a one-way trail.

In addition, trails ride differently in different directions. The view is different, the flow is different, and the challenges are different. In essence, having two-way trails doubles the riding opportunity. This is especially important in OHV parks or other areas with low-mileage trail systems. One-way trails should be the exception and not the rule.

That being said, there are places where it is appropriate to have one-way trails. There are two elements necessary to make them work: one is that there be a limited number of controlled access points to the one-way trail, preferably no more than two; the second is the need for increased signing to adequately warn and educate the riders as to the proper direction of travel. With the signing comes an increase in monitoring to ensure that the signs stay in place. Many learner loops and kiddie tracks are one-way. Some most difficult technical trails are one-way since the ground is so technical that encountering a rider coming up an obstacle as another rider is coming down the obstacle could leave no way to stop or pass.

A one-way trail does not guarantee safety or ensure that there isn't a rider going the wrong direction, even with adequate signing. Consider as an example, if a rider starts down a one-way trail and has some type of mechanical or personal issue, human nature will dictate that the rider will take the quickest way back even if that means going the wrong way on a trail. There is always a risk of collisions on OHV trails. However, there are much better and more effective engineering methods to decrease potential impacts with two-way trails than are possible with one-way trails. These other methods have the advantage of keeping seat time greater.

Using Existing Infrastructure: Roads and Trails

There is a tendency among managers to use existing elements in their project area, usually roads and user-created trails. The rationale is that using existing infrastructure reduces ground disturbance by using what is already there; roads and user-created trails were intended for motorized use and therefore they should serve well as designated motorized trails; reduces construction costs; possibly simplifies the environmental analysis and process; and potentially placates project critics. While all of these may be true, there can be adverse effects from a recreation and OHV management standpoint. Most roads were intended to provide a transportation experience, not a recreation experience. Many user-created trails follow the path of least resistance or maximum vehicle stability to get from Point A to Point B, which usually means that they follow the draws or ridges. These are called fall line trails and they are not desirable because they channel water, which leads to scouring, soil movement (erosion), and sedimentation. Many user-created trails just happened, they weren't designed. Many were created by competitive events, so they may satisfy that experience but they do not satisfy the needs of recreational riders. A trap that planners can fall into is to assume that since users made the user-created trails they must provide a quality experience for the users. Some do, but most do not.

Trails and roads that are not properly designed can have unwanted characteristics, giving unwanted results.

Tip, Trick or Trap?

Tip: Create a recreation experience, not a transportation experience

This user-created fall line runs right up the bottom of a swale, so water drains in from both sides and has no place to go except down the trail. As the water gains velocity, it starts to scour the tread surface and carry sediment to the bottom. This is evident by the trench eroded down the middle of the trail.

Many existing roads and trails are likely to be non-sustainable and offer a low or poor recreation experience. This is directly counter to two of the three elements for success: provide for the riders' needs and design for sustainability.

Is the solution not to use existing roads and trails? Absolutely not. Let's be realistic. Most trail systems use existing infrastructure to some degree because it's there and no one can afford to start from scratch. The challenge for the planners is to creatively explore what they have, but not automatically be married to it. The key is separating out the roads, trails, or segments that are sustainable, provide variety, and contribute to a quality experience, and can be incorporated without incurring increased maintenance. Utilizing existing infrastructure can be a useful trick or an expensive trap.

This straight trail following a seismic line does not provide a quality experience

This trail segment has both quality and sustainability

This road provides a recreation experience

This existing trail segment is not sustainable. Being confined to this existing corridor is creating resource impacts.

This road provides a transportation experience

Existing roads can:	Existing trails can:
Be too straight (poor flow)	Be too straight (poor flow)
Be too fast (Reduced seat time)	Be too fast (Reduced seat time)
Be too boring (poor experience)	Utilize the fall line (ruts and erosion)
Have long, sustained grades (no roll)	Have long, sustained grades (no roll)
Have poor drainage (not sustainable)	Have poor drainage (not sustainable)
	Provide inconsistent difficulty (poor experience)

Variety

Variety and its benefits have been mentioned several times in this chapter because it is an important management tool. Riding on the trails is the primary reason OHV riders visit a riding area. Expanding the variety, and thus, the experience adds to the quality of the riders' experience. Planners can expand the variety by adding loops, narrow trails, trails on roads, changes in difficulty, changes in topography and vegetation, youth training areas and learner loops, mudbogs, play areas, or technical challenge courses.

Providing variety is an effective OHV planning and design tool that will help ensure management success.

This rest was during a 'group' ride. It was a beautiful day and a beautiful setting. The different machine types took different routes. They used trails, roads, road to trail conversations; encountered flat terrain and steep terrain; experiences smooth and rough trails; and went through areas of high vegetation and no vegetation. There was great variety and lots of smiles; a WOW experience.

Quality

The final tool is quality. Quality doesn't mean expensive, it means simple, effective, well-maintained, and well-managed trails and facilities that meet the riders' needs. Quality is created when there are trails with adequate mileage, a high fun factor, and creative variety; a simple well-organized kiosk that has maps in the map box; the information on the map matches the signing on the ground; a toilet that looks and smells clean and is stocked with paper and sanitizer; and the trails and the signing look professional and are well-maintained. Quality is the effective application of all of the components of the Great Trail Continuum: planning, design, implementation, maintenance, management.

Breaking News! Always use quality materials (for OHV trail systems)

Need more? Learn more here...

Designing Sustainable Off-Highway Vehicle Trails, Kevin G. Meyer, USDA Forest Service, Technology & Development Program, 1123-2804P-MTDC, 2013

Management Guidelines for OHV Recreation, Tom M. Crimmins, National Off-Highway Vehicle Conservation Council, 2006

A Look Back

Here are some of the OHV management elements discussed in this chapter:
- The need for managed recreation

The three key elements for success:
- Provide for the Riders' Needs
- Design for Sustainability
- Develop an Effective O&M Program

Understanding the riders' needs and desires:
- Fun, fun, and more fun. People recreate to have fun.
- Connect with nature. Find our roots and a simpler existence.
- Escape from society
- Relieve stress
- Physical exertion and exercise
- Challenge for their vehicles and themselves
- A variety of experiences and difficulty levels
- Build camaraderie with friends and family engaged in the same activity
- A sense of belonging to a group
- A legal place to ride and feel welcome
- Enjoy quality facilities: kiosks, toilets, camping, etc.
- Enjoy quality trails, signing, and mapping
- Access to water features, scenic viewpoints, and unique features
- The opportunity to view wildlife

The 4Es: Engineering, Education, Enforcement, Evaluation =
successful project implementation = successful OHV management

Sustainability defined: sustainable trails flow & roll with the landscape
The 3 Ds: Dispersal, Dispersal, Dispersal
Understanding seat time and recreation activity time
The trap of one-way trails
- Using existing infrastructure: roads and trails
- Creating a recreation experience, not a transportation experience
- Variety = high-quality recreation experience = successful OHV management
- Quality = control = effective OHV management

Chapter Two

Planning: The Foundation of a Successful Project

Respect the Land, the Water, the Wildlife and the Rights of Others

Creating a sustainable trail or trail system is very similar to building a house: it takes a vision, a good plan, a solid foundation, sound construction practices, and then proper maintenance to protect the structure's integrity. If the proper time and effort is not spent in each one of these steps, the entire project could be jeopardized.

THE GREAT TRAIL CONTINUUM

This is the basis for the concept of the Great Trail Continuum. Each component is equally important and each component must be effectively performed and implemented in order to create a great trail. Some planners look at planning as a white elephant; a paper exercise that wastes time, wastes money, and is not productive. But it is an essential component of the continuum. Why is it called a continuum? Because the process never stops. The team plans, designs, implements, maintains, and manages. Then using the 4Es, the team monitors the results and if something isn't working, members plan, design, and implement corrective action. This is called adaptive management. It is important because a trail is imposed on a dynamic landscape, therefore the trail and its management must be dynamic. There will always be a need for change.

Tip, Trick or Trap?

Tip: A trail is placed on a dynamic landscape, therefore the trail and its management must be dynamic

Chapter 1 discussed the three elements for success: provide for the riders' needs, design for sustainability, and develop an effective O&M program. Neither of the first two elements can be achieved without first planning for them. The essential steps in the planning process are:

- Develop a vision
- Conduct a site assessment
- Refine the vision
- Build a resource map
- Develop a trail concept plan
- Develop trail management objectives (TMO)
- Perform any required environmental analysis
- Build broad-based support
- Assemble the remaining foundation building blocks

This is a swamp buggy trail in Florida. Though quite different, the principle of Providing for the Riders' Needs applies here just as in any other OHV trail.

Develop a Vision

Developing a vision means that planners must ask the following questions: What needs to be done? What can be done given the constraints of the site, resource concerns, politics, or management? What vehicle types will be accommodated? What experiences will be provided? What opportunities are there for difficulty levels and challenges? What facilities will be provided? What opportunities are currently being provided in the area or region? What levels of visitation can be expected? Where will this system fit into the big picture; what is the niche?

The vision is important because it provides a target or goal. If planners don't know where they're going, they don't know when they get there or, more importantly, they don't know how to get there. The vision should be written down, and the entire project team and stakeholders should be in agreement so everyone is working together toward a common goal. The vision can change as more information is collected about the project area. It also needs to be realistic, attainable, and affordable. It is one thing to obtain funding for construction, but it's another to obtain funding for operation and maintenance in the long term.

Vision without Action is a Daydream.
Action without Vision is a Nightmare.

The team also needs to understand the uses that are currently occurring at the site. Planners should go out and look at the trails; look at the impacts, if any; and talk to the riders to find out what they like, don't like, and want. Planners can then refer back to the first key element for success: provide for the riders' needs.

Planners must understand the use before they can develop a vision.

Without proper planning a great vision can become a trail nightmare.

A key consideration in planning for riders' needs is to understand that OHV riders travel in groups and that generally those groups have a mixture of vehicle types. It is not unusual for a group to have OHMs and ATVs or ATVs and ROVs. If at all possible, provide a variety of trail widths that interconnect at intervals to accommodate those different vehicle types. By doing this, a group can ride their respective trails and still have the opportunity to meet up with the rest of their group. It is a definite benefit to have an OHV specialist on the planning team. If one is not available, consider adding a club member, state or provincial association member, or an OHV expert.

Resorts and campgrounds connected to a trail system offer variety for the riders and a positive economic impact for the surrounding communities.

Planners should next consider their niche by asking about other opportunities that are currently being provided in the area or region. Will the trail provide something different or unique? Where will customers come from? If most of the customers are within a couple of hours driving distance, most of the use will be day use. If a motorcycle rider can ride 50 miles in a day, then there should be at least 50 miles of trail. However, if customers will be coming from outside of the area, then they will likely be coming for a weekend or long weekend. If that motorcycle rider is here for 2.5 days, there should now be 125 miles of trail or there should be other facilities and activities to occupy the recreational time that customers are on site.

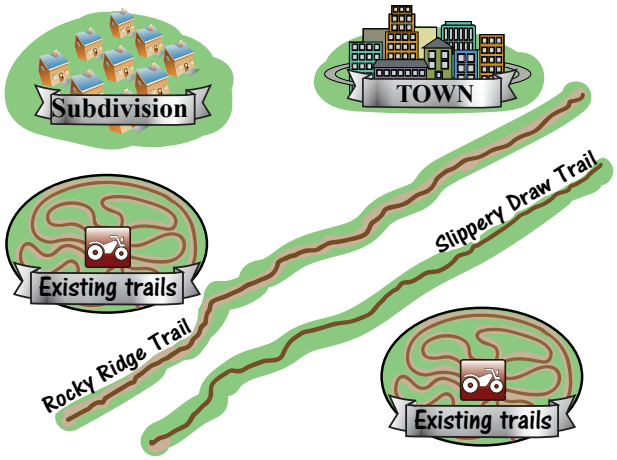
The Vision
With no challenging terrain available, this rock garden was created. This group had a blast and spent more than an hour in this 200' section.

Having a grasp on the demographics has a definite influence on the project planning beyond just the miles of trail being provided. If customers are coming for a weekend, where will they stay? Perhaps there

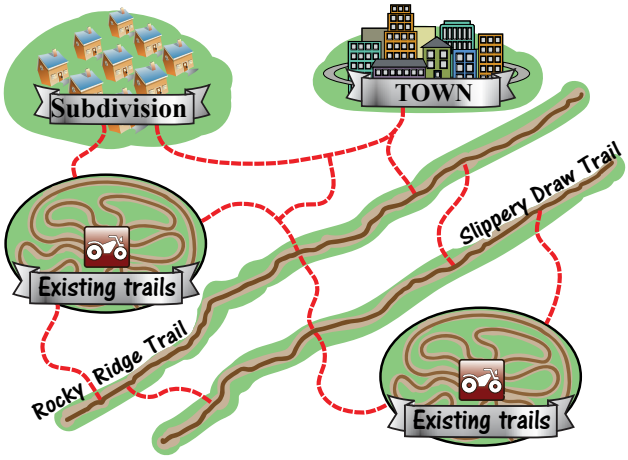
should be a campground, or maybe there are local motels or RV parks that could use an economic boost from the trail system or OHV park. An important consideration, though, is do these existing facilities have adequate parking and turnaround space for big rigs? What about an event area for closed course races, drag races, tractor pulls, or other competitions? Some parks provide non-OHV activities such as zip lines, activity areas for volleyball or badminton, and playgrounds. Other areas provide equipment rentals or food concessions.

Are there ponds or lakes that could provide swimming or fishing opportunities? Could the trail or trail system connect with other trail systems or towns to provide multi-day ATV, ROV, or dual-sport touring? If so, there is the potential to create some outstanding and unique recreation experiences. The Hatfield-McCoy trail system in West Virginia and the Paiute trail system in Utah not only provide fabulous riding but also are huge economic boosts to the local economies because they connect the trails to the communities.

All of these potential activities could contribute to the essential element of variety. Few people ride their OHV for 10 hours straight every day. Planners should provide a creative mix of activities and experiences.



Taking isolated trails



and adding connections to make a trail system

Will there be events on the trails? Depending on the soils, vegetation, and topography, trails that will have competitive events may need to be designed differently in order to be sustainable. Many soil types cannot endure a high volume of use in a short duration of time. This also applies to OHV parks where there may not be events on the trails, but there is a high volume of use on generally a low-mileage trail system.

When developing a vision, it is easy to become micro-focused on just the area of concern, but the planning team should step back and look at the big picture. Instead of looking at one trail, planners should look at developing a system of trails. Instead of looking at a group of individual trails, they should look at developing a managed trail system. On a broader scale, planners should consider if there is an opportunity to link several trails or groups of trails to several communities. All of these can add to the quality of the recreation experience and to the effectiveness of the management of the use.

Trail system features	Meet riders' needs
Loops	Connectivity
Mileage	Seat time
Dispersal	Seat time
Scenic diversity	Variety
Terrain diversity	Variety

Conduct a Site Assessment

To continue the vision, the planners need to conduct a site assessment to determine the feasibility of the vision. Will the site support the vision? If not, what can it support? The assessment needs to look at the topography, soil types, vegetation, climate, known resource concerns (wildlife habitat, riparian areas, cultural resources, etc.), known management constraints (conservation areas, restrictive management areas, etc.), known stakeholder issues,

existing uses and their impacts, safety issues with the current uses, and the feasibility of adding other recreational activities. All issues need to be assessed and documented. If no one on the team has the expertise to conduct this assessment, consider having a consultant do it. Consultants may see things that the team has not considered and their eyes are unbiased, objective, and professional.

This area was assessed to determine its suitability for OHV trails and its recreational value. The result? Outstanding!

Refine the Vision

So far, the team has acquired: a) an understanding of the physical characteristics of the site; b) a site assessment; c) comprehension of the vehicle types and the OHV recreationists; d) a grasp on the types of experiences to be provided; and e) knowledge of other OHV opportunities in the area or region (niche). With this broader knowledge, it's time to refine the vision statement. Below is a sample vision statement from the Gypsum City OHV Park in Fort Dodge, Iowa.

Gypsum City OHV Park is a community partnership developed and dedicated to enhance recreational opportunities and promote tourism and economic diversity. With its many diversified activities and year-round usage, the goal is to provide a place where families can enjoy the Iowa outdoors in a beautiful well-managed setting. High-quality sustainable trails will provide a range of experiences while well-designed facilities will cater to the needs and comfort of our visitors. The Park will provide a legal designated place for OHV recreationists, and the vision is for the Gypsum City OHV Park to be the premiere destination for not only Iowa, but the entire Midwest.

Build a Resource Map

The next step is to build a spatial database with all known information about the site. Often this is called a resource, inventory, opportunity, or constraint map. This data is best recorded as layers in a program such as a geographic information system (GIS). Each type of information is recorded in its own layer, and the layers can be easily turned on or off depending on the type of information needing to be displayed on the screen or map. Commercial-grade global positioning system (GPS) units have the ability to store a wide range of information about each trail or trail segment. These are called data dictionaries and they can be downloaded to form the GIS layers. Data can be collected as to the road and trail widths, use type, grade, trail condition (degradation), surface type, indicators of erosion, condition of road and trail structures, etc.

Many GPS units on the market have the capability of taking photographs and linking them by position to the trail being inventoried. This can be extremely helpful, especially if the planner is not the person collecting the data. The photos can be great tools to show general trail width and condition; indicate trail problems; portray difficulty; portray soil and vegetative type and cover; show existing signing; or highlight unique features, opportunities, or habitats.

The following information should be collected for the resource and planning analysis utilizing existing databases, GPS collected information, and field data.

- Roads divided into major, minor, and primitive roads and classified by federal, state, county, and city ownership
- Existing trails, designated and user-created
- Water features including lakes, ponds, creeks, springs, wells, irrigation lines or canals, known wet areas, known riparian zones, and livestock water troughs

- Utility lines and corridors, both above and below ground
- Fencelines including gates, cattle guards, and corrals
- Grazing allotment boundaries
- Existing facilities including trailheads, parking areas, camping areas, toilets, shelters, motocross tracks, and training facilities
- Property boundaries, road rights-of-way, or other easements
- Known wildlife corridors, raptor nest sites, animal dens (bear, rattlesnake, etc.), beaver dams, etc.
- Known threatened, endangered, and sensitive (TES) species and their habitats
- Known cultural sites
- Noxious or non-native plant populations
- Management area boundaries including old growth, deer winter range, general forest, watershed boundaries, and tree farm license boundaries
- Soil type, and terrain stability
- Vegetative type and cover
- Active commercial operations such as mines or logging
- Existing rock pits, quarries, borrow sites
- Points of interest including lookouts, historical sites, viewpoints, cabins, and wildlife viewing areas
- Any unique features including rock outcrops, cliffs or rimrock, rock slides or scree, interesting formations, unique vegetation, scab flats, and meadows

Tip, Trick or Trap?

Tip: For inventory of the trail centerline, the smoothest GPS tracks will be obtained by riding the trail, but assessing the condition of that trail is best done on foot

The inventory data will be displayed as points, lines and polygons.

Point data are used for controls, points, unique features, nest sites, etc.

Line data are used for fencelines, utility corridors, roads, trails, etc.

Polygon data are used for management boundaries, cultural sites, non-native plant populations, water features, etc.

Although this is a lot of data, planners should remember that the goal is to design a sustainable trail or trail system that protects resource values and provides high-quality recreation experiences. These objectives can only be accomplished by having thorough knowledge of the site.

The next step in the process is to develop a trail concept map. For planners to produce a good product, they need multi-resource, accurate, and complete data. It can be expensive to collect this comprehensive data; however, planning is the building block or foundation of the trail system. It will be cheaper and more efficient to gather the information now than to have a critical resource issue surface after the construction crews and equipment are on site. In addition, the person doing the trail layout and design must be intimately familiar with almost every square foot of the site. When that person stumbles across a trail or other feature that was not on the inventory, everything must stop until that feature is explored, GPS inventoried, and incorporated into the trail concept plan as either a designated or closed route. Paying for good data upfront can save project dollars and time later on in the process.

Features like these should be included in the inventory and utilized whenever possible.

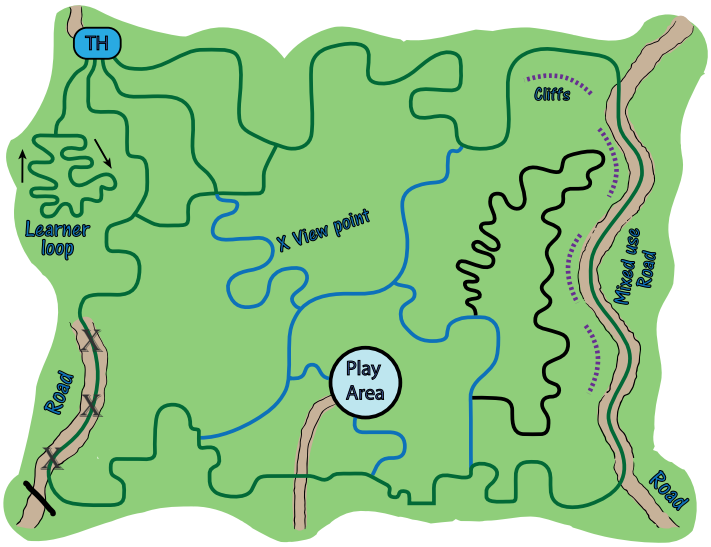
Who should be collecting the field inventory data? Ideally, from a consistency and continuity standpoint, it should be the trail planners and designers. That way, the same set of eyes and evaluation criteria are used to gather the data and translate it into a plan on paper. Often that is not possible. Sometimes club volunteers gather the data, but they may not have the skills to recognize sustainability issues or understand resource values. Sometimes, agency personnel collect the data, but they may not have a good grasp of desired rider experiences, difficulty, the elements of a sustainable trail, or recognize potential opportunities. Planners could consider hiring contractors with OHV expertise who can gather quality data quickly and efficiently.

The resource map is a working document; therefore, it reflects the information currently available and can change as additional or modified data is obtained.

Develop a Trail Concept Plan

Given the knowledge of the project area, the vision, the understanding of the vehicles to be accommodated, the desired recreation experiences to be provided, and the inventory map, planners can now sit down and start mapping out a conceptual trail system. In designing a trail system, the planners must understand:

- The statutory and administrative requirements
- The resource values and constraints
- The users and their desired experiences
- The landscape
- The issues
- The politics
- The climate
- The existing condition
- The vision



Creating the concept plan is a complex and cerebral process. Depending on the size of the project area, it can be a huge task. If there isn't someone on the planning team who is qualified to perform this task, it might be beneficial to consult with a professional trail planner. This is also a good time to talk about the importance of developing open, honest working relationships with the resource specialists. These relationships must be based on unbiased professionalism and trust. Without that, the cohesiveness and the effectiveness of the planning team could be diminished.

A Case in Point...

The planning for the Shoshone OHV Trail System in north central Nevada began in 2003. The members of the local club, the Northern Nevada ATV Association, were excited and anxious to get a new riding opportunity. They spent years attending meetings with stakeholders, the county, and the Bureau of Land Management. The environmental analysis process took years to complete and then was further delayed by an appeal. During that time, there was a change in the county commissioners and support at that level was no longer assured. It took eight years before construction could finally begin and by then the energy of the club had waned, membership had dropped, some members had developed health problems, and others had quit out of frustration. However, the club as a whole prevailed. Without the dedication and persistence of the club, the project may not have come to fruition.

Not only is the development of the trail concept plan a huge step in the process, it is the first step that produces a tangible visualization of what the project will look like. Up until now, there is usually only a map with a project area boundary on it. Having a visual aid can stimulate and encourage the planning team and invigorate the clubs and potential volunteers. Getting from project inception to trail concept plan can take

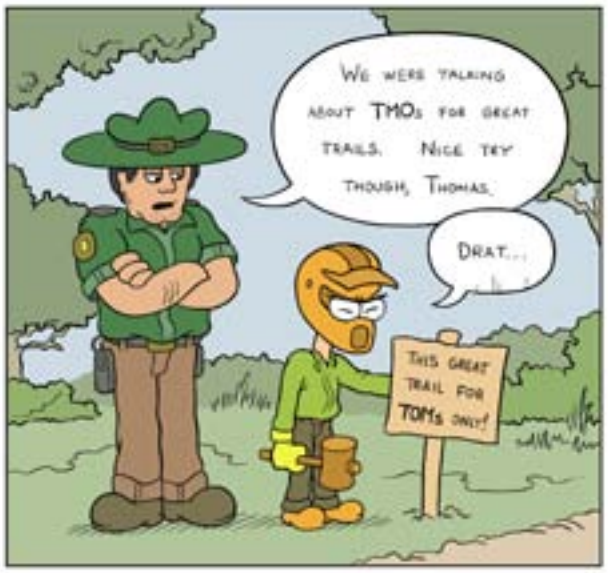
years. It is very difficult for any group, especially one made up of volunteers, to maintain energy and enthusiasm for that long of a period. The trail concept plan is a good tool to take to the stakeholders so they can see how the proposed trails may affect their interests. Lastly, having the trail concept plan in hand is a huge advantage when seeking grants or other funding opportunities.

The development of the trail concept plan is the true foundation of the trail system, and it is such an important step it is discussed more thoroughly in the next chapter. Once the trail concept plan has been reviewed and any necessary revisions made, the next step is to develop alternatives if necessary.

Develop TMOs

The trail management objectives (TMO) document describes the use and management of a trail and outlines the following:

- The primary uses and vehicle types
- Other allowable uses
- The desired recreation experience: transportation road, recreation road, trail, loop trail, destination trail
- The intended difficulty level (this may change once the trail is finally located on the ground)
- Design guidelines including clearing width, tread width, and grades
- How the trail will be constructed: machine or hand-built
- Maintenance frequency and methods
- Trail management such as open all year, seasonally closed for wildlife, closed during wet season
- Frequency of trail inspection and assessment
- Any specific resource concerns or issues associated with the trail including grazing allotment, wildlife, cultural sites, sensitive plant sites, water quality, and nearby residents



By documenting this data, TMOs provide continuity as well as operation and maintenance consistency. Personnel will change, but the trail will still be on the ground and the new personnel will need to know the vision and intent. Over time, the TMOs should be reviewed and revised as use, use type, climate, and landscape changes occur.

The TMOs are the thread that weaves the continuum together. The designer must know the intended user, the intended difficulty level, and how the trail will be constructed. Construction personnel must know the user and the difficulty so that technical features like rocks, logs, and roots can be left or removed. Maintenance personnel must understand the use, the desired experience, and difficulty in order to properly maintain the trail (so they know to cut out a log or keep a technical feature). Whoever is inspecting the trail needs to understand the resource values and determine if they are becoming impacted. Those people also need to determine if the trail is still providing the desired experience or difficulty level and ascertain if maintenance, reconstruction, or relocation is warranted.

Perform Any Required Environmental Analysis

A lot of good solid data and work has gone into the formation of the trail concept plan, so it can often be used as the proposed action in the environmental analysis process. Each agency, state, or province has different legal requirements and processes for environmental review. It is absolutely critical that their requirements be identified and followed. Environmental review can add months or years to the project planning but that time period can be reduced by having a solid trail concept plan based on sustainability and resource protection.

On federal land in the United States, the National Environmental Policy Act (NEPA) legislates the environmental review process. Under that umbrella, each federal agency then adopts additional regulations and policies for their jurisdictions. There are three levels to NEPA and each level increases in process and complexity.

First is Categorical Exclusion (CE or Cat Ex), which is a category or list of actions that, barring extraordinary circumstances, do not individually or cumulatively have a significant effect on the quality of the environment. These categories vary widely between agencies; however, designation or construction of new roads and motorized trails are not generally included. Depending on the agency, a CE may be used for minor reconstruction or relocation of an existing trail.

Tip, Trick or Trap?

Tip: Planning Virtues:
- Patience
- Persistence
- Long-Term Commitment

Second is Environmental Assessment (EA), which is the most common and used when the expected effects of the proposed action are well understood to have no significant impacts. The process usually, but not always, explores alternative ways to achieve the purpose and need, analyzes the effects of those alternatives, and affirms that the selected alternative with appropriate mitigations has no significant environmental impacts. If the EA concludes with a Finding of No Significant Impact (FONSI), the environmental review process is complete. If it doesn't, then the EIS process must be followed.

Third is the Environmental Impact Statement (EIS). This process is used for projects that may have a significant environmental impact. An EIS will almost always explore more than one alternative that meets the purpose and need. The alternatives display options and trade-offs between significant issues. The EIS discloses the effects of those trade-offs and how they will be mitigated and concludes with a Record of Decision (ROD).

Often, the processes for an EA and EIS are similar in that both have:
- Purpose and need statement: What is it and why is it needed?
- Proposed action: A course of action that could be taken.
- Scoping: Asking for public input for issues, concerns, opportunities, or other courses of action. Sometimes this is done through public meetings.
- Alternatives: Usually one of these will be no action or no change, one will be the proposed action, and then one or more alternatives to the proposed action.
- Analysis: Review of effects of the proposed action versus the alternatives.
- Public review and comment.
- Final agency decision: A final document with a ROD or FONSI and required findings is issued, often with administrative appeal opportunities. The final could be altered from the draft due to the public comments.

Scoping and Stakeholder Involvement. Scoping is an essential component in the NEPA process. While not every project goes through the NEPA process, in every project area, there are individuals or groups who have an interest in the area or who could be directly affected by the project. Scoping needs to be done to determine the interests and stakeholders. A contact list should be developed and those stakeholders notified of the project and its progress. This is important because any or all of the interests may have issues or concerns with

Trail enthusiasts need to be good partners to help agencies develop their trails.

the proposed trails in the project area. It is far better to flush those issues out early, rather than to have irate opponents surface later. When all of the issues are on the table, planners can address them either by changing the trail concept plan, developing another alternative, or changing the scope or level of mitigations. Time allows the planners to better understand the issues and also allows the opportunity to build a working relationship with the interested public.

There are two types of interested public: special interest groups and stakeholders. Special interest groups have an indirect interest, advocacy, or philosophical position. These groups lobby for a position and they could be OHV groups, conservation groups, or timber groups. Stakeholders are individuals, groups, or entities that have a direct and active interest in the project site. Stakeholders could include riding club(s), private inholders, range permittees, timber interests, mining interests, other tenure holders, neighboring residents, utility companies with corridors through the project site, irrigation districts, tribes and First Nations, hunters, and other trail user groups.

A Case in Point...

The NEPA process was followed for the Lost Ox OHV Trail System in Ely, Nevada. An EA was prepared, a FONSI was signed, and there were no appeals. Grants were secured and a contract was let to perform trail layout and design. Several months later, four hunters realized that the project could affect "their interests". They went to the county commissioners and got their support in opposition to the project. That group had been in favor of the project until a recent election changed the commisioners. Then the hunters went to the media and started beating the war drums of emotionalism. A town hall meeting was held followed by more meetings with the Bureau of Land Management. The result? The Decision was vacated, the contract cancelled, the project forever dropped, and a loss of more than $1 million in grant funds. The NEPA process was followed, but could the outcome have been different with more scoping and public involvement early on?

Sometimes the stakeholders are brought together as a group with regular meeting dates. These can be called an advisory committee, oversight committee, or steering committee. These committees can be a good forum for an open discussion of the issues. They can also be a forum for heated debate, collusion of interests, and shifting focus to positions (to interests that impede rather than expedite the process). If a group is formed, an experienced and impartial moderator should facilitate the group to keep it focused and moving in a positive direction.

It can be more effective to meet with the stakeholders individually rather than in a group, and it is very productive to conduct that meeting in the field if possible. In the field, it is easier to deal with the real issues, the conversations tend to be less polarized and dramatic, and the perspective of the issues and scope of the landscape is much better than gazing at a map. Like the resource specialists, it is important that planners develop a positive, professional working relationship with the stakeholders. This relationship does not stop when the planning is finished, it continues through the implementation and beyond.

A meeting with stakeholders in the field.

No discussion about stakeholders, planning, and environmental review processes would be complete without talking about the 3Ps: politics, politics, politics. There are politics in everything, including in a family, club, state and provincial organization, and work environment. Certainly, in dealing with relationships with stakeholders, interest groups, the land managers, and their staff planners must put on their political hat and diplomatic face. This is not a realm where the "damn the torpedoes, full speed ahead" approach is appreciated or effective.

Building one-on-one relationships with stakeholders. At left, the Okanagan Trail Riders Association (OTRA) uses its operator and equipment to help the range permittee dig up and repair plugged up pipes to a water trough. Below, the OTRA worked with the representative of the tree farm license holder to install barriers and signs to deter hill-climbing at a private gravel pit.

Involvement means building trustful working relationships, even with people who may have very different philosophies. Successfully working with multiple interest groups can be like walking a tightrope. Smiles and sincerity can open doors; negative body language and careless remarks or actions can close them. A wise man once said that there is a time to talk and a time to listen. The wise approach when walking into a new group is to listen first and talk second or not talk at all. By listening, planners can better understand issues, agendas, underlying motivations, and under the table alliances. Listening builds trust and allows planners time to mold their thoughts into effective comments.

Change happens often in planning, including with use levels; use types; climate; sensitive plants and animals appear and disappear; sometimes trail locations, grades, and structures are tried, but they didn't work as expected; and sometimes there are errors in the initial planning or implementation that need to be corrected. Since a trail lays on a dynamic landscape, the trail and its management must be dynamic. In the NEPA process, two ways to facilitate change are 1) survey and assess the effects of a trail corridor, not just a trail, and 2) include adaptive management verbiage in the NEPA document.

Establishing a corridor of 50, or better yet a 100, feet on each side of the trail centerline gives the designer room to make final alignment or grade adjustments prior to construction. It also provides flexibility during construction to move the trail slightly if solid rock or other unsuitable material is encountered. And finally, as the planning team moves along the continuum into long-term maintenance and management, a corridor allows room for minor relocation of the trail as the condition of the trail, its use, or its environment changes.

A Closer Look...

Adaptive Management
Advantages:
- Flexibility to change
- Increased sustainability
- Proactive management
- Increased rider satisfaction
- Decreased resource impacts

Adaptive management verbiage means including a few sentences in the NEPA document that say: "If this happens, the team will consider or do that." For example, "If use increases to the point where the trail is no longer sustainable in its current location, the team will consider moving it". Or "If there is a catastrophic fire or weather event that affects the sustainability of the trail, the team will consider moving it". Some simple wording in the body of the document and consideration in the effects section can expedite the need for changes later on because the change is still meeting the intent of the document.

Build Broad-based Support

Some people vehemently dislike OHVs. This sentiment can complicate the planning process as managers and planners need to sort out the physical issues from the emotional issues. Physical issues can usually be addressed and mitigated; emotional issues are more difficult to resolve. The issue of sound can be mitigated, but "I don't like OHV noise" cannot. Because of this, it is critical that the OHV club provides support to the planners and land managers and that they speak with a unified voice.

A Case in Point...

Let's go back to the Lost Ox OHV Trail System in Ely, Nevada. The project was initiated by the BLM in an effort to be pro-active in providing for and managing the rise in OHV use. There was no local ATV club, so there was no local support base. Even though there are a lot of ATVs used for ranching and hunting, most of those users did not see the benefit in developing a trail system since they could already ride almost anywhere they wanted. So when the support of the county commissioners was lost and the media turned negative and there was a public outcry to stop the project, the BLM was left standing alone and they couldn't support the project.

The more people or groups that work together, the stronger the planner's position will be to promote and defend the project. It's never fun to stand alone in a sea of adversity, so having partners and supporters is a definite advantage. Some of the best partners can be stakeholders who can see a direct benefit to themselves. Talk to them individually, find out their needs or concerns, and determine how the project can address them. City officials, county commissioners, and regional districts can also provide a good support base. Planners should talk to them and show them how the project benefits the community and the economy. Local support is far more effective than non-local support, so while it is a benefit to have a letter of support from state or provincial officials or user associations, that support is not the same as support from those who are directly affected.

Tip, Trick or Trap?

Trap: Don't fall into the trap of arguing or defending your project or position in the media

This is another arena where effective use of the 3Ps is essential. The media tends to feed on contention because that's what sells their product; however, sometimes planners can find reporters who are interested in the project and fairly report what they see. This is an asset, so planners should capitalize on it. Opponents will focus the media on negative aspects of the project. Planners need to turn that around and find, focus on, and highlight the project's positive aspects.

Tip, Trick or Trap?

Trap: All non-motorized recreation groups are opposed to motorized recreation. This is a trap because opening new motorized trails which allow non-motorized recreation can create additional opportunities for all trail users.

Assemble the Remaining Foundation Building Blocks

Several other components or building blocks are necessary to complete the planning foundation. Just as having broad-based support builds solidity, planning documents also add to the solidity of the project. They can answer questions before they are asked, can address concerns early on, and put the planners and managers in a proactive, knowledgeable position. These documents include the management plan, sign plan, map, architectural theme, barrier design, monitoring plan, interpretive plan, and rehabilitation and erosion control plan.

Management Plan. A management plan provides programmatic direction and guidance, and includes these key components:

- Documents the vision
- Fully describes the trail and facility opportunities to be provided
- Establishes the vehicle and rider rules and regulations
- Establishes hours of operation, seasons, and weather restrictions
- Establishes who will administer the site and who will perform operation and maintenance

- Discusses whether there will be events
- Documents the decisions of the steering and advisory committees
- Discusses OHV use of roads
- Outlines the mitigation of issues
- Describes who will perform enforcement
- Outlines the role of volunteers
- Discusses who will do education
- Lists design guidelines for trails and facilities

Sign Plan. Signing and mapping are the two primary means that management has to communicate with its customers while they are on site. Simple, consistent, effective signing is critical to the success of any project. The sign plan establishes direction regarding the types of signs, shapes, colors, messages, materials, and placement.

Map. While it's too early in the process to produce a user map, planners can still include an example of what the map could look like. It is more important to have a map be functional than to have it look pretty and be expensive. The map must be rider friendly and effectively provide riders with the information they are looking for.

If the signs and the maps do not clearly work together and tell the riders where they should go, the management for the area has failed. This will cause impacts. Since these areas are critical, they will be discussed in more detail later in this book.

Architectural Theme. Many projects have an architectural theme to give the project an identity and a brand. Sometimes the theme conforms to the recreation opportunity spectrum (ROS), which provides guidance for the look and recommended materials in a setting that ranges from primitive to urban.

Barrier Design. Barriers control and direct use. Planners should have a barrier design that is used consistently throughout the project. Just like signing, riders learn to recognize a barrier and what it means. Barriers do not need to be tall, obtrusive, physical barriers. A low barrier that blends with the setting can be more effective and visually appealing. The riders' eyes are constantly scanning to pick a line to ride. It doesn't take much of a barrier for the roving eye to see that a potential pathway is not the best line.

A hydrologist monitors the stability of a beaver dam above this trail.

Monitoring Plan. There are two types of monitoring plans: formal and informal. Formal plans are specific and scientific. They involve establishing photo points, plots, and data collection points to measure and

record changes in the trail or surrounding environment. They can include water quality monitoring or radio collaring game species to assess changes in behavior and physiological effects. Formal monitoring often requires specialized equipment and specially trained personnel which make it expensive and labor intensive, two attributes that are generally in short supply. When budgets get cut, monitoring is often on the top of the list. This can result in incomplete data that doesn't result in a conclusion. It can also put the managing agency in the awkward position of not doing what it said it was going to do.

Formal monitoring plans need to be:

- Relevant: What information does the team really need to know?
- Feasible: Can the data be obtained with the available personnel and equipment?
- Affordable: Given budget limitations, what data gives us the most useful information for the dollar?

Talking with the riders regarding their experiences at your trail system is important. Be sure to talk about all aspects including the trails, the facilities, the signing, the mapping, etc.

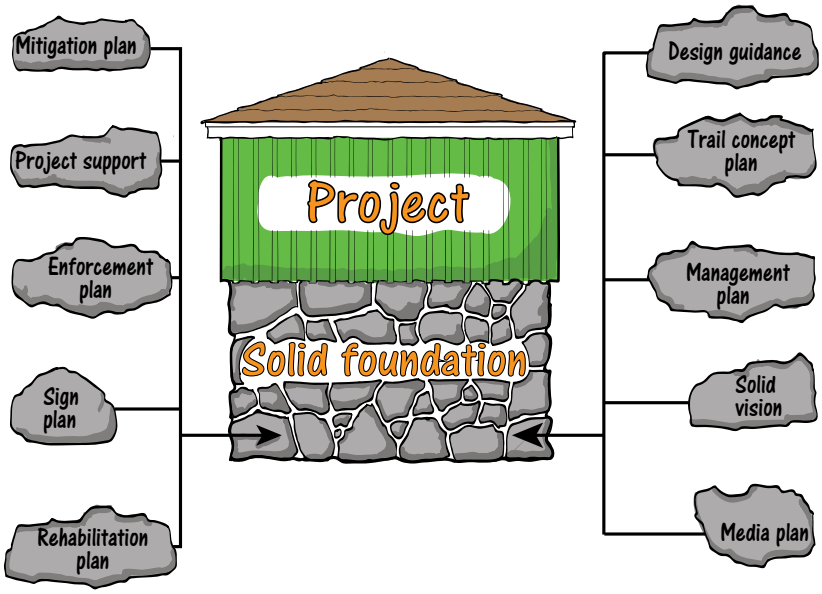
Informal monitoring is the fourth E in the 4Es: Evaluation. What is really happening? These are simple questions with readily attainable answers through observation, photos, trail counters, user surveys, and rider encounters. Are the trail management objectives being met? Are resource protection measures effective? Is there a high level of customer satisfaction? Is there compliance with the rules and regulations?

Informal monitoring has three elements: observe, record, report. Most field-going personnel including volunteers become the observers. Data can be collected with digital cameras, and information can be recorded on a simple monitoring form. The forms and photographs then need to be turned in to the person responsible for storing and compiling the data.

This interpretive sign adds to the rider experience along an ATV trail.

Interpretive Plan. Motorized recreationists are no different than any other recreationists; they like to understand their natural environment and learn about the history and geography of the area. Interpretation can benefit management by giving riders an understanding and appreciation of various resources or resource management activities and objectives. Interpretive sites can serve as destination points for the riders, they add seat time, and they increase the overall recreation experience of the riders. The sites are a win-win. Interpretation can be elaborate with expensive kiosks, or simple self-guided handout information with numbered posts along the way. Interpretation can engage resource specialists in the project area, it can bring a myriad of potential partners to the table, and it can provide new sources of grant funding.

Rehabilitation and Erosion Control Plan. This plan describes the methods that will be commonly used to close and rehabilitate prior impacts or undesignated trails or areas. It also explains the tools that will be used to control erosion and protect water quality during and after construction. If specific problem areas are known, the plan should address specific remedies for each site.



The more solid the foundation, the more likely the project will succeed.

Most of these plans can be simple documents that don't take a lot of time or money to prepare and some of these plans can often be incorporated into the management plan. Of all, the sign plan can be the most intricate and complex, but it doesn't have to be. Sometimes, a few representative pictures of typical signing could suffice. The important point is that all of these plans serve as blocks that build a solid foundation for the project. The broader the foundation, the more stable the structure, and the more likely it will succeed through project implementation.


A rock check dam being constructed to control erosion and stabilize a gully created by an old hillclimb.

If the project is an area with existing unmanaged OHV use, there could be a maze of user-created trails, resource impacts, social conflicts, negative media, and public outcry. All of these can complicate the planning process because it becomes difficult to separate the past from the present and future. There is another element: fear. Fear over what has happened in the past and fear over what could happen in the future.

Some tips to help deal with those issues and build positive relationships:

- Be patient, but persistent.
- Work to build trust at all levels.
- Do what was agreed upon and document it.
- Seek professional advice.
- Utilize the 4Es and all of the tools in this book.
- Maintain the high road.
- Address issues because they don't go away.
- Recognize that conditions will change; the past is not the future.
- Record everything new or changed on the project site.
- Use photos and brief verbiage in project newsletters or implementation updates.
- Be willing to conduct multiple field trips with stakeholders.
- Focus on the big picture, not on minor setbacks.
- Feed positive, pertinent, and truthful information to the media and stakeholders.

Some great trail planning strategies:

- Minimize the use of roads. Due to their large tread watersheds, roads are generally not sustainable and will increase maintenance costs. Roads increase speed, decrease seat time, and can decrease the recreation experience.
- Minimize the use of existing trails. Most existing trails were not designed and purpose-built for the use and most are not sustainable and will lead to resource impacts and increased maintenance costs.
- Seize opportunities for new construction. Most purpose-built trails are sustainable and provide a higher level of resource protection and rider experience.
- Maximize the use of existing structures to reduce construction and maintenance costs and reduce resource impacts.
- Plan for change in the landscape, climate, use type, or use level.
- Include adaptive management verbiage in NEPA documents and provide a corridor for the trail.

Here, water quality and sedimentation were an issue. Woody debris was placed in a herringbone pattern between rock check dams in a heavily eroded trail leading to a creek that feeds the community water intake.

Major structures like bridges, culverts, and fords are expensive to build and maintain. It is becoming increasingly more difficult to install these structures due to water quality or aquatic species regulations. Utilizing existing structures on roads, trails, or railroad grades can reduce cost, reduce process, and reduce potential resource impacts.

A Look Back...

Here are some of the planning elements discussed in this chapter:

- Develop a clear vision to guide the planning process
- Conduct a site assessment. The assessment will give the planner in the office a clear picture of what is on the ground.
- Refine the vision
- Conduct a thorough inventory and build a resource map
- Develop a trail concept plan
- Consider creating trail systems, not just trails
- Develop TMOs
- Conduct any required environmental analysis
- NEPA basics: CE, EA, EIS
- Include adaptive management verbiage and/or corridors
- Understand the importance of stakeholder involvement, including rider involvement
- The 3Ps: Politics, Politics, Politics
- Build broad-based support for your project
- Assemble the remaining building blocks of the project foundation:
    - Management plan
    - Sign plan
    - Map
    - Architectural theme
    - Barrier design
    - Monitoring plan
    - Interpretive plan
    - Rehabilitation and erosion control plan

Chapter Three
Developing the Trail Concept Plan

Know before You Go. Find Out before You Ride Out.

Up to this point, the only visual concept of the project may have been a project area boundary displayed on a map or perhaps a boundary with a bubble-diagram of potential facilities or opportunities. The trail concept plan will be the first tangible document that displays what the vision could look like on the ground. It's an exciting step.

The trail concept requires a broad vision. What will be provided and what could it look like? But vision doesn't end there. For a quality project, vision will be required in every step of the planning, design, and implementation process. In developing the concept plan, planners should shift their vision from the regional scale down to the landscape scale. Creative vision will be required to search for opportunities that may not be so obvious and to link those opportunities into a trail system of logical loops that will provide quality recreation experiences and resource protection.

Developing a concept plan is like working on a giant jigsaw puzzle. The vision, inventory, resource data, opportunities, and constraints are the pieces. How do they all fit together? Can they fit together in more than one way?

The first step is to have a thorough knowledge of the project area. In developing a concept plan, the planners must understand:

- **The riders and their desired experiences.** Planners cannot provide for the riders' needs until they understand those needs. Who are the riders? What are the vehicle types and sizes? What are their motivations and desired experiences?
- **The landscape.** What are the soil types? Are there any soils with naturally occurring asbestos, arsenic, or other harmful elements? Are there any contaminated soils on site? If there is rock, what kind is it? What are the vegetative types? What is the topography? Are there springs, perched water tables, or permafrost?
- **The issues.** The issues can include everything from noise, dust, wildlife disturbance, and water quality to potential conflicts with non-motorized recreationists. If there are clubs, is their support unified? Are there conflicts with stakeholders?
- **The politics.** What is the level of agency commitment? Are there multiple agencies or ministries involved? Are they all supportive? Is there community support and club support? Is there anyone against the project and, if so, why?
- **The climate.** What is the range of temperatures? Are there one, two, three, or four seasons? What is the average annual rainfall and snowfall? Does the rain come as gentle daily showers or intense thunderstorms? What are the humidity levels? What are the wind patterns? Will the use be seasonal?
- **The resource values.** Are there high cultural values, wildlife values, water values? Are there threatened, endangered, or sensitive (TES) plant or animal species? What are the land management allocations?
- **The statutory requirements.** What are the state or provincial licensing requirements, registration requirements, and definitions of OHVs? What legislation may be applicable (federal, state and or local laws regarding clean water, wildlife and fisheries protection, forest management, operator use restrictions, legal and designated routes, environmental protection, etc.)?
- **The existing condition.** What uses are currently occurring in the project site? What levels of use? Seasons of use? What impacts, if any, are occurring? In looking at the existing trails, roads, skid trails, game trails, and stock trails, how durable are the soils? What grades and length of grades appear to be resilient and sustainable?

- **Management constraints.** Are there budget or time constraints? Can only certain types of work be done due to the source of funding or deliverables in a grant? Does new construction have to be minimized? Does management desire the incorporation of all existing roads and trails, or only those portions that can be made sustainable? Are there road or trail density constraints?
- **Vision.** What is the intent and goal of the project? What facilities are to be provided? Will the project be an open riding area or will there be trails or a trail system, or a mixture of trails and open riding areas? Will the trails be used in the winter by a different user group?

The answers to these questions will affect how the various pieces of the puzzle are fit together. Time to get started.

Section 1: Compile and Refine the Data

Just like the jigsaw puzzle analogy, the best place to start is by assembling the obvious pieces like the border. For the trail concept plan, this equates to examining the constraints and eliminating the "no-go" zones, marking out the "partial-go" zones, and identifying the "don't-want-to-go" zones. A query of the GIS resource layers should quickly identify polygons for these three zones.

Control Points

Control points are features that have a direct influence on where a trail goes. There are two types of controls: a place where riders have to be (positive control point), and a place where riders can't be (negative control point). The planners' first trips to the project area should focus on identifying control points. The more of these that are found early on, the more solid the trail concept plan will be. When an impassable ravine or other feature not previously identified is found, the process can come to a halt. The feature needs to be added to the concept plan and the trail corridors adjusted accordingly. Sometimes these adjustments can significantly alter the concept plan, and that consumes time and project dollars.

Some common **positive control points** are trail termini, road and creek crossings, points of interest, etc.

Termini of the Trail. Certainly, the first thing planners need to know is where a trail starts and ends. Does it start at the trailhead, staging area, campground, or someplace else? With existing facilities, sometimes the termini are obvious, but if the project area is a clean slate, the first order of business is to determine where the trailheads, campgrounds, or other facilities will be located. Depending on the site, this task can be a challenge.

Road Crossings. First of all, is it legal to cross the road? If it is legal, where are the crossing locations that have flat approach grades and adequate sight distance given the speed of the traffic on the road. Some road crossings may require a permit from the road authority. If so, these should be obtained early in the planning process.

Points of Interest. Planners should identify unique features, interpretive points, and naturally occuring features which add interest and seat time to the riders' experience.

Creek Crossings. Every agency and area has different criteria for stream crossings, especially if it is a fish-bearing stream or a tributary to a community water source. The first thing planners need to do is determine the classification for the stream and any associated agency, state, federal, or provincial laws or regulations. As with roads, some streams may require a permit with seasonal constraints to work in the stream.

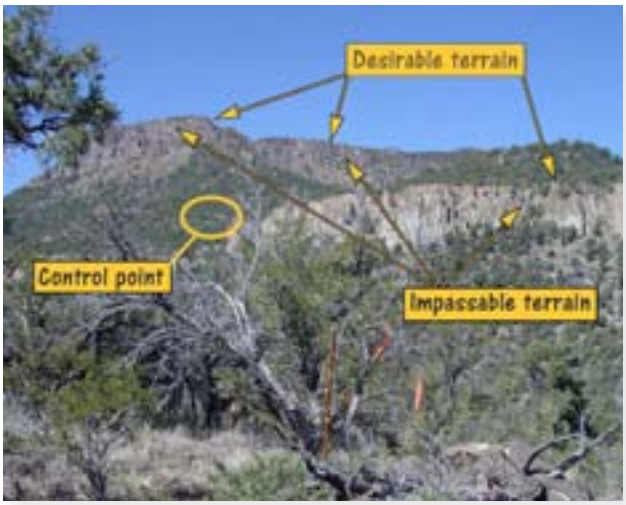
The best practice for crossing perennial streams is to avoid tire contact with the water. This offers the most protection for the stream and the environment by minimizing the risk of sedimentation. This involves the installation of a bridge, culvert, or in low flow streams, well-placed cobble rock to keep the tires out of the water.

If it is legal and appropriate to cross the stream on-grade with a ford, a qualified person must determine where the crossing points are that have good approach grades, a narrow riparian corridor, and the lowest stream flow. These ford crossing points become control points.

Where bridges are required, proper bridge sites also become control points. These are sites where there are stable banks for the bridge abutments to set; where the stream is down in a channel so there is a good elevation drop from the top of the bank down to the stream level; where the stream flow is straight to minimize scouring of the banks; and where the bridge span will be the shortest possible. Planners can find these sites, but usually an engineer will be required to assess the site and perform any necessary engineering surveys.

Saddles. These are a break or the lowest points in a ridge line. Some regions refer to them as gaps or notches. If a trail needs to cross a ridge, a saddle will require the least elevation gain and loss. In very rugged, technical terrain, the saddle may be the only place to cross the ridge line.

Existing Road Infrastructure. When it comes to major stream crossings with bridges, major culverts, or pipe arches, it can be a good strategy to try to utilize existing road infrastructure for these crossings. Not only does it save project dollars, it can reduce potential environmental impacts. Contact the road authority and obtain any necessary permits. There will need to be additional signing for mixed use and that should be addressed in the sign plan.



This picture shows cliffs which are impassable terrain for traversing up or down the slope. However, being on top of the cliffs is desirable terrain with a WOW opportunity for a trail. The only way to access the rim is through a gap in the rock which also becomes a control point.

Some common **negative control points** are impassable, unstable, or undesirable terrain and prohibited or restricted areas.

Impassable Terrain. These controls could be cliffs; deep, heavily eroded ravines or gullies; lakes and ponds; or fault lines.

Unstable Terrain. These could be landslides, slumps, avalanche chutes, or any area with steep ground and unstable soils. On slopes of more than 30 percent, avoid areas that have a shallow lens of soil on top of slab rock. A terrain stability map can help identify these areas, though often they need to be ground-truthed for accuracy.


After searching ¼-mile upstream & downstream, this was the only bridge site that would work to cross this very sensitive stream. It was not perfect (few are), but there was topographic relief on both sides, a straight channel, and minimal scour of the banks. This site became a positive control point. The next challenge was to get the trail down to it.


Steep scree slopes like this are high maintenance for trails. Many occur in snow country where snow creep will constantly drag rocks into your trail tread.

Undesirable Terrain. Wet areas fall into this category as well as those areas that will be wet like flood plains. While rock rubble fields like scree can create a beautiful and technically challenging trail, they can be high maintenance because rock is constantly sloughing off into the trail. The wider the tread, the bigger the issue. If the trail is to be wide and of low difficulty, scree becomes a negative control point.

Examine the Constraints

Prohibited Areas. What are the areas where a trail can't be put? These areas are usually dictated by resource management rather than by the physical characteristics of the site. As no-go zones, they become negative control points. Examples of these areas are rare or sensitive vegetation areas, bald eagle management areas (BEMAs), areas of critical environmental concern (ACECs), and community water intakes or water reservoirs.

Cultural resource sites usually fall into the no-go category; however, if they are subsurface, sometimes they can be crossed if they are mitigated by trail hardening or by additional monitoring of the tread depth. Seek and follow the recommendations of the archaeologist.

Private property boundaries and agency boundaries are generally no-go areas unless agreements are in place to cross into areas of other ownership. The lease or tenure boundaries for active mineral extraction are generally no-go areas depending on how firm the project area boundary is.

Restricted Areas. Bird nest sites, especially those of TES species or indicator species, are often restricted. A trail can't go under the nest, but it can go a specified distance away from the nest. Planners should find out the restricted area for that particular species and draw a circle around each known nest site. These partial-go zones also become negative control points. Rattlesnake dens or other dens may have similar protection. Some cave entrances, particularly those with sensitive bats, may be restricted. Water features like wells, springs, and water troughs often have a restricted area around them.

A den of rattlesnakes in a culvert

Some areas like deer or elk winter range may have seasonal restrictions such as winter closures. The requirements, if any, change by agency, state, or province. Planners should take the time upfront to identify these areas. It will make the plan more solid and environmentally defensible.

Riparian areas are often restricted. Trails can often cross them at 90 degrees to minimize impact, but they usually can't meander through them. The number of crossings may also be restricted. In some cases, trails through riparian areas need to be elevated or hardened. Some jurisdictions may require a permit to cross riparian areas.

Big game connectivity corridors are often restricted. Like riparian areas, a trail can usually cross them at 90 degrees, but not meander through them. Often there is a buffer zone around private property. Some reservoirs, especially those associated with community water intakes, also may have a buffer zone.

Undesirable Ground. Each project has areas where there could be trails, but it's not desirable to have trails. The first is flat ground. Flat ground? Isn't it cheaper to build a trail on flat ground? Actually, no. A trail on flat ground can become a trench over time making it difficult to drain water off the trail. Flat ground can hold water that saturates the soil and creates mudholes. It is also more difficult to maintain the designed tread width on flat ground since riders will push out the edges to pass or to get around standing water that can't drain. This results in trail braiding and widened trails.

Closely associated with flat ground are wet areas: riparian areas, bogs, wetlands, springs, or any area where the water table is at or close to the ground surface. These areas have saturated soils and are rich in flora and fauna diversity. It is best to avoid them. Wet areas are certainly red flag areas and usually become negative control points.

Large, open grassy, or sparsely vegetated areas go on this list also. Unless there is some topography or rocks, it is difficult to maintain the integrity of a serpentine alignment in these areas since riders can see the next curve and cut cross-country to intercept it. The alignment eventually becomes braided and straight. Unless natural or manmade barriers are used to protect the alignment, the designers are forced to flag in a very lazy S that is close to straight. This increases speed, increases impacts, and decreases seat time.

Flat ground, wet ground, lack of woody vegetation to deter use can lead to impacts.

Tip, Trick or Trap?

Trap: Building, maintaining, and managing use is MORE difficult on flat ground than on sloped ground. Slopes of 15% to 45% are ideal.

Depending on the type of riding, open areas can also be an issue. Any area that may have speed events should not have a large amount of trail in an area where sights are visible for long distances. The riders will cut the trails in order to gain position. This will result in trail braiding and straighter trails.

Although flat ground is thought to be erosion-proof since water doesn't run off of it, flat ground is more susceptible to erosion due to lack of drainage. Water collects on the surface and it is difficult and expensive to remove.

The more difficult the machine is to turn, the less likely a serpentine trail in an open area will stay intact. However, an OHV trail with a tight set of curves creates a technical challenge.

Trails through meadows fall into this category, but trails through recently harvested cut blocks or through recent burns do not. The natural environment is dynamic, not static, so change is a given. The planners and designers must visualize how a denuded area will look in 2 years, 5 years, and 15 years. Depending on the growing environment, the pace of recovery can be amazingly dramatic.

Though very scenic, this trail would be better located on higher ground and in the trees to provide varied views of the meadow without being in the meadow. Note the lazy S alignment. In the wet season, this trail probably intercepts and carries water from the yellow arrow to the blue arrow.

This fall line trail cannot drain, is not fun to ride, and is not in harmony with the natural landscape. Trails need to lay lightly on the land, not conflict with it.

Three of the areas of concern just discussed are shown on this map.

This motorcycle trail follows the spine and fall line of the ridge. It is becoming rocky because the soil fines are being washed away by the lack of drainage control.

Once again, avoid fall line trails. They generally have sustained (long, unbroken) grades and poor drainage so water is typically channeled down the trail. It usually requires manmade structures to provide drainage, and these are costly and difficult to construct correctly, expensive to maintain, decrease the rider experience, and can fail in a significant weather event. Sometimes in technical terrain with tightly spaced controls on each side, the only option is to use the fall line. In these cases, mitigations like more drainage structures, trail hardening, or increased maintenance frequency are required.

Tip, Trick or Trap?

Trap: Do not fall for fall line trails; they will fail

Ridgetop trails can also be undesirable. If the slope of the ridgeline is uniform with a long and sustained grade, these trails become fall line trails. The sight line is often long on these trails and this tends to increase rider speed and decrease rider experience. The better alternative is to design a trail that serpentines up and crosses from one side of the ridge to the other. This breaks up the sight line and increases the trail aesthetics, creates positive drainage, and increases the rider experience by constantly changing the viewshed of the rider.

Examine the Opportunities

This next phase is the fun part. It's time for the planners and designers to look at desirable terrain.

The ideal ground has a 15 to 45 percent sideslope with deep, stable soil and vegetative cover. Trees are preferred over brush, brush over grass, grass over a barren slope. Patches of thick trees or brush allow the designers to lay in a tight, technical serpentine alignment that slows down the riders, adds seat time, adds difficulty, and adds trail distance. Dense vegetation helps control tread width and protects the integrity of the alignment by deterring short-cutting of the curves.

A challenge for the planners and designers is to provide technical difficulty for the riders and still have a durable trail. For ultimate durability, look for rocks: boulder fields, rock gardens, solid slab rock that is on a slope, rimrock, slickrock, rock ledges or stepups, and hummocky broken ground. Rock provides opportunities for challenging trails while still maintaining durability.

This is approaching the upper limit in slope, but still good ground. Trees anchor the trail, hold the soil, inhibit splash erosion, control trail widening, and deter off-trail use.

Slab rock like this is a designer's dream. It provides challenge, fun, and durability. After being in the trees, popping out on an outcrop like this provides vegetative and topographic change plus a scenic opportunity. The moss and lichens on the rocks can be very beautiful.

Broken, uneven sideslopes with benches provide terrain diversity that gives the designers opportunities to reduce grade to provide drainage and flatter areas to change direction with a climbing turn. Terrain diversity also adds to the rider experience.

Desirable features include dramatic, unusual, or subtle features like rock formations; topographic edges like cliffs and rimrock; vegetative edges like the edges of meadows, cutblocks, and burns; old-growth forest; unique vegetation (twisted character trees, fields of wildflowers, tiny patches of moss or lichens, etc.); and vegetative changes such as moving from open to dense vegetation.

Rimrocks may be impassable terrain, but being on top of them is WOW terrain; a feature that will create a memorable experience.

Understand the Human Element

Where do riders (or any recreationists) want to go?

- **The Highest Point.** It is human nature to get to the highest point of land, not only for the view but also for the sense of achievement.
- **Water.** Lakes, ponds, creeks, springs, waterfalls are a natural attaction.
- **Viewpoints.** Whether it's the highest point of land or just a break in the trees, people love scenic views of the landscape.
- **Historic and Interpretive Sites.** Riders enjoy seeing old mines, cabins, ghost towns, abandoned equipment, mills, etc. Those along with any interpretation of the natural environment enhances the riders' experience.
- **Wildlife Viewing.** Riders of all ages enjoy seeing wildlife, including deer, elk, turkeys,

This is a great example of a poorly located trail on good broken ground with benches. This trail could have been more fun, longer, and durable if it had utilized the terrain and vegetation. The trail goes right up the spine or fall line of the ridge. This proved to be unsustainable, so pavers were installed to harden the trail. This is also a great example of investing a large amount of time and money into a bandage fix on an existing trail that doesn't solve the real issue of poor location.

bears, beavers, raptors, wild horses, and even snakes.

- **Food.** There is something about getting a burger on the trail that is very appealing to most riders. Food is a natural human attraction.

What do all of these six items have in common? They all provide a destination, a goal for the ride; they all provide photo opportunities; they all extend the time the riders are on the trail; they all provide an opportunity for riders to socialize with their group, which is an important element in OHV recreation; and they all add to the quality of the recreation experience. Around the campfire at the end of the day, these will be the highlights that everyone will talk about. These are the places that riders want to go. If at all possible, the planners should get them there.

It was difficult to get through the control and onto the top of the cliffs, but once there, this trail was destined to become the signature trail of this trail system.

Tip, Trick or Trap?

Tip: Invest in a good pair of hiking boots. OHV reconnaissance is best done on foot

Why? From a quality recreation and an effective OHV management standpoint, planners should always try to work with human nature rather than against it. The trail should take people where they want to go. It's the WOW factor; that is what riders should say at the end of the trail. Planners should strive to find the WOW points and put them on the inventory and into the trail concept plan.

Designers with vision controls the viewshed of the riders. They can be creative like artists, framing the picture for the rider. WOW!

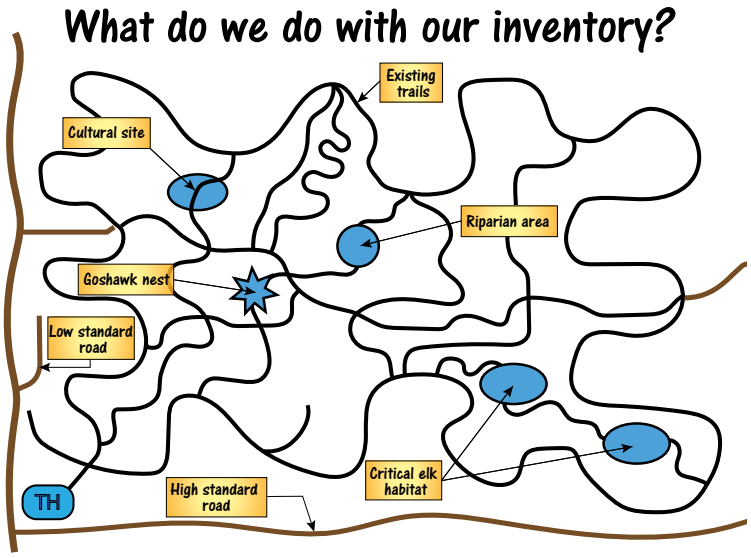
Tip, Trick or Trap?

Tip: For effective OHV management, it is always to your advantage to work with human nature, rather than against it

WOW features: durable, scenic, fun, challenging.

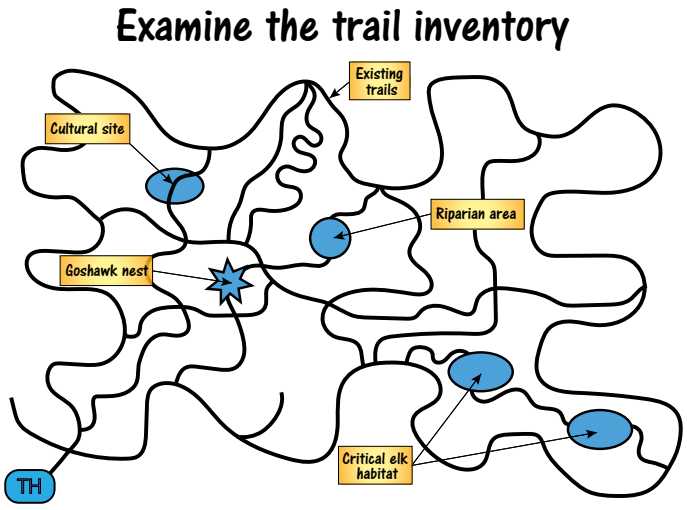
Section 2: Assemble the Data into a Trail Concept Plan

Now that the data has been gathered, it's time to organize and manipulate that data so it can start making sense. The inventory data will be displayed as a maze of points, lines, and polygons. To make sense of them, planners and designers should assign colors or other attributes to the data and then organize it into groups. Groups could be roads, trails, resource data, water features, opportunities, and constraints. This is what a typical inventory could look like with trails and roads as lines and resource concerns as shapes.

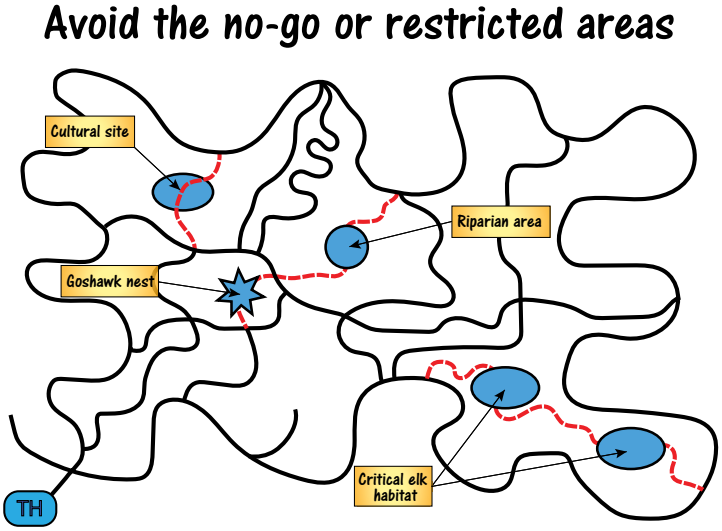


Examine the Trail Inventory

Planners should first look at the trail data and eliminate the obvious. Look at the trails that lead into the no-go or restricted zones. If the assumption is made that all of the resource areas of concern require avoidance, then the trails leading into those areas would be slated for closure in the trail concept plan.

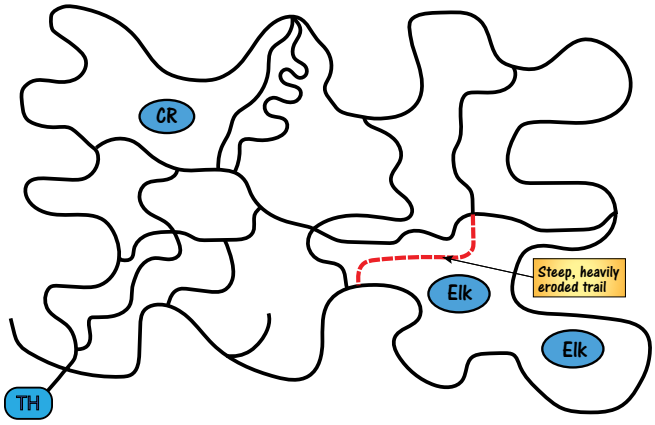


Next, planners should look at the trail inventory and data dictionary information and identify: a) which trails or sections of trail are sustainable and provide a quality recreation experience; b) which trails or sections of trail need some relocation or reconstruction to become sustainable and provide a quality experience; and c) which trails or sections of trail are non-sustainable, cannot be made sustainable, or do not provide a quality experience. Those trails in "a" and "b" will remain on the trail concept plan for the time being. Those trails in "c" will be slated for closure. Sometimes, there isn't enough information in the inventory to make these determinations at this time, but often the planners can make subjective assumptions by looking at the alignment and grades of the existing trails. If the alignment is straight and gains 100 feet of elevation in only 200 feet (50 percent trail grade), it is probably a hillclimb or fall line trail and is probably not sustainable.

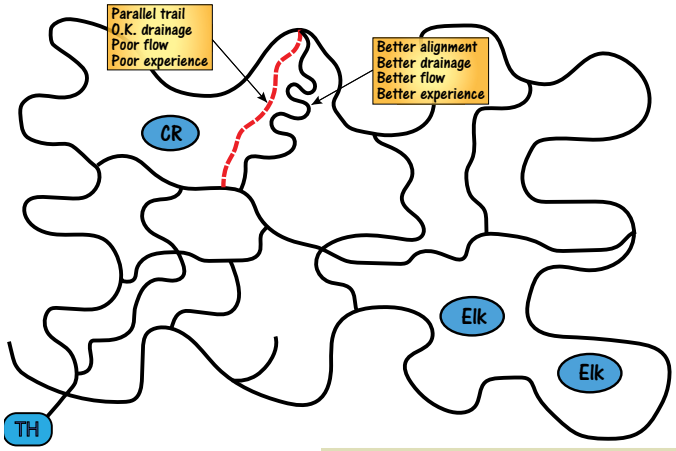


If there are two trails that parallel each other and both go from Point A to Point B, examine the inventory data to determine which one has the most sustainable characteristics and provides the best recreation experience. Keep the most sustainable one and consider the other for closure. If both trails can be made sustainable and one provides a higher degree of challenge, consider keeping both trails if they fall within trail density or other constraints.

Eliminate non-sustainable trails



Eliminate un-needed trails



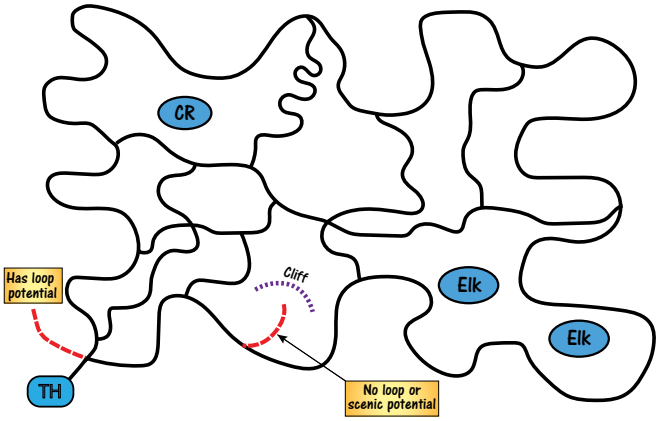
Often, the existing trails do not flow in the proper direction. They go up the slope, but sustainable trails go across the slope. If the existing trails do not provide access toward a desirable area or feature, they will become possible candidates for closure. The point here is to start eliminating the obvious. These trails can always go back on the trail concept plan if needed once the process progresses.

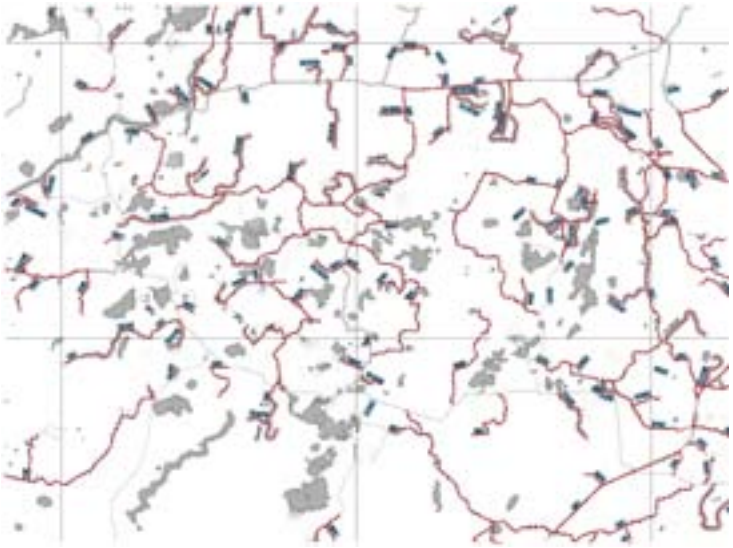
Tip, Trick or Trap?

Tip: Destination trails are only good if there's a destination at the end of them

Next, planners should look for dead-end trails. There are two types of dead-end trails: those that end at a destination and those routes that just end. The former are opportunities, the latter can be traps. If a trail ends at a viewpoint, unique feature, or structure (i.e., a destination), then the trail will work as a dead-end trail. If the trail just ends, planners should look for a way to loop it back into another trail. From an OHV management perspective, no one likes to ride out to the end of a trail and turn around and come back the same way. This significantly detracts from the quality of the recreation experience. Instead, riders will tend to look for various ways to connect into another road or trail and this can lead to a proliferation of user-created trails and potential resource impacts, and management has lost control of the use. If for some reason it is impossible to make a loop out of a dead-end trail, consider slating it for closure.

Eliminate dead-end trails





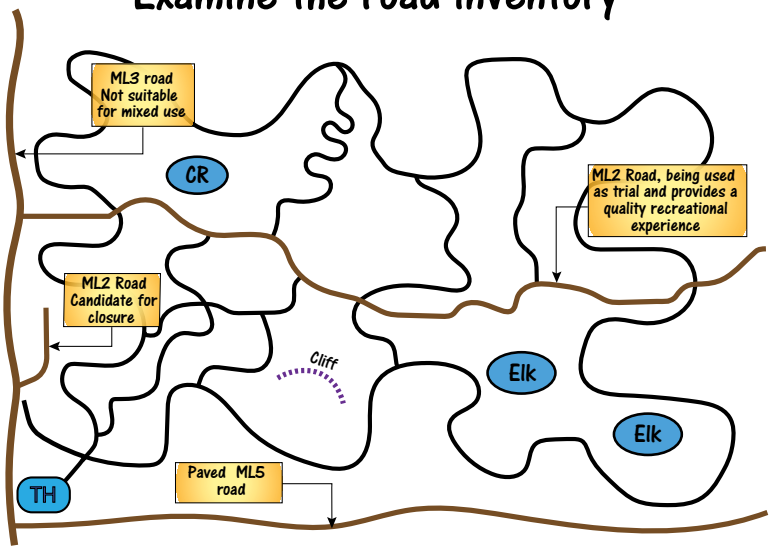
To the astute planner, these dead-end routes should signal a red flag from an OHV management and recreation experience standpoint. Work with human nature, not against it.

Examine the Road Inventory

There is a wide range of road classifications and standards from interstate highways to primitive logging roads. For simplicity, it works quite well to have just two standards or two colors for roads: one for primitive low-standard roads that are suitable for high-clearance vehicles; and one for higher standard roads that are maintained for passenger cars. These would correspond with the USDA For-

est Service road classifications of Maintenance Level 2 roads (ML2) and Maintenance Level 3-5 roads. Just like the trails, planners should look for the obvious. Which roads can have mixed use? Which roads can be closed and converted to trails? Which roads will require the least maintenance? Which roads provide a transportation experience and which provide a recreation experience? Answering these questions will help the planners determine the roads or sections of roads that could or should be incorporated into the trail concept plan.

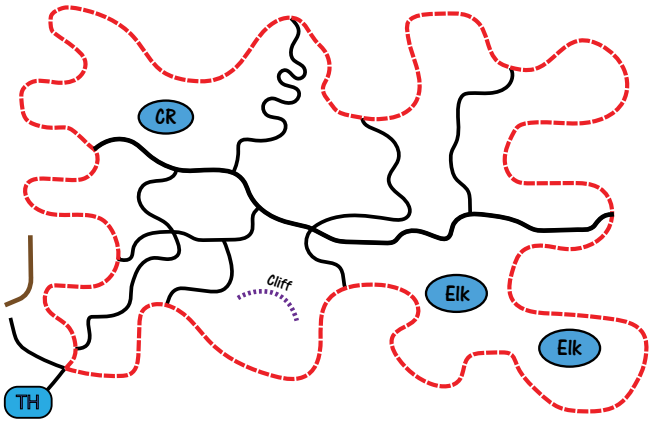
Examine the road inventory



Establish a Perimeter Trail

It isn't always possible or desirable to have a perimeter trail, but there are advantages to having one. Potentially, it will be the longest trail in the trail system and that is always desirable from a mileage and seat time standpoint. The perimeter trail can also serve as the boundary trail and can help riders recognize the outer limits of the project area. The perimeter trail is a loop in itself, but it also provides loop opportunities for all of the connector trails that tie into it. In this example, the perimeter trail has nine trail connection points that create a wide variety of potential loop opportunities.

A perimeter trail has advantages

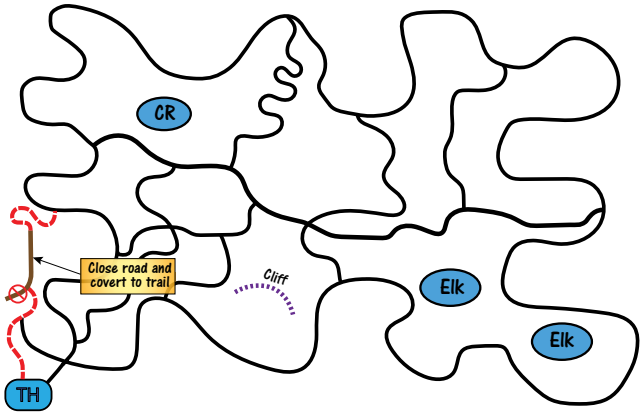


Note: The entire perimeter trail does not have to have the same identifier (trail number or name) although it can be desirable. Also, all segments of the perimeter trail do not have to have the same difficulty level although again, it is desirable to have consistent difficulty. If the difficulty does change from trail segment to segment, make sure the riders have the option to maintain the original difficulty level by taking another loop.

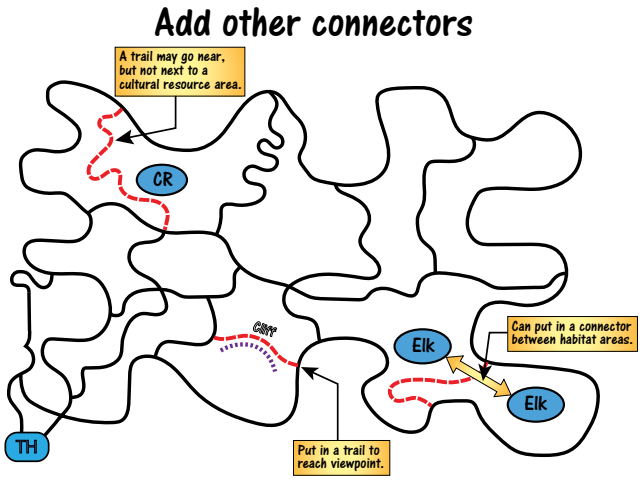
Connect the Remaining Pieces

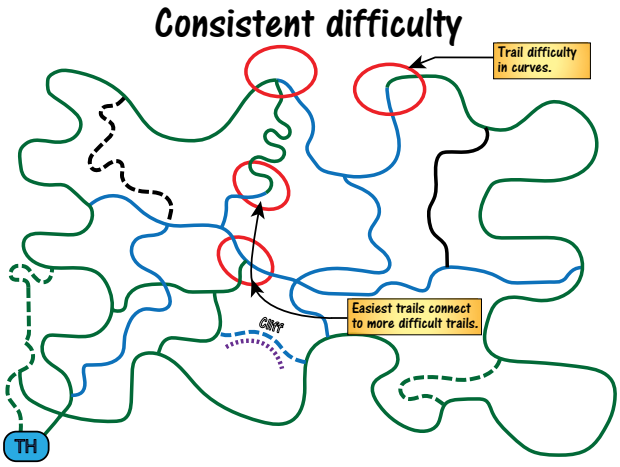
So far, planners have eliminated trails or portions of trails, but now they need to connect the remaining pieces into a trail system with logical loops separated by difficulty level or by the recreation experience offered. Connecting the suitable roads, the suitable trails, positive control points, and opportunities into a system of trails and loops while avoiding the negative control points, prohibited areas, restricted areas, and undesirable areas can be a challenge.

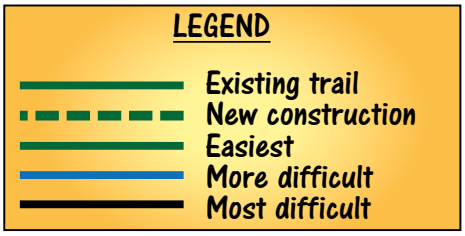
Add a connector out of the trailhead

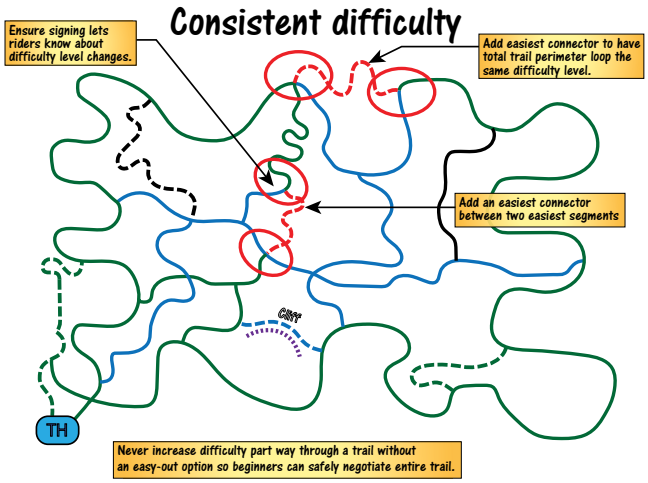


To quickly disperse riders and reduce encounters and tread impacts, it's desirable to have more than one trail out of the trailhead. Having several small loops in the proximity of the trailhead provides warm-up loops for riders and short practice loops for kids and families.









The example shows a dead-end trail and a road suitable for closure that can be used to provide two more loops. This example also shows that the planner had to eliminate the trail through two critical elk habitats. After talking with a wildlife biologist, it was agreed to cross the big game connectivity corridor between the two habitat areas as long as the length of trail within the corridor was minimized. The planner also found an opportunity to capitalize on some technical terrain in the northwest corner of the project area that avoided the cultural resource site. The dead-end trail that went to the base of the cliff was eliminated. There is a great scenic view from the top of the cliff and a trail across the rim was added to enhance the experience.

Establish Difficulty Levels

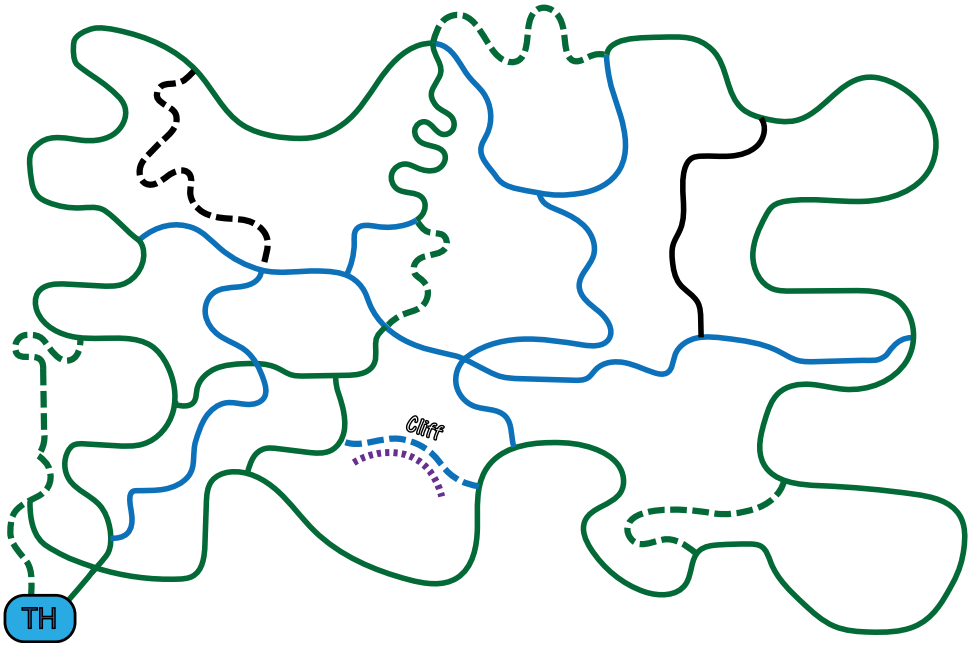
This step-up is a great technical feature to keep, however the trail on both sides of it was much easier and less experienced riders became trapped here. Rather than increase the difficulty level for the whole trail, an easier route around this feature was built.

Often there isn't enough detailed information to establish difficulty levels at this time, but if some of the difficulty is known, planners can start plugging that information into the trail concept plan. Planners and designers often hear: "I want more of the tough, technical stuff." The reality is that the percentage of riders desiring that experience is the lowest, so often the most difficult trails are the ones that are under-utilized. Planners still need technical trails to provide that opportunity, but the bulk of the recreational riders are seeking the easiest and more difficult trails.

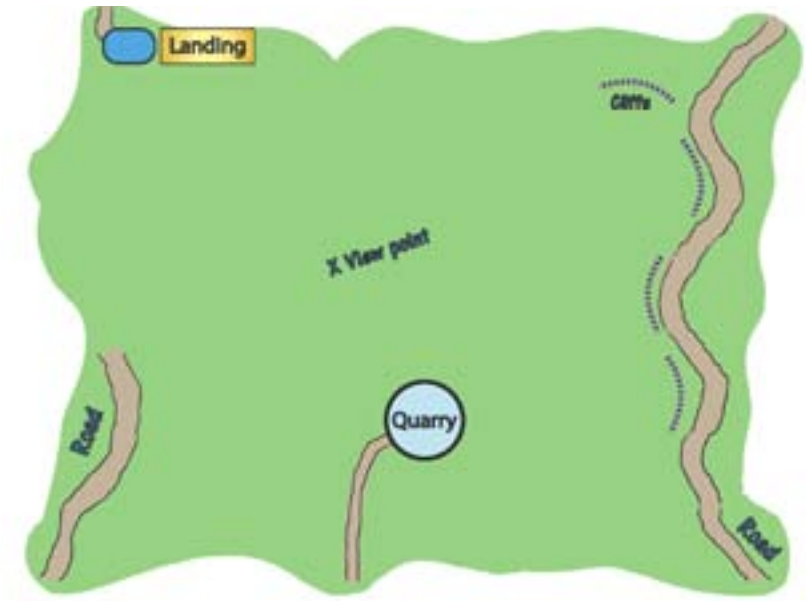
Planners can assign the standard colors for difficulty with green being easiest, blue being more difficult, and black being most difficult. In general as the difficulty increases, clearing and tread widths decrease, grades can increase, and obstacle size and number increase.

To help manage risk and avoid trapping riders by forcing them to ride over their skill level, there are two guidelines: a) difficulty levels must only change at trail junctions, not between; and b) never terminate an easier trail on a more difficult trail. If there is one or more short sections of more difficult terrain on a trail, instead of increasing the difficulty level of the entire trail, planners should consider making an easier trail around that section in line with the difficulty level of the rest of the trail. These easier sections around an obstacle are called easy-outs.

The completed concept plan



For this example, the planner saw there were four areas with issues. In the center, two easiest trails terminated on a more difficult trail. The solution was to correct the inconsistent difficulty by connecting the two easiest trails together with an easy route and leaving the more difficult trail as a loop (but signing it as more difficult).

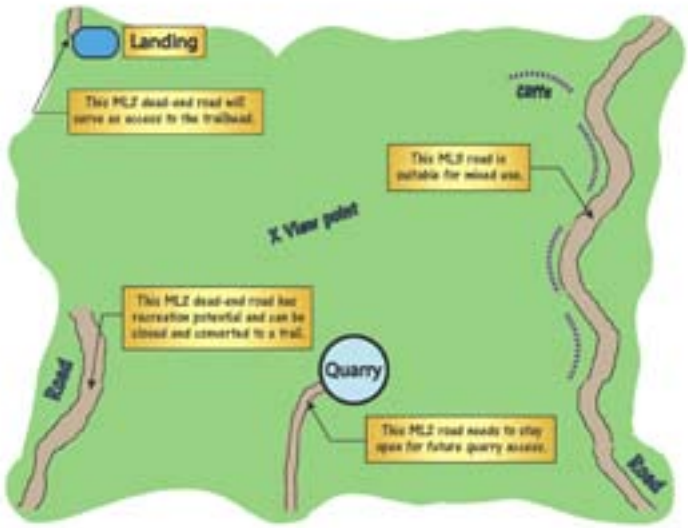


At the top on the perimeter trail was a section of trail that was more difficult with the easiest trail on each end. There was no way to loop around that section and still be on an easy trail. Using the planner's knowledge of the ground and examining the contour map, it was decided to build an easiest connector trail to avoid the more difficult section. This added another loop to the trail system and made the difficulty of the perimeter trail consistent.

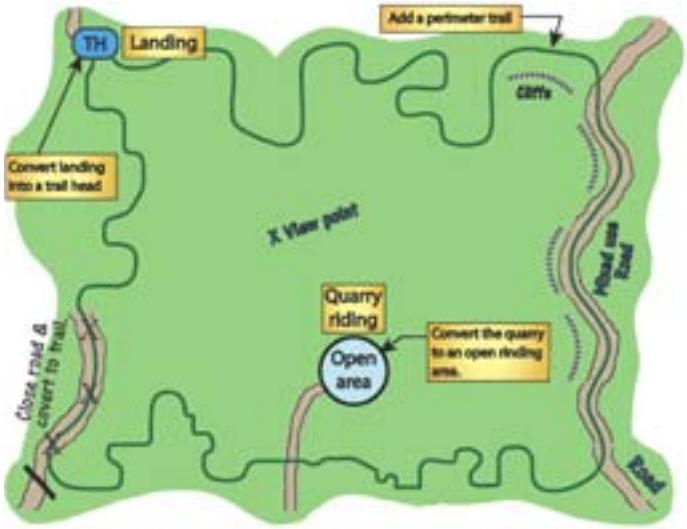
And the trail concept plan (above) is now complete.

In another example (starting at left), the inventory shows that there were no existing trails, but there were some interesting features like the viewpoint, cliffs, a landing, and a rock quarry.

The landing was large enough to be converted into the trailhead. The rock quarry, though still in occasional use, was suitable to serve as a good open riding area. There was a great potential viewpoint in the center, and the rocky ground above the cliffs could provide some good technical riding opportunities.

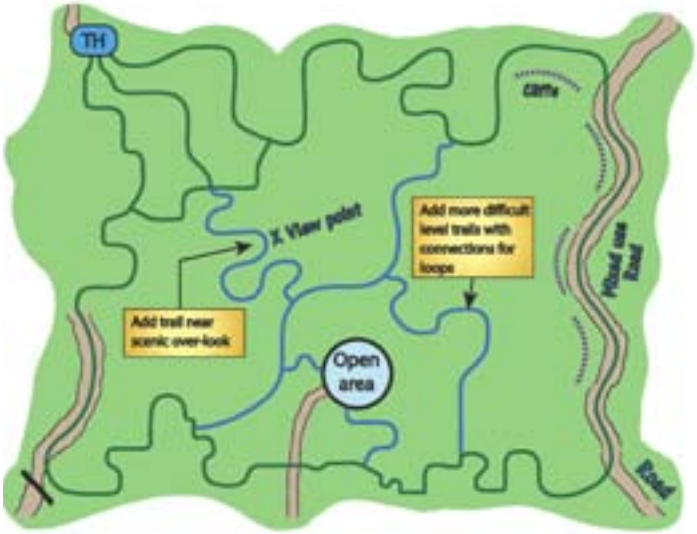


Planners started the trail concept plan by examining the road inventory.

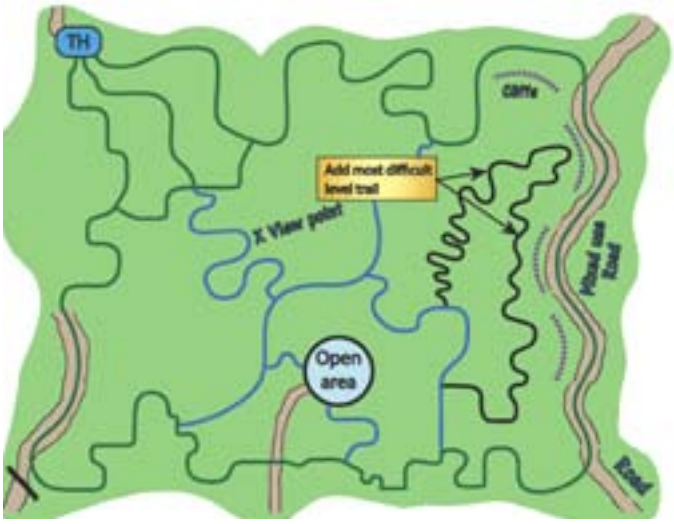


They continued by establishing a perimeter trail that incorporated the road options discussed above.

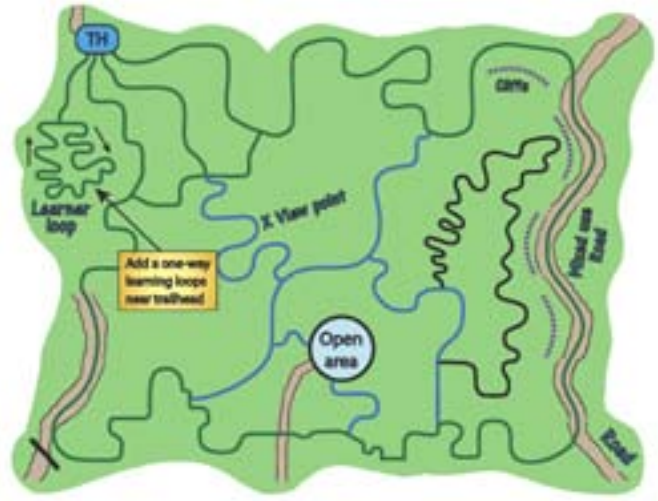
Next, they added some loops out of the trailhead. These serve as warm-up loops and as a means to disperse riders quickly out of the trailhead area.



Then they added some more difficult loops and connected the open area into the system. In doing so, planners also connected in the outstanding viewpoint. Note: Since the viewpoint is a signature feature of the trail system, it is desirable to have the access trail be an easiest trail so that everyone can access it. In this scenario, however, that was not possible due to the grades and technical rocky ground surrounding the viewpoint.



Planners then drew on some most difficult trail to take advantage of that rocky ground by the cliffs.



And finally, they added a learner loop adjacent to the trailhead. This is a directional one-way trail. All other trails in the trail system are two-way. The trail concept plan is now complete.

Tip, Trick or Trap?

Trap: Many design guides specify the number of turns per ¼ mile

The trail alignment should be constantly turning. This creates flow, enhances the rider experience, increases seat time by decreasing speed, inhibits water flow and presents more opportunities for effective drainage, and decreases tread maintenance.

Take a Break

Planning a trail concept is a tough mental process and should not be done hastily. At this point, planners should put down the trail concept plan for a couple of days. Then they can go back and review the plan again. Planners should review if they have maximized the opportunities and minimized the constraints. Can they add more loops or miles? Do they see something differently? If they do, then they can fine-tune the plan. If they don't and still agree with all of the previous decisions, it's time to move on.

Develop Trail Data

Once planners are satisfied with the quality of the product, they can start building a database or spreadsheet with the following trail information:

- How many total miles of trail will be provided?
- How many miles of trail for each use type?
- How many miles of trail construction for each use type?
- How many miles of trail reconstruction for each use type?
- How many miles of roads will be closed?
- How many miles of existing trails will be closed?

Send It Out for Review

Planners should now present the completed trail concept plan on an appropriate base map that at least displays topography, administrative and project boundaries, and key resource areas to the planning team and the project management. When the draft is reviewed and approved by the specialists, the planners should present the proposed concept plan to OHV clubs or other interested stakeholders. If substantive comments are received, planners should incorporate them into the trail concept plan, or if the comments call for a different approach, they should incorporate it into an alternative.

Develop Alternatives

If it is necessary to develop alternatives, now is the time to do that. In developing the concept plan, planners have analyzed a lot of data and made myriad decisions. At this stage, planners should keep most of what they have, but take the options that they didn't use and incorporate them into alternatives. Then they can develop a trail database for each alternative.

A Case in Point…

Planning for the Riders' Needs

The Maryland Department of Natural Resources (DNR) managed large areas of land that contained no designated OHV routes, however unauthorized OHV use was taking place leading to resource degradation. The Department realized that closure alone would not solve the issue of unmanaged OHV recreation; they also needed to provide designated areas for OHV use. The DNR began working with local riders to develop a plan. Initially, they considered creating a test area that would prove the concept that providing OHV recreation was a part of managing OHV use. To this end, they developed a concept plan containing 15 miles of trail with a difficulty level of easiest. To validate this idea they shared the concept with OHV consultants. After a review, the consultants agreed that providing OHV designated routes was a great move, however, the test area needed to be an OHV destination with miles of quality trails and varying difficulty levels. Having only one small designated OHV area with only easiest difficulty level trails can lead to further resource damage. Riders want to do the right thing and stay on designated trails. Too few trails can lead to resource damage from over-use. Not meeting the riders' needs for skill levels can lead to user-created trails.

The Maryland DNR is now working to develop an alternative concept plan which will better meet the needs of the riders. Had the DNR not sent their concept plan out for review, it may have built a trail system that would have failed to meet the riders' needs.

Develop Generic Design Guidelines

Generic design guidelines can be written for each type of trail and will give broad design parameters for an OHM trail, ATV trail, ROV trail, or 4WD trail. Sometimes, the guidelines are called design parameters, but the term "guidelines" is preferred because it infers flexibility (the word "parameters" can infer a set of limits). The design guidelines can be used in environmental documents to help establish acres of impact. They also give the stakeholders, and eventually the trail designers, a description of the intended vision for each type of trail.

It should be noted that a guideline is just that: a guide that gives potential ranges. Those ranges can and will change from the north side to the south side of the area and as soil type and vegetative cover changes. Some design guidelines have been developed for national application but that just won't work because there are too many regional and local variables. It is best to take a sample guideline and modify it for local conditions based on local knowledge and field experience. Some guidelines are also becoming so detailed that, if interpreted literally, the designers can be or feel restricted from seizing onsite opportunities. The have also been applied as the "rule" but this doesn't work either. There are principles, but few rules. This book is about making informed decisions based on actual site conditions. Planners can't do that if their decision space is administratively removed.

Develop Generic TMOs

It is too early in the process to develop trail management objectives (TMO) for each trail, but a generic TMO document can be written for each type of trail separated by difficulty level. This will provide important information and continuity to the person doing the location and design. Once the trails are located on the ground and all adjustments have been made to the concept plan, trail numbers, names, and agency identifiers will be added and the trail concept plan will then become the design plan or final project plan. At that time, TMOs can be written for each trail. If there is a need for the management of the trail to change, the TMOs should be updated.

The process of developing the concept plan is now complete; however, the plan is a working document so it will change as better resource data, additional inventory data, or better field knowledge of the project site is obtained. It is important to point out that a concept plan is just that, a concept. Its accuracy and completeness are directly dependent on the amount of time invested

in the field and office to develop it. Some plans are compiled in a couple of days, and others are developed over a period of weeks or months.

The plan will now be handed over to the person doing the trail location and design (L&D). Certainly, for a seamless, consistent, and cost-efficient process, it is highly desirable for the planner and the designer to be one in the same. The designer will take to the field and perform a thorough reconnaissance of the entire project area; that person will validate or complete the road and trail inventory data; confirm the control points and look for others; and start to ground-truth the feasibility of the concept plan. Obviously, the more time spent in developing the concept plan, the less time will be needed to validate it and refine it. To do a good job of trail layout, the designer will need to become familiar with nearly every square foot of the project area, which can involve a considerable investment of time and money. That is why it is cost-effective for the planner and designer to be one in the same. The designer can build on the previous knowledge rather than starting from zero.

	Sample ATV Trail Design & Difficulty Guidelines			
	(These guidelines are to assist in design, construction, and maintenance. Any guideline should be adjusted to reflect local experience and actual site conditions.)			
		Easiest	**More Difficult**	**Most Difficult**
Grade: Grade should roll and not be sustained	Typical grade	< 20%	< 25%	< 30%
	Max. Pitch	Maximum grades are the exception, not the rule		
	Grade	15% - 20%	20% - 30%	> 30%
	Length	Variable 50’ - 100’ dependant on soils,use type and use intensity, and climate. As grade increases, length on grade should decrease.		
Clearing:	Width	60” to 72”	50” to 60”	50” (maximum)
	Height	7’	6’	6’
	Helmet and leg slappers	Few	Many	Common
Tread:	Width (minimum)			
	Sideslope <25%	60”	50”	50”
	Sideslope 25% - 70%	60” to 72”	55” to 60”	50”
Surface:		Some roots or rocks, obstacles rarely exceed 6-8” and are imbedded solidly in tread; obstacles generally on tangents; tread plane relatively flat with 15% max. outslope for short sections; sweeping curves and some circular climbing turns, more open alignment with circular longer radius curves; sand acceptable and some sections of slippery clay or loose material.	Many roots or rocks, obstacles rarely exceed 8-10” and are loose; obstacles on tangents and some on curves; tread plane flat to irregular with 25% max. outslope for short sections and long sections with less outslope; climbing turns and some circular switchbacks; sections of tight alignment with circular short and long radius curves; sand acceptable and long sections of slippery clay or loose material.	Very many roots or rocks; many obtacles exceed 10”; obstacles on tangents and curves; tread plane very rough and irregular with long sections exceeding 25% outslope; non-circular climbing turns and switchbacks; long sections of very tight alignment with non-circular curves; entire trail may be soft sand, slippery clay, loose material or mud.
Exposure:		None	some, potential injury	Could be common, potential serious injury.
Maintenance:		Trais receive appropriate maintenance to remain within their TMO, maintain effective signing, and to protect resource values.		

Need more? Learn more here...

Designing Sustainable Off-Highway Vehicle Trails, Kevin G. Meyer, USDA Forest Service, Technology & Development Program, 1123-2804P-MTDC, 2013

Management Guidelines for OHV Recreation, Tom M. Crimmins, National Off-Highway Vehicle Conservation Council, 2006, System and Route Planning

A Look Back...

Here are some of the key trail concept plan development elements discussed in this chapter:
- Provide for the riders needs through good planning

The project planner must understand:
- The riders and their desired experiences
- The landscape
- The issues
- The politics
- The climate
- The resource values
- The statutory requirements
- The existing conditions
- Management constraints
- The vision

As planners compile and refine their data, they must:
- Examine the constraints
- Identify control points
- Examine the opportunities
- Understand the human element

In assembling the data into a trail concept plan, planners should:
- Examine the trail and road inventory
- Establish a perimeter trail into logical loops and connect the pieces
- Avoid or minimize dead-end trails
- Establish difficult levels
- Take a break from the project
- Send it out for review
- Develop alternatives, generic design guidelines, and generic TMOs

Chapter Four
Engineering and the Natural Environment

Providing for the riders' needs is one of the key elements for success discussed in Chapter 1. Those needs were examined in Chapter 2 and incorporated into the trail concept plan in Chapter 3. The link between getting those needs on the ground and designing for sustainability is covered in this chapter on engineering.

The Tools for Success

- Provide for the riders' needs
- Design for sustainability
- Develop an effective O&M program

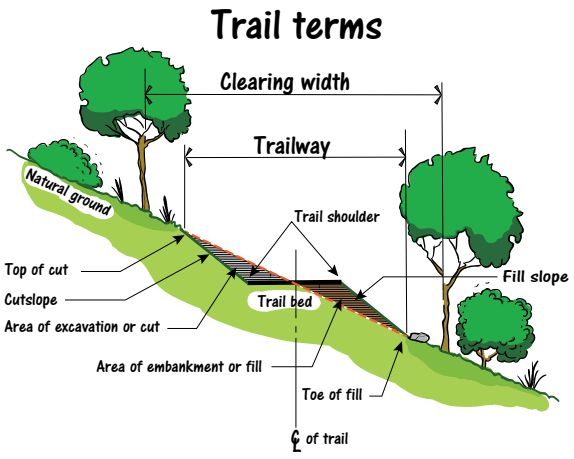
Engineering isn't just circles and squares or tangents and curves; it's understanding the natural environment and applying scientific knowledge to address or solve practical problems in that environment. Engineering is used to solve or mitigate trail issues or concerns. For example, what will happen to a particular soil when the forces of an OHV tire are applied to it? If the soil displaces, how will it be mitigated? The more engineering knowledge and experience that the designers have, the more tools they have to design a fun and sustainable trail under a variety of circumstances and conditions. Having creative vision is one thing, but being able to put that vision on the ground is another. In otrder to put a trail on the ground and keep it there, designers need to understand the physical properties of that piece of ground and the physical forces that will be applied to it.

Vision without Action is a Daydream
Action without Vision is a Nightmare
but Vision and Action without Engineering Ensures Disaster

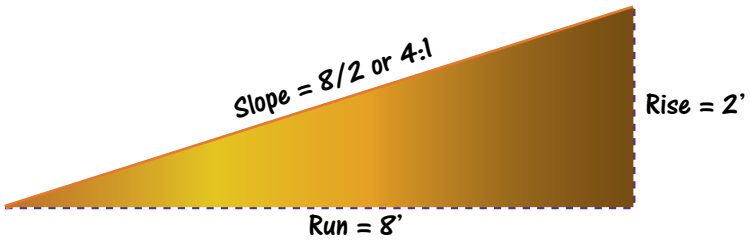
Section 1: Trail and Engineering Terms

Understanding Trail Terms

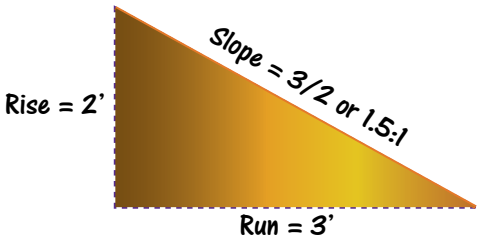
The three trail types are terra firma or land, water, and over-snow. For the purposes of this book, terra firma trails are discussed. The winter use of summer trails and the summer use of winter trails (snowmobile trails used for OHV trails) are discussed later in this book.



Horizontal run is the distance a slope runs along the ground. The vertical rise is the distance the elevation of the slope is increased. The angle of the cut slope and fill slope is normally expressed as a ratio of the horizontal run over the vertical rise. If a run is 1 foot and the rise is 1 foot, the slope is 1/1 or 1:1. If a run is 2 feet and the rise is 1 foot, the slope is 2/1 or 2:1. If a run is 1 foot and the rise is 2 feet, the slope is 1/2 or .5:1.



For this example there is 4' of run for every 1' of rise.

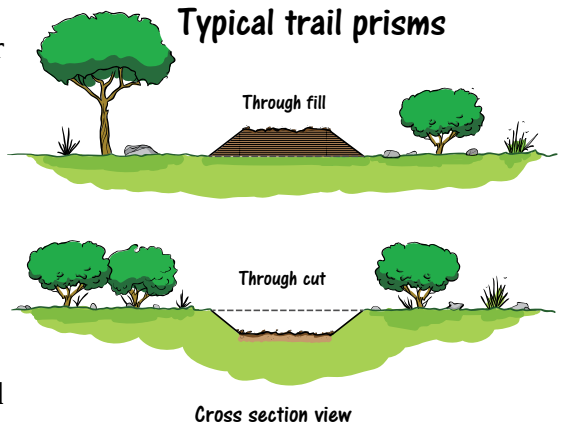


Here, there is 1.5' of run for every 1' of rise.

Backslopes are commonly 1:1 or steeper (.5:1) and fill slopes are commonly 1.5:1 or flatter (3:1). The soil type dictates the slopes that will be most stable for that particular type of soil. (More on that later.)

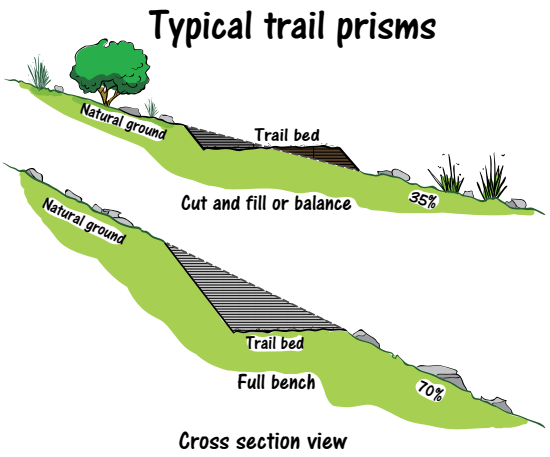
The trailway is the area from the top of the cut to the toe of the fill. By tracing a line down from the top of the cut to the inside trail shoulder, across the trailbed to the outside shoulder, and down the fill slope to the toe of the fill, a trail prism is created.

On flat ground with a sideslope of 0 to 10%, the entire trail prism is either going to be above the natural ground, called a through fill; or below the natural ground, called a through cut.



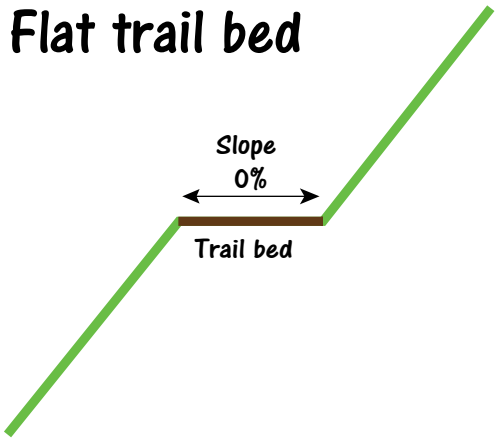
As the slope of the natural ground steepens to around 35%, the trail prism lies on the ground as a cut and fill or balanced section, which means that the amount of material excavated or cut will compact into the amount of embankment or fill needed.

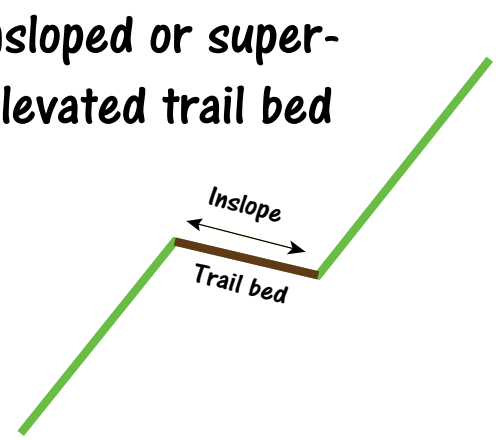
On sideslopes of 70% or steeper, the ground is too steep for a stable fill to be constructed so the entire trail prism is excavated. This is called a full bench section. The material excavated is usually wasted over the side, but with the proper equipment and sufficient funding, it can be hauled back to be utilized for fills elsewhere on the project. This is called end haul and it may be required in sensitive areas that do not allow the wasting of material.



Why is the trail prism important? The prism can be dictated by the slope of the topography, but that isn't always the case. Trail design is all about options and making informed decisions after weighing the advantages and disadvantages of each option. If the trail is in a wet area or in an area subject to heavy rainfall, a through fill prism raises the trailbed above the natural ground so it will stay drier. In the through cut scenario, water will become channeled and collect on the trailbed making it more difficult to drain the water off the trailbed. When fills become saturated with water, they can fail. Whereas trails constructed as full bench prisms will have the least risk of failure. Given the soil, climate, and storm patterns, designers may choose to build an entire trail as a full bench or a through fill prism, or they may choose to use all four prisms and apply rock hardening in areas of through cut or cut and fill. Is one wrong and one right? No. What is important is recognizing the thought process and evaluating options.

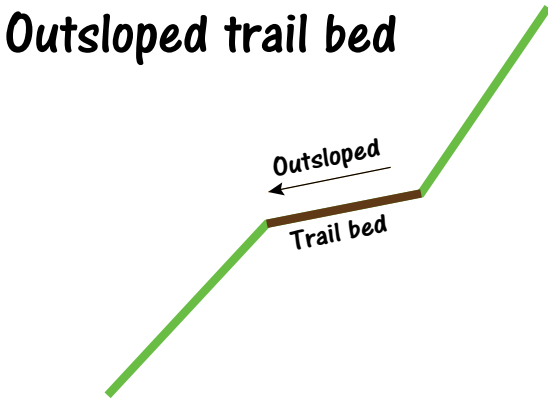
The trailbed is normally configured into one of four shapes: flat, insloped, outsloped, and crowned. While flat is the most common for OHV trails, insloped, outsloped, and crowned trailbeds can be used to control and direct the flow of water.





An insloped trailbed sheets the water to the inside so the inside shoulder essentially becomes a ditch unless a ditch is actually constructed as part of the trail prism.

When inslope is constructed on curves, it is generally used to superelevate the curve. This holds riders into the curve and allows riders to carry more speed through the curve, which increases flow and can decrease tread impacts.



An outsloped trail is intended to sheet water evenly off the outside shoulder of the trail.

Continuously outsloped trails are awkward, if not difficult, to ride on an OHV. This is especially true in wet slippery soils and on curves where the outslope acts as a reverse superelevated turn that tends to slide riders off the curve, rather than hold them on it.

A short section of outslope is usually used in grade reversals, grade breaks, or rolling dips to help force the water off the trail.

The crowned trailbed is intended to sheet the water in both directions. Most roads are constructed with a crown, but it is far more difficult to build a crown and maintain it on a narrow, natural surface trail. Crown can work well on wider trails that are hardened to hold their shape.

For any prism other than flat, the key to have it effectively sheet water is regular maintenance. If the team doesn't have the budget, personnel, skillset, or equipment to routinely perform this maintenance, do not rely on a shaped trail prism for water control.

Design and Management Implications of the Trail Prism

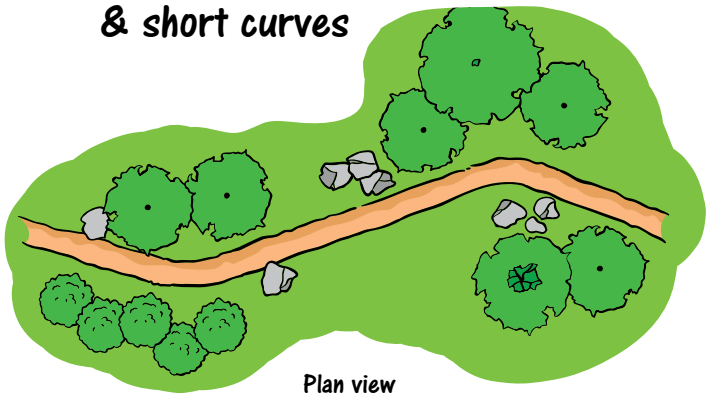
The configuration of the trail prism can affect the stability of the trail.

- A full bench prism will always be more stable than a cut and fill prism.
- Mechanical compaction during construction will improve the stability of the trail and the durability of the trail tread.
- The shape of the trailbed can affect water flow, trail flow, trail difficulty, rider experience, and rider safety.
- An outsloped trailbed should not be used in fine-grained soils that become slippery when wet.
- Any trail prism other than flat will require increased maintenance to keep the shape functional. Relying on maintenance and the shape of the trail prism to control the flow of water can be a trap.

Understanding Engineering Terms

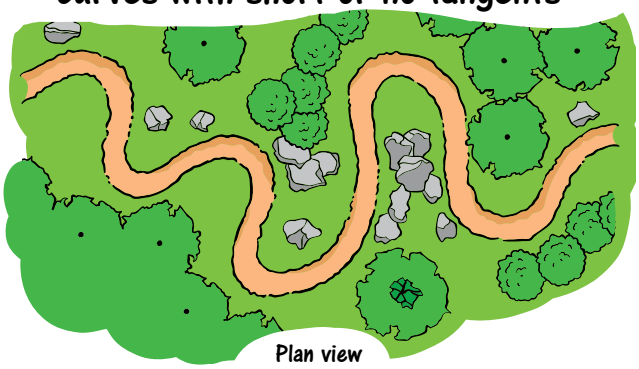
Engineers see the world in a three-dimensional view that allows them to take any point along a trail and view it on paper or on the computer in 3-D. The three views are the plan view, the profile view, and the cross-section view. The plan view is from the top looking down on the horizontal alignment of the trail. The horizontal alignment is comprised of a series of tangents (straight lines) and curves (arcs). The shorter the tangents, the more serpentine or curvilinear the trail becomes. A curvilinear trail provides more flow, and a linear or straight trail provides less horizontal flow. While the linear trail appears to be fast and boring, it does have its place in the realm of OHV trail design.

A linear trail has long tangents & short curves



Plan view

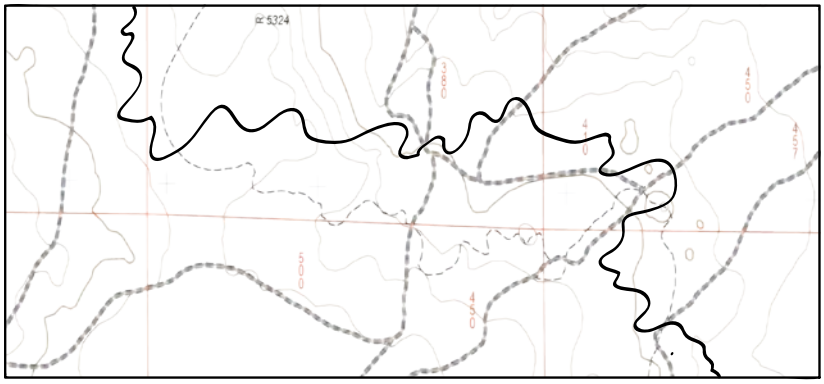
A curvilinear trail has many long curves with short or no tangents



Plan view

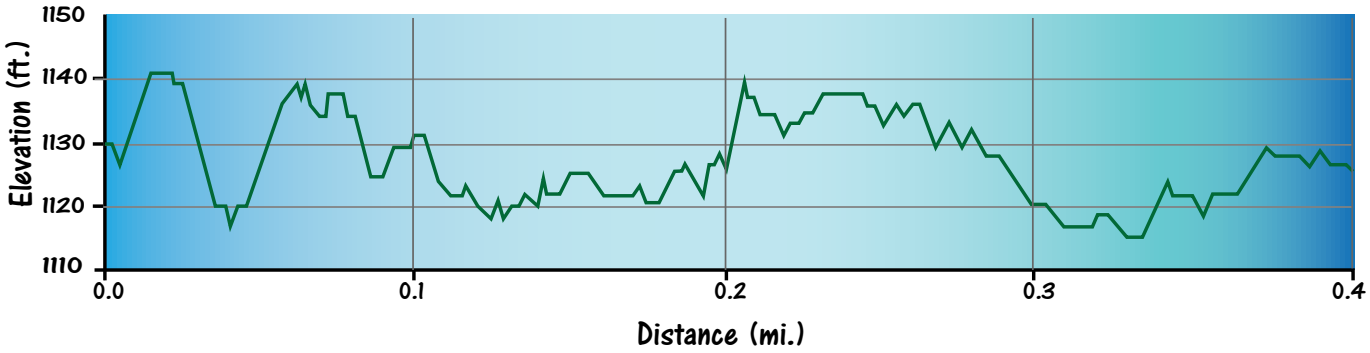
The plan view shows the trail route. What it does not show is the smoothness of the trail surface: smooth equals fast, rough equals slow. The plan view also does not show the character of the vertical alignment. For that, the profile view is needed.

The profile view is from the side. It shows the vertical alignment of the trail. The vertical alignment is also a series of tangents and curves that represent the elevation or grade changes from one point to another along the trail. Horizontally, a trail should constantly move from side to side, and vertically, the trail should constantly move up and down. Both of these are essential for sustainability and quality rider experiences.



This is the plan view or aerial view of a trail segment

Trail grade is one of the most critical elements and often the most abused element in OHV trail design. As grade increases, so can rider experience, but water velocity also increases, which potentially decreases trail tread stability and sustainability. This is a major dilemma in design: how to create a fun trail without excessive grades. (More on this later.)

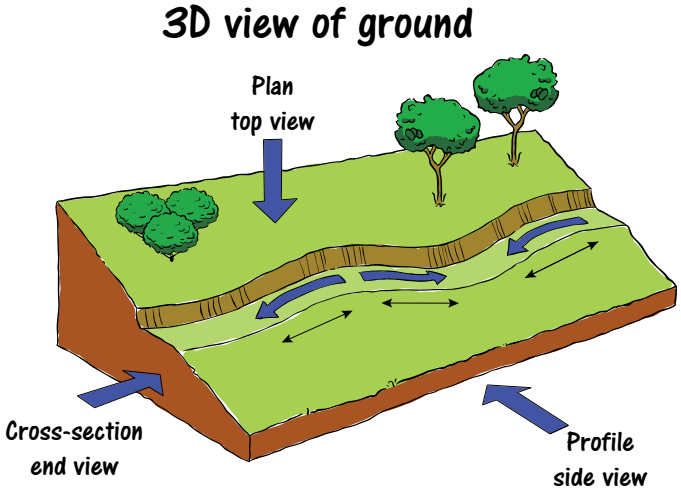


Above is the profile view of the same trail segment shown in the plan view. A rolling grade has recurring grade reversals, which means that the grade goes up and then it goes down. Grade reversals are 100% effective at stopping water flow down the trail. The shorter the interval between grade reversals, the less water volume, velocity, and potential erosion and sedimentation.

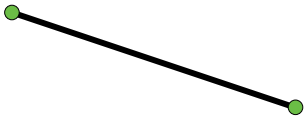
The third engineering view is the cross-section view, which is a cutaway view of the trail's transect, slicing into the ground and then viewing it from the end.

The schematic below summarizes the three views. Note the frequent grade reversals.

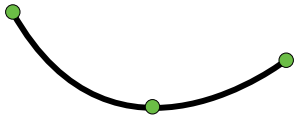
Tangents and curves comprise the horizontal alignment of the trail. Any two points make a line or tangent and any three points can make an arc or curve.



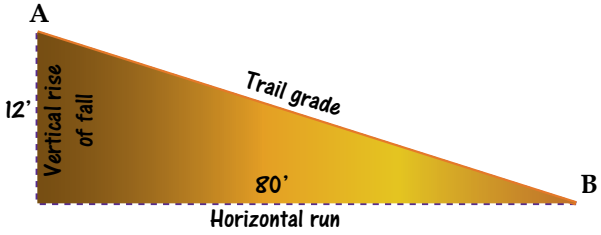
Any two points
make a line or tangent



Any three points
make an arc or curve

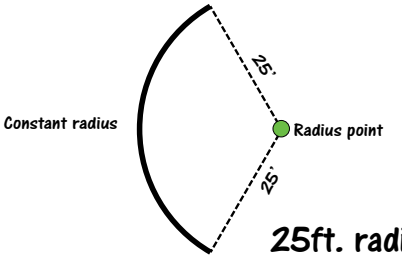


How to calculate trail grade
between any two points



Rise / Run x 100 = Grade
12/80= 0.15 x 100 = 15%

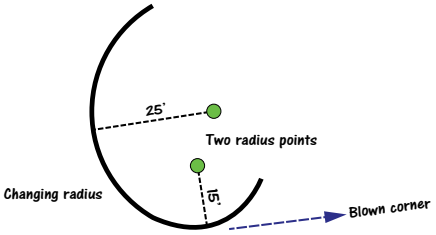
Circular curves are measured in degrees or in radius. This is a simple curve



25ft. radius curve

There are two types of curves: circular and non-circular. Circular curves have a constant radius as in a circle, and non-circular curves have no radius as in a spiral or parabolic shape. Circular curves have three main configurations: simple, compound, and broken back. Simple curves have a constant radius and are easy to ride in either direction. The smaller the radius, the sharper the curve.

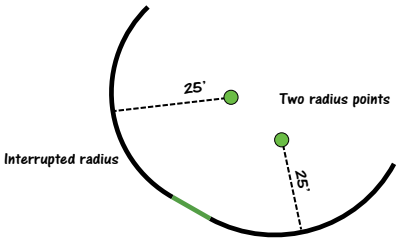
Compound curves are two simple curves of different radii connected together



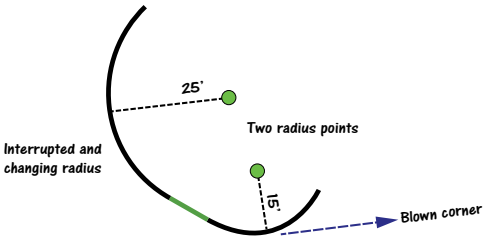
Compound curves start with one radius and end with another. In this example to the right, the curve is rideable in a clockwise direction, but not easily rideable in a counterclockwise direction. Why? Riders will adjust their speed accordingly to negotiate the larger radius curve, but as the curve tightens, they will be carrying too much speed, which often results in blown corners. Riders cannot easily stay on the trail unless they brake suddenly to lose speed. This results in skidding and excessive tread displacement. From an experience standpoint, compound curves increase difficulty when riding in the direction of decreasing radius.

Broken back curves are two simple curves connected in the middle by a short tangent. If both curves have the same radius, they can be rideable from either direction.

Broken back curves are two simple curves connected together by a short tangent



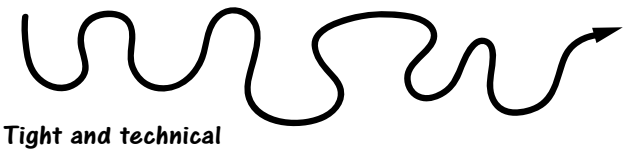
Broken back curve with curves of different radii



If the two curves have a different radius, then they are similar to the compound curve. In this example, it will be rideable in a clockwise direction, and not easily rideable in a counterclockwise direction, which again can result in tread impacts and blown corners. Like a compound curve, a broken back curve with tightening radius increases difficulty in that direction.

It is human nature to accelerate as the sight line increases. As the length of a tangent increases, the speed increases accordingly. Having a chance to increase speed improves the rider experience by adding variety, but it also decreases seat time. Designers and managers need to recognize that most riders will ride a trail as fast as they can within their skill level. This is part of the desired challenge of providing for the riders' needs. Most riders challenge themselves. This means that speed and any resulting impacts are always factors on any trail.

Open and flowing

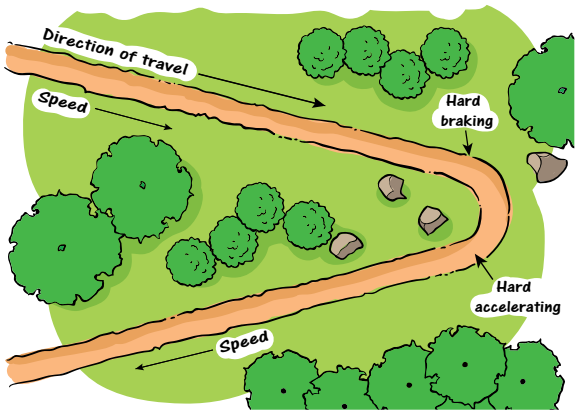


Tight and technical

Poor flow - abrupt transitions from one type of flow to another

Whether a trail is linear or curvilinear, the tangent lengths, curve radii, and the sequencing of those tangents and curves can affect the trail flow, difficulty level, rider experience, and potential tread impacts.

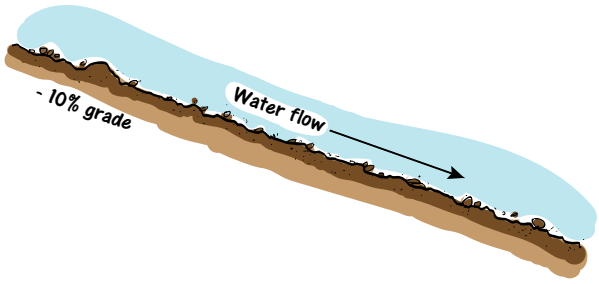
Impacts created by design



Speed increases with the length of the tangent, but what happens when the tangent ends in a curve? If there is a long tangent and then a short-radius curve (poor flow), riders will have to brake hard to negotiate the curve. Coming out of the curve, the riders eye the next tangent and start rolling on the throttle. These two actions result in increased forces being applied to the trail tread creating potentially severe tread impacts called brake chop and acceleration dishing. These two impacts can be reduced by: a) shortening the tangents, b) increasing the radius of the connecting curve so it can be negotiated at a greater speed, c) superelevating the curve so riders can carry more speed through the turn, or d) a combination of the above.

Tangents and curves play a similar role in the vertical alignment of the trail. A long tangent in this case means a long grade up or down, which again can result in an increase in rider speed. It also means that any water on the trail is going to increase in volume and velocity, which will increase erosion. Both of these actions can create significant tread impacts. Short or no tangents between curves increases the rider flow in the horizontal alignment. It also increases rider flow in the vertical alignment and decreases water flow.

Constant unbroken grade

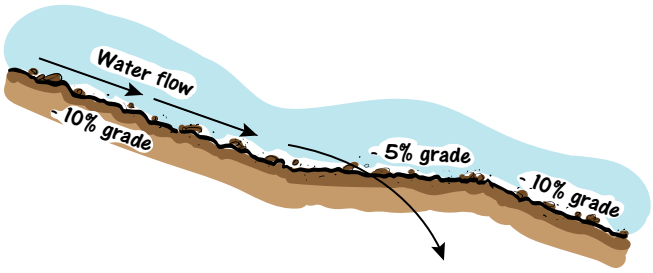


No opportunity to drain

Water collects on the trail and then starts flowing down grade. The longer it flows or runs, the more velocity it gains and the harder it becomes to turn the water so it will drain off the trail. On a constant or unbroken grade, it is very difficult to effectively get water to drain off the trail. Four main profile shapes are utilized to get water off the trail: grade break, grade reversal, rolling dip, and waterbar.

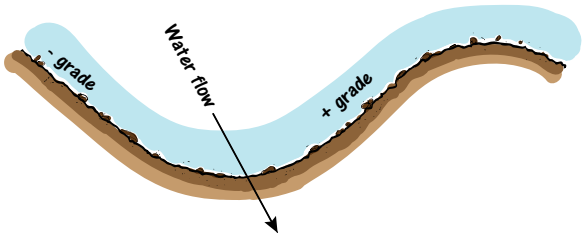
A grade break is a place where the prevailing grade flattens off for a while without changing from negative to positive. As soon as water hits the flatter section of grade, its velocity reduces significantly and it will start to drop its load of sediment. If the trailbed is outsloped here, there is a good opportunity to turn the water and drain it off the trail. The flatter and longer the grade break, the more effectively it will drain.

Outsloped grade break



Opportunity to drain

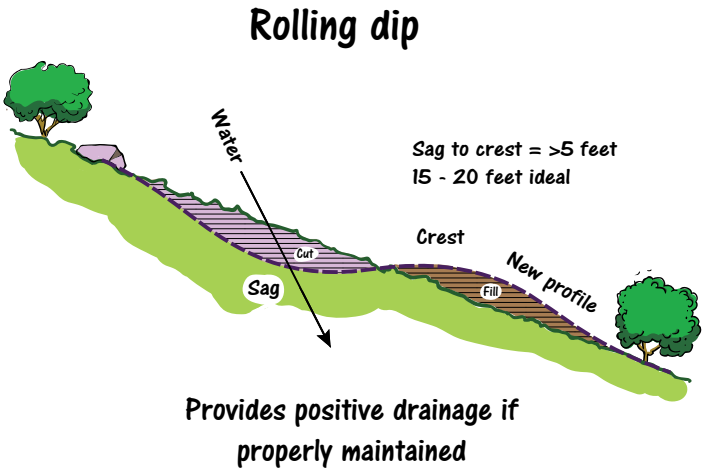
Grade reversal



Guaranteed to drain if properly designed

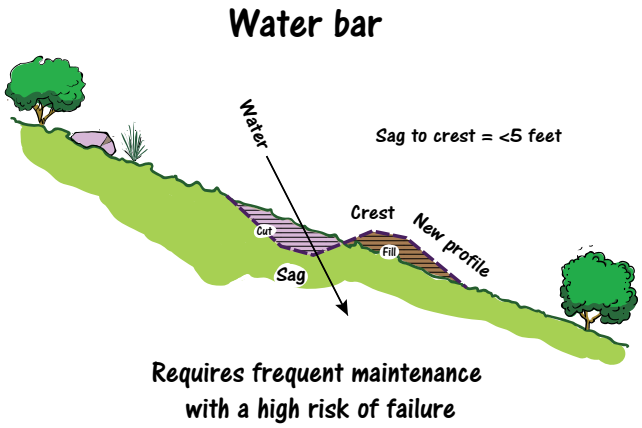
As discussed with the profile view, rolling the grade by changing from negative to positive is 100% effective in stopping water flow down the trail. This is called a grade reversal and it is flagged into the trail location on new trails or the relocation of existing trails; therefore, it is a natural feature and not a manmade structure. The longer the grade reversal and the greater the elevation difference from the bottom to the crest where the grade rolls down again, the more

rideable and effective it will be. Ideally, the grade is reversed for 50 feet or more, but the minimum is three times the design vehicle length unless terrain features are incorporated. There should always be a minimum of two feet of elevation difference or gain, otherwise the forces of tires, rutting, and erosion may cause them to fail. If properly designed, a grade reversal will not fail to function due to weather, amount of use, or lack of maintenance (though ponding may occur). Because of this, a grade reversal is always the preferred method to provide drainage.



A rolling dip is usually installed on a long section of constant grade to provide drainage where there was previously none. Many refer to these as grade reversals and technically they are, but they are a manmade structure, not a natural terrain structure like the grade reversal. Rolling dips are often installed as a maintenance or reconstruction action on roads, road to trail conversions, and user-created trails. They do work, but they require regular maintenance to stay effective. The longer the distance from the sag to the crest of the dip, the more rideable and more effective the dip will be. About 15 to 20 feet is ideal. The shorter the distance, the more the dip functions like a waterbar. On steeper grades, a rolling dip acts like a ski jump. In doing so, forces are applied to the crest, which will increase the need and frequency for maintenance. Also on steeper existing grades, the over-steepened slopes going into the sag and out of the crest may exceed the maximum grade for durability for a given soil type.

Waterbars, the last category, are also used on existing trails but are not effective on OHV trails. They are short rolling dips with only 2 to 5 feet from the sag to the crest. These create an abrupt hump in the trail and the force of the tires against this hump will cause rapid deterioration and failure of the structure. On ATVs, ROVs, and 4WDs, waterbars are uncomfortable to negotiate and typically there is hard braking going into them and acceleration coming out of them, which results in lack of flow and further tread impacts. Waterbars require the most maintenance and are the least effective method to drain water off the trail. Rolling dips roll and flow, waterbars don't.



Design Implications of Horizontal and Vertical Alignments

- The configuration of horizontal and vertical alignments affect rider experience, rider speed, and rider flow, and have some effect on the velocity and volume of water.
- Trail flow is a constant series of serpentine horizontal and vertical curves. Flow does not necessarily equal speed.
- Less flow potentially has more tread impacts. High flow equals a high fun factor.
- Water creates issues and it only flows downhill. A grade reversal blocks that downhill flow and if provided regularly, reduces the velocity and volume of water.

Guidelines and Rules

It is human nature to want hard numbers: what is right and what is wrong? Many people will ask, "How steep is too steep?" As is often the case, the answer is, "It depends." The next question people ask is, "Then what is a range or a guideline?" This is a trap not only because of site variables but also because guidelines tend to become rules.

One such rule is that all trails should be outsloped at 5%. In principle, there is nothing wrong with outslope. Every opportunity to get water off the trail is a benefit. The tread shape, however, will change over time from the shape it had right after construction through the forces of compaction, displacement, and erosion. Unless the tread is regularly maintained or is hardened to maintain its shape, the outslope will likely fail, especially with OHV trails. It's a trap for designers to assume that outslope will work. On curves, outsloped trails can be awkward to ride in a motorized vehicle. On tangents, riders will tend to hug the upslope edge and potentially widen out the trail. In areas with slippery soils and steeper terrain, an outsloped trail can increase the difficulty level by increasing the exposure or risk of the vehicles and riders sliding off the trail.

Another rule is called the half rule. It states that a trail grade should not exceed 50% of the grade of the sideslope, so on a sideslope of 30%, the trail grade shouldn't exceed 15%. The theory is that if the tread is outsloped, overland water will sheet across the trail if the grade is less than 50% of the sideslope, but will be intercepted by and run down the tread if the grade is more than 50% of the sideslope. This is a trap. On motorized trails, the outslope will likely fail; the tread will become a trench; and water will be intercepted by and run down the trail. While flatter grades are a definite benefit, designers of a motorized trail should always assume that any water intercepted by the trail will run down the trail. The key point for the designers is to recognize that the steeper the grade, the more velocity the water will have, so the length of the grade needs to be shorter to reduce the potential for scouring and sedimentation.

One final rule is called the 10% average grade rule. While increasing grade increases the risk of erosion, designers also need to recognize that increasing grade enhances rider experience. The problem with this rule is that most people don't understand what it means or how to apply it. This so-called 10% Rule often gets misinterpreted to mean that the maximum grade for a trail should not exceed 10%. This is not correct. It means that the average grade on a given section of trail should not exceed 10%. In the example above, there are plus and minus grades with some up to 29%, but the average grade from Point A to Point B is 8.2% over a distance of 1.5 miles. (6875 – 6225 = 650' rise, 1.5 X 5280 = 7920' run).

What if the grade was a straight line from one end to the other? The grade would still be 8.2%, but would it be sustainable? No. So the length of the trail segment has a significant bearing on the outcome of the average grade. What length should be chosen? There are too many variables for this rule to be useful. Instead of rules, field personnel need to understand the physical forces that will be applied to the trail and make informed choices.

Section 2: Physical Forces Affecting the Trail

Things that make OHV trails unique from a design and sustainability standpoint are the vehicles themselves which have a motor, weigh more than most other trail modalities, and have torque of a wheel under power. These all create forces that are applied to the ground. Designing for sustainability requires understanding how the forces of compaction, displacement, and erosion impact the trail.

Compaction, Displacement, Erosion

Compaction is the downward force of the vehicle onto the ground. The amount of this force is influenced by the weight of the vehicle, occupants and gear, the number of tires, and the size and inflation pressure of the tires. Compaction is measured as pounds per square inch (PSI). As the contact area of the ground increases, the PSI of contact decreases. A 500-pound vehicle with four tires has more contact area, thus less PSI, than the same vehicle with two tires. In snow, sand, and mud, riders typically decrease the air pressure in their tires. This gives them more grip because their tires have more contact area.

Displacement is the physical movement of the trailbed surface particles as a result of the ground contact and torque of the vehicle. The softer and less cohesive the trailbed surface is, the higher the potential for displacement. Displacement is a force caused from human and animal interaction with nature, such as from tires, horse or other animals, a person walking, etc. A tire with high air pressure will generally cause more displacement than the same tire with lower pressure.

Erosion is the movement of the tread surface particcles due to natural causes like water and wind. Again, the softer and less cohesive the trailbed surface is, the higher the potential for erosion. If displacement has also occurred, the potential for erosion increases since soil particles have already been loosened and ruts have been created to channel the water and thus increase its velocity and potential for scour.

A basic theorem of physics 101 is that for every action, there is an equal and opposite reaction. If the OHV applies 100 PSI of downward force to the tread surface, the tread surface will react with 100 PSI of upward force. The amount of upward force will always equal the amount of downward force. If the trailbed surface is inflexible, as in solid rock or pavement, the physical forces are depicted by the diagram below. The downward and upward forces represented by the size of the arrows are equal and directly opposite.

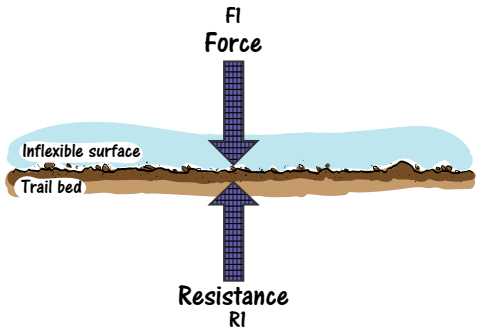
A Provoking Thought...

For every action, there is a reaction

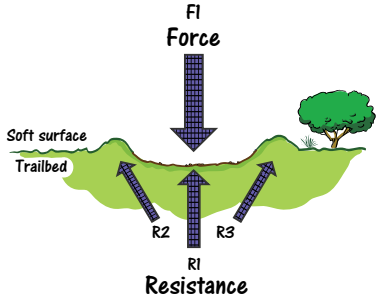
You cannot touch something without it touching you

You cannot touch someone without being touched

As the hardness of the trailbed decreases, the tread surface cannot support the downward force so the tread deflects and the upward forces are sent in different directions. Here, the downward and upward forces represented by the sizes of the arrows are equal but indirectly opposite. This is how ruts and berms are created in the trailbed. The softer the tread surface, the deeper the rut and the higher the berm. This action is mitigated in one of four ways: a) harden the tread surface so the forces become more equal and directly opposite; b) decrease the amount of force applied by having more tires or more ground contact area, which equates to less PSI; c) decrease tire pressure; or d) a combination of any or all of the above.



Resistance = Force (RI=FI)

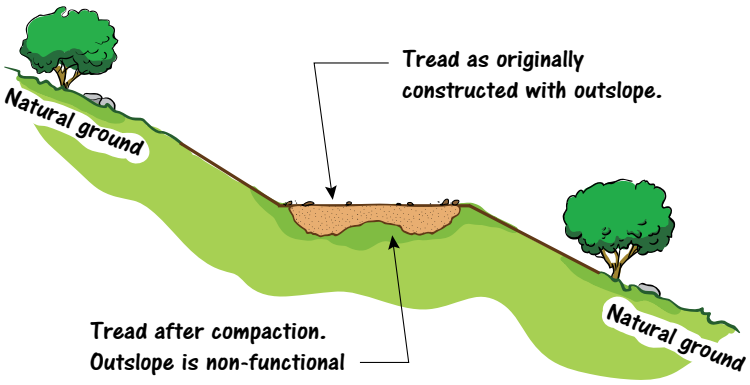


Resistance = Force (RI+R2+R3=FI)

The Interaction of Compaction and Displacement

When OHV tires are put on a newly constructed trail, compaction will start almost immediately and will cause the trail tread to compress. Naturally, the compaction will occur the most wherever the tires have had the most passes over any one place on the surface. For a single-track OHM trail, the compaction will be mostly in the center of the trail, but on an ATV, ROV, and 4WD trail, the compaction will create two ruts on either side of the center. Over time, the entire compacted tread will be lower than the untrafficked tread and potentially lower than the surrounding ground.

The effects of compaction



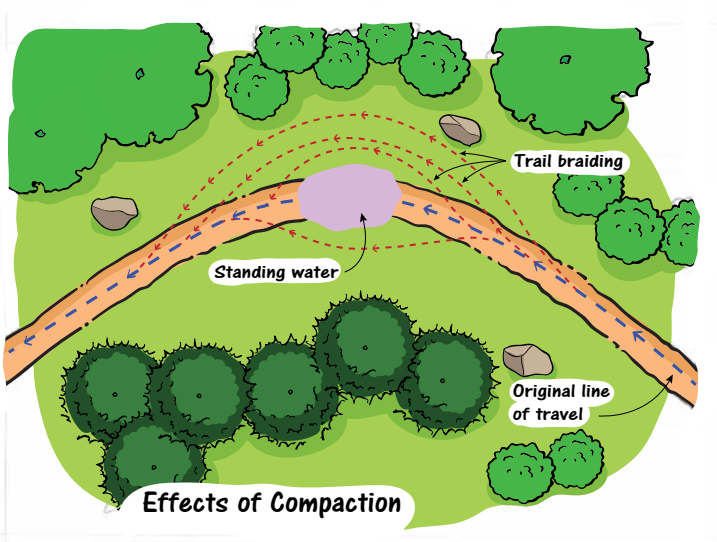
Why is this important to know? If the tread was constructed with outslope, water will no longer come down the slope and sheet across the trail as originally designed. The water will now be trapped in the ruts of the trail and will either collect on the trail or run down the trail.

As compaction occurs, the soil particles in the tread become packed together tighter as voids become filled with finer material. This makes the tread surface less porous, so now water is less likely to be absorbed into the tread. Instead, water will either pond on the surface or accumulate and run down the trail. There will be more water since it is not soaking in. As the grade increases, the velocity of the water will increase, which will increase the likelihood of scour or erosion.

The designers must recognize that these actions will occur and plan to force the water off at regular intervals through knicks, rolling dips, or best of all, grade reversals.

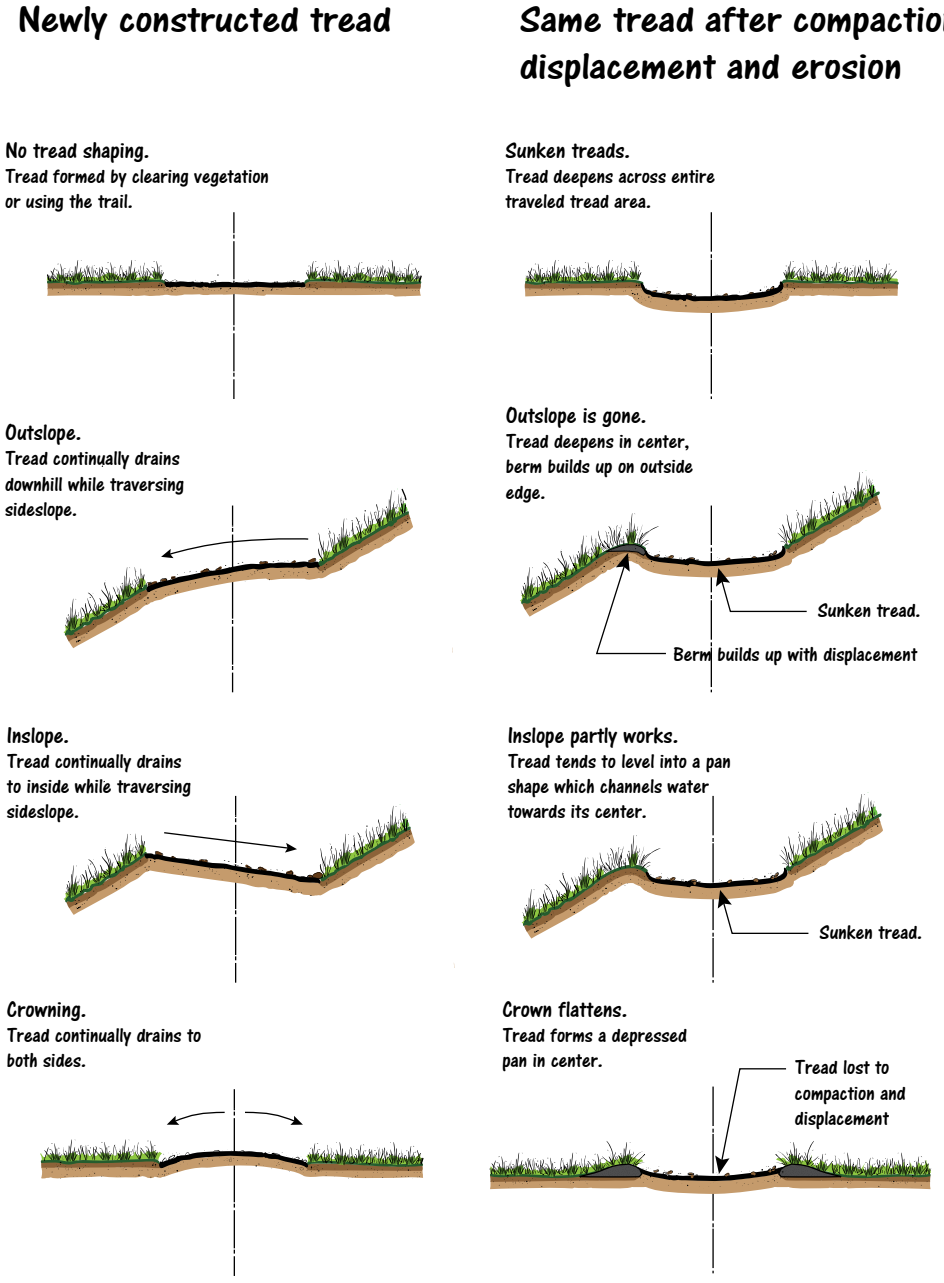
On flat ground, the compaction will cause water to pond up in low areas. If the trail is not confined by vegetation or topography, riders will tend to go around these ponds thus widening out the trail tread or make alternative routes that results in trail braiding.

Once all of the voids are filled and the tread is consolidated, compaction will cease unless the vehicle types change. This may happen naturally, as when a new type of allowed vehicle begins to ride the trail. This can also be caused when the land managers open existing trails to new types of vehicles. If the managers allow ROVs on trails that previously only allowed ATVs, the forces on the trail will change because of the difference in vehicle weight and size. It is important that the managers recognize and plan for the potential impacts prior to changing vehicle trail designations.



The trailbed is constructed using one of four shapes: flat, crowned, insloped, or outsloped. The important point to remember here is that unless conditions are ideal, which rarely happens, all of these shapes will change over time with vehicle use and become rutted, entrenched, or concave. After compaction has occurred, the trail could be restored to its original shape through maintenance if the funding and equipment with skilled operators are available to do so. If this is not done correctly, the tread material can easily become unconsolidated and the compaction, displacement, and erosion process will start all over again.

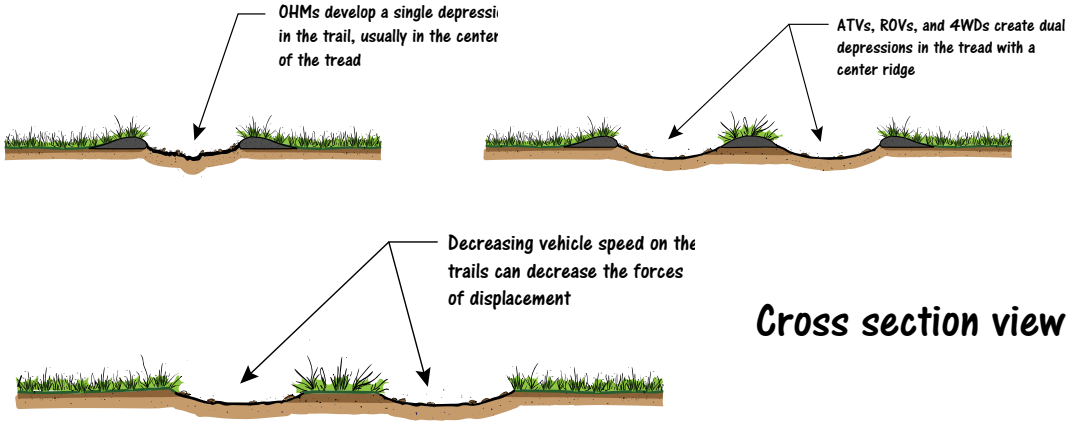
The forces of vehicle compaction can be reduced and the integrity of the trailbed shape can be significantly improved if the trailbed is compacted during construction with a roller or other equipment. This can be labor-intensive and expensive. For the roller to have full ground contact, often rocks and roots are removed. The down side of this is that the trail no longer looks and feels natural and some riders object to that. The character has changed and so has the trail experience, but the tread is far more durable.



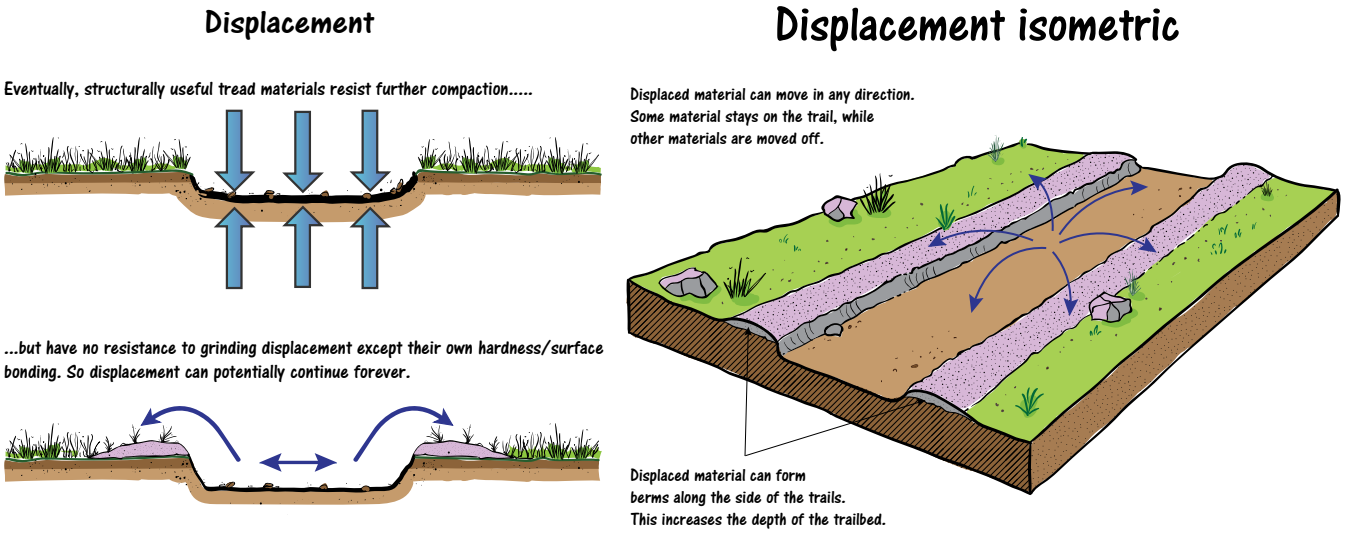
The crowned trailbed is more difficult and expensive to construct, but given good, non-saturated soils, once the forces of compaction, displacement, and erosion are applied, it is the only shape that is still close to the original ground line, rather than a trench below the ground line. This can be a benefit since it will make it easier to drain water off the trail and help keep the trail tread from becoming saturated.

While compaction slows down and can even cease, displacement does not. The force and torque of tires creates constant displacement of the tread surface. In addition, the forces of braking and accelerating and the centrifugal forces try to slide the vehicle to the outside of curves. All of these create progressive grinding of surface particles and displacement of the tread surface. Embedded rocks can get dislodged and solid rock can get ground away over time. Faster speeds and steeper grades will exponentially increase these forces and their effects.

Since compaction consolidates the tread particles, compaction makes the tread less susceptible to displacement and erosion, but it never stops these other forces. Trails will change over time and designers need to recognize that. In some scenarios of soil type and climate, the change has no effect on the functionality of the trail or can sometimes improve it, but in other scenarios, that change can lead to drainage issues and the loss of the trail's integrity.

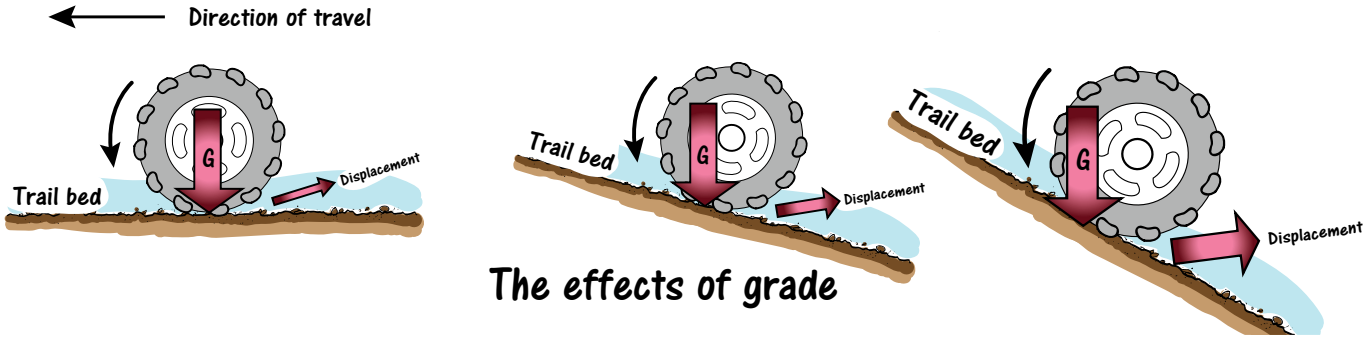


Hardening is a tool that can be utilized where needed in that latter scenario, but as with mechanical compaction, hardening changes the character and feel of a natural surface trail. Instead of riding on dirt and natural terrain features, the riders are now on gravel or some other unnatural surface, which is like riding on a miniature road. While it provides variety, it is not the experience that most trail riders are seeking. What is the effect of displacement on a grade? The gravitational force (G) is always a vertical force. When the trail is flat, the gravitational force is close to perpendicular to the trailbed. The torque of the tire still creates some displacement.



As the grade increases, the gravitational force is no longer perpendicular, but is being applied at an angle to the trailbed. This angle, combined with the torque of the rotating tire, disrupts trail tread. More particles and rocks are dislodged and displacement increases.

As the grade increases more, the angle between the G force and the trailbed decreases, which makes the G force a more effective tool to dislodge tread particles. This increases displacement even more.



The effects of grade

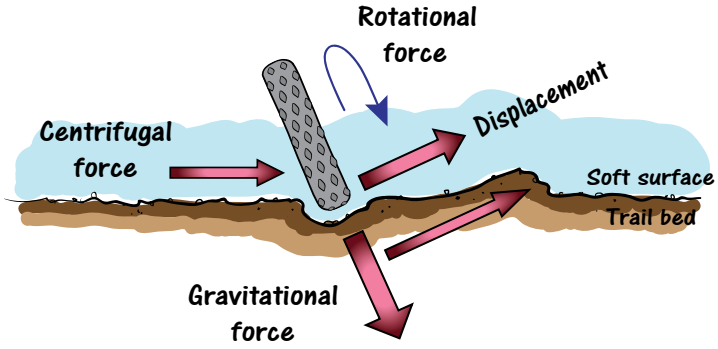
What is the effect of displacement on a curve? Just like on a grade, the angle of the force being exerted combined with the sideways centrifugal force dislodges tread particles. These particles are always thrown to the outside of the curve where they accumulate and eventually form a superelevated curve. The faster the vehicle speed and the softer the trail tread, the more rapidly the superelevation forms. If not confined by vegetation, the trail will continue to widen out until the superelevation is fully formed. Depending on the soil type, speed, and amount of use, this could take a few months or a few years to occur.

Some riders do not like superelevated corners because they don't appear natural and riders feel like they're on a motocross track instead of in the woods. Even in dry climates, superelevated turns can entrap water causing ponding and even soil saturation after heavy rain events. However, one advantage of superelevation is that riders can carry their speed through the turn without braking going into it and accelerating coming out of it. This creates flow and a very high fun factor.

What else does it do? By having a superelevated turn, designers can eliminate or certainly reduce two of the three forces that accelerate displacement: braking and accelerating. Since the angle of the superelevated turn is now closer to perpendicular with the tire, the amount of centrifugal force is also greatly reduced as is the amount of displacement. This reduces tread impacts and reduces maintenance needs and costs.

If the trail was originally constructed with superelevated corners, there is less widening of the trail over time and compactive forces can start much earlier. A superelevated corner increases tread stability and reduces the loss of tread material because the banked tread contains the displaced soil particles and they roll back down into the tread.

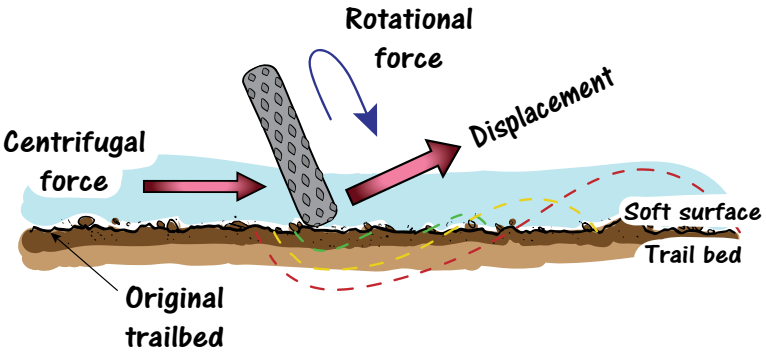
Forces exerted by a motorcycle on a flat curve



Tip, Trick or Trap?

Tip: Superelevated curves equal superelevated rider experience

The development of superelevation

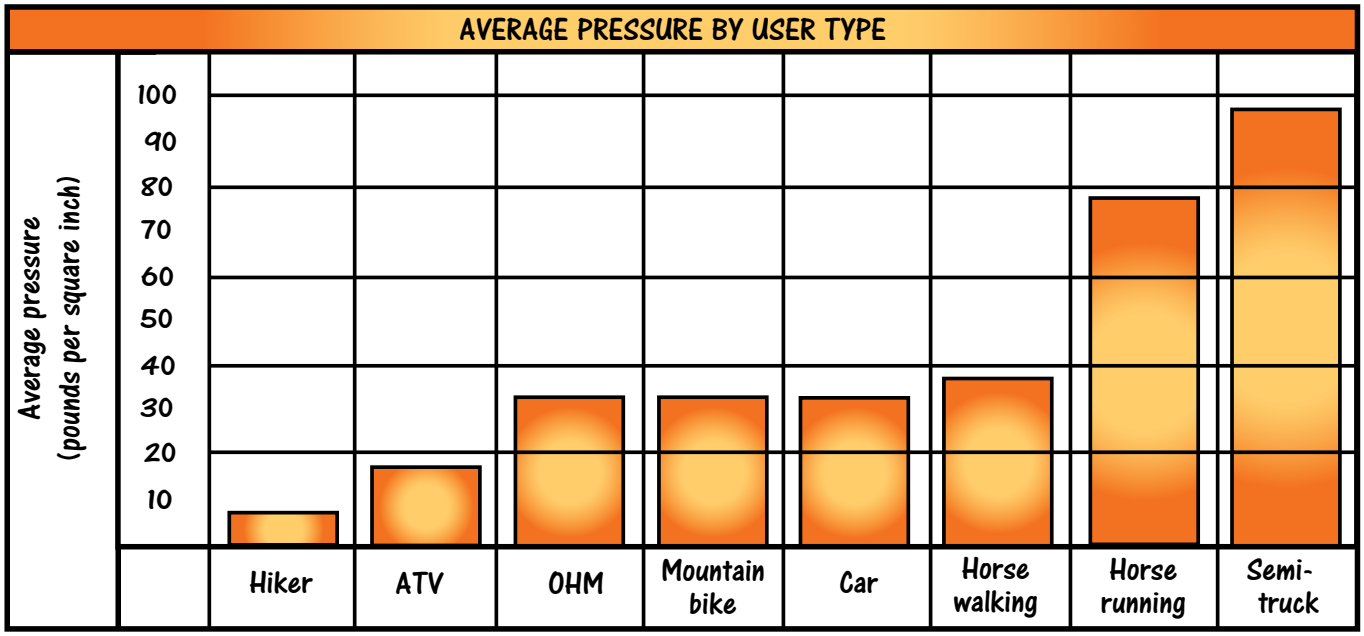


Superelevated curves can reduce the effects of displacement. On a curve like this, any soil particles that are displaced will roll back down into the tread.

A series of back-to-back superelevated curves is like riding a roller coaster with a super high fun factor that produces smiles and adrenaline.

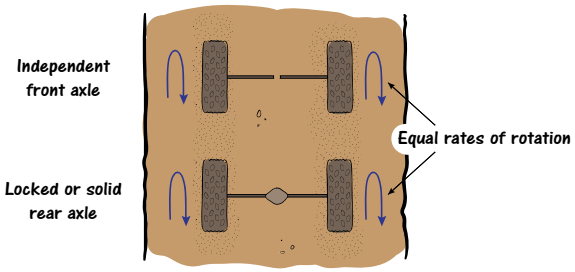
Special Considerations for Four-Wheeled Vehicles

There are some special considerations when the OHV has four instead of two wheels. One obvious difference is that now there can be at least two drive tires next to each other (two-wheel drive OHMs have a single drive tire forward and rear) delivering rotational forces and potential displacement forces to the ground. Depending on tire size, inflation pressures, actual vehicle size, and weight and loading, those forces may or may not exceed those exerted by a motorcycle. The real difference, though, comes into play on curves.

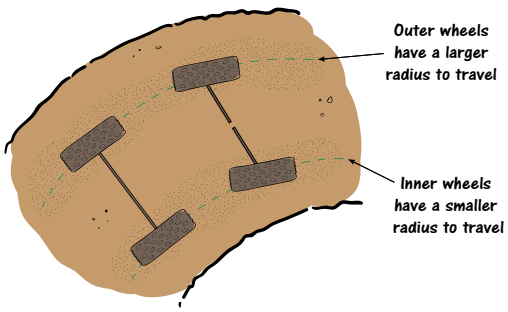


When a four-wheeled vehicle is on a curve, the outside tires are on a larger radius than the inside tires. That means that the outside tires have to travel farther and faster to stay in line with the inside tires. If the tires roll independently like those on the front axle of a rear-wheel drive vehicle, the outside tire will roll more and the inside tire will roll less to get around a curve. The drive tires behave differently. If the drive axle is solid or if the differential is locked, the two tires turn at the same speed and cannot roll independently. This means that as the outside tire is traveling farther to get around the curve, the inside tire is going at the same rate, but has a shorter distance to travel, which causes wheel hop and tire spin on that inside tire. Depending on the trail surface, these forces can cause severe displacement. Non-cohesive soils, loose rocks, or pavers and other materials used for trail hardening can be churned up, broken, or moved. These forces must be considered while designing the trail.

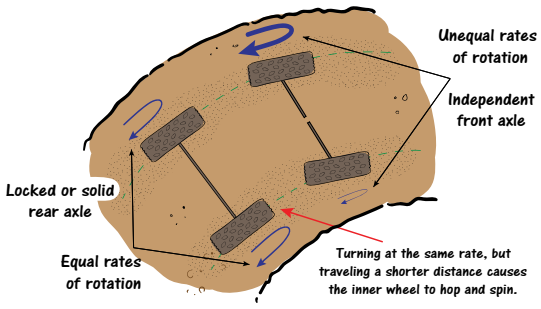
Four-wheeled vehicle on a tangent



Four-wheeled vehicle on a curve



Four-wheeled vehicle on a curve



Increasing the vehicle width increases the effect because of the larger difference in radius between the inner and outer wheels. Increasing the grade increases the effect because of the additional

torque being applied to the tires. Increasing the curve radius decreases the effect because the outside tire has to turn less to keep up with the inside tire. Other than rotational forces, there is no churning effect on tangents because both tires travel the same distance at the same speed. The effects will be most noticeable on a climbing turn since it involves grade and a turn.

Erosion

The third force is erosion, which is the movement or removal of the tread surface particles due to natural causes like wind and water. Poor trail design and lack of effective drainage can accelerate erosion. Soil particles displaced by vehicle tires are more susceptible to erosion. Vehicle operation during periods when the soils are most susceptible to displacement, such as very dry or very wet (saturated), can create ruts that channel water and increases its velocity and scouring action.

Erosion is generally viewed as being bad, but it is a natural, ongoing, and eternal process. The Grand Canyon is viewed as spectacularly beautiful, but it is a product of eons of erosion.

Here are some key points on erosion:

- Erosion is a natural process that is caused by weather patterns or weather events, whether they are major or minor events.
- Major rain events and catastrophic storms like tornadoes and hurricanes will happen and they will result in erosion.
- Given the right conditions, even normal weather patterns can and do cause erosion.
- Steep ground is not needed in order for erosion to occur. The potential for erosion is everywhere and it is non-selective.
- Erosion is cumulative. Even minor soil movement from a single storm can add up to significant soil loss over several years of storms.
- While erosion cannot be stopped, designers and managers can take measures to minimize it through good design and trail management.
- The trailbed is a precious resource. Once the tread particles are displaced and eroded, they are generally gone forever. It is more efficient to be proactive and invest time and money up front in design to protect that resource rather than be reactive and try to fix the trail after the damage has occurred.
- Even if everything is done right and a sustainable trail has been built, erosion will occur to some degree. The fact that there is erosion does not necessarily mean that the planners and designers have failed or that the trail will fail.

Tip, Trick or Trap?

Tip: It is better to understand nature and work with it, rather than against it. We cannot control nature.

An early fall event on these dry sandy soils resulted in severe displacement. A high wind or thunderstorm could result in major impacts and soil loss.

Chapter 3 included a tip that said planners and designers are always better off trying to work with human nature rather than against it. That same concept applies here.

Dirt in the air and grit in the teeth: it's part of the experience, but it's erosion.

They cannot fight a natural process and must learn to live with it. They can, however, do some things through design to reduce the impacts of that process on our trails.

The Interaction of Compaction, Displacement, and Erosion

With any natural surface trail, the vegetation at the surface gets removed and roots that hold soil either get cut through construction or broken through use. These actions weaken the soil and expose it to the forces of compaction, displacement, and erosion. Compaction can help minimize displacement. If displacement is minimized so is erosion potential; therefore, compaction helps reduce erosion also.

Many soil types appear to be stable at a given time of year, level of use, and moisture content. Change any of those three variables and the soil stability will change, which means that the potential for displacement will change. Clay soils turn to gumbo when wet. Sandy soils turn to flour when dry. Soils with low stability cannot endure a high volume of use in a short duration of time, as in an OHV event or race, unless they are frozen or have the optimum moisture content, which rarely happens.

A rill of water forming after a rain shower

When the surface of clay or silty soils is dry, the smaller particles become easily dislodged by the displacing action of tires and become airborne, hence dust is created. Most people, especially the riders, see this dust as a nuisance and pray for a breeze to blow it out of their way. However, what is occurring here is erosion. Those soil particles that are blown away are now gone forever, resulting in tread material being lost every year due to dust and wind.

After even a minor rain event, small rills or channels may form in the trail and at the downhill end of each rill will be a small deposit of sediment. These can seem innocuous, but over time they build up and can fill the bottoms of rolling dips and block the entrances to lead-off ditches. These rills can start forming within just a few feet of a drain and they can form on any grade, not just the steep ones.

Notice the rills of water draining down the slope and into this trail. Notice also how quickly the rill down the edge of the trail deepens as more water feeds into it and the water velocity increases.

Sedimentation from erosion can fill up drainage structures and cause them to fail, but ruts caused by displacement can do the same thing. Water collects in those ruts, becomes channeled, increases velocity, and can blow right by lead-off ditches and under-sized rolling dips. This is another reason why properly designed grade reversals are preferred over man-made structures; they cannot fail.

A Closer Look...

Evaluation or monitoring is the fourth E in the 4Es discussed in Chapter 1. Whoever is monitoring a trail needs to have an eye trained to spot those little rills and sediment deposits and watch for the gradual filling of drainage structures so that maintenance can be scheduled in a timely manner. If this is not done and the deposits are allowed to accumulate, the next major rain event could wipe out the drainage structures and create severe trail damage, extensive sedimentation, and unneeded resource impacts. Just as important as scheduling maintenance is to have that monitoring person take the next step and ask: "Where is this water coming from? Can we reduce or eliminate it?" This is what the 4Es are all about: asking why and implementing adaptive management. Too often, the issue is overlooked and these questions are not asked as the person climbs on his OHV and rides on up the trail. In doing so, the trail manager is taken from a potential proactive position and placed in a potential reactive position after the real damage occurs. Chapter 2 stressed that assessments need to be done on foot. On a machine, managers are traveling faster and are focused on other things besides the little insidious forces at work on the trail tread. Managers can see more, understand more, and be more effective on foot.

As the rills join together farther down the slope, the volume and velocity of the water increases even more resulting in scouring and erosion. If the source of the water feeding into this slope cannot be diverted, there will be long-term issues. A mitigation here could be to install an armored ditch to collect and channel the water down the slope. The ditch would need to be lined with cobble size or larger rocks to prevent further erosion and to dissipate the energy of the water.

Water will always take the path of the least resistance. This lead-off ditch gradually filled up with sediment due to lack of maintenance and the next major rain event blew right by the ditch and over the rolling dip.

This trail appears to be stable, but it is actually the product of years of sedimentation as evidenced by the log buried in the fill. Unless the source of the water carrying this sediment is found and corrected, this trail will not be sustainable.

The alluvial fans in the desert appear timeless and unchanging, but they are the product of erosion and sedimentation that started when the mountains were created. The sediment in these fans can be several thousand feet thick. The erosion process has not stopped and will continue forever.

This is a good example of displacement and erosion at work. This grade is too steep and too long without adequate drainage. Over time, water has carried away all of the fine material that bound this tread together leaving only a loose "rock garden." The trail above and below this section would be rated as EASIEST, but this section is no longer suitable for novice motorcycle riders. This lack of drainage has not only removed a lot of soil, it has created inconsistent difficulty which could put a novice rider at risk.

A Second Look...

It was discussed previously how erosion has washed away the fines and left a rock garden on this section of trail. What if that water has no direct connectivity to a stream? What if this trail had a higher difficulty level? What if our options to relocate this long grade are limited? Is it okay to accept this? Under certain conditions, the answer can be yes. For example, as long as signing and mapping reflect the appropriate difficulty level, the trail could be managed as More Difficult. On the easier trail sections on both ends of this, some simple entrance management techniques could be implemented to indicate to the riders that there will be more difficult sections to negotiate.

Section 3: Understanding Tread Materials

Natural surface trails generally use the native soil as the tread surface. Some soils are more stable and durable than others. Indeed, soil type is one of the key elements, if not the key element, in trail design. Unless the soil is modified or hardened, it will dictate the steepness of grade, tightness of alignment, frequency of drainage, smoothness of the trailbed surface, and the level of difficulty. Tread materials are generally composed of a mixture of soil and rock.

Soils

Soils are composed of different mixtures of sand, silt, and clay (called the soil separates) with the additives of organic matter (humus) and larger mineral fragments such as gravel-sized material. The mixtures of the soil separates define the texture of the soil and the texture influences the

behavior of the soil. Will it drain? Will it displace? Will it be slippery? It is very common for the soil type or soil mix to change several times on any given trail, so the designers must be constantly watching for these changes and adjust the design accordingly.

Clay soils have the smallest particle size and the particles are shaped like flat platelets. The platelet shape makes clay very durable when there is sufficient moisture to bind the particles together. They can hold a lot of water, which makes them poor draining, and when wet, those platelets slide over each other, which is what makes a clay soil so slippery. Clay has high cohesion and that means it holds onto and binds particles together. That's why it feels sticky when moist. A quick field test is to take a handful of the soil, apply enough water so the sample is moist (wet, but not saturated), and then make a fist to form it into a ball. A clay soil will form a ball. Then rub hands together to try to roll the material into a pencil shape. A clay soil will roll into a pencil; the thinner the pencil, the higher the clay content.

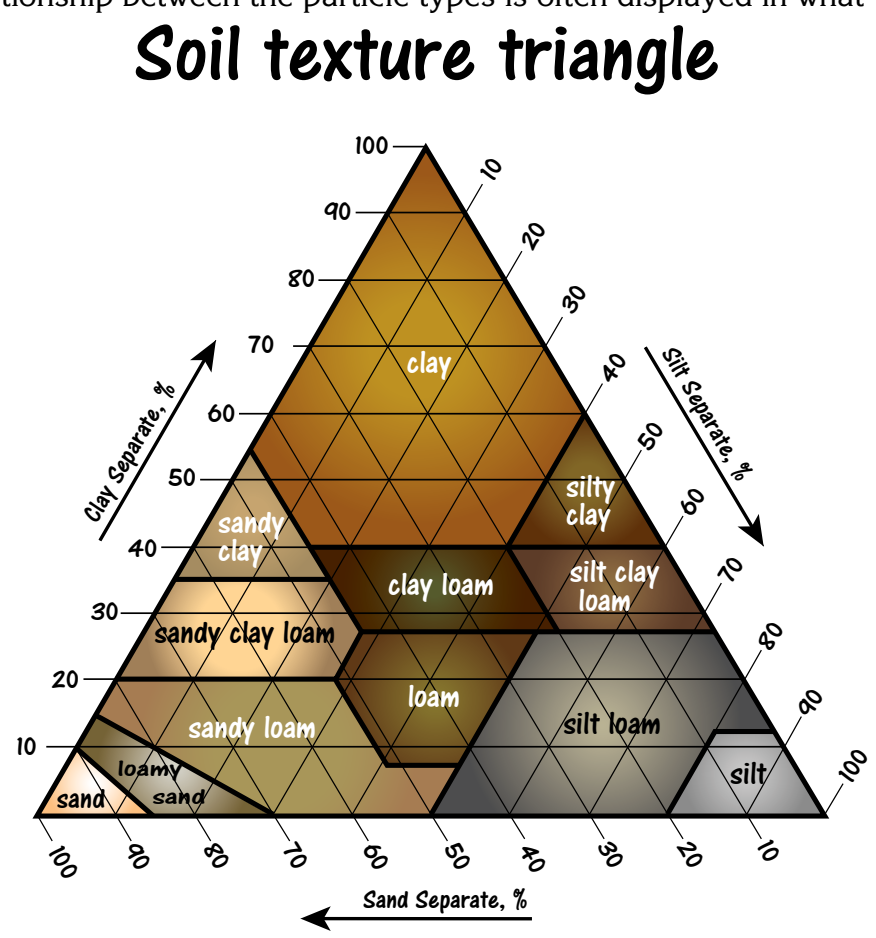
Silt soils are the next larger particle size though the particles are still small and not visible. Silt feels smooth like flour. Due to their particle size, there are numerous voids between them, so they can hold a lot of water but not as much as clay, so they drain better than clay. Silt has medium cohesion, so it will also bind particles together to make a firm trail tread. In the field test, a silty soil will form a ball and feel smooth, will not be as sticky as clay, and will not roll into a pencil.

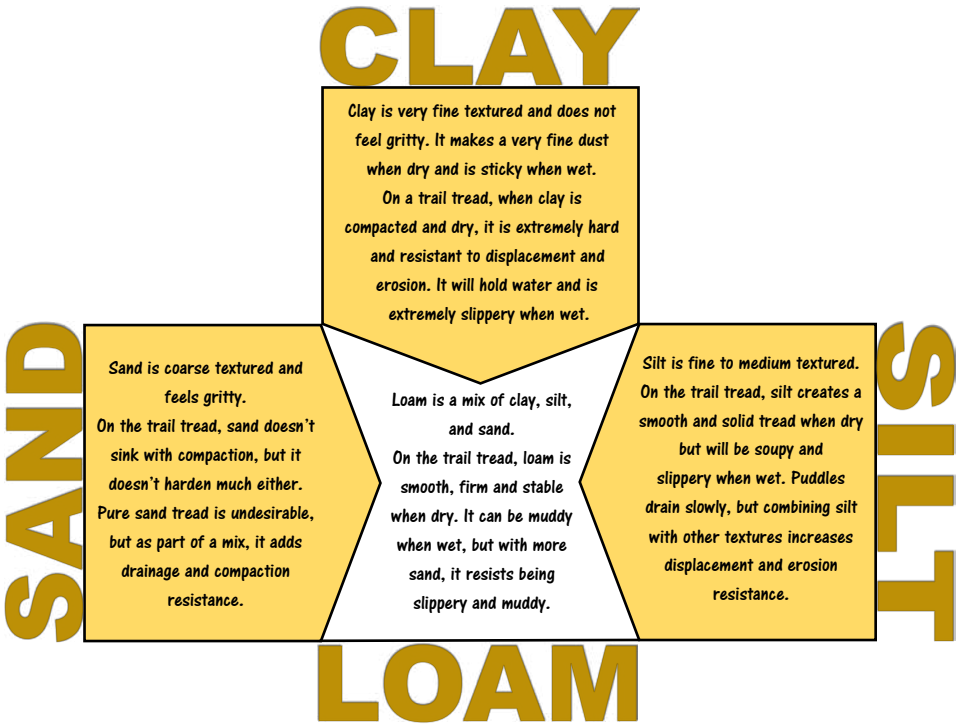
Sand has the largest particle size and is visible and gritty. The pores between the particles are large, so water drains through them very easily. Pure sand has no cohesion and does not bind with other particles, so sand does not compact and is therefore easily displaced. In the field test, pure sand will not form a ball and will disintegrate easily when pressed lightly.

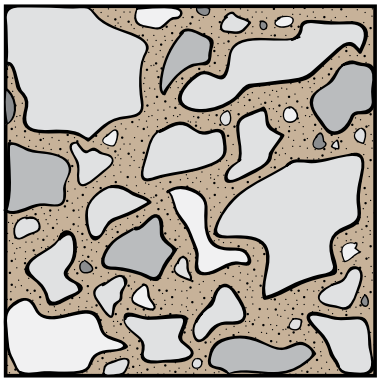
Rarely is a soil one pure particle type. Instead, it is a mixture of the three soil separates, which is a good thing since pure soils are not desirable for a trail tread. When mixed together though, the soil, which is called **loam**, tends to have more of the advantages of each of its components and less of the disadvantages. The relationship between the particle types is often displayed in what is called the soil triangle with clay, silt, and sand in each of the three corners and the combinations of loam near the center.

The table displays the properties and behaviors of each soil type.

Humus is a dark brown to black layer of decomposed organic material often referred to as the A horizon. When mixed with the soil separates, humus significantly increases the bulk density and moisture retention characteristics of the soil. Being organic, it also adds nutrients that stimulate plant growth which in turn can help stabilize the soil. Like the soil separates, in the right mix humus is good, but the higher the percentage of humus, the more muddy the soil will become making it very susceptible to displacement and erosion.





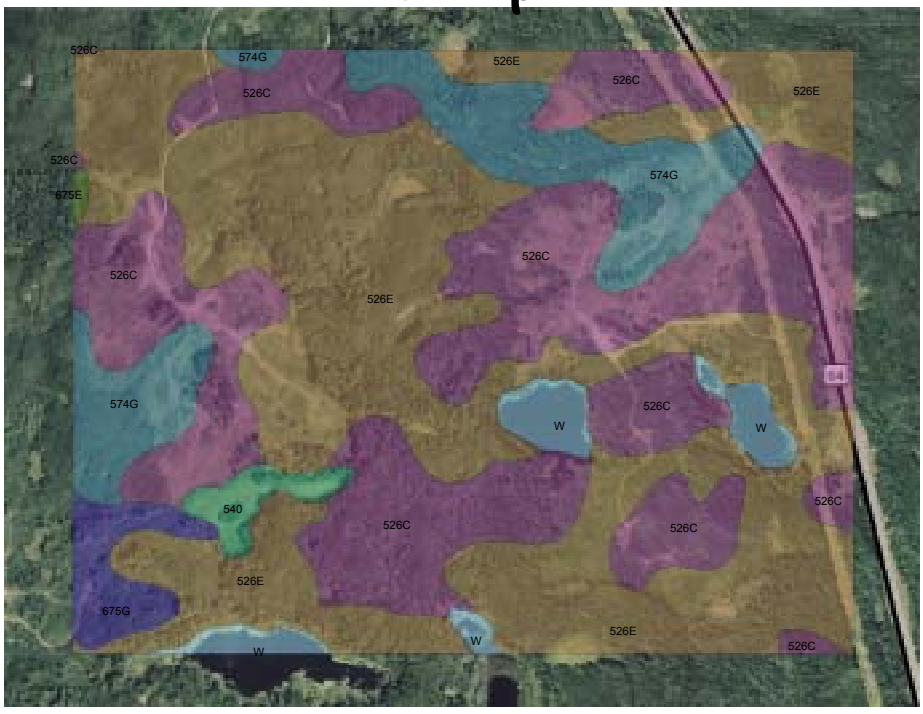


A wide range of particle sizes from clay and silt and larger makes the best soil for trail tread. The smallest particles are binders, larger particles better resist displacement and erosion while providing strength in wet conditions, and medium particles of all sizes add structure that helps stabilize the tread. Compaction greatly strengthens such treads by eliminating spaces and improving binding.

The ideal tread material is a loamy mix with humus and a significant gravel content. Such a mix will provide stability, durability, and drainage. The mixture will be able to withstand the forces of compaction, displacement, and erosion. Unfortunately, that ideal mixture is generally not very prevalent, hence the need to either modify the trail design parameters or modify the tread material.

There is comprehensive soil mapping and information available for every state and county in the United States through the USDA National Resources Conservation Service (NRCS). NRCS provides tables that interpret soil map units for different uses. Those interrelations vary depending upon the age of the surveys, but often there are interpretations for light roads, or foundations that may be useful to the trail planners. Their website has just about everything planners and designers would need to know about soils. Soil mapping for Canada is available through the Agriculture and Agri-Food Canada, National Soil DataBase (NSDB). Many federal, state, and provincial agencies also have their own soil mapping database. As with any area mapping product, the level of detail may not be sufficient for the desired application, so some level of ground verification is usually needed to ensure the accuracy of the data.

Soils map



An example of soil inventory mapping from the NRCS. Depending on the detail of the mapping effort, the mapping polygons may include small areas of other soils called "inclusions," or may describe soil complexes or associations. The mapping unit description and interpretive tables that accompany the maps will help you extract valuable information from the soil survey.

Rocks

Most tread materials also contain unconsolidated bedrock or loose rocks. In the right mix of size, shape, and content, rocks can add to the durability of the soil. And like soils, these materials are also categorized by size. There are four classes:

- Gravel: 2 to 75 millimeters (mm) (sand size to 3")
- Cobbles: 75 to 250 mm (3" to 10")
- Stones: 250 to 600 mm (10" to 24")
- Boulders: larger than 600 mm (larger than 24")

These materials are a benefit to any trail tread because they provide weight bearing and durability by resisting the forces of compaction, displacement, and erosion. They also add to the natural character of the trail, so they increase the rider experience. A challenge for OHV trail designers is how to provide challenge and still have sustainability. Rocks can help provide that opportunity. Soils with a high angular rock content may allow the designers to increase the grade. Exposed bedrock, firmly embedded rocks, slab rock, slick rock, and boulders can provide outstanding technical challenge while maintaining tread durability.

This rock outcropping was used as a pivot point for a curve in the trail. The rocks help stabilize the soil and increase the variety in the trail.

Unfortunately, a rock is not always as hard as a rock; some are durable and others are not. The three types of rock are igneous, sedimentary, and metamorphic. Igneous rocks have solidified from a molten state. They are tough, hard, and have little texture or layering. Examples are granite, dense basalt, and obsidian. Sedimentary rocks have been formed by the accumulation of particles that have been compressed under heat and pressure to create rock layers of hardened sediment. These are not as hard or durable as igneous rocks. Because the rocks are compacted in layers, each layer may have a different density and bonding strength, hence the layers can separate under the forces of turning tires. Examples are sandstone, limestone, shale, and gypsum. Metamorphic rocks are older rocks that have been altered by extreme pressure, temperature, or chemical actions. These are tough, hard rocks. Examples include quartzite, schist, marble, and gneiss.

The high rock content on this grade has made it durable. The grade is steep (25%) but short (50'). In spite of a dramatic increase in use, this slope has changed little in 15 years of monitoring.

Depending on their compositon and hardness, some rocks on or near the surface tend to weather more than others. The forces of expansion and contraction created by hot and cold cycles cause micro-fractures and the freeze-thaw action of water expands

those fractures and weakens the rock. Therefore, rocks near the surface may become rippable even though they appear solid. Depending on the type of rock, this weathering could make the rock rippable for a few inches or a few feet. As designers lay out a trail, they should be looking at and assessing the protruding rock. Is it rippable or is it tied to the center of the earth? Should it be taken out, circumvented, or left as a challenge feature? A couple of quick pokes with a pick or other implement will give designers a hint as to the solidity of the rock. The designers should remember that the material will be harder below the surface.

With the softer rocks moguls can actually develop in the rock; grooves can be cut into it by tires. Softer rocks used as technical features can literally disintegrate over time. Rocks that have cracks or fracture lines are likely to break along those lines under the forces of vehicles. Does that mean that the designers should avoid utilizing the softer rocks? No, any rock is better than no rock, but the designers need to realize that changes will occur. Ten years of durability is better than none, and ten years of providing a high-quality rider experience is better than none.

Another type of common tread material is decomposed granite or DG. It is granite rock that has weathered and broken down into various sizes from gravel to sand-sized particles. Depending on the area and the mix of sizes, it can be a good tread material or a very poor one. It tends to have round particles, but if there is a good mix of sizes, or if they have been mixed with other soil types, especially clay, they can produce a durable tread. If the particles are homogeneous regardless of their size, they do not bond together and displace very easily.

Volcanic rock, being molten from the ground, is igneous rock that includes basalt, rhyolite, and andesite. Basalt is the most common and it has several forms depending on how quickly the lava cooled and how much gas was trapped in it forming vesicles. A gray lava flow is basalt. It can be very hard and durable with a low vesicle content, but it gets weaker as the size and number of vesicles increases. The reddish lava rock are cinders. They are highly vesicular. The tan to white pumice has so many vesicles and trapped air that it floats. Cinders and pumice make poor tread materials because they are granular, weak, and non-cohesive. They will compact over time, but they are dusty as they break down and with no cohesion, they displace very easily. Loose pumice on the surface of the trail tread can float away in a heavy rain, which is undesirable in a tread material.

Design Implications of Rocks

- Bedrock or well-embedded rocks provide superior resistance to compaction, displacement, and erosion.
- Angular rock binds well with other tread materials as long as the voids between the rocks are filled with a variety of other rock and soil particle sizes. The more rock, the more durable the tread becomes. This could allow for steeper grades.
- Round rock like river rock does not bind well with other tread materials and can be easily displaced.
- If all of the rock particles are homogeneous in size, both angular and round rock can be displaced. Consider mixing in clay and other soil and rock particles as a binder.
- Rocky treads tend to drain well so they do not become muddy when wet, but they can get slippery.
- Gravel, cobbles, and stones can be used to harden wet areas.
- Hard rock doesn't erode, but the soil particles around it does. Frequent drainage is still important to control water volume and velocity.
- Soft rock can break down and erode.
- Rocks with horizontally oriented sharp edges can be tire busters and rim benders. Either break off the edges or pad the approaches to them to reduce the angle and force of impact.
- While surface rocks provide variety and challenge, less experienced riders will often try to ride around them if possible, which creates widening of the trail. Strategically place boulders, logs, or other barriers to deter this widening. Better yet, if possible, provide an easy-out around the rocky area.

As the soil at the base of this rock slab gets displaced, it will be increasingly difficult to negotiate this black diamond designated trail. This rock slab provides challenge and a WOW experience.

This trail uses a short, but steep climb, to add challenge. The steep grade is stable because the tread is made up of large rocks firmly embedded in the soil.

Solid rock outcroppings make great opportunities for challenge.

This shale rock is durable, technical, and has an outstanding WOW factor.

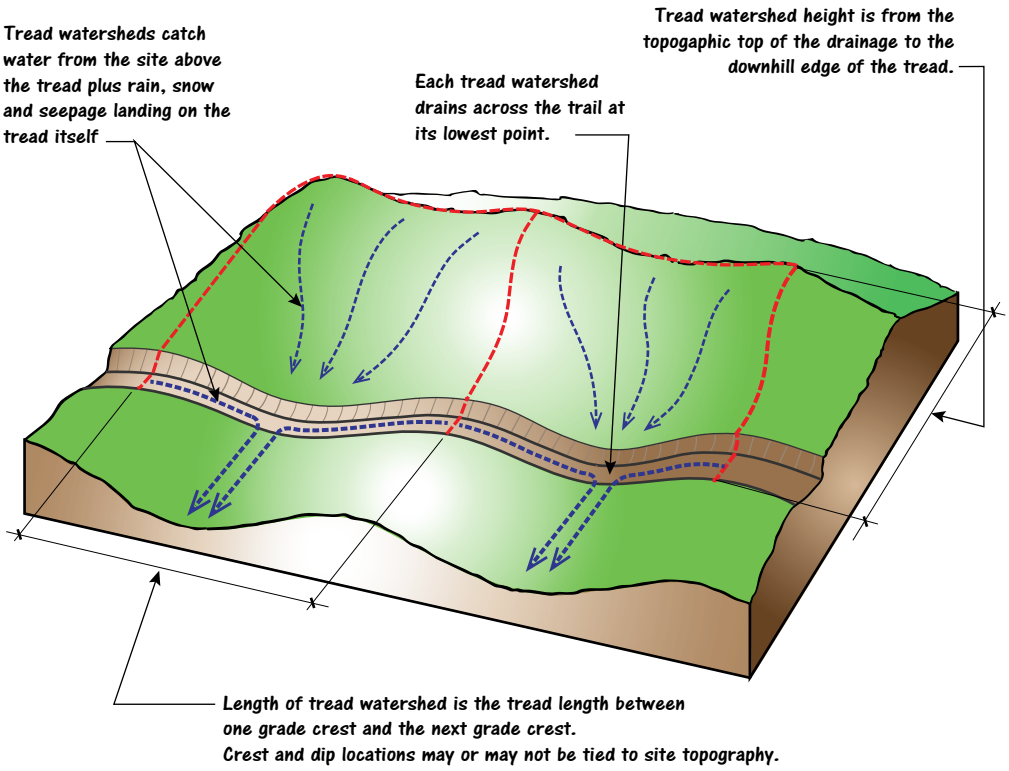
The natural process of erosion has provided a durable and exciting technical challenge along this stretch of trail.

Firmly embedded angular rocks on trail providing technical challenge

These rocks are too small and not embedded well enough to withstand the forces of this 4WD trail. They will displace causing diminishing challenge of this run and potentially unacceptable site impacts.

Section 4: Understanding the Dynamics of Water

In trail design, speed and water create issues, but both can be managed through proper design. Designers can roll the grade to force water off the trail at regular intervals. Many factors influence how water is forced off the trail, including soil type, topography type, frequency and intensity of use, control points, trail grade, tread width, vegetation (ground cover and tree canopy), climate (arid or wet), and seasonal weather patterns (potential for high-intensity thunderstorms). All of these can affect the amount of water collecting on the trail tread and the behavior of that water. To manage that water, designers need to focus on not only the water on the trail but also the sources of that water. Certainly, as it rains water is falling directly onto the trail tread, but it is also falling on the land above the trail. Some of this water is absorbed into the ground, some of it runs as an overland flow onto the trail, and some of it drains as a subsurface flow and spurts like a spring in the trail. How much water is this and how does it influence the design? Determining how much water may enter the trail profile involves looking at the bigger picture of the landscape and dividing it into tread watersheds.



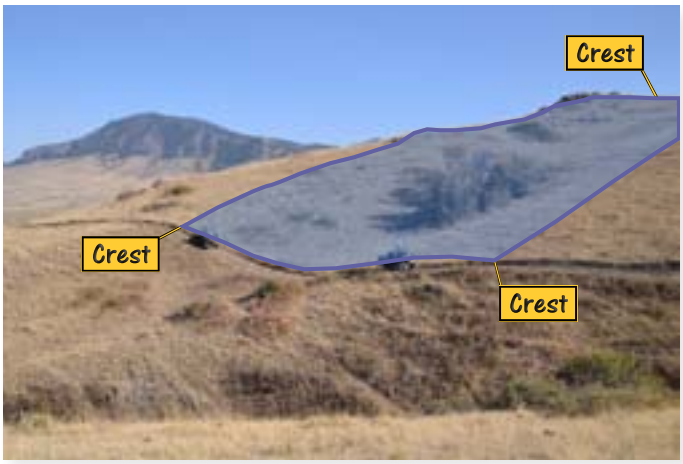
Tread Watersheds

The tread watershed is the area from one grade crest to the next grade crest and all of the land that drains into it from the top of the ridge or a topographic crest.

The topography of the site controls the height of the tread watershed, but designers can control the length of the watershed. Through the actions of compaction, displacement, and erosion, the tread sinks over time and the integrity of whatever shape it had at the time of construction is usually lost. When the tread sinks, it traps the water and the tread becomes a conduit or channel for the water to run. The water will run from the top of the grade crest to the bottom of the grade sag. The longer water runs on a grade, the more velocity it gains, and the more potential it has for scour or sediment delivery. This is called runoff erosion. To increase sustainability, these runs must be as short as possible.

Tools to Manage Water

The designers control water by rolling the grade, which not only helps make the trail sustainable, it enhances the rider experience and fun factor. This is one advantage of designing for OHVs: with a motor, riders don't mind going up, back down, and up again. It's not a chore, it's fun.



Tip, Trick or Trap?

Tip: Topography is your friend because it can be drained. Avoid flat ground.

In order to roll the grades and provide point drainage, designers must have the trail on a sideslope. Flat ground with flat grades does not allow the designers to control the size of the tread watershed and it becomes difficult to drain the water away from the trail.

This is one of many reasons why roads do not make good sustainable trails: the grades do not roll enough and their watersheds are too large. Roads are generally much wider than a purpose-built trail; therefore, the road surface is collecting more water volume than a trail, which can result in accelerated erosion, washouts of the road shoulders, or slope failures below the road drainage points.

This severe erosion occurred below a road drainage point after a high-intensity thunderstorm. The sediment carried all the way to a sensitive creek below.

When rolling dips are constructed on roads with long sustained grades to provide additional drainage, what is really occurring is that those grades are being broken up into smaller tread watersheds. This works but rolling dips require regular maintenance or they are prone to failure under normal or extreme weather events. The better alternative, if available, is to take the trail off those road segments so it can be built with rolling grades that provide shorter tread watersheds and will not fail.

Water Volume + Water Velocity = Increased Runoff Erosion Potential

Here is one example to put things into perspective. A mile of 12-foot roadway has a surface area of about 1.5 acres. A rain event of only 1" will produce about 40,000 gallons of water on this roadway. That same 1" rainfall on a mile of trail with a 50" tread will yield about 14,000 gallons of water. If that trail has a grade break every 300', then the amount of water flowing to each drainage point will be reduced to about 315 gallons. This is the water just landing on the trail. It does not include the water flowing onto the trail from the rest of the tread watershed. As the velocity of the water increases, the number of soil particles and the size of the soil particles being carried away increases. There are variables, but the velocity of the water can double when the grade quadruples. The velocity of the water flow on an 8% grade is twice that of a 2% grade. When the velocity is doubled (2X), the volume of sediment that can be moved quadruples (4X), and the size of particles that can be transported octuples (8X). Clearly, the key to creating a durable trail is to effectively control and manage the water.

This trail has a long, steep grade, and poor soil type; all ingredients of non-sustainability. Like the rolling dips in roads, these belted waterbars reduce the distance that water runs thereby reducing the size of the tread watersheds. Unfortunately, these won't work. As you can see, riders are already starting to ride around the waterbars and as soon as this happens, ruts will form to channel the water and bypass the waterbars. The result is failure. A bandage fix like this is all too common and it doesn't address the root of the problem: poor trail location.

Designers can reduce the water volume by keeping the tread width as narrow as possible and by reducing the size of the tread watershed. They can reduce the water velocity by reducing the grade and reducing the size of the tread watershed.

There are four factors which affect the runoff volume and speed:

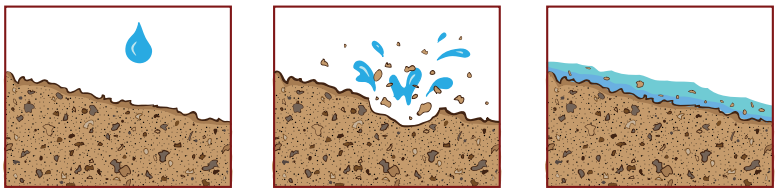
- The height of the tread watershed affects the volume of water.
- The steepness or slope of the topography affects the speed of the water.

- The soil type affects the absorption of the water. If the soil type is hard like clay, has a high rock content, or is slab rock, very little water will seep into the ground and the runoff potential increases.
- The amount of vegetative cover affects the speed of the water. Thick forests or grasslands slow the runoff rate and act like energy dissipaters to stop or divert the direction of the runoff. The less the vegetation, the higher the runoff potential. With vegetation comes vegetative debris called litter such as sticks, branches, needles, and leaves on the ground. This accumulation of litter helps reduce runoff potential. This is why there can be devastating erosion after a wildfire; the vegetative cover has been removed.

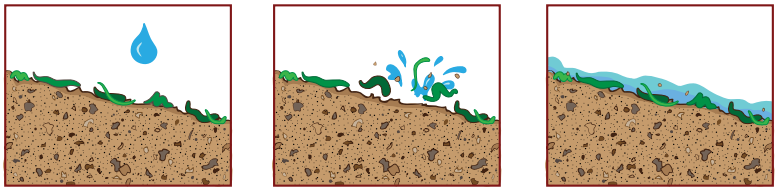
The height of the watershed above this trail is relatively low, but the topography is steep with low vegetative cover and exposed soils. The runoff potential here is high.

Runoff erosion is created by water volume and speed, but there is another type of erosion: splash erosion. The force of the water, even a raindrop, hitting the surface dislodges soil particles and can actually make little craters in the soil. This displaced soil then becomes subject to being carried away by surface water. A tree canopy can act like an umbrella by intercepting the initial force of the raindrops and allowing them to fall gently to the ground below. By locating a trail in the trees, the potential for splash erosion can be reduced. Ground cover and the accumulation of vegetative litter also protect the soil from splash erosion.

The ideal time to design or assess a trail is during the wet season when the amount and effects of the water are clearly visible. Unfortunately, that isn't always possible, so it's important to visualize how the site looks when wet. Sometimes looking at existing road and trail cuts can give clues as to the water dynamics. As a trail is being located, all potential water sources to the trail must be examined. Direct rainfall or snowfall, perennial streams and creeks, and seasonally wet drainages are obvious, but other water sources may not be that obvious. There may be a subsurface flow of water and the trail, once cut into the sideslope, may intercept that water. Groundcover can often



With no protective cover, raindrops can splash soil particles up to 3' away. Soil particles and aggregates that have been detatched are then transported down the slope by runoff water.



Tree canopies and vegetative cover cushions the fall of raindrops and reduces or eliminates splash erosion.

This heavy tree canopy helps protect this trail from splash erosion. The high rock content in the tread will add to the durability of this trail.

A high-intensity rain storm shortly after this fire resulted in a massive overland flow that washed across this trail, filling it with mud.

Tip, Trick or Trap?

Tip: Significant weather events such as 100-year floods can't be predicted, but designers must assume they will occur and protect the trails accordingly

Though not steep, the grade on this fenceline trail is too long making the tread watershed very large. This area is subject to high-intensity thunderstorms, so the erosion risk here is high.

This is a view of the bottom of a large tread watershed. The soils on this site are very poor. When the spring storms started, so did the erosion. Though grassed in, look at the rills on the slope that are feeding water to this drainage point.

Though dry, the rills at the base of these rocks indicate springs during the wet season. Even in the winter, the moss is an indicator of a different micro-climate.

cover up tiny rills that will feed water into the trail. Springs can dry up and be hidden. Designers should look at the base of rock outcrops for evidence of seeps. A change in vegetation to a type more indigenous to moisture can be a good clue along with moss, lichens, and small dry rills.

A Closer Look...

Designers should keep trail grades as low as possible. What does that mean? Increasing grade increases the risk of erosion, but increasing grade also enhances the rider experience. If the rolling grades on the trail never exceed 10%, it would probably be quite sustainable, but how fun would it be to ride? Provide for the riders' needs has been a fundamental guiding principle throughout this book. The designers must be constantly assessing the risk factors in each segment of a trail and weighing reduced grade vs. increased rider satisfaction. The designers should ask if they can push the grade at this point or not. If not, what other options can be employed to enhance the experience? Trail layout and design involves a very complex mental process of asking questions and answering them. The intent of this book is to teach designers and planners which questions to ask.

Some of the erosion risk factors are listed below:

Risk Factor	Lower Risk	Moderate Risk	Higher Risk
For the Tread			
Tread Grade	<12%	12%-20%	>20%
Length of Tread Watershed	Short	Medium	Long
Tread Width	Narrow	Medium	Wide
Stability of Tread Material	High	Medium	Low
Tree Canopy Over Tread	Thick, continuous	Intermittent	None
For the Watershed Above Tread			
Surface Area	Small	Medium	Large
Slope	<20%	20%-40%	>40%
Soil Type	Well-drained, sandy	Loamy, moderately drained	High rock content, clay, impervious
Vegetative Cover	Thick forest, thick litter cover	Medium vegetation, grassy, shrubby, no litter	Light vegetation, bare soil

The higher the number of risk factors, the shorter the tread watershed should be unless other mitigations are implemented like hardening or ditching.

Design Implications of Water Dynamics

- During trail layout or trail assessment, carefully examine all potential water sources and analyze their effects.
- Trail grades should be kept as low as possible, yet still provide the desired experience.
- Tread watersheds should be as short as possible by rolling the grade.
- Trail tread should be as narrow as possible. If converting a road to a trail, any excess width should be removed.
- Seek out vegetative cover whenever possible.
- Avoid steep, open slopes whenever possible.
- Consider other design or management mitigations such as reducing the grade, hardening the tread, increasing the maintenance frequency, or temporary closures to minimize potential effects.

Management Implications of Water Dynamics

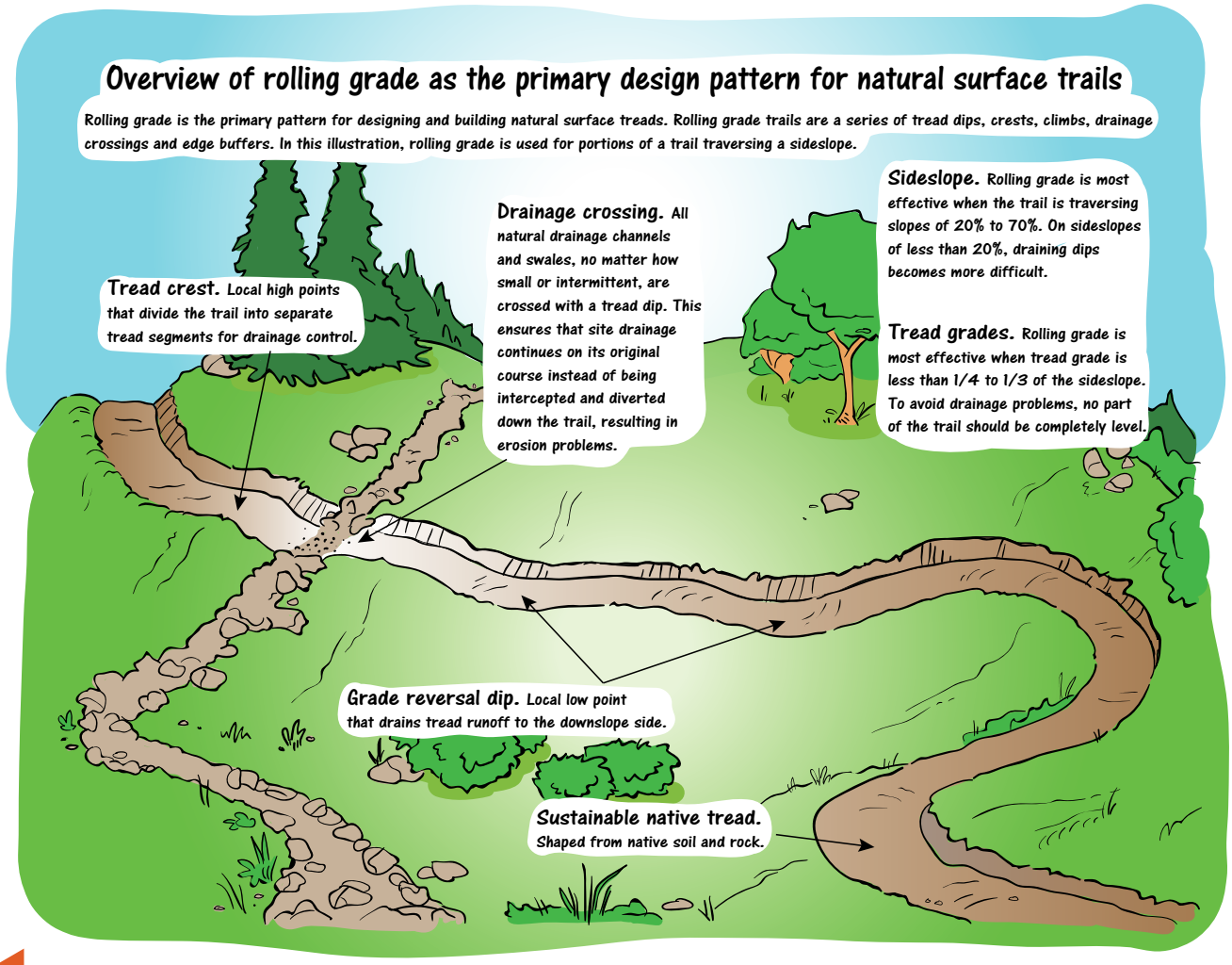
If designed properly, trails will be most susceptible to compaction, displacement, and erosion within the first year after construction. After the first year, compaction helps reduce displacement and erosion risk to some degree. Delaying the opening of a trail can assist natural weather events to help compact trail tread. If a trail is constructed in the fall, consider closing it to use until the following spring. If a trail is constructed in the spring, consider closing it until there have been several weather events.

- If possible, do not schedule an event on a trail within the first year after construction.
- Schedule events during the times when soil stability is likely to be the highest.
- Train trail personnel to look for indicators of problems before they become major issues.
- Schedule and perform routine maintenance.
- Consider closing the trail to use during periods of tread instability.
- Use websites and other media to educate riders to avoid riding during periods of tread instability.

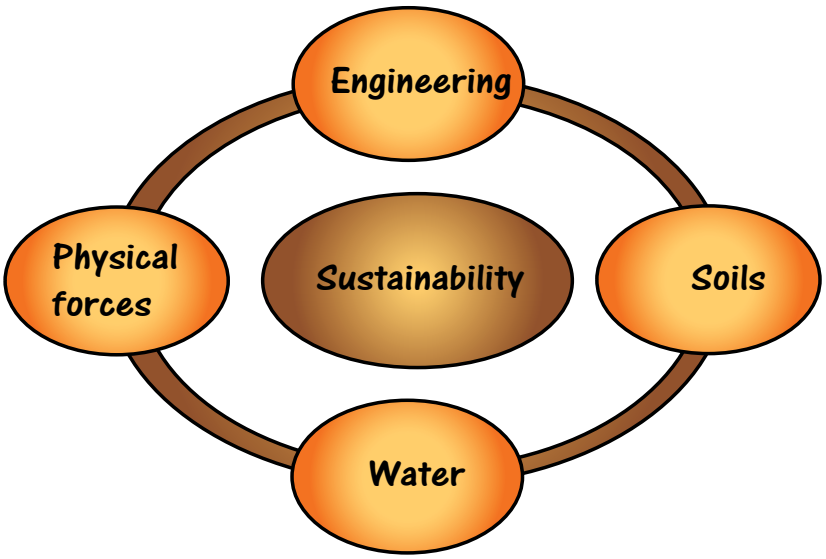
The Elements of Sustainability

It is important to understand the elements of resource sustainability: engineering, the physical forces, soils, and water. This gives a better understanding of the natural environment and how to create a great and sustainable trail.

Who needs this understanding? ALL field personnel. The trail planners and designers, but also the people conducting assessments or condition surveys, maintenance personnel, key volunteers and partners, construction supervisors, and the managers all need to have the ability to look at a piece of ground and understand what is or could be going on there. With that knowledge, they can be pro-active and implement adaptive management in a timely fashion. It isn't by accident that all of these personnel fit into the Great Trail Continuum. A great trail is only created by effectively and equally applying all five elements of the continuum together.



Elements of sustainability



Tip, Trick or Trap?

Trap: The "it's been there forever" trail: It is not uncommon during planning for riders to show planners one of their secret trails. It is often an old race trail that runs up the slope at 40+%. It is stable, grown in, shows little signs of erosion, and can be a really fun trail. The riders want this trail incorporated into the designated trail system and their argument is that "it's a great trail and it's been there forever."

Often, the only reason that trail is stable is because just a handful of riders know about it. If incorporated into the trail system, instead of having six riders per year, the trail could have six riders per day. The trail will not be sustainable and will fail because the use level was changed significantly. Designers should not fall into this trap.

Need more? Learn more here...

NRCS website: http://www.nrcs.usda.gov/wps/portal/nrcs/site/national/home/

NSDB website: http://sis.agr.gc.ca/cansis/nsdb/index.html

Designing Sustainable Off-Highway Vehicle Trails, Kevin G. Meyer, USDA Forest Service, Technology & Development Program, November 2013

Natural Surface Trails by Design, Troy Scott Parker, Natureshape, LLC, 2004

Trail Planning, Design, and Development Guidelines, Minnesota Department of Natural Resources, 2006

Trail Solutions, IMBA's Guide to Building Sweet Singletrack, International Mountain Bicycling Association, 2004

Water Harvesting from Low-Standard Rural Roads, Bill Zeedyk, Zeedyk Ecological Consulting, LLC, 2006

A Look Back...

Here are some of the elements discussed in this chapter:

- Engineering is the link between providing for the riders' needs and designing for sustainability
- Vision without action is a daydream, action without vision is a nightmare, but vision and action without engineering ensures disaster
- How to calculate grade: Rise/Run x 100 = Grade
- Sustainability Basics: Designers should keep the horizontal alignments moving by using curves and short or no tangents, keep the vertical alignments moving by rolling the grades, minimize the grades, minimize tread width, minimize the size of the tread watersheds, avoid the fall line
- Curvilinear trails increase sustainability
- Both circular and non-circular curves can affect flow and trail difficulty
- Grade reversals provide the most effective drainage
- The physical forces of compaction, displacement, and erosion must be managed through design
- The key to good design is to understand the natural forces and predict their effects
- The trail tread is composed of a mixture of soil and rock. The designer must understand the mixture and the properties of the soil and rock at the trail location
- Designers should keep tread watersheds as small as possible
- Speed and water are issues. Vegetation and topography are friends.
- The key to a durable, quality trail is to effectively manage water
- A quality trail depends on the effective and equal application of all five elements of the process: planning, design, construction, maintenance, and management

Chapter Five
Preparing for the Field

Riding Takes All of Your Wits, Don't Impair Them

The most important and gratifying part of creating great trails occurs in the field. The saying that even a bad day in the field is better than a good day in the office is very true. The field is where the creative juices can flow; where there are options, challenges, and opportunities; and where all of the pieces of the puzzle come together. The planning and design team members can apply their understanding of the landscape, environment, recreation use, and physical forces to make informed decisions that will most benefit the riders while ensuring the protection of the resources. To make effective use of the time in the field, team members need to arm themselves with tools and techniques and have as much knowledge of the area as possible.

Section 1: Gearing Up for the Field

Safety and Risk Management

The field is a wonderful place, but it is full of personal risk. Before heading to the field, the team needs to take some time to examine the risk factors and mitigate them. The primary objective every day is to come back safely and the team does that by stacking the odds in their favor; being prepared and alert. What is the weather forecast? Dress accordingly. Are the soils slippery when wet? Wear appropriate footwear. What insects are in the area: bees, mosquitos, ticks, chiggers, scorpions? Wear appropriate clothing; take insect sprays; and look before walking, sitting, or reaching. If someone is allergic to any bites or stings, take an Epi kit. What animals are present: bear, deer, elk, moose, or domestic livestock? Don't be too proud to wear a bear bell or pack bear spray. What poisonous reptiles are present? Again, look before walking, stepping, and reaching. Snake gaiters are hot, bulky, and certainly not fashionable, but the peace of mind they offer is worth it. What poisonous plants are in the area? Know what they look like and where they grow and dress accordingly. Vehicles are needed to get the team in and out of the field every day. What condition are the trucks, ATVs, OHMs, etc. in? If there should be a mechanical malfunction, how will the team get out? Is there party or drug activity in the area? Are there people who want to live off the grid? Be aware and avoid walking into a situation that may put the team at risk. Finally, know the team members' physical limitations. If team members don't think they can safely traverse the terrain on a given day, don't go. Stay in and catch up on paperwork.

The proper gear helps you have a safe and enjoyable day in the field. Minimizing your risk will help ensure that you can enjoy another day tomorrow.

Certainly, one of the best things to do to keep the odds in a team's favor is to carry and use personal protective equipment (PPE). This may include riding gear, chainsaw gear, climbing gear, hardhats, high visibility vests, etc. There is no valid excuse to not wear it. Manage risk and keep everyone safe. No one can do trail work if they're hurt.

Being prepared can turn a cold, wet lunch from something to endure to an enjoyable event. When you take a bite of your sandwich and you get more bugs than sandwich, it's time for the bug nets.

The goal of all of this is not only to keep team members safe, but to maximize the efficiency of the time spent in the field. Many agencies formalize the project analysis and self-protection process on a Job Hazard Analysis (JHA) form.

Basic Field Instruments

Whether doing reconnaissance of a project site, assessing an existing trail, performing trail layout and design, or establishing construction controls, the team needs to have an array of tools available to help perform whatever task is needed. Once in the field, the office, supply room, and shop are in team members' day packs.

Consider taking a variety of key instruments and tools. A short list is described below. Additional information can be found on the Great Trails website at www.greatohvtrails.com.

A **clinometer** is an invaluable little device used to measure the percent of slope or degree of slope between any two points. It requires binocular vision and takes a little practice to use, but it is the number one companion of any trail designer. The clinometer is not highly accurate and if it gets knocked around in the field it can lose calibration. There is no calibration adjustment, but a good test is to shoot the grade to the uphill point and then once there, shoot the grade back to the downhill point. If they are off by 3 or more percent, it's time for a new one.

A **GPS receiver** uses global positioning satellites to pinpoint position, track progress, approximate elevation, and establish waypoints. Many have a built-in camera, radio, barometer, compass, or other handy features. Even recreation grade units are highly accurate. Team members should learn how to navigate and use the TRACKBACK or GOTO features on the GPS before they need them.

Taking handwritten notes or typing in waypoint data on a GPS receiver can be laborious. Instead, it's faster and easier to record the data on a **voice recorder**. This data can be digitally downloaded and saved to a computer. A voice recorder app on a smartphone can also be used.

Though a lot of other devices have built-in cameras, a quality pocket-sized **digital camera** still takes better pictures and offers more functions. Because there can never be enough photos taken in the field, it's a good idea to have one at all times. Don't forget a fully charged spare battery. A flexible mini-tripod is also handy to capture the perfect shot.

Roll-up **100-foot cloth tapes** are very handy for measuring or designing structures or facilities.

Small multi-blade, **multi-function tools** are invaluable in the field.

Spare batteries should be packed for whatever device uses batteries. Field time is valuable. Don't have it cut short because of dead batteries.

Team members should have **radio communication** so they can coordinate and work together more effectively and safely. The little consumer-grade GMRS or FRS radios have a good range and good call quality.

Flagging and Pin Flags

The flagging that comes in a roll is called ribbon flagging and it is offered in a variety of colors and patterns. Flagging is used to mark the trail alignment as well as various work items. Most projects have a list of flagging protocols that spell out the color and pattern to be used for each work item. It is very important that the flagging used for a trail does not conflict with what is used by other agencies or industry for timber sale boundaries, road surveys, proposed utility corridors, mining claims, seismic lines, transect surveys, etc.

Ready for the field with the day pack, pin flags and carrier, and pre-tied paper clips on an embroidery hoop.

A key point to remember about flagging is that it is not very durable. Deer, cows, rodents and insects eat it; the UV rays from the sun can fade the color in just a few months; and the wind, hail, and cold tear it to shreds. Hanging long streams of flagging is great for visibility, but it is more susceptible to the critters and the elements and thus has limited longevity. Shorter flags last longer. Since a large percentage of the flags will disappear, tie them close together. A 15-foot interval works well. It can be several years from the time a trail is designed to the time the trail gets constructed.

What is the best method to tie the flags? A simple overhand knot works well for temporary flags. A key thing about knots is that they should be simple to tie and untie when there are changes. A double overhand knot is not simple to undo. A bow knot is simple. One pull on the loose end and it comes off. Unfortunately, if that pull is coming from an animal, the flag will be lost. A loop knot works well. Fold the piece of flagging into a loop, place the loop over the limb, and pull the tails through. This simple knot is easy to tie and untie. Repeat the process for a double loop.

A simple loop knot is easy to tie and untie and it's durable. (loosely tied to illustrate the knot)

It takes more time, but tying a double or triple knot will last significantly longer and after a couple of years, only the knot will be left. The downside of using multiple knots is that it is very difficult and time-consuming to remove the flags to change the line. Tie the multi-knots on the last pass through a flagline, not the first.

A trick is to pre-tie flags onto smooth jumbo paperclips. These are easy to clip on and off, are durable, and are more visible when only the knot is left. There are four main advantages to the paperclip trick: it eliminates the fumbling and pain of trying to tie a knot in a briar patch; knots are tight and consistent since they are tied in a warm controlled environment; it is fast, clip it on and move on; and rather than focusing on reaching in and tying a difficult knot, the designers can stay focused on what the trail grade, alignment, or drainage is doing.

The paper clips come in boxes of 100. Tie a box at a time and hook them onto a string. When ready to use, transfer them from the string to a slightly modified steel spring-tensioned embroidery hoop from a fabric store and head to the field.

The loop knot tied onto a jumbo paper clip is a slick trick: fast, efficient, durable.

A pin flag is a wire whip with a colored flag on top. The length of the wire and the size of the flag vary. Pin flags are handy in open areas or meadows where there are few trees or brush to hang flagging. The longevity of pin flags can be shorter than that of ribbon flagging. The flag tends to break off in the wind and cold leaving only a rusted wire as a marker. The wire will usually stay in place and at least the critters won't eat it, but it can be very hard to find once it is no longer shiny or if it's in tall grass. It is best to install the flags at short intervals. Pin flag carriers or quivers are available in a variety of lengths. Pin flags provide a great visual because they highlight the flow of the trail. They can be especially helpful when creating circular curves in the field.

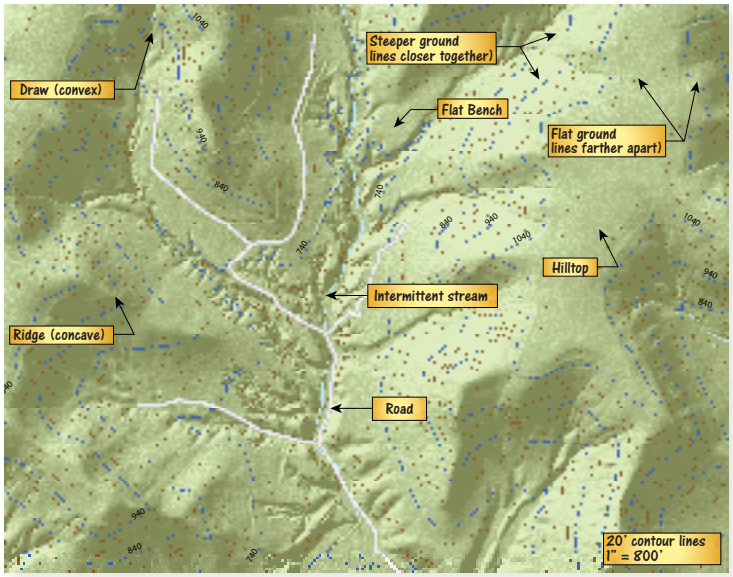
Re-flagging is necessary on most projects that won't be implemented within one year. Making an accurate survey of the flagline with a good GPS is essential in order to re-establish the line.

Section 2: Finding the Way in the Field

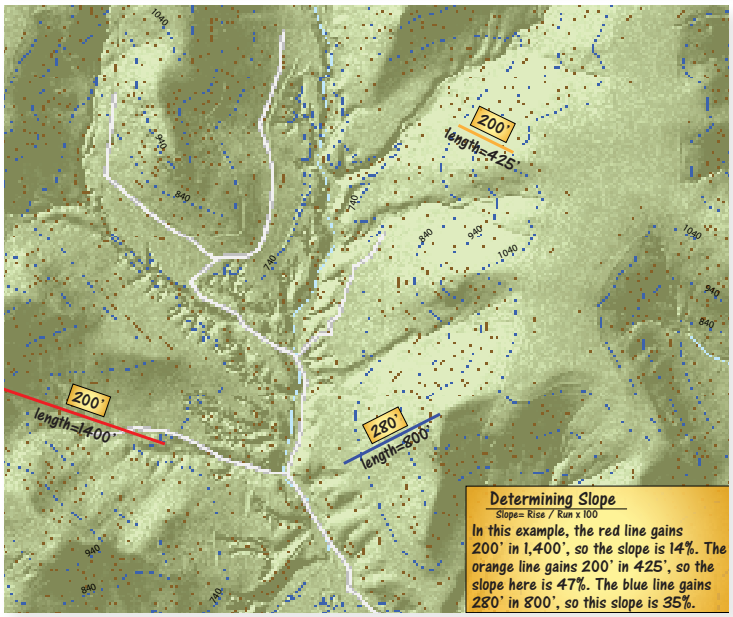
Before going to the field, planning and design teams should arm themselves with as much knowledge of the site as possible. They should study maps and imagery for valuable information on the site, where to go, and how to get there. Resource data in GIS layers can show opportunites as well as constraints. Knowing how to use a GPS receiver in conjunction with maps can help the team efficiently navigate to where they want to go and can tell them where they are in relation to the opportunities and constraints. Mapping technology is constantly evolving with more recreation-grade products, higher quality, more features, and lower cost.

Using Topographic Maps in the Field

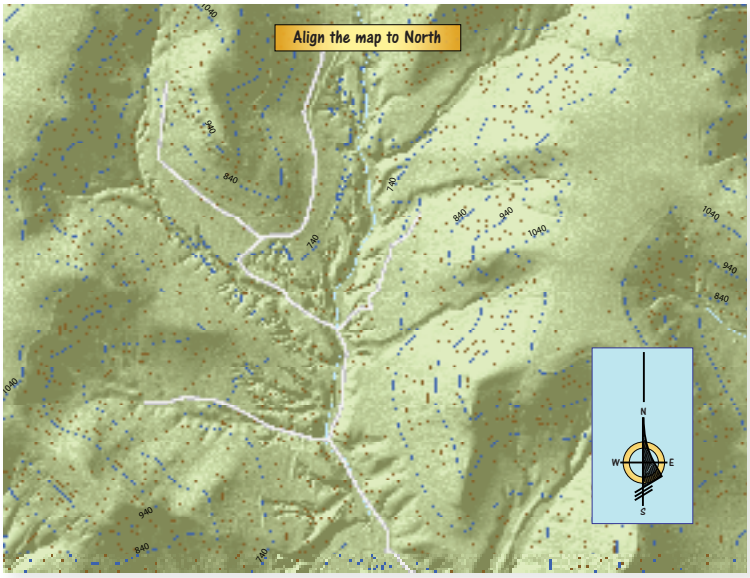
Topographic (topo) maps illustrate features such as contour lines, mountains, roads, trails, streams, lakes, towns, buildings, power lines, forested areas, open areas, and other features. These features are mapped using aerial photographic interpretation called photogrammetry. In the United States, most of this mapping was done by the U.S. Geological Survey. The entire country is divided into named rectangles and the maps are referred to as USGS quadrangles, or quad maps.

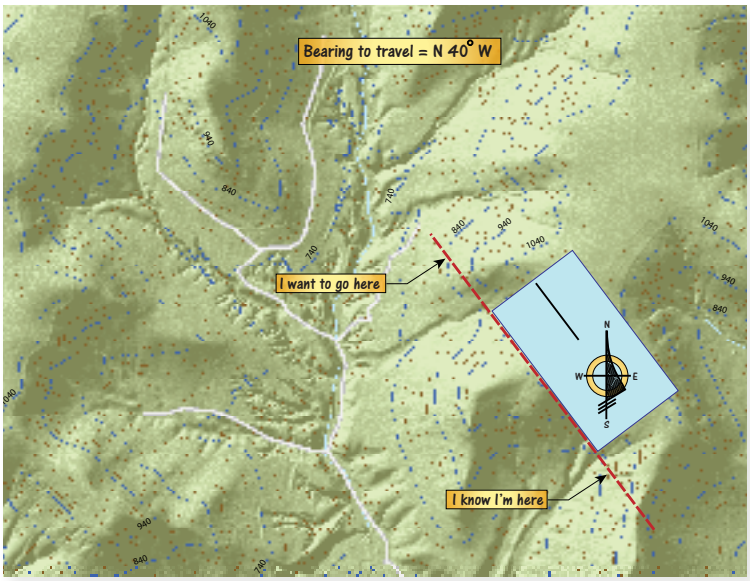


Contour lines are informative features on topo maps and represent points of equal elevation (height) joined together to form a line. Contour lines typically represent elevation intervals of 10, 20, or 40 feet. The exact contour height above sea level is less important than how the lines represent the shape and slope of topography. The closer the contour lines are together the steeper the topography is. Contour lines also illustrate ridges, valleys, and depressions. Convex lines pointing uphill represent valleys or drainages. Concave lines pointing downhill represent ridges or hills. Contour lines that are concentric circles indicate a hilltop. Saddles are flat areas on a ridgeline often between two hilltops. Saddles are indicated where the same contour line on each side of a ridge comes close together without touching. Lines that have small segments at right angles to the contour line represent depressions or sinks and are typically wetlands, lakes, or holes. A contour line ending at the edge of another one depicts a cliff that has height but no width.



Topo maps are useful not only because they show vertical relief as contour lines, but also because they are plotted in a horizontal scale, usually 1:24,000 or 1:50,000. This means that 1 inch equals 24,000 inches (or 50,000 inches). Because topo maps are two-dimensional, the distance is horizontal distance, not slope distance. The slope of the ground or the grade of a trail can be calculated from the elevation difference and the horizontal distance between any two points. As planners and designers become more familiar with contour lines, they will be able to understand slope simply by studying the contour lines. An experienced trail designer can create a conceptual trail alignment by drawing it on a topo map and then refining it in the field.





While topo maps can be used to plot a trail, there are often features such as large rocks and sometimes ledges that do not appear on contour maps. Aerial imagery used in conjunction with the topo map can help identify these features, but often they need to be located in the field, marked on the map, and recorded with a GPS unit.

Using Aerial Imagery in the Field

While topo maps and other maps are very useful, they still don't allow a clear visual of the landscape before venturing into the field. Aerial photographs merged into a seamless map are available from several software sources. Some are free, but the ones with highest quality imagery and the best drawing and editing tools are not. With aerial mapping, planners and designers can see the ridges, draws, creeks, ponds, rock knobs, cliffs, vegetation type and density, timber management units, wildfires or fire management units, and other important features.

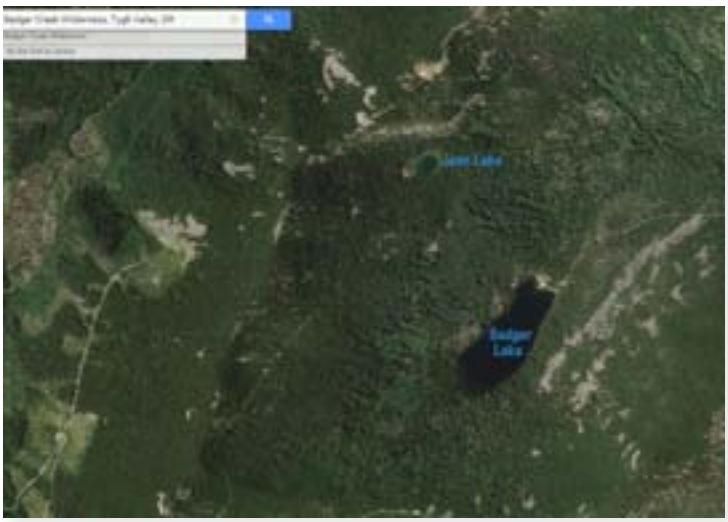
The most common free aerial mapping is Google Earth and the software for most GPS units can view the tracks and waypoints in Google Earth. While it is primarily used to view data, it can also be used as software to create very basic data by drawing points, lines, or polygons. GIS data can be exported from other software as KMZ or KML files and easily overlaid in Google Earth. Layers exported to these formats can easily be added by clicking on them as an email attachment or as a link on a webpage, or opened from within the program. The end user must have Google Earth software loaded on a computer and have an internet connection for this software to work. Aerial photography and terrain data are automatically loaded into Google Earth if an Internet connection exists. The quality of the aerial photography depends on the area of interest, but it tends to get very pixelated as the user zooms in.

Two views of the same landscape: above, a 2-D topo map with shaded relief showing Badger Lake using DeLorme Topo North America software; right, a projected 3-D view of the topo map with shaded relief.

Another useful tool is the ability to record a flyover path, which can also be shared with others. For example, a recorded path can illustrate the alignment of a proposed trail as a 3-D flyover.

Many of the better GPS units have aerial maps available at a cost from the manufacturer that can be downloaded and used as a base map in the GPS. Assuming that the mapping is current, this feature allows planners and designers to view the landscape not only where they are, but also where they may want to go. They can view a desirable feature on the GPS screen and the unit will give them a bearing and distance to get there. This can be a real timesaver when exploring new ground.

An aerial view of Badger Lake using ExpertGPS software.



The same view using Google Earth software.

Using GPS Technology

The global positioning system (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit around the world by the U.S. Department of Defense. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use the GPS signal. A GPS receiver or unit is used to receive the information from satellite signals and uses triangulation to calculate the person's exact location. Essentially, the GPS unit compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Adding measurements from a few more satellites enables the receiver to determine the person's electronic map or as a coordinate such as longitude-latitude. A GPS unit must be locked on to the signal of at least three satellites to calculate a 2-D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the person's 3-D position (latitude, longitude, and altitude). Once the person's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, altitude, sunrise and sunset time, and more.

Atmospheric and topographic conditions can affect the quality and strength of GPS signals and cause distortions in the data. The location of satellites at given times of the day provide for better or worse signal strength, which affects the accuracy of triangulation. This is typically only important when trying to locate a feature within a foot or two of where it is actually located. Cloudy, rainy, or snowy conditions can have an effect on signal strength and of course lead to moisture build-up in the electronics. GPS signals can be distorted by bouncing off buildings and rock cliffs. When working in areas with tall hard surfaces or in a deep canyon, it may be necessary to use higher quality GPS units that can filter distorted data or switch to the use of a map and compass in these areas. Another technique is to capture a good GPS position from a nearby high point and then measure a bearing and distance from that GPS position. Dense forest canopy can also have a significant effect on GPS signal strength. This can be overcome by using higher quality GPS units or using a combination of GPS, map, compass, and laser range finder. GPS units are usually more accurate after they have acquired GPS data for at least 15 minutes. A good accuracy test for a GPS unit is to see how accurately it is locating a known point such as a road intersection in an open area.

GPS units come in many sizes, colors, and most important price ranges. There is a general correlation between price, accuracy, and functionality. The most commonly used and lower cost GPS units are incorporated into smartphones and tablets. Smartphones formerly only used cellular signals to triangulate location; most now have GPS receivers so their navigation apps can work in remote locations. While these devices are more suited for general navigation purposes, they can be used as GPS units if they are thoroughly tested to make sure they provide adequate accuracy and a reliable signal. GPS accuracy is usually measured in both horizontal and vertical precision.

A Closer Look...

How are you going to use your photos? While it may be convenient for your GPS or other device to take pictures, the quality of those pictures may not be as good as with a digital camera. They may be fine for trail file or condition assessments, but they may not have the desirable quality for presentations and formal documents.

For general navigation and trail design work, planners and designers should find a GPS with an average horizontal accuracy of 3 meters or less. This means the GPS unit will consistently provide an average position within 3 meters or less of the actual location. Accuracy for vertical measurement, or elevation above sea level, is less precise and will usually be within 30 to 100 feet of the actual elevation. A couple of the most important features when shopping for a GPS include the ability to easily download GPS data from the unit and to display topo maps or other imagery on the unit. One of the biggest downsides of recreation-grade units and software is that they don't allow for large format printing. Only what is shown on the screen can be printed, so making a map involves the laborious process of printing several pages and cutting and pasting them together.

When selecting a GPS unit, make sure it has the ability to connect to a desktop computer or send files electronically.

GPS units are very useful tools for a wide range of uses. Some of the most useful functions for trail-related work are provided below.

- Provide an accurate geographic location
- Provide the straight-line distance and direction to a destination
- Record the day's travel as a track, creating an accurate bread crumb trail to reverse and follow home, or use as backup data
- Provide the altitude within 30 to 100 feet
- Record or refer to destinations as waypoints
- Record or refer to trail alignments as tracks
- Load custom base maps on the GPS, including data such as topo map, slope map, recreation sites, trails, campsites, trailheads, sensitive areas, private property, etc.

A conceptual trail design alignment can be completed on a desktop computer and then loaded on the GPS unit. The loaded alignment can be used as a reference line while refining the trail design in the field.

On the right, the GPS cursor shows a location right on a contour line. With the same map datum, it is easy to find the same location on the topo map. Note how the elevation displayed on the GPS matches the contour line elevation.

A geotagged photo documenting a water issue

Smartphones and some GPS units geotag digital photos, which can be used to document the location of trail alignments, features, and scenic views.

Video and voice recordings can also be geotagged to provide more detailed documentation of trail designs and conditions for construction and maintenance purposes. If a video is geotagged to an entire trail GPS line, a split view of a map and video can be used to illustrate a trail design or existing trail. This provides a virtual tour of a trail before it's constructed.

Geotagging records a GPS coordinate within the header data of a jpeg photo. Software such as GeoJot can be used to create GIS points from this geotag information, which can then be illustrated on the GPS for future field work or on maps. GeoJot software can also be used to geotag photos from standard digital cameras using a GPS track or track log. There are digital cameras such as the Ricoh GPS camera that can assign location attributes to photos. This type of camera greatly improves efficiency and quality of digital photography.

Tip, Trick or Trap?

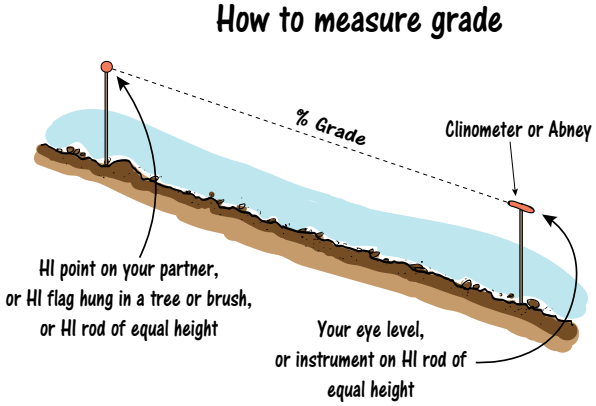
Tip: Practice, Practice, Practice

Spend plenty of time to get familiar with using your maps, compass, and GPS unit. Don't wait until you are in an emergency situation to learn how to use and trust all of the features of your GPS.

Transferring files from a GPS to a computer used to be difficult. While there are many kinds of files used by GPS units, there now are free tools such as the Minnesota DNR Garmin GPS tool and the GPS Bable tool available to convert between these types of files. ESRI ArcGIS software also imports and exports to the most common types of GPS files, including GPX files.

Section 3: Applying Engineering in the Field

Before going to the field, planners and designers need to be able to measure grades and apply basic engineering principles to measure or calculate lines, areas, and volumes.

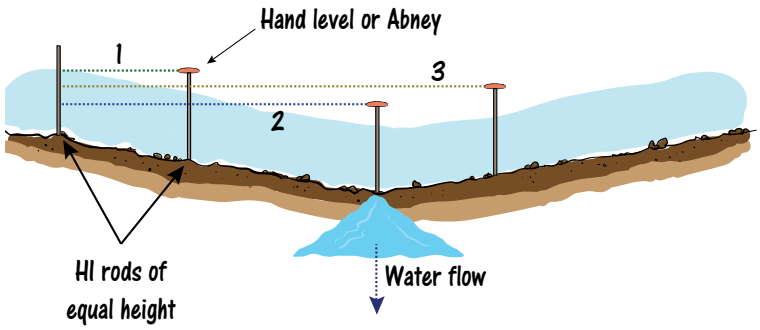


How to Measure Grade

There are three primary methods of measuring grade in the field. The first is the two-person method. On flat ground, two people stand toe-to-toe in front of each other. Using a clinometer or Abney, one person puts the bubble on zero percent and notes the spot where that hits his or her companion (chin, tip of nose, hairline, etc.). That spot becomes the height of instrument (HI) point or zero point on the partner.

Sighting on that same spot as the partner moves up and down the slope will give the percent of grade difference between the two people.

Determining the low point using the HI rod method



The second method is the HI rod method. Take two rods, sticks, or lath of equal length. If there are two people, have one person hold one rod stationary and vertically level while the other person moves up or down slope. If there is only one person, pound one rod into the ground just far enough so it will stand by itself. Put the other rod next to the first and mark the spot where the second rod is level with the top of the first or stationary rod. The first person moves up or down slope with the second rod. That person uses a clinometer or Abney to shoot between the mark on the top or the level marking of the first rod and the second. The result will be the grade difference between the two rods. On flat ground, up or down slope can be visually deceptive. Don't guess. This method is foolproof.

The third method is the one-person method. At a starting point, tie a short flag at eye height on a tree limb or brush (this becomes the HI flag), move ahead and up or down the slope as needed, sight back at the HI flag with the clinometer or Abney and the result will be the difference in grade or slope between the person and his or her starting point. This method does not work well in open areas where there is no vegetation at eye height or in places with very dense vegetation where the HI flag can quickly become obscurred.

Tip, Trick or Trap?

Trap: Never rely on your "eye" to determine grades, especially on flat ground or when determining the low drainage point in a trail

How to Find the Lowest Point in a Grade Sag

On very flat ground or when trying to determine the low point of a drain, the HI rod method works very well. It is usually best to mark off elevation lines on the stationary HI rod and create a makeshift leveling rod. Take a tape measure and make a short dash at 1-inch intervals with a magic marker. It is best to use a hand level or Abney level set on zero because these are more accurate than a clinometer and they usually have magnification in the optics for easier reading. In the example above, sight #1 is below the top of the stationary rod, so elevation has been dropped. Sight #2 is below sight #1, so elevation is still dropping. Sight #3 is above sight #2, so elevation is now rising. Go back to the area of sight #2 and take a couple more shots at the stationary rod. The lowest reading or sight point on that rod will be at the low point of the trail.

How to Lay Out a Circular Curve without Instruments

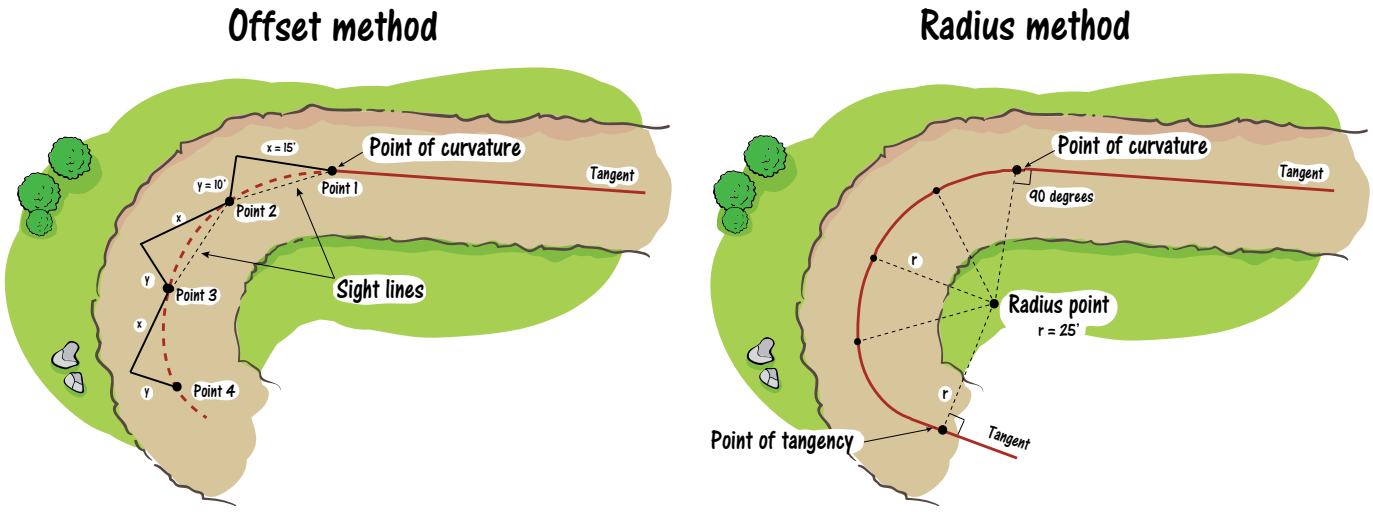
A lot of work field technicians do is conducted without assistance, so to make effective use of time, they need to be able to perform basic engineering applications by themselves. As discussed in Chapter 4, circular curves provide improved flow, increased rideability, and reduced

To be effective, climbing turns must have a smooth radius curve.

tread impacts. There are times when it is essential that the curve be circular such as when designing a climbing turn. These types of turns are the most effective way to gain elevation on a motorized trail, but they must be smooth, flowing, and circular; or significant tread impacts can develop.

Any two points make a line and any three points can make a curve; that same progression can be applied in the offset method to make a curve. It is best to practice this technique in an open field with good visibility. At the starting point of the curve (called the PC or Point of Curvature), insert a pin flag or lath into the ground. This is point one.

Walk ahead 15 feet (x) staying on line between point one and the tangent behind it. From that point, measure 5 feet (y) in the direction the curve will go and insert another pin flag or lath at that offset point. This is point two. Walk ahead another 15 feet staying in line with points one and two. From there, measure 5 feet in the direction of the curve and insert another pin flag or lath. This is point three. A degree of curvature for the curve has now been established.



Planners and designers can now visualize how the curve is taking shape. They can continue this process until the curve is completed (called the PT or point of tangency). They can add intermediate flags as needed between points and adjust any that look out of place.

To make a tighter curve, increase (y) or increase (y) and decrease (x). Once planners and designers have practiced this technique, they can use steps or paces instead of measuring the distances. When they have mastered the technique, they will be able to lay out any curve using just flagging and their eyes.

Another method for laying out curves is the radius method. For this method, the radius (r) of the curve is known. If it isn't known, estimate the radius that will fit the site and then adjust it up or down as necessary. For example, assume a 25-foot radius is needed. From the starting point or PC, turn 90 degrees to the back tangent and measure 25 feet in the direction of the curve and insert a pin flag or lath. This is the radius point of the curve. From this point, measure out 25 feet and insert pin flags along the arc of the curve. If trees or brush are in the way, make several arc measurements. Add intermediate flags as needed between points and adjust any that look out of place.

In case you don't remember your basic geometry or trigonometry, we created a special crash course for you in Chapter 5 on our website. Find it at www.greatohvtrails.com.

This is a well-designed and well-constructed climbing turn. The person building the trail must have the same vision and understanding of OHV recreation as the person designing the trail or a great design will not become a great trail.

A Look Back...

Here are some of the elements discussed in this chapter:

- When preparing for the field, recognize hazards and manage risk. Take the proper clothing and survival gear and always wear the appropriate personal protective equipment (PPE).
- Take instruments to measure and record data easily and effectively in the field.
- There are pros and cons of flagging and pin flags. The paper clip trick and fingerless gloves will make the process of hanging flagging faster and less painful. Pin flags or stake flags generally have a shorter lifespan than flagging.
- Though only 2-dimensional, learning to read contour maps can give the field technician a good 3-dimensional view of the ground.
- A contour map, aerial imagery, GPS, and a compass are basic tools for efficiently navigating in the field.
- Points, lines, and polygons are the primary geometric shapes used in identifying and mapping important features and data.
- Three common methods to measure grade: 2-person method, HI rod method, 1-person method. Remember: Rise/Run x 100 = Grade. Never eyeball grade or drainage low points.
- On flat grades, use the HI rod method to find the low point for drainage.
- Two methods to stake a circular curve in the field without instruments: offset method and radius method

Chapter Six

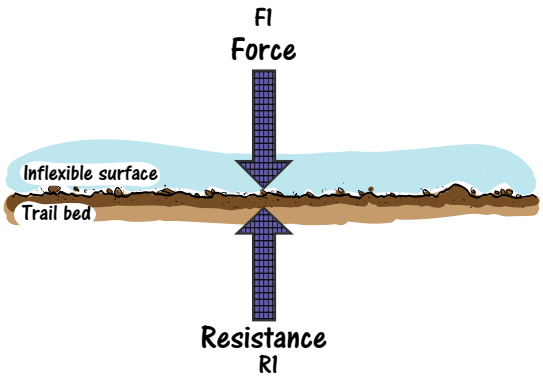
Tools in the Toolbox: Soil Stabilization and Trail Hardening

Stop Invasive Species in Your Tracks

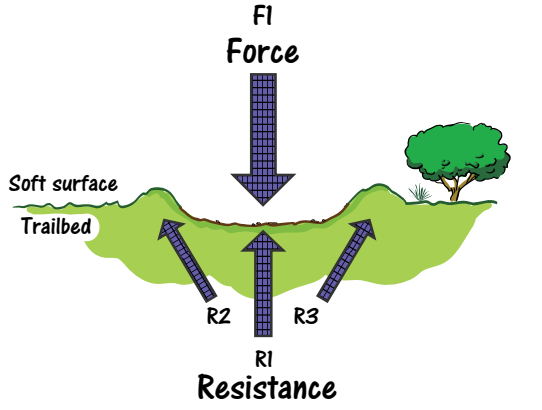
There are times when trails must go through wet areas or soft soils, and there are times it is desirable to have them there to enhance the scenic quality, variety, and rider experience. There are times when no matter how good the soil is, it can't withstand the vehicle volume of use or weight. There are also places, as in road and structure crossings, where the approaches need to be enhanced to ensure smooth transitions. All of these scenarios require some type of tread reinforcement.

Chapter 4 discussed the physical forces and the fact that for every force down, there is an equal and opposite force up. On a hard surface, the upward force is equal to and directly opposite the downward force. As the surface softens, the vertical upward force decreases and lateral upward forces increase resulting in soil displacement and berms. A goal for a durable trail is to minimize displacement, and one way to accomplish that is to increase the strength of the tread surface.

There are two ways to increase the strength of the tread: stabilization, where another material is mixed into the soil, and trail hardening, where another material is added on top of the soil. Before discussing these two methods, Section 1 explains geosynthetics, which are often used in both soil stabilization and trail hardening.



Resistance = Force (Rl=Fl)

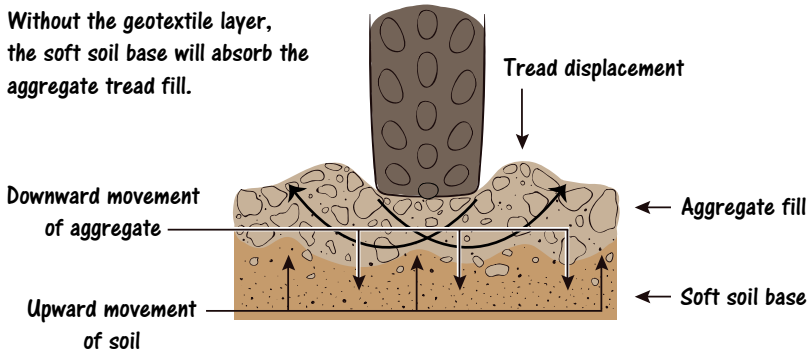


Resistance = Force (Rl+R2+R3=Fl)

Section 1: Geosynthetics 101

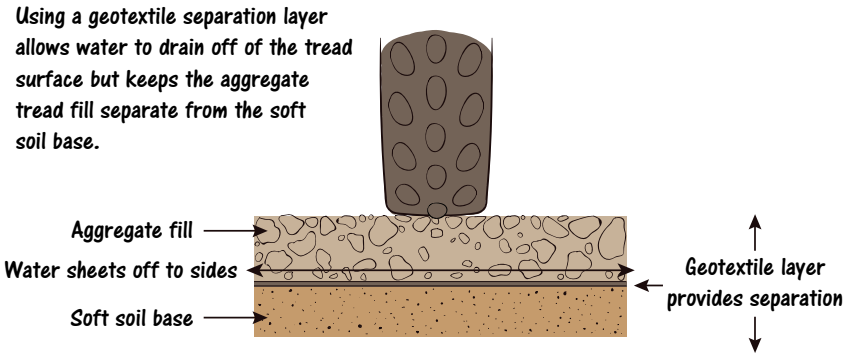
Geosynthetics Defined

Geosynthetics are synthetic polymers that are woven or formed into a variety of shapes. These materials perform six major functions: reinforcement, separation, drainage, filtration, containment, and erosion control. The first four functions are most commonly used for trails and are explained below.

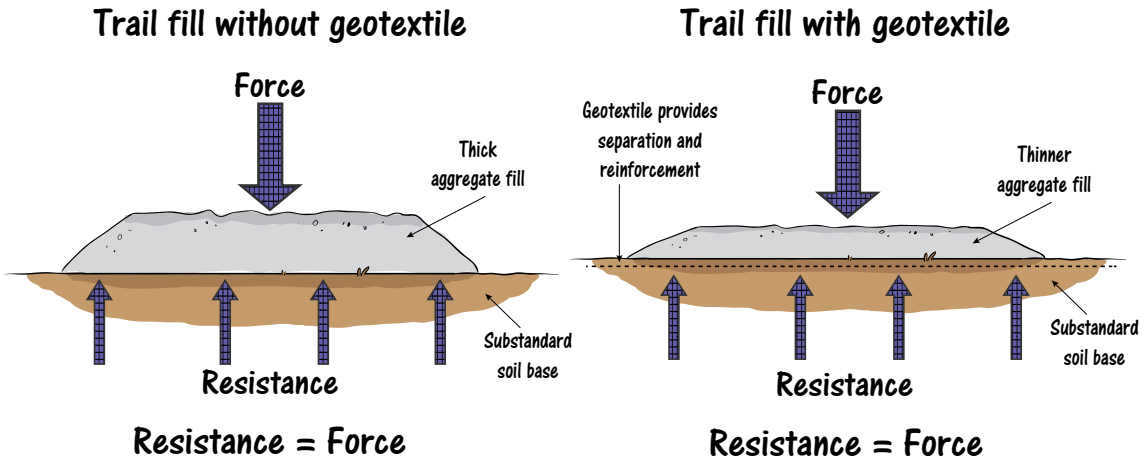


The tough polymer fibers give the geosynthetics lateral and longitudinal tensile strength, which provides reinforcement and helps prevent deformation under a load. This tensile strength distributes the load over a wider area reducing the PSI of the load and improves the weight-bearing capacity of the material above it. Since the geosynthetic supports much of the

load with little deformation, less force is directed down into the layer of soft soil resulting in less displacement and less subsoil pumping. The geosynthetic acts as a structural bond between the good upper layer and the poor lower layer, which increases the weight-bearing capacity of both layers. Using a geosynthetic or a geosynthetic layer can reduce the amount of fill needed on a tread surface, saving costs and maintenance in the long-term.



A layer of geosynthetics is used for separation and prevents good material, like crushed rock, from intermixing with poor material, like soft or saturated soil. For example, many times rock is placed in a mud hole but in a couple of years it has disappeared. When moisture conditions are right, the rock gets pushed into and absorbed by the soft soil. Geosynthetics provide important separation of and reinforcement between the layers of rock and soil.



Some geosynthetics are used for drainage and designed to allow water to drain laterally across them so water is diverted off to the sides rather than down, which reduces the saturation of the subsoil and increases its strength.

Some geosynthetics are used for filtration and designed to allow water, but not soil, to pass through their pores. It is this filtration property that makes silt fence and French drains so effective.

Common Geosynthetics Shapes

The most common geosynthetics shapes are: geotextiles, geogrids, geonets, geocells, grass pavers, and geocomposites.

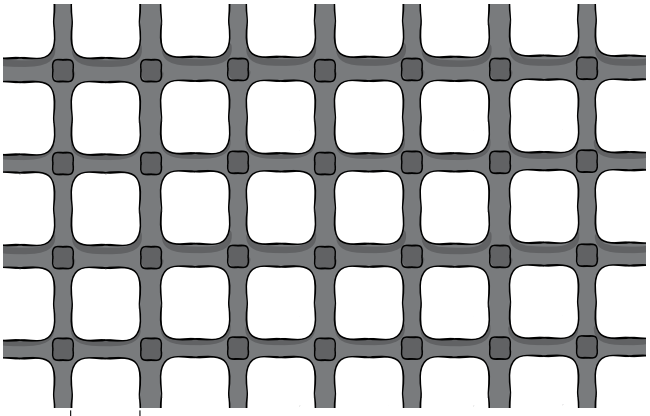
Geotextiles are synthetic fabrics that are most commonly used for separation, reinforcement, and filtration. These are great for OHV trails because they allow water but not soil to seep through and their tensile strength can support heavier loads.

Felt like products are easier to use than slick products because they are easier to cut and place on curved trail sections.

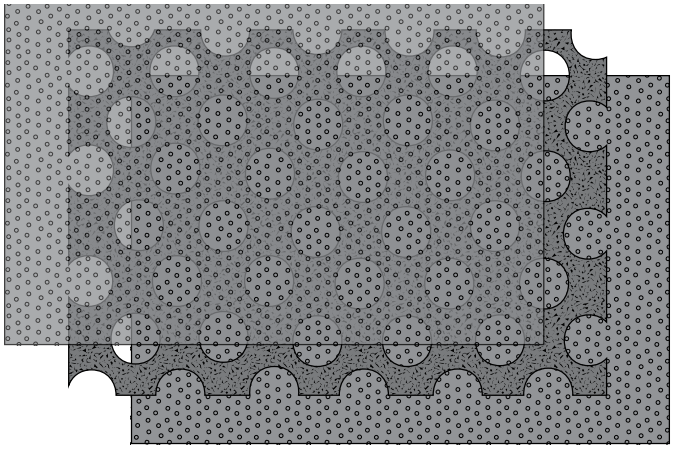
Geogrids are polyethylene strands that are bonded into a grid pattern like a fish net. They are heavier and less flexible than geotextiles and therefore provide a higher level of reinforcement. They are often used in retaining

walls and buttresses for added strength and shear resistance. For OHV trails in wet areas, geogrid is often put down over a layer of geotextile fabric and topped with a layer of coarse rock. This combination provides a superior level of separation and reinforcement.

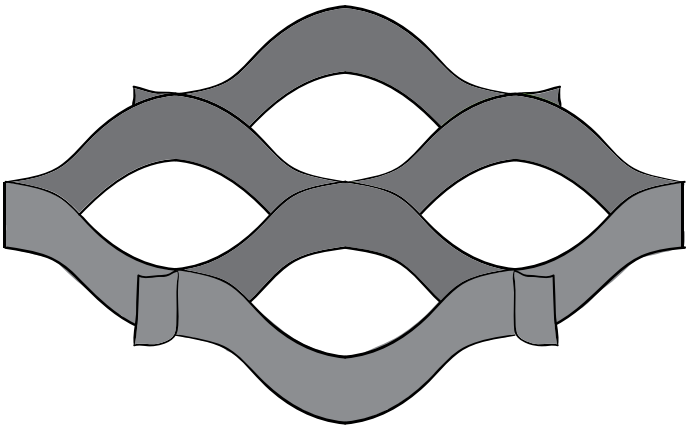
Geonets are a composite consisting of a thick geogrid sandwiched between two layers of geotextile. Because there are two layers of fabric, they provide excellent separation and reinforcement, but they are primarily designed to allow water to flow through the center grid and off to the side of the trail.



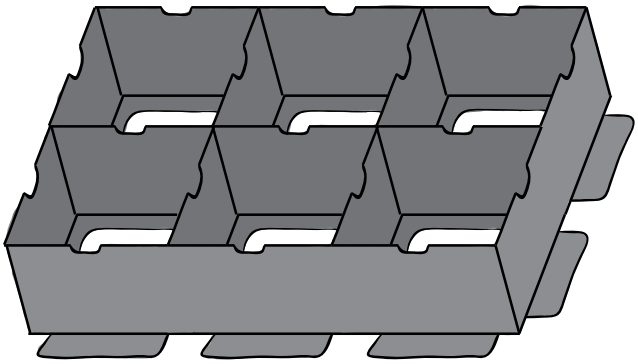
Geogrids provide exceptional reinforcement and are usually placed on top of geotextile when separation is also needed.



Geonets are considered a geocomposite because they incorporate more than one type of geosynthetic.



Geocells open up like an accordian and provide great lateral containment. The fill material needs to drain well so it doesn't squish out of the cells.



Grass paver is tough and rigid which provides excellent reinforcement while allowing for direct tire contact.

Geocells are polyethylene strips that are bonded into a honeycomb shape. They come in a variety of thicknesses, and are shipped flat for easy transport and then expanded on site. Once expanded, the honeycomb is filled with good soil, rock, or a mixture, which is then compacted. The cells contain the material so it can't displace out to the sides and each cell provides increased load-bearing and rigidity. The primary function of geocell is to provide reinforcement, not separation, so when it is used in a wet area with saturated soils, a layer of geotextile is put down first to provide the necessary separation.

Grass paver is a category of very stiff panels that can provide cellular containment like geocell but has a partial bottom that gives it excellent reinforcement properties. The panels interlock,

which helps to distribute the load, reduce PSI, and stabilize the structure. Lightweight and easy to use, this is the one category of geosynthetic that is designed for direct tire contact.

Tip, Trick or Trap?

Trap: Installing only geotextile under a non-cohesive soil is not a quick fix

Why? Because the tires will quickly displace the soil cover and expose the geotextile. Once that occurs, the integrity of the structure will be compromised and it will rapidly deteriorate.

Geocomposites such as sheet drains have a large cross section that allows drainage. If geotextiles are placed under the trail tread, the sheet drain should be oriented with the geotextile on the bottom and the plastic core on top. This orientation reduces the amount of fill needed.

This is an excellent example of boxing in the trail hardening to provide lateral and longitudinal support. Unfortunately, the cover over this geocell has been lost and the structure is rapidly degrading. The large cobble rock in the center section is actually holding up better.

Here are some key points on geosynthetics:

- The need for any structure requiring a geosynthetic is a potential red flag indicator of poor trail location. Explore other options first, if available.
- Some geosynthetics are not UV stabilized so they deteriorate when exposed to the sun. Check specifications before purchasing and store them in their original wrappers out of sunlight.
- Ensure that the fill material covers the entire top and sides of these UV sensitive geosynthetics and is maintained at this level. Geosynthetics are tough, but most are not designed or intended to be used as the tread surface. Forces from the tires will quickly break down the material, tear it, and displace it.
- When used for trail hardening, the geosynthetic installation must be wider than the designed trail width. The more the load is centered, the more effective the weight-bearing will be. This keeps the tires off the shoulders of the installation, which protects them from displacement.
- Because of its reinforcing property, less fill is needed with a geosynthetic to attain the same weight-bearing capacity as a fill without it. This reduces the amount of material that needs to be hauled in and reduces the cost of the installation.

Tires and geotextile do not mix.

Section 2: Soil Stabilization Techniques

Just as gardeners treat the soil to add nutrients and organic matter, trail designers can fortify some soils to add structural strength. The intent is to give the soil the ideal clay content for binding and the ideal rock content for loadbearing strength. Benefits include increased strength to withstand heavy traffic pressure (reduced displacement), reduced sedimentation (soil loss), and increased intervals between heavy maintenance operations. Another advantage of stabilization is

that in most cases, the trail retains its natural appearance and character, which enhances the rider experience. Designers should consult with an engineer, geologist, or soil scientist to determine the best treatment for a particular soil. The amendment process is simple: excavate the top layer of the tread, mix in the amendments usually with a rototiller or similar machine, spread the mixture back out onto the tread, add water if available, and compact it with a roller. Adding a layer of geosynthetics between the original soil and the treated soil will further increase the durability of the trail.

Tip, Trick or Trap?

Tip: The fist test: a simple field test for assessing water content and soil strength

Put a sample of soil about the size of a golf ball in the palm of the hand and make a tight fist. If the mass easily flakes apart, it is dry and below the Optimum Moisture Content. If the mass is firm and resists breaking apart, it is at or near the OMC. If water squeezes out of the soil, it is wet and above the OMC.

Soil Stabilization Materials

There are five common types of soil stabilization materials: clay, lime, aggregate, mix, and chemical.

A non-cohesive soil is one that has a low clay content. One way to remedy that is to add clay as a binder. This will not work for fine-grained soils like sand because the clay adds binder, but not load-bearing capacity. However, if the soil is course-grained with a high rock content, just adding clay can work quite well. There can be a fine line between not enough and too much clay, so getting the right mix is important but hard to control in the field.

Above, a rototiller on a 3-point tractor hitch makes an effective mixing implement. Below, an adjustable spreader box towed behind an ATV was used to measure out bentonite clay. The clay was too fine and the spreader box did not work well.

Lime has long been used to stabilize wet soils, especially wet clay soils. It dries the soil, bonds it together, and increases its load-bearing capacity. It has been successfully used under roads, runways, and building foundations, but there is little documentation on its use on motorized trails.

Some soils have a high clay content, but not a high rock content. Adding aggregate, which binds with the clay, increases the structural strength of the soil. Crushed rock works the best because it is highly angular and the rock points tend to lock the rock in place, but other rock can work also.

For non-cohesive fine-grained soils like sand or pumice, the soil lacks clay and rock content, so amending the soil with a mixture of clay and aggregate can work quite well.

Bentonite clay being rototilled into non-cohesive pumice soil.

A variety of chemical products are available which provide dust abatement by stabilizing the tread surface. Some are salts like magnesium chloride and calcium chloride and some are polymers like Road Oyl®, Soiltac®, Envirotac®, and Soil-Sement®. To be effective on trails, these products cannot be applied topically and must be disked or rototilled in for deep penetration. While there have been some studies of chemical stabilization for accessible trails, there has been limited testing of its use for OHV trails.

As an experiment, a section of this heavily used trail was stabilized with crusher reject (often called dirty rock, it has a lot of fines and angular material which can bind up like concrete). The rock was rototilled into the non-cohesive soil in an attempt to reduce displacement and mogulling. It worked. Ten years later, the stabilized section is firm and has retained its original prism while both ends have heavily displaced and moguled.

Tip, Trick or Trap?

Tip: The ribbon test: a simple field test for assessing the clay content of the soil

Add water to a sample of soil until it is at its optimum moisture content. Then take a small sample of soil about the size of a golf ball and squeeze it into a ribbon between thumb and forefinger. If the ribbon breaks apart in <1" sections, the soil is sandy. If the ribbon breaks in <2" sections, the soil is a clay loam. If the ribbon is >2" sections, the soil has a high clay content.

For some soil types, a variety of chemical dust abatement treatments can help stabilize the soil as well as prevent dust.

Here are some points regarding soil stabilization:

- Even with a mix design from a specialist, field application and mixing methods are crude at best and consistency is difficult to attain.
- The application and mixing is labor and equipment intensive and thus expensive.
- Because of the cost, a common mistake is making the stabilized soil layer too thin. Tire action can quickly break through it creating potholes and maintenance equipment can quickly wear it away. Minimizing the design to save money is a false economy.
- Unlike a road, runway base, or building foundation, trails have roots and rocks. In order to obtain a uniform depth and consistent mix, those need to be taken out, which adds to the cost and detracts from the naturalness of the trail.
- If chemicals are being considered, check for regulations that prohibit or restrict their use. A permit may also be required.
- When considering a project, check with local road or trail authorities to see what their experience has been. There may be a local mix or a local material that has exceptional qualities.
- Don't be afraid to experiment.

When the spreader box plugged up, the eyeball measuring and hand distribution methods were used.

Section 3: Trail Hardening Techniques

Gravel and Stoning Reinforcement

Often the easiest and cheapest way to harden a wet spot or a soft spot is to simply add rock to it. A well-graded crushed rock works the best since the fine components fill in the voids between rocks and the crushed angles lock the whole mass together. Because crushed rock binds together so well, it is more impervious to water, which helps prevent the further saturation of the underlying soil layer. Most times people use whatever material is readily available to save cost. That's okay, try it and see how it works. Typically, the rock should be 3 - 4" or less. Anything larger than that can be too rough to comfortably ride with a motorcycle, but may be okay for ATVs, ROVs, and 4WDs.

With a nice serpentine alignment, this hardened trail harmonizes with the landscape. Notice the tightly compacted densely-graded aggregate.

This trail has been hardened with open graded crushed limestone from a nearby source. The trail drops into a sensitive watershed and hardening was required as a mitigation to reduce potential sedimentation. Though the rock was inexpensive due to its proximity, the poor gradation does not provide sufficient binding to prevent moguls on this grade, so maintenance costs are high.

Stoning works well in soft non-cohesive soils and in seasonal wet areas. It does not work in perpetually saturated soils. Stoning provides a host of benefits: a) it provides both bearing and binding for increased weight capacity and decreased rutting and displacement; b) it reduces or eliminates trail widening or braiding by creating a firm trail tread; c) it protects the underlying soil layer from erosion thus reducing sedimentation; d) it has a rough surface and doesn't form rills so it reduces the velocity of the surface water, which makes it easier to drain water off the trail; and e) being more durable, it increases the interval between required tread maintenance.

On the negative side, stoning: a) reduces the naturalness of the trail and detracts from the rider experience; b) can conflict with the aesthetics of the setting, especially if the rock color does not harmonize with the landscape; c) can cover up roots and rocks that are challenge features; d) can increase speed and therefore decrease seat time; and e) in wet or clay soils, can gradually sink in and need replacement.

This straighter alignment and light color aggregate makes the installation more visually intrusive.

This rock is almost uniform-graded. While it will reduce the velocity of water running down this trail, it has no binder to hold it together. Given the steep grade, this rock will quickly displace and form wheel ruts as the tires seek firm ground to gain traction.

A Closer Look...

Rock mixtures like crushed aggregate are categorized by the size of the largest rock size and the mix of progressively smaller particle sizes. There are three main categories:

- Uniform-Graded. This is rock where all the particle sizes are about the same. A 4" UG would have all rocks about 4" in diameter. There are no fines to fill the voids, so the rock does not compact or bind together well, but it does allow water to drain through it.
- Open or Poorly-Graded. This has a mix of particle sizes, but they may not be progressively smaller. PG will bind together better that UG, but will not stay compacted and will not drain water as well.
- Dense or Well-Graded. This rock has progressively smaller particle sizes so that all voids between the particles are filled. WG compacts tightly, stays bonded together, and has the best weight-bearing capacity. Water will run off the surface rather than drain down through it.

Due to a lack of load bearing, tire ruts have developed as this fine rock has been pushed into the mud.

Other Trail Hardening Materials

There are seven other commonly used materials for trail hardening: cobble reinforcement, geotextile fabric, grass pavers, geocell, pavers, slab rock armoring, and tire mats. There are also inventive materials or "others".

Cobble reinforcement is similar to stoning except it uses rock that is 6 to 10" or less in size. Cobbles work well because they have a large surface area for increased load-bearing and that surface area also reduces the tendency of wet soils to suck the rock down into oblivion. Because cobble rock is usually uniform-graded, the voids between the rocks allow water to run through them, thus providing load-bearing as well as drainage. This is why cobble rock is used in drains.

In wet, mucky areas, cobble rock is often put down first, worked into the ground, and then covered with a layer of smaller-sized gravel. This allows water to drain through the rock subsurface, but the tread surface is smoother. The combination has less displacement since a mix of particle sizes holds the tread surface together.

When soils are wet more frequently than seasonally or if they are saturated, any applied gravel or cobble will eventually get sucked down into the soil and disappear. In this case, a layer of geotextile fabric will provide separation of the wet and dry layers and provide reinforcement by distributing the load over a wider surface area. This technique is simple, effective, and probably the most widely used trail hardening method.

This mixture of cobble and smaller rock is being spread over a layer of geotextile to provide load bearing for this ROV trail.

The trail through this draw used to be a mudhole in the spring. A layer of 8-10" cobble rock was put down and then topped with a layer of finer 4-6" cobble rock. It has not displaced after four years of heavy use. Even in a wet year, the cobble provides bearing while allowing water to run through it and over it.

Geotextile Fabric. When soils are wet more frequently than seasonally or if they are saturated, applying gravel or cobble won't be a long-term fix. Eventually, the stones will sink into the soil and disappear. In these cases, a layer of geotextile fabric will provide separation of the wet and dry layers. It will also provide reinforcement by distributing the load over a wider surface area. This technique is simple, effective, and possibly the most widely used trail hardening method.

Note the flared inlets on the culverts. These not only funnel the water into the culvert, but also retain fill material to keep it from sloughing off into the culvert.

Geotextile is being put down to provide separation and reinforcement on this Alaska trail.

Grass pavers can be placed directly on the surface with sandy or wet soils or placed on a layer of geotextile in saturated soils. The geotextile provides separation and additional reinforcement. Some varieties of grass pavers are the only geosynthetic that can take direct tire contact. It can be used as is or covered with a layer of fill for additional support and a more natural appearance. When placed directly on the surface with no geotextile or fill layer, the holes in the bottom of the panel allow vegetation to grow up through the panel. This results in less site disturbance, increased soil stability since the root zone is not disturbed, and increased visual appeal. The panels can be easily cut in the field to create curves or irregular shapes. Geoblock® is a grass paver often utilized for OHV trail hardening.

This is a good installation that is confined on the sides and segmented into blocks with treated timbers. However, water has not been managed and the cover of fill is being eroded away. Over time, this will weaken the structure and make it more slippery to ride. Tire impact forces on the timber may cause it to dislodge resulting in potential movement of the grass paver panels.

If only dual-track vehicles use this trail, why armor the entire width? The geotrack installation uses two rows of grass pavers attached to plastic timbers. Note how the grass pavers have been cut to form an angle. The entire installation was then covered with soil and rock.

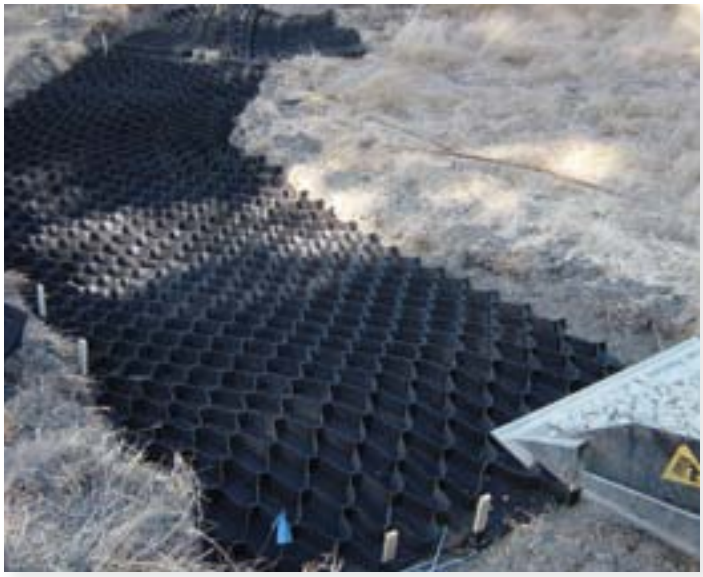
Though able to withstand tire contact, grass pavers will break down under repeated tire impact. This end panel should have been angled down into the soil to provide a shallower impact angle. It could also be protected with a log or treated timber pinned into place. The left side has been dug down and is confined and protected, but the right side is vulnerable to damage by tires and should have been framed in or protected by fill. It appears that riders are avoiding the approach impact and are riding off to the right.

Grass pavers makes an excellent hardened approach to this bridge installation.

They did a nice job of making a circular curve on this installation, but a poor job of confining it. Unfortunately, riders are short-cutting it either to avoid the structure or to take a quicker path and the edges of the GeoBlock will start to break down. Strategically placed debris or a barrier would remedy this.

Notice how the installation was excavated down below natural ground elevation. This provides containment and support for the structure. The cells were filled with uniform graded rock and then everything was covered with fill layer of soil and rock. Maintaining an adequate cover layer is critical to ensure the integrity and longevity of the structure.

Geocell is commonly used for retaining walls and other support structures like bridge abutments. It is available with perforated or non-perforated cell walls. It has been used for trail hardening, but many of those installations have failed due to the lack of maintaining an adequate layer of fill. Geocell will disintegrate if exposed to direct tire contact.



One advantage of geocell is that it is easy to make curves. In this installation, geotextile has been placed under the geocell to provide separation and additional support.

The fill for this bridge approach and bridge abutments has been constructed in layers of geocell filled with a good soil and rock mix. Note the grass paver panels to insure a smooth transition onto the bridge deck.

The fill layer over this installation was not maintained. Direct tire impact displaced the material in the cells and destroyed the integrity of the structure.

This geocell bridge approach is in the process of disintegrating. Bridges and other structures can be very slippery. Having an approach on a curve is not desirable since the vehicles are still on the curve once they hit the bridge deck which increases the risk of losing control and sliding into the railing. The curve also creates more lateral tire forces which act to increase displacement on the geocell and deck approach. Note the lip on the bridge abutment (arrow). This will bounce a motorcycle tire off the ground and increase the risk of sliding on the bridge deck.

Tip, Trick or Trap?

Trap: Never assume that the pavers will stay in place because they are heavy concrete with edges that will bite in

Anchor or confine the pavers. OHVs exert tremendous rotational and lateral forces that must be counteracted by strong anchors.

This is an excellent example of a trail hardening installation that will likely fail. On the plus side, the material is framed into sections which help prevent movement. The gap between these two sections (yellow arrow) serves as a log culvert. On the minus side, this cobble surface is rough to ride on and the rotation action of the tires will displace the rocks out of the Geocell (red arrow) and the exposed cells will start to break down. The life and functionality of this structure could have been extended if it had been covered with a layer of well-graded aggregate.

Both of these pavers are designed to interlock. These are easier to install and they allow for flex, but they resist lateral movement. The ones on the right are pre-formed with holes so they can be tied together which further inhibits movement.

Pavers include concrete blocks and cinder blocks. When installed properly, these are tough, durable, and can withstand direct tire contact. The concrete edges provide traction, so pavers can be used on very steep grades. They are heavy, so transport into the site can be a challenge, and their installation is labor intensive, but pavers are one of the most commonly used trail hardening methods.

There are as many examples of poor installations using pavers as there are of good installations, but here are three points to ensure success with pavers:

1. The pavers must lay on a smooth, even surface. The bedding could be compacted native soil if it is a cohesive soil that won't displace. Compacted gravel will provide a firm bedding and bearing for the pavers. If the soil is always wet, a layer of geotextile can be put down under the bedding material to provide separation and reinforcement. Roots, rocks, or any surface protrusions can cause a paver to break or move.

2. When pavers are allowed to move, the installation will be doomed to failure. They must be thoroughly anchored or confined in place to prevent movement. It is easy to assume that since they are so heavy, they will never move.

3. In some soils, such as non-cohesive soils like sand, pumice, or wet muddy soils, the pavers are likely to move even if they are pinned. Also, factors like the grade and alignment can affect the forces being placed on the installation. A 100' stretch of pavers on a 35% grade exerts huge downward forces on the bottom pavers and enough force for the installation to eventually blow out at the bottom. The best, most durable, and longest lasting installations are divided into sections and are confined on all sides with logs or preferably 4x4 or 6x6 treated timber that is pinned in place. Each section performs independently and has no impact on the others. Downward and lateral forces are controlled and contained and the pavers cannot move. An additional benefit of framing is that the edges are supported and protected. This helps prevent breakage. As soon as breakage starts to occur, movement will soon follow.

A Closer Look...

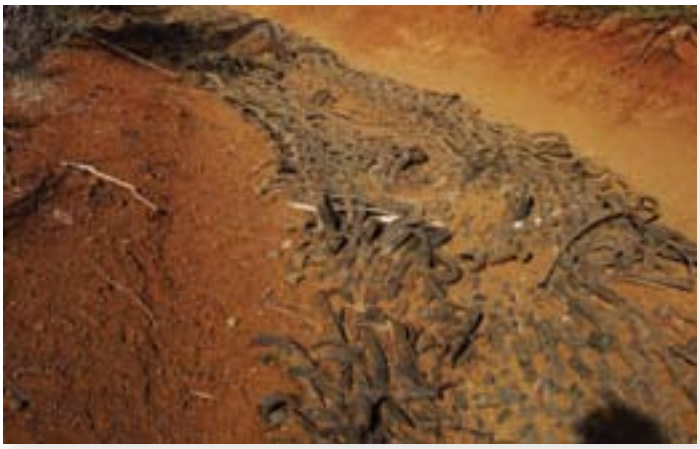
A key consideration in the design of any trail hardening, but especially rigid structures like pavers and slab rock, is the forces being applied to them. Vehicle size and weight are factors, but more important is the vehicle width. Vehicles with solid axles or locked axles have different rates of rotation between the inside wheel and the outside wheel. The wider the axle, the bigger the rotational difference. This results in the exertion of twisting forces that cause either the tire to spin and hop, or the tread surface to twist and move, or both. Structures that are poorly bedded and confined can be displaced and destroyed by these forces. Acceleration will compound the forces, so where possible minimize grades or grade changes on hardening structures. Also, the larger the turning radius, the less rotational difference between the inner and outer tire, so larger radius turns will have less impact than small radius turns. This is especially important on climbing turns, which combine grade changes with the directional changes. Interlocking pavers or structures that are confined with frames will help resist these forces.

Depending on the availability of materials or access to the site, flat flagstone-type rocks or other materials can be used to harden short sections of trail. As with pavers, proper bedding and prevention of movement are essential.

The approach to this technical step-up is being armored to prevent the step from getting higher and eventually becoming unrideable.

These rock slabs are well-placed and keyed together, but they lack confinement. Rotational and centrifugal forces will gradually displace them.

Recycled tire mats have been available in some fashion for many years. Though using recycled material is good for the environment, the mats to date have not held up well to the forces of OHV use.



Right and above, once again, the key to success is keeping the material anchored. Once it is allowed to move, it will self-destruct.

Trail hardening can be expensive, but there may be local sources of materials available for free that might work quite well. Don't be afraid to experiment. Trying something and having it fail may be disappointing, but it's probably still better than doing nothing at all.

This hardening installation is composed of chunks of sidewalk that was headed for the landfill. Being heavy and angular, the pieces should key together very well. Notice that they have been embedded so that the edges are contained by the natural soil.

This hardening installation is another recycling project. A brick and concrete high school was being torn down and was headed for the landfill, but a heads-up project planner thought to grind it up and try it for trail hardening. The material was free, it worked, and it set up like concrete due to a good mix of particle sizes. This was a win-win for the project, the community, and the environment.

Here are some things to consider about trail hardening:

- Product manufacturers can assist in product selection, application, and design specifications.
- A key consideration before installing any trail hardening is how it will be maintained. A relatively thin layer of fill over a structure requires awareness and a light touch by maintenance workers, especially when using equipment.
- It is also critical that the layer of fill over a structure be maintained at the designed depth to prevent exposure and damage to the material underneath.
- In areas with limited trail access points, another consideration is how maintenance equipment will be able to get from one end of the installation to the other without damaging the structure. If the maintenance equipment is a trail dozer with steel tracks, what will that do to pavers or grass pavers without a layer of fill?
- Placing heavy angular material directly on top of geotextile can tear the fabric and affect the integrity of the structure.
- Don't be afraid to experiment with unusual or locally available materials or methods.
- Trail hardening projects can be labor and equipment intensive so they can provide great opportunities for volunteer work parties or for creatively seeking new partnerships for the task and project.
- Depending on the soils, reducing speed and increasing the flow of the trail by changing the alignment can reduce the need for hardening in some situations.
- Trail hardening is often seen as a "fix" for steep grades and excessive erosion, but the forces at work need to be understood. Tire action and displacement is one, but water volume and velocity is the other. Hardening does little to manage the water, so it is essential that as much water be removed from the trail as possible before the water gets to the installation.
- It may be better and less expensive in the long run to move a trail instead of hardening it.

The Good...

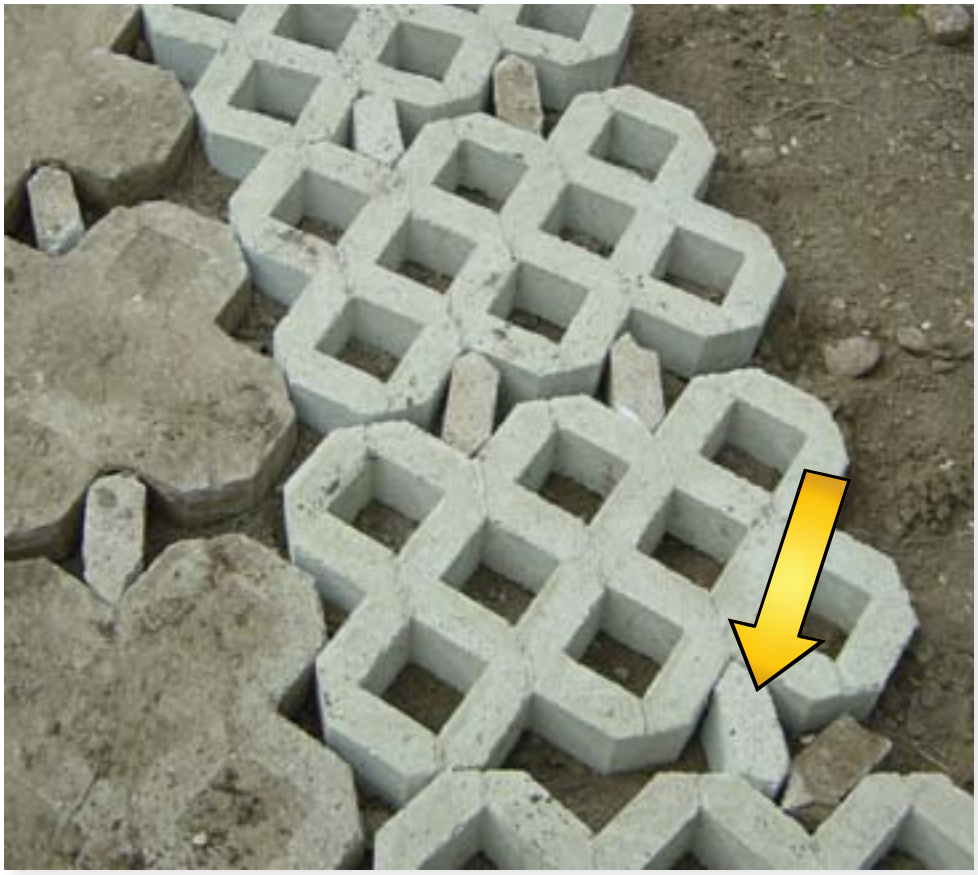
This installation has been framed in which not only resists movement, but provides lateral support and decreases the chance of breakage.

The eroded trench of this site provides natural containment for the blocks. The fill is a densly-graded aggregate that is holding together nicely.

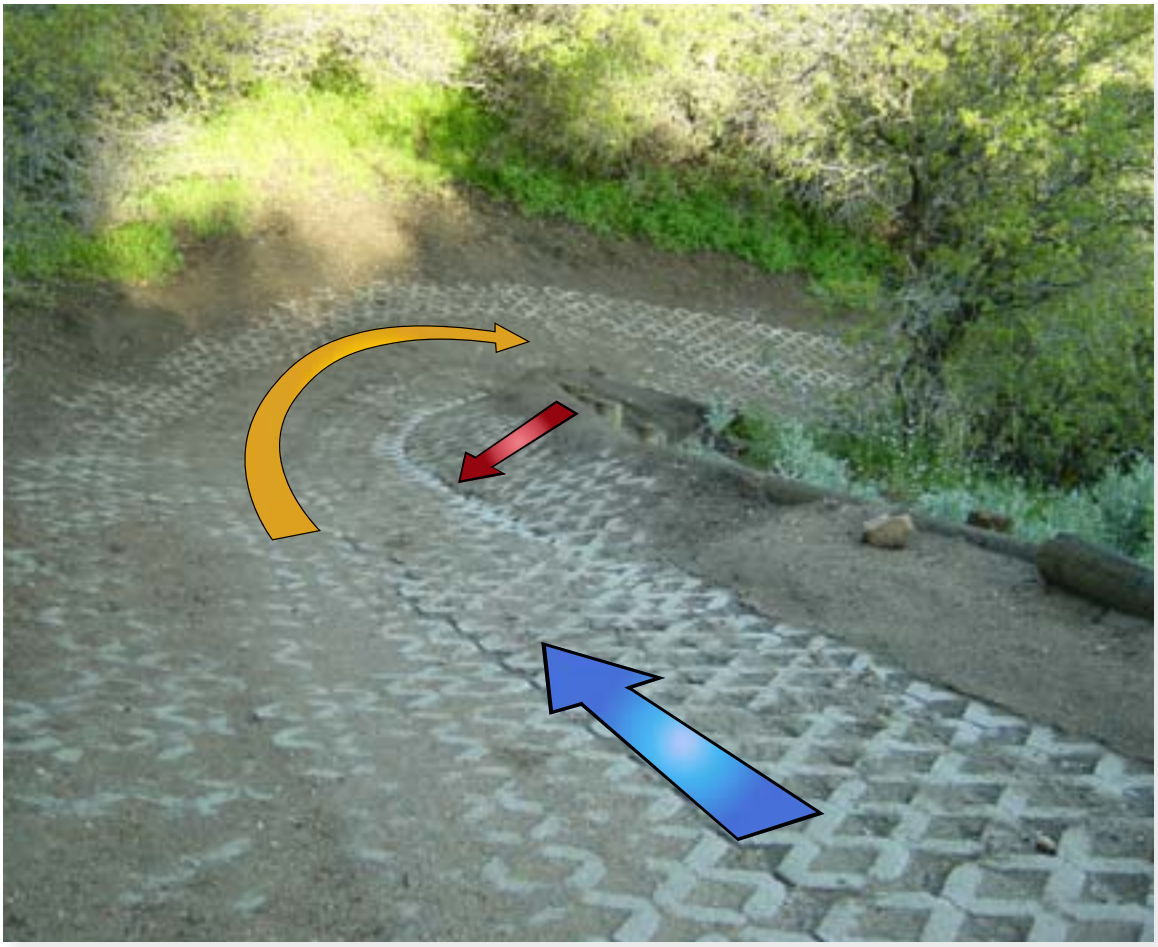
To help manage tire forces, it is important to have a smooth transition onto any structure. Here, the last four end blocks are angled down into the soil. This also helps anchor the structure and resist movement.

Not contained or framed, but this soil binds like concrete. The logs are pinned in a wishbone pattern to help drain water off to the sides and to force riders to stay on the structure. This is a nice touch.

Well contained, these blocks make a beautiful and functional approach to this bridge deck.



These blocks are being laid to form a curve. Notice how spacers have been placed to maintain the shape and resist movement.



This is a beautifully hardened climbing turn. The edges have been embedded and are well protected. The curve is super-elevated so speed is easily carried through the turn and lateral forces are reduced which helps to minimize the risk of block movement. Riders hug the inside edge, so the inside is armored which keeps riders on the structure and resists breakage of the edges. The V on the inside edge also keeps water on the structure and resists erosion.

This steep grade approaches 30%. The sides are contained by the shape of the site and the installation is framed to absorb the downward forces. Nicely done. It is essential that the water be effectively managed before it reaches the top of this slope.

These interlocking blocks are being tied together to build this ford. This design resists movement from the lateral forces of the water, but still allows a little flex in the structure. Any non-interlocking blocks would not stay in place and would soon fail in this situation.

The Bad...

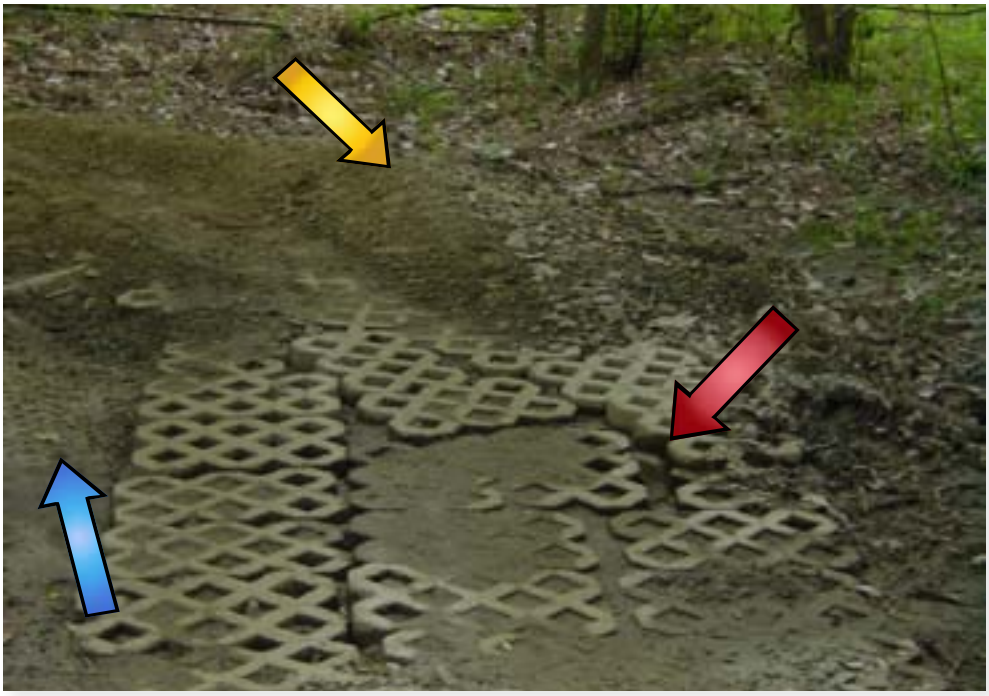
This armored drain dip is a great idea, but is subject to failure. Why?

1. The curve in front of the bike will exert lateral forces on the single row of blocks and they will be subject to movement.
2. The sharp angles of the blocks armoring the crest will receive increased impact forces from the tires which will result in movement.
3. The right edges of the blocks on the crest are poorly supported and these blocks will likely slough off to the right as the fill softens and erodes.
4. Riders will tend to use this as a jump which will increase the forces imposed on the structure.

The edges are not contained and will be subject to movement and breakage (yellow arrow). The blocks were poorly bedded (red arrow) creating an irregular surface which will result in movement and breakage. Water has been poorly managed (blue arrows). Soils saturated by the pond will allow the blocks to sink, deflect, and eventually break. A lead-off ditch should have been constructed on the left to drain the low area (maybe it was, but poorly maintained). The log on the right actually inhibits water flow into the grass behind it and deflects the water onto the trail which increases ponding.

For the most part, these pavers have been embedded to resist movement. The leading edge (blue arrow) should have been angled down for a smooth transition or otherwise protected with a treated timber. Without frontal support, the leading edges will be subject to breakage. All of the roots were not removed (yellow arrow) so there is irregular bedding which will result in movement and eventual breakage and failure. As the trees grow and roots expand, they will pop out the pavers.

It looks like this structure had a cover of fill at one time. The curve has caused displacement of the material and has formed a berm on the outside edge (yellow arrow). Water apparently drains across the middle which has washed away the fill material there. Due to the curve, the lateral forces are starting to move the blocks. Notice the increased gap (red arrow) between the outside blocks and the inside blocks. Riders are also being allowed to short-cut the structure (blue arrow) and ride off the inside edge. This will lead to block breakage and movement.



What's wrong here?

1. The steep uphill road approach does not allow riders a place to easily stop and start up again, so they probably won't stop at all.
2. The stop sign nailed to a tree is obscured by vegetation and does not allow adequate sight or reaction time. It should be on a post within 24" of the trail.
3. Concrete blocks have a taller profile than other blocks. This makes them more prone to movement and breakage, so it is more critical that they be confined.
4. Water draining off the road (arrows) is eroding the right edge of the blocks which will increase the risk of movement and failure.

Bedding and containment are important because concrete blocks are brittle. Note the broken blocks (yellow arrows) on this relatively new installation. The wide gap between these blocks (red arrow) will invite movement. The railroad tie provides a strong anchor for the bottom of the structure.

Tip, Trick or Trap?

Trap: Manage your risk

Poor construction + poor maintenance + poor management = Increased tort claim risk.

The Ugly...

Poor bedding + no containment + movement = failure. You can see (arrows) where riders are going up the right side to avoid this installation.

No containment, no protection for any of the edges, and uneven surfaces. Note the settling that has occurred (arrow) between the two rows of blocks. Given a choice, which there is, any rider would avoid this.

Pavers poorly bedded and placed on an uneven surface of rocks will move and fail.

The results of a poor installation: broken pavers, two eroded trenches instead of one, risk, resource impacts, and a mess.

Poor paver installation in this stream crossing resulted in resource impacts. Cobble stone would have been a better choice.

Need more? Learn more here...

Geosynthetics for Trails in Wet Areas: 2008 Edition, USDA Forest Service, Technology & Development Program, 0823-2813-MTDC, April 2008

Managing Degraded Off-Highway Vehicle Trails in Wet, Unstable, and Sensitive Environments, USDA Forest Service, Technology & Development Program, 0223-2821-MTDC, October 2002

Wetland Trail Design and Construction, USDA Forest Service, Technology and Development Program, 0123-2833-MTDC, September 2001

Having an army of volunteers certainly helps with a trail hardening project.

A Look Back...

Here are some of the elements discussed in this chapter:

- Soil stabilization and trail hardening are primarily needed in:
  - Soft soils
  - Wet soils
  - Any soil that cannot support the vehicle volume or weight
  - Structure approaches (including roads)
- Stabilization is mixed into the existing soil, trail hardening is placed on top of the existing soil
- The need for stabilization and hardening can be a red flag indicator of poor trail location, excessive grade, or poor soils. Look for alternatives where appropriate
- Geosynthetics provide reinforcement, separation, drainage, and filtration
- Except for grass pavers, tire contact with geosynthetics must be avoided
- When applying stabilization products, it is difficult to attain a consistent mix design in the field
- Stabilization and hardening methods are expensive and labor-intensive. Cutting corners in the design or installation will affect the longevity and integrity of the structure.
- Hardening products need to be properly bedded, confined, and anchored to resist movement.
- Don't be afraid to experiment such as using local material sources or seeking local expertise
- For installations that have been designed and built with a fill layer, it is critical that the depth of that fill is maintained over time. If that isn't likely to happen, consider another option.
- Engineers, geologists, soil scientists, etc. can have valuable insight. Consult them during the planning.
- While planning hardening and repairs, consider the largest and heaviest vehicles using the trails including reconstruction equipment; especially steel tracked equipment
- Hardening is a manmade structure that is added onto the trail. Manage your risk through proper design, installation, maintenance, and management.

Chapter Seven

Tools in the Toolbox: Structures

Smart Enough to Ride? Smart Enough to Get Trained

A large part of the success in the engineering of a trail system is to know what to do in a particular situation. Certainly with a new trail location or the relocation of an existing trail, the first option is to avoid potential issues. However, there are a multitude of structures available that can help mitigate almost any circumstance.

Structures help meet two of the three elements for successful OHV trail systems: provide for the riders' needs and design for sustainability. Many structures enhance the OHV experience by providing variety either visually or in tread surface character. Structures provide a more stable, durable trail tread, which increases rider safety and the fun factor. Increasing stability and durability is what designing for sustainability is all about: protecting resources while providing a quality recreation experience. OHV management is facilitated when riders want to and are able to stay on the trail.

Here are some key points to remember when selecting and designing structures:

- The vehicle specifications (width, weight, etc.) critical to the trail design may not be those of the OHV using the trail; they may be the trail dozer used to construct or maintain the trail, or the snow groomer in the winter.
- Some agencies use structures as a management tool to limit the width of the vehicle that can use the trail, for example, making a bridge 24" wide to preclude use by ATVs. Structures can be expensive and this tactic can be short-sighted when larger vehicle access is needed for maintenance or reconstruction; vehicle sizes or types change; or management direction changes. Proper entrance management is a better option.
- Many structures require professional engineering calculations on material strengths, vehicle loads, snow loads, and watershed analysis to determine bridge, culvert, or arch sizes. This is not a place to cut corners since underdesigned structures can lead to catastrophic failures and public safety issues. Manage risk and liability by having your structures properly engineered.
- The need for multiple structures can be a red flag indicator of poor trail location. Explore other options if they are available.

Neither of these bridges has been designed to accommodate the vehicles that need to use them. Hardhats may need to be substituted for helmets in certain cases.

- Structures require regular inspection and maintenance. The cost and personnel to perform these tasks must be built into the operation and maintenance (O&M) program.
- The longevity of most structures depends on use type, use level, soil type, climate, proper design, proper installation, and proper maintenance.

Section 1: Water Control Structures

An essential key for a durable trail is managing water. Structures help drain water off the trail, allow water to flow under the trail, help raise the trailbed above the ground water level, drain water across the trail, and drain it away from the trail; all of which help manage water.

Draining Water Off the Trail

There are several ways to help get water off the trail: rolling dips, outsloped sections or kinks, and waterbars.

Rolling dips are man-made grade reversals constructed on existing trails with long sustained grades or steep grades to reduce the size of the tread watershed. They are also used in new construction where there is no other opportunity to reverse grade to provide drainage. The key to good rolling dips is just that, keep them rolling.

This is a nicely constructed rolling dip. Notice the distance from the sag to the crest and notice how the grade smoothly rolls into and out of the dip.

Here are some general points about rolling dips:
- Any manmade structure requires maintenance. A rolling dip will never be as effective and as maintenance free as a grade reversal.
- Rolling dips must roll. The shorter the distance from the sag to the crest, the more abrupt and less functional the rolling dip will be. If it feels like a rider will fall into a hole when riding, the dip is too short.
- The structure will fail more rapidly in non-cohesive soils like sand or cobble rock or a sand and rock mix.
- Armoring a rolling dip with mechanically compacted crushed aggregate will increase the effectiveness and longevity of the rolling dip by: a) reducing the velocity of the water so it can be more easily diverted off the trail; b) hardening the trail tread to reduce rutting; and c) protecting the crest from displacement.

When controlling water with rolling dips:
- Use the trail alignment to help turn the water. Place the structure either on a tangent, or better yet, on a curve that turns in the direction the water should go. Trying to turn the water in the opposite direction of the curve will usually result in failure.
- Locate the rolling dip where there is a break or flattening in the grade. This will help slow the water down so it can turn and flow off the trail.
- Drain the water off the trail before the grade and after the grade, not mid-grade.


The best way to start building a rolling dip is to borrow as much material for the crest as possible by using lead-off ditch or drainage sump excavation. Excavating the sag to build up the crest increases the grade going into the dip, reduces the flow of the dip, and can make it more difficult to drain water out of the dip.

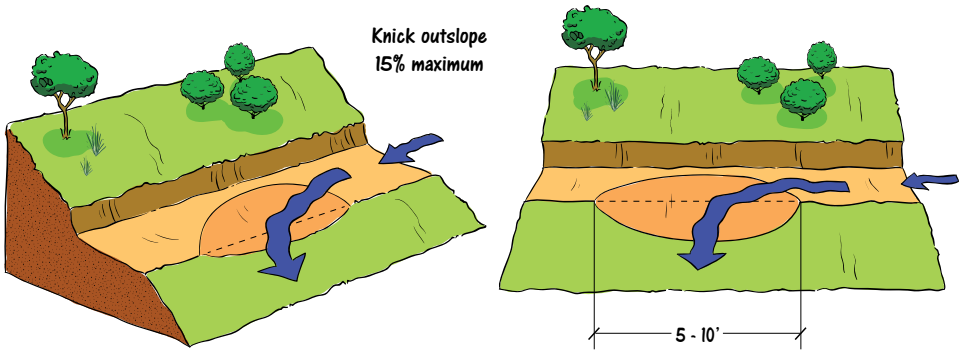
Rolling dips and grade considerations:
- Avoid installing rolling dips mid-slope on grades over 15 percent. The approaches become too steep and riders lose most of

their momentum. Riders must roll on the throttle to get going again, which results in tread impacts and increased maintenance.

- On steeper grades, rolling dips can invite riders to make jumps out of them.
- Generally, as grade increases, tread watershed size increases, or soil quality decreases; the spacing between dips needs to decrease.
- As the grade increases, the transitions into and out of the rolling dip must proportionally increase.
- The steeper the grade, the more difficult it is to make the dip reverse grade. Often, the best that can be achieved is a grade break, which can easily be breached by rutting when the soils are saturated and most vulnerable.

Use the trail alignment to help you turn the water. This dip is trying to move the water in the opposite direction of the curve. The gradual formation of superelevation on the outside of the curve will work to defeat the flow of water in that direction. This installation will work briefly. Then the formation of a berm will block the lead-off ditch and water will pond up in the sag of the dip. This pond will build in depth until it saturates the crest. Tire ruts forming in the soft crest will lead to breach and failure of the structure.

An outsloped section or knick is a short piece of trail that has been steeply outsloped at 8 to 10 percent or more to provide drainage. These are best used in grade sags or flat low areas that tend to puddle water. The difference between a knick and a rolling dip is that there is no sag and crest in a knick. Instead, a section of the trail is cut away in a "C" shape and the excavated material is removed from the site. A dip forces water off the trail while a knick allows the water to run off the trail. Knicks can be effective on flatter grades up to about 5 percent, but on anything steeper, too much



The flatter the trail grade, the more functional and durable the dip will be. This one is perfect: long, flowing, and deep.

Though this dip rides nicely, it wasn't constructed with enough elevation difference from the sag to the crest. Due to the soft, non-cohesive soils, displacement from a few motorcycles has already created a rut deep enough for the rolling dip to fail.

outslope is needed to turn the water. In these situations, riders will tend to hug the uphill side of the trail, and water carried by tire ruts will soon deform and breach the structure. Rolling dips are a far better alternative.

Avoid flat ground. Even with outslope, the water won't drain off the trail if it has no place to go. This lead-off ditch has plugged up or was under-sized and needs maintenance. A drainage sump may be a better alternative.

This trail has been outsloped to provide drainage. The rocks at the outlet serve as energy dissipaters and are a nice touch.

When constructed, this trail was outsloped so the small drainage entering from the left would drain across the trail. Through compaction, displacement, and lack of maintenance, the trail bed is now lower than the ground on the downhill side, so the water runs down the trail. Now, a rolling dip should be installed here. In reality, there was an error in the initial location and the alignment should have pitched up on the arrow line to create a grade reversal and positive drainage.

When constructed, this low spot was outsloped to drain water. Through compaction, displacement, and lack of maintenance, the trail bed is now lower than the ground on the downhill side. So the water ponds up in the trail which is causing trail braiding. The trail now requires reconstruction and armoring with rock to help maintain the shape and provide additional bearing when it is wet.

One of the biggest issues with waterbars is that, given a choice, riders will go around them. Here a log was brought in to force riders over the waterbar, but riders are going around it also. Due to lack of use, note how green the original trail tread is between the waterbars.

Earthen water berms can be a quick fix for OHV trails, however they don't last long and need to be replaced often.

Waterbars are shallow structures that are used to drain water off the surface of a trail or road. They can be made out of a combination of rubber belts, logs, rocks, treated timber, or dirt. They are usually installed at about a 30 degree angle so that water will hit the structure and be directed off the trail. As a drainage structure on a motorized trail, none of these are effective because they are too abrupt and they fail due to the tires rolling over the structure. Logs are slippery at an angle and dislodge, rocks become dislodged, and dirt gets displaced. Though widely used historically, they are now being replaced with rolling dips, which are far more effective.

This log reinforced waterbar is currently working. A couple of reasons for that are that riders are forced to go over the waterbar because vegetation prevents going around it, and because the trail is wide enough for riders to square up and avoid hitting the potentially slippery log at an angle. Note the sediment being deposited (arrow) as the water slows before it flows off the trail.

A belted waterbar has a piece of conveyor belt sandwiched between two 2"x 6" treated boards. The belt sticks up out of the boards a minimum of 6" and the structure is buried in the trailbed so that only about 3" of the belt protrudes above the surface. The belted waterbar has long been thought to be an effective drainage structure option for wheeled trails, but that has not proven to be the case. The main reason for their failure has been misuse of the structure.

There are six main reasons why waterbars fail:
1. Most belted waterbars are not constructed properly and have too much exposed belting, which becomes ripped or flattens over and becomes slippery.

2. Most installations are not long enough and invite riders to ride around them.

3. Most are not installed in the proper location where the trail alignment or grade will help them work.

4. Many have been installed on a fall line trail in an effort to make a non-sustainable trail more resistant

This log waterbar is doing nothing but putting an obstacle in the trail. With the amount of water coming down from above, the need for this waterbar is a red-flag indicator of a much bigger problem.

to degradation. Waterbars can be an aid in some situations, but not a cure-all. Other options like relocation should be considered first.

5. Many have been installed on excessive grades (hillclimbs) and the tires damage them or water rushes over them.

6. Lack of maintenance. Any manmade structure requires maintenance and eventual replacement. Waterbars require frequent maintenance.

The fact is that the need for any waterbar is a red flag indicator of a bigger problem. Water is running down the trail due to excessively steep grades, excessively long grades, excessively large tread watersheds, or failure to recognize and seize other drainage opportunities. Rolling dips are a better option, but in most situations, the best long-term solution is trail relocation.

This treated timber waterbar provides a formidable obstacle from below (blue arrow) and being full of sediment, it provides ineffective drainage (yellow arrow). The issue: the tread watershed is too large. Poor soils cannot sustain this grade that is too steep for too long. The solution: relocation.

Draining Water Under the Trail

Several structures are available to help direct water under a trail, including bridges, arches, culverts, headwalls, catch basins, and trash racks.

Bridges are used to span streams or other terrain that cannot be traversed on the ground like a deep, rocky ravine; and they can add to the aesthetic beauty of a trail and the quality of the recreation experience. There is a wide array of materials available for bridge building, including steel, treated timber, log stringer, fiberglass, and other composites. Many are prefabricated, which aids in transport and assembly. Choice of materials can depend on local availability, local preference, or conformance with a local or agency architectural theme. Fiberglass, though not as aesthetically pleasing as other materials, is lightweight and easier to transport and assemble at the bridge site. Its initial cost can be higher than other materials, but transport and assembly costs are much lower.

This prefabricated steel bridge is durable and has a natural appearance in this open setting.

Things to think about for bridges:

- There are specific criteria for bridge site locations and they are critical to the longevity and integrity of the structure. Seek help from a bridge specialist, engineer, or hydrologist.
- Most bridges will require a permit of some kind. Find out what is needed and what the requirements are for erosion control, etc. Get permitting started as early in the process as possible. It can take some time.
- Many streams have conditions or restrictions for operating equipment in or near the stream. Gather the information before mobilizing materials, equipment, and personnel.
- Time and unusual weather events can negatively affect a bridge's integrity. Public safety trumps

With transport and assembly advantages, a fiberglass pony truss bridge can work well in a variety of settings.

This log stringer and treated timber bridge spans an extremely sensitive creek that was a hotbed of controversy. Though there were less expensive design options, its beauty and functionality was worth the cost as it allowed this project to move forward.

If there is no railing, rub rails provide a margin of safety on OHV bridges. This is a nice, low-profile treated timber bridge.

cost, so manage risk. Regular bridge inspections by a qualified engineer must be conducted and documented.

- Make the bridge large and durable enough for the largest vehicle using the bridge. In most cases this is construction or maintenance equipment, including snow groomers.
- In wet conditions, tires, especially OHV tires, can slide across the boards of a bridge. Ensure a rail or a rub rail is on the bridge to catch the tires before they go off the side.

Arches are used to allow water to flow under the trail. They are slightly elliptical and come in either an open or closed bottom configuration. Open bottom arches are most common in trail work. They have a flange on the bottom edge that allows them to be pinned in place with rebar. Arches are available in a variety of sizes and come in corrugated galvanized metal or corrugated high-density polyethylene (HDPE) plastic. Plastic is usually preferred due to its lighter weight and ease of transport and installation. Arches have a wide and low profile that gives them several advantages: a) the streambed or drainage bed is left in its natural condition; b) the flow of water is less restricted, yet the capacity to carry water is one-third more than a similar sized culvert; c) the wider mouth of the arch is less likely to plug up with debris; d) the width of the arch makes it easier to clean out; and e) the arch shape is stronger than a round shape.

Durable, lightweight, and easier to clean out, an arch is a good choice for trail projects.

Culverts are another structure that allows water to run under the trail. The most common culverts are corrugated metal pipe, often referred to as CMP, and corrugated plastic pipe, commonly referred to as CPP. The metal pipe is aluminum or galvanized steel. The plastic pipe is HDPE. Metal pipe comes in a variety of shapes: round, elliptical, box, pipe arch, and arch. Round corrugated aluminum is the most common metal culvert for trails since it is 70 percent lighter than steel and just as strong. Plastic pipe comes in round and arch shapes. The round pipe is available with a single wall, which is corrugated inside; or a

dual wall, which has a smooth interior.

There are two types of corrugations: annular and spiral. Annular is easier to band together, but each corrugation can become a sediment trap. Spiral tends to clean itself out better since one corrugation leads to the next.

Plastic culverts are usually preferred for trails due to their light weight and ease of transport. They are also easier to cut in the field. Most culverts come in 20-foot lengths and have available bands to connect sections together as well as elbows, flared inlets, drop inlets, downspouts, and other attachments.

There are drawbacks, but culverts allow water to drain under the trail and keep the tread dry.

When culverts are undersized, the results can be disastrous and expensive. Spend the money up front to do it right the first time.

It is dry now, but this runs a lot of water in the winter. Two plastic pipes in this shallow drainage keep the trail fill low and provide a safety net to handle unusually heavy flows. Two pipes have to be carefully bedded to prevent water from running between them.

The first culvert (yellow arrow) was properly installed in the drainage. The second culvert was added later possibly to drain a spring but was not installed properly due to rocky ground. Manage your risk. The second culvert does nothing but create a safety hazard and an opportunity to ruin what was a good section of culvert. A side ditch draining into the first culvert may have been a better solution here.

A flared inlet and headwall are being added to this culvert to help funnel the water into the inlet. Though a small diameter culvert like this may be adequate to handle the flow of water, it is very hard to keep cleaned out.

This heavily superelevated curve is a blast to ride, but water runs to the inside, gets trapped, and ponds up. The solution? Add a culvert.

Here are some key points on culverts:

- Culverts need to be sized correctly to accommodate the maximum high flow events from the drainage area. Failure to do this can result in a catastrophic failure.
- Any pipe less than 18” in diameter is more prone to getting clogged with debris and harder to clean out. Ensure there is routine inspection and maintenance for these structures.
- Culverts can fail in a significant weather event causing the culvert and the trail to wash out. This may result in not only a severe trail impact, but also has the potential to impact sensitive habitats or fish-bearing streams below. For these reasons, fords or armored drains are usually a better alternative if management allows tire and water contact.
- Dual wall plastic pipe with the smooth interior tends to flush itself out during rain events or can be flushed out manually with a hose.

- Check the classification of the stream before installing a culvert. Some small streams, even ephemeral ones, are classified as fish-bearing and may require a bridge or other mitigations to allow fish passage.
- Cover depth will be lost through erosion, wheel displacement, and maintenance. To minimize the risk of having an exposed structure, culverts should have a minimum of 12” of fill over the top of them.
- Installing two smaller diameter culverts rather than one large one can increase the flow without increasing the height of the fill required to adequately cover the pipe.

A headwall is a structure that surrounds the inlet of a culvert or arch and has three functions: 1) to keep the trail fill from sloughing or eroding off and blocking the entrance of the culvert; 2) to help funnel the water into the culvert inlet; and 3) to dissipate the energy of the water and protect the toe of the trail fill from eroding. Headwalls are normally constructed of rock, but bags of pre-mix concrete are also used.

A catch basin is often constructed as part of a culvert or arch installation, especially where the water needs to turn in order to enter the culvert. It usually consists of a headwall and an “L” shaped berm or wingwall either made of or lined with cobble rock. The water enters the catch basin, hits the back of the berm where its energy is dissipated, and then is allowed to turn and enter the culvert. Catch basins will fill up with debris and sediment and require routine inspection and maintenance.

Culvert headwalls are always a nice touch. This rock headwall supports the trail fill.

When rock is not available or when extra support or protection is needed, bags of premix stacked dry will make a solid headwall. They will absorb moisture over time and solidify into a concrete block wall. Do not use sandbags since the bags will eventually rot and your structure will disintegrate.

Note how water is running past this culvert rather than flowing into it. This installation would be more effective if there was a rock catchbasin to help turn the water into the culvert.

As the wrappers fall off, a premix headwall can look a little shoddy, but that is temporary. To avoid that, the wrappers can be torched off after the concrete has set.

This trash rack is properly placed in advance of the inlet and the widely spaced bars will let water and smaller debris through.

This trash rack has been placed directly over the culvert inlet. The slots in the expanded metal are too small and will catch finer debris. Through a lack of maintenance, it is becoming overgrown with brush which will inhibit its effectiveness. With the next high water, the dead sticks and limbs could easily plug up this structure.

A trash rack is installed in advance of the inlet of some culverts or arches to collect sticks, logs, and debris to prevent them from blocking the inlet. They are usually widely spaced metal screens or vertical metal bars. Sometimes, they are placed directly over the inlet, but this defeats the purpose as debris can plug up the culvert inlet. By preceding the inlet, the debris gets collected, but water can still flow through or around the debris to get to the culvert inlet. As with many structures, the key to their effectiveness is regular inspection and maintenance.

Elevating the Tread Above the Water

Sometimes, it is desirable or necessary to cross broad wet areas. Boardwalks, corduroy, side ditches, puncheons, and turnpikes can all be used to elevate the tread above the water.

A boardwalk is essentially a trail on stilts that keeps the trail above the water level and out of sensitive riparian vegetation. Though expensive to construct, boardwalks allow access through sensitive environments, provide interpretive opportunities, are extremely aesthetic, and provide a unique riding opportunity that adds to the quality of the trail experience. Riders will remember the boardwalk and talk about it around the campfire.

This boardwalk is being built over a wet trail area. The boards are placed length-wise to help keep OHM tires from slipping across wet boards.

Though more expensive to design and construct, placing bends in the boardwalk improves the look and feel of the structure and enhances the rider experience.

Corduroy is an old technique of placing logs perpendicular to the wet area so that water runs through the voids of the logs and the vehicle tires run on top of the logs. This is generally not a long-term solution since the logs will eventually rot. There are two basic configurations for corduroy: logs placed on stringers and logs placed directly on the ground. Both can provide an uneven, slippery surface. When placed directly on the ground, some logs will sink or heave. In high water, they can float providing an unstable trailbed. Both methods can be rudimentary, but if properly installed and consistent with the management objective for the trail, they do work and will offer a unique riding experience and challenge that can add to the quality and excitement of the day's outing.

This poorly crafted installation was thrown together during an exceptionally wet spring. It is too short, too narrow, and some of the logs are floating. Some ditching should have been done to help drain the water better. This is a good example of the issues usually associated with corduroy: poor patch jobs that don't address the problem and usually degrade into a hazardous situation.

This is nicely constructed with poles of the same length and diameter. Unfortunately, it isn't long enough. This is a common and costly problem with many tread structures.

Corduroy anchored onto stringers will last longer and create a more stable tread. This is an example of a poor quality installation. The stringers already show signs of rot and the corduroy logs should have been cut into even lengths.

This is a well done installation that is fun to ride and adds to the rider experience.

In the backcountry, corduroy is sometimes used as a bridge. This is not a recommended practice and should be considered a temporary bandage due to its structural instability. Grade should be avoided with corduroy, especially in wet climates. The slippery, uneven logs on this installation make it a liability.

A puncheon is basically a bridge that lies on the ground. It has stringers, deck, and rub rails that are laid on mud sills. It looks like boardwalk, but a boardwalk is on stilts which elevate it off the ground. Puncheons are typically used to cross wet, boggy, or seasonally wet areas. They can be used to bridge small creeks and protect sensitive resource areas like threatened or endangered plants or cultural sites. Materials are generally logs, sawed timber, treated timber, or a combination of those materials. Depending on how soft the ground is, the mud sills are placed directly on the ground or in shallow trenches that are dug down to firm ground, filled with rock or gravel, or filled with gravel on top of geotextile for increased bearing. The most common fault of puncheon installations is that they are too short and mudholes develop on each end. Be sure to terminate them on firm or higher ground. The approaches to structures like this are still subject to compaction and displacement, which creates low spots. To avoid this, the approaches should be hardened with rock or a geosynthetic with a rock cap. Puncheons can be slippery when wet, so grades need to be kept to less than 5 percent and approaches need to be on a tangent, not a curve. As with many other structures, puncheons enhance the riding experience while protecting resources.

One of the oldest trail structures, puncheons can be beautiful, functional, and fun to ride. Note the muddy spots where the structures end too soon (arrows). These should be filled with rock or hardened with a geosynthetic and a rock cap.

It's harder to construct, but a curved line usually fits the landscape better than a straight line plus it enhances the rider experience.

Side ditches generally run parallel to the trail and help drain the trail tread by allowing ground water to seep into the ditch. The lower the groundwater level is, the drier the trail tread will be. When converting roads to trails, a good practice in wet areas is to use whatever excess width is available for a ditch. This helps drain the trail, enhance the trail experience by having a narrower trail width, and reduce the surface area of the trail. Like ditches along roads, side ditches need cross drains at regular intervals to reduce water volume and velocity and to help maintain the natural hydrology of the landscape.

A side ditch was cut along this trail to help drain the trail tread. However, it does not have adequate cross drains so the water is running too long and too fast which has resulted in erosion. Cross drains need to be added here or the ditch lined with rock to dissipate the water's energy and protect the ditch side walls.

Water will always take the path of least resistance. A mudhole developed by water from this spring saturating the soil below it. A ditch was cut towards the log (arrow) to drain the spring water away from the trail. There was a layer of solid rock that prevented the ditch from being cut lower than the trail tread, so even though some water flows down the ditch, gravity will still pull water down the impermeable rock layer and into the trail. An alternative is to blast the ditch lower or install a French drain in the trail.

This trail runs up a draw which has springs on both sides of the trail. In the wet season, this flat area at the outlet of the draw would become a saturated mudhole. Ditches were cut down both sides of the trail to intercept the spring water and drain the trail tread. The excavated material was used to raise the trail elevation of the tread and a culvert was installed to drain the ditch water under the trail (arrow).

Three years later, the trail tread is high and dry and lush vegetation is growing in the ditches. Use the 4Es. Evaluation is a valuable tool to show what is working (or what isn't). Pictures like these can give managers positive encouragement, can mollify critics, and build support with stakeholders.

Turnpikes have myriad variations, but the principle is always the same: use fill to raise the trail tread above the water table. The higher the tread is, the drier it will be. There are two configurations of turnpikes: ditched and ditchless. Ditched turnpike is most common and uses parallel side ditches to lower the water table. The excavation from those ditches is used as borrow to raise the elevation of the trail tread. However, there are times when sensitive resources prevent the excavation of a ditch or where the side ditches will interfere with the natural subsurface hydrologic flow of water by changing its direction. In these situations, a ditchless turnpike, called a causeway, can be used.

A combination of log and rock causeway. One advantage of rock is that it is easier to make curves. This installation flows very nicely and the structure is in harmony with the site.

An example of ditched turnpike. Ruts are forming in the trail tread because either the ditches are not deep enough, or the ditches do not drain under the trail at regular intervals. If water is allowed to pond in the ditches, it may saturate the trail tread.

Tip, Trick or Trap?

Trap: The process of creating a great OHV trail does not end with construction

It must be followed with long-term monitoring, maintenance, and management

Most turnpike installations start with a layer of geotextile to separate the fill material from the underlying mud or poor quality native material and to increase the load-bearing capacity of the structure. Some installations encapsulate the fill with the geotextile, often called the sausage or burrito technique. Most turnpikes have logs, rocks, or treated timber to confine the fill to keep it from sloughing off into the ditches. The best surface, if available, is gravel or crushed rock with a shallow cap of soil to provide a durable tread surface and to help maintain the shape of the trail tread.

Ditched turnpike may require cross drains, culverts, and lead-off ditches to drain the side ditches. Over time, the ditches will slough in and collect debris, so regular inspection and maintenance is needed to retain the shape, depth, and function of the ditches.

This ditchless turnpike has been in place 10 years and has crushed gravel on top of geotextile. Much of the gravel has worn away or has been displaced and it's time to maintain this structure with another load of gravel. Note the wet spots appearing next to and behind the ATV.

Causeways can work well in seasonally wet areas with soils that drain well. They may not work well in perpetually wet areas with saturated soils since

This is a drier site and the ditches are very shallow, but probably adequate. This may have been an old road corridor. If not and the trail was located here, it is way too straight and does not look natural. Create a trail experience, not a transportation experience.

the structure may slowly sink into the ground. The use of a wider geotextile base or other geosynthetic materials may remedy this.

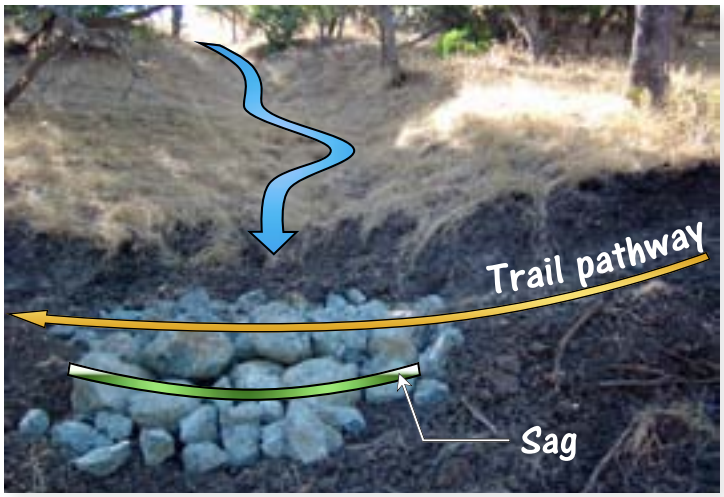
If a supply of mineral soil is available, a turnpike can be cheaper and easier to build than a puncheon, have less maintenance, and have a longer lifespan. Like many other structures, riding on a turnpike is different and adds to the rider experience.

As with many structures, there are short-term impacts upon implementation. Don't let those impacts deter your design decision. Above, a section of recently constructed turnpike on a road-to-trail conversion. Right, the same section one and a half years later. High, dry, and a great single-track experience.

Moving Water Across the Trail

Water from springs, seeps, or ephemeral streams can saturate the trail tread and create mudholes. There are two ways to move the water across a trail: drains and fords.

Drains are structures that carry water across the trail either on the surface or under the surface. Surface drains are a trench outsloped so the water runs across the trail and the trench is filled with cobble rock that provides weight bearing for the vehicles while allowing water to flow through the voids in the rock. These voids will eventually fill up with sediment and the water will then flow over the surface of the rocks. The most common subsurface drains are the French drain and curtain drain. The French drain is usually used to carry water under the trail from a point source of water like a seep or spring. It is a trench dug laterally across the trail, lined with geotextile, filled with clean drain rock, and then the geotextile is folded over the top. Usually, a perforated drain pipe is added as well to help carry the water. Unfortunately, the geotextile usually plugs up over time at



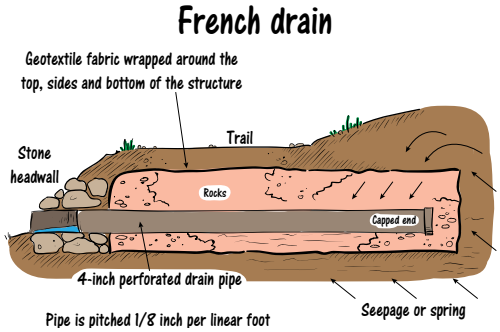
At some point, water will run down this drainage way, either from a thunderstorm or snowmelt. A hardened drain protects the tread and any fillslope from erosion. A properly designed trail would have a grade sag here so the tread drains from both directions at this point.

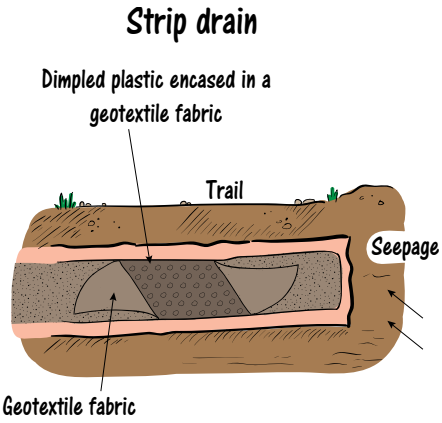
This seasonally wet crossing has been hardened with cobble-sized rock. This is simple and effective and there is no culvert to clean out or plug up. In arid country, runoff from a high-intensity thunderstorm can wash out a culvert, but a hardened drain will likely endure.

This area has pistol-butted trees above the retaining wall (red arrow). This is an indication that the ground is slowly moving or slumping. Trail locators should watch for these indicators and avoid the area if possible. For this area, relocation was not an option and a curtain drain has been installed within the retaining wall to collect and drain water seeping out of the bank. The pipe exits off to the side (yellow arrow).

the inlet causing the structure to fail. Also, if drains are not installed deep enough or if the cover material is not maintained, displacement will expose the geotextile and the integrity of the structure will begin to fail. For these reasons, a culvert or an armored surface drain may be a better alternative.

Curtain drains are installed longitudinally above the trail or along the inside shoulder of the trail. They intercept a sheet flow of subsurface water to prevent it from saturating trail tread or from pumping up through the trail tread with repeated traffic. Depending on the depth of the subsurface water layer, these trenches can be considerably deeper than those of a French drain. They're usually lined with geotextile on the sides and bottom and filled with clean gravel or drain rock. They may or may not have perforated pipe in the bottom. Since they typically intercept a linear water source rather than a point water source, they can be 100 feet or more in length. For lengths greater than 50 feet, the water that is collected needs to be drained across the trail at regular intervals. The cross-drains can be surface drains at a grade reversal or rolling dip, or subsurface drains like culverts, or French drains.





Prefabricated geocomposite sheets or strip drains are also available that function just like curtain and French drains only they're a whole lot easier to install, less expensive, and easier to replace if necessary. They are a piece of dimpled plastic encased in a geotextile fabric and they are available in rolls of various widths and lengths. The trench for these is much smaller and is backfilled with correspondingly smaller volume of sand rather than rock. Strip drains can be an alternative to the traditional trench drains that may be worth considering. Note: If too close to the surface, they can collapse under the weight of vehicles.

As with any structure, these drains need regular inspection and maintenance. French drains especially can clog with sediment and debris at their input point.

Fords are an on-grade, wet-tire crossing that can offer an alternative to the expense of a bridge or the risk of a culvert. They aren't appropriate in some settings and their use is not allowed everywhere. The biggest issue with fords is the potential for sediment delivery from vehicle tires directly into the stream. From a rider standpoint, fords can offer fun, challenge, and a unique riding experience. There are advantages of fords over culverts: fords don't have to be cleaned out, they can tolerate wide fluctuations in flow, and there is generally less risk of a major structure failure or washout.

This ford is hardened with concrete boat ramp planks. These are commonly used and they work quite well.

A flat stream gradient, gravel bottom, and gravel approaches make this a very suitable location for a ford. Low cost, natural appearance, and high rider experience are all benefits.

A few well-placed boulders on the downstream edge and this simple ford is complete. The cobble rocks in the bottom of the ford could have been removed and replaced with smaller rocks for a smoother crossing depending on difficulty level.

Boulders on the downstream side help reduce the gradient of this ford and the banks are well armored with large cobbles for stability and reduction of sediment delivery. However, if fish need to pass through this site, this design could be an issue and an option like a culvert may need to be considered.

Things to consider with fords:

- Fords work best on ephemeral or low-volume streams with low, stable water levels generally not exceeding 10" during the season of use.
- Check the classification of the stream before considering a ford. Fish-bearing streams or those with direct connectivity to community water intake will likely have restrictions or prohibitions on sources of sediment delivery. Some type of permit will likely be required.
- Check management plan direction, NEPA direction, agency policy, and state and local laws for restrictions and prohibitions before building a ford.
- As a general guideline, the farther upstream the crossing is, the more likely that a ford will be acceptable.
- For stability, the stream gradient must be very low or the ford will erode away.
- Trail approach grades should be low (4 to 10 percent) to minimize sediment delivery. Dropping off a steep bank into the creek creates a poor, non-sustainable approach.
- The stream bottom should be gravelly, not sandy or muddy. If it isn't, then some type of hardening will be required.
- A stream bottom with small-sized cobble rock can work well. A crossing with larger sized rocks would need to be consistent with the difficulty level of the trail.

Redirecting Water Away From the Trail

There are three ways to carry water away from the trail and redirect the flow of water to a more desirable location: lead-off ditches, sumps, and sediment basins.

Lead-off ditches are commonly used to drain grade reversals, rolling dips, and outsloped sections. If the material is suitable, push excavated material from the ditch onto the trail to be utilized as tread material, not away from the trail. As in all structures, regular inspection and maintenance is required to keep the structure functional.

On flat ground, it can be difficult to ditch the water away from the trail. One solu-

A new trail on the contour intersects this old fall line trail. This ditch carries water from the closed trail and redirects it into the natural drainage using the cobble rock as an energy dissipater. Note the log across the ditch entrance to catch the riders' eyes.

tion is to build a sump, which is essentially a hole in the ground that will collect any runoff water and allow sediment to drop. A sump will eventually fill up with sediment and will need to be cleaned out in order for the sump to remain functional. The trail tread material that a sump captures can be re-used on the trail. Sumps can also be used to keep runoff water from flowing into an area where it shouldn't go. When constructing a sump, it's important to make it big enough to accommodate the expected runoff volume from an average storm. As in leadoff ditches and rolling dips, when digging a sump never waste the excavated material. Instead, use it as tread material or as material to build up the crest of the rolling dip. Sumps make a good source for borrow material.

A nice lead-off ditch was constructed to drain a rolling dip, but as riders' eyes scan this area, it is difficult to determine a ditch or a trail going off to the right. A millisecond of uncertainty can draw a rider into the ditch. To avoid this, it is a good practice to place a small log across the ditch entrance so it spans the ditch without blocking the flow of water.

Similar to sumps, sediment basins collect runoff water from the trail and allow it to drop its load of sediment before flowing out over the spillway. The difference between a sediment basin and a sump is that a sump generally has no outlet. Sediment basins are usually used in the vicinity of streams to reduce sedimentation and hinder the direct connectivity of water from the trail to the stream. The basin should be of sufficient size and depth to handle normal runoff. In general, a sediment basin has some form of hardening. The entrance can be lined with cobble rock to dissipate the water energy. The back and side edges are usually an earthen berm lined with cobble rock. Sometimes the berm is reinforced with geotextile under the rock. The outlet or spillway is slightly lower than the rest of the berm and it is usually rock lined as well. The bottoms of the basins can be lined with rock, but this can hinder the maintenance task of periodically removing the deposited sediment. Sediment basins will fill up with debris and sediment and require routine inspection and maintenance.

Tip, Trick or Trap?

Tip: Tread material is a precious resource. Any suitable material excavated for a structure should be incorporated into the trail tread.

Before rehab efforts could begin on this heavily eroded trail, the source of the water had to be diverted away by ditching it into the natural drainage courses.

Due to the flat terrain, this rolling dip has little elevation difference between the sag and the crest. The lead-off ditch also has a flat gradient and it is almost full of sediment. Notice how the water is flowing past the entrance to the ditch and is almost breaching the rolling dip (arrow). If maintenance isn't performed shortly, this structure will likely fail.

Sediment basins allow a trail to drain water into the proximity of a stream and still protect the water quality of the stream. Notice the rock armoring in the outlet.

Without the sump, this water would just drain down to the trail below where it has the potential to gain more velocity and create more erosion. It would have been better if at least the back wall of this sump (arrow) was armored with rock. If it ever saturates and breaches, the flood of water could create unwanted and unnecessary impacts.

The excavation from this sump was used to construct the crest of this rolling dip. It appears that the sump could be bigger. Note the sediment (arrow) that has been deposited in the trail tread before entering the sump and how muddy the water is in the sump. This material can be reused.

Using Existing Structures to Control Water

Structures that are used to cross major streams can be very expensive to build and maintain. A strategy that can reduce those costs and reduce potential environmental impacts is to utilize infrastructure that is already in place, such as road or other trail crossings. This may not be desirable from a purist trail perspective, but it is desirable from a practicality and management perspective. The infrastructure could be a simple ford, a large multi-plate culvert, or a bridge. In many cases, the existing infrastructure is already in the best crossing location and other options may be limited or not as suitable. If it is a road structure, access would require mixed use of the road but this could be for just the minimum distance required to cross the stream and get to a point where there is good trail egress with flat grades and adequate sight distance.

Several things need to be in place before utilizing existing structures:

- The trail needs to be directed to the existing infrastructure and this is not always possible.
- When using the structures of an existing trail, determine if the trail uses are compatible with the existing structure and if the structure will safely accommodate the OHV width and weight.
- Existing stakeholders need to be consulted to flush out any concerns and to build and maintain stakeholder cooperation.

The cost of a major culvert installation like this can be prohibitive, so routing the OHV use onto this road to share the structure only makes sense.

- Appropriate signing will be necessary to warn everyone that the structure will be multiple-use.
- When using existing road infrastructure determine if it is legal to have mixed use on the road.

The strategy of using existing infrastructure has been implemented very successfully on many projects. Short-term benefits include reduced environmental analysis, reduced engineering costs, and reduced project implementation costs. But the long-term benefits can reap bigger rewards in reduced maintenance and replacement costs. It may also foster cooperative efforts between motorized and non-motorized stakeholders.

Erosion Control Structures

Erosion control structures are commonly used and often required on construction sites to prevent stormwater runoff from entering streams, riparian areas, or other sensitive areas. Their function is to reduce the velocity of the water and to trap sediment. They are also used to aid in closure; stabilization; rehabilitation of old trails; and any time the runoff is expected to be higher than normal and tax existing drainage facilities, such as after a wildfire, during or after a logging operation, or during an unusually wet rainy season. Erosion control structures are usually temporary structures since they do not have long-term effectiveness or durability.

This trench is a heavily eroded motorcycle trail in sandy soil. The sediment movement was halted by stabilizing the trenches. This was successfully accomplished with rock and log check dams, woody debris placed in the bottom, and ditches to drain water into its natural channel.

The most common types of erosion structures are check dams; energy dissipaters; silt fences; straw or coir wattles; and straw, hay, or other bales.

Check dams are used to close or rehabilitate heavily eroded trails or to stabilize the continuing erosion and growth of ravines. The word "dam" is a slight misnomer since most check dams allow water to percolate through them. The principle of the check dam is to reduce the velocity of the water so it will drop its load of sediment behind the dam. Eventually, the dam will fill up with sediment, which will help stabilize the floor and sides of the ravine or trench. The dams should be installed at regular intervals down the full length of the ravine or trench. Though check dams can be difficult to install, they are highly effective. Materials are usually cobble rock, logs, and treated timber, though steel guardrail has also been used. While curbing erosion from above, the dams also act as barriers to deter riding from below.

These log check dams were installed to stabilize and rehabilitate this old motorcycle hillclimb. After four years, use has been deterred and the impacts are starting to heal.

Above, material has started to fill in and revegetate behind this rock check dam. Rider access from the top and bottom was blocked and signed as closed.

An energy dissipater is any structure that slows, redirects, or interferes with the flow of water. Water velocity is what erodes the soil, so the amount of sediment being carried by the water is directly proportional to the velocity of the water. The most common dissipater material is cobble-size rock or larger, but logs, steel, woody debris, or other materials can be used as well.

A dissipater should be considered at the outlet of any corrugated culvert installed on a grade exceeding 10 percent and on any smooth-walled culvert exceeding 5 percent. An energy dissipater should be considered at trail drainage

Installing an energy dissipater at a culvert outlet

points that have the potential to drain a high volume of water, especially if that drainage point is on a fill or a steep slope. Armoring the slope with rock reduces the velocity of the water and protects the slope from erosion.

A blanket of cobble rock at the drain point of this trail protects the fillslope from scour and erosion. This protection is especially important where there is the potential for high volume and high velocity water flows.

In order to get bridge materials and equipment up this old road, silt fence had to be installed any place there wasn't a vegetative barrier between the road and the stream.

Silt fence is a water-permeable geotextile fabric held upright and anchored to the ground by regularly spaced stakes. The fabric allows water to slowly seep through it, but filters out the sediment carried by the water. One advantage to using a silt fence is that it is readily available at most large home supply stores or farm and ranch stores. It can quickly become unsightly and should be removed after it is no longer needed.

Silt fence was installed at the base of this fireline to protect runoff and sediment from entering this sensitive stream. It often comes pre-attached to wooden stakes, but they will not last as long as metal T-posts.

Straw or coir wattles are commonly seen in the ditch lines along most road construction projects. They are net bags filled with straw or coconut fibers so they look like small logs. They come in a variety of diameters and lengths and are usually staked in a herringbone pattern at regular intervals in a drainage way. When used in trail or slope rehabilitation, they are placed on the contour at regular intervals down the slope. The steeper the slope, the shorter the interval. Wattles break the slope into smaller watersheds, which reduce water volume and velocity. The wattles trap sediment, but allow water to filter through slowly.

Wattles placed as part of the rehab of old hillclimbs. Between the wattle rows, the area is usually seeded and covered with mulch.

Above, rows of wattles staked closely together as part of the rehabilitation of this steep slope.

Bales have the advantages of availability, easy installation, and portability. Bales placed at regular intervals down a slope prevent water from gaining too much volume and velocity. This protects the seeding, mulching, and other erosion control efforts. In addition to straw bales, cedar shaving bales are also available. Cedar bales are heavier than straw, but they last longer and do not need to be certified as weed-free. Bales can also be used as a visual and physical barrier.

Bales are relatively easy to transport to the site and stake in place. They are effective erosion control devices and they provide more of a visual barrier than wattles.

Bales of cedar shavings work well, last longer than straw, and don't need to be certified weed-free.

Section 2: Terrestrial Control Structures

Retaining Structures

There are two types of retaining structures: gabions and retaining walls.

A gabion is a rectangular wire basket that is filled with rock. Once filled, a wire lid is secured in place. Gabions are support structures that are commonly used for bridge abutments, retaining walls, and stream bank protection. The top of the gabion should not be used for the trail tread since the wire mesh will eventually break and puncture tires.

Gabions are being used to support these two bridges. The baskets are a good alternative when there isn't a solid foundation.

Retaining walls hold material in place and include bin walls and crib walls. Bin walls are closed wall structures that are back filled to create a gravity fed retaining wall. Crib walls are created by stacking members (timber, steel, etc.) which creates a void that can be filled by rock or soil. Materials typically used for retaining walls include log, stone, treated timber, geocell, encapsulated geotextile (grass pavers which can be filled with dirt and stone to create a wall), interlocking concrete blocks, and steel guardrail sections. Often, the inside of the structure is lined with geotextile, which increases strength and helps contain fill material. Retaining wall kits are also available that provide durability, portability, and ease of assembly.

Log walls are classic and natural, but not as durable as other materials. This is a good example of a crib wall.

Common uses for retaining walls include the following:

- To support the trail fill when sideslopes are too steep, too unstable, or when full-bench construction is not desirable or feasible.

- To contain or stabilize the cut bank in steep ground, unstable soils, or loose rock like scree.
- To minimize the footprint (size of cut slope and fill slope) of the trail to enhance aesthetics or to protect resources.
- To contain trail fill material on bridge approaches and abutments so soil doesn't leach into streams, riparian areas, or other sensitive resources.

If available, rock is certainly the most aesthetic material, but it is best suited for small structures unless skilled crews are available to construct multi-tiered installations.

The Sutter retaining wall is a kit that uses treated lumber and prefabricated channel posts and caps. With ease of transport and installation, it can significantly reduce the cost of a retaining wall.

Interlocking concrete blocks (sometimes called no-pins) are a common material when there is good equipment access to the site. This wall was built to protect a trail from road fill slough. It is a new installation, so its success is not yet determined, but it appears to be too short to accomplish the objective.

This bridge approach bin wall has nice clean lines and makes a beautiful installation. Once vegetation is re-established, it will blend well with the landscape.

Structures for Controlling and Directing Access and Use

Managing entrances and using tank traps, barriers, fences, gates, and cattle guards all help control and direct the riders' direction.

A couple of well-placed boulders can effectively send the message that this trail is for single track only.

Entrance management is accomplished with a structure or a combination of structures and signing to inform the rider of the type of vehicle or vehicle width allowed on the trail. Bollards, barriers, or sections of fencing are often used to restrict vehicles exceeding a certain width from entering the trail. Entrance management is also a technique used to inform riders of the actual difficulty they will be encountering on the trail. Too often, a more difficult or most difficult trail does not appear challenging at the entrance to the trail, so riders start riding the easier part of the trail and then encounter a section with a technical challenge that may be beyond their riding capabilities. With entrance management, technical features (often called

Treated wood bollards are commonly used for entrance management. However, there is too much space on either side if the goal is to stop larger vehicles from entering.

filters or qualifiers) consistent with the difficulty level are placed across the entrance of more or most difficult trails so riders immediately know the level of skill needed or the requirements of the vehicle for the trail to be successfully negotiated. This protects the riders, but also protects the trail from undue impacts. For risk management and for rider safety and enjoyment, this technique should be used at the entrance of any trail that does not appear to be as difficult as it is signed.

Steel pipe is vandal-resistant and sends a stronger message when one is needed.

Effective entrance management controls use and sets expectations by answering questions for the rider:

- Which trail is it? This is indicated by a trail marker that shows at a minimum a direction arrow, and the trail number.
- What is the difficulty level? This is shown on the trail marker and indicated on the ground by a filter when necessary.
- Who can use it (use types)? This is shown on the travel management sign and sometimes shown on the trail marker. Width-limiting devices or barriers can be used to prevent some types of uses from accessing the trail.
- When is it open or closed? If necessary, this can be shown on the travel management sign or other regulatory sign and is often indicated on the ground by a gate or barrier across the trail entrance.

Other information that is often provided at a trail entrance is a “Two-Way Trail” warning sign or “One-Way” or “Exit Only” regulatory signs when appropriate.

Simple, innovative, and effective.

A

This is a good example of an entrance management installation: well-placed barriers backed up with good signing. The 4Es at work.

Anyone could move these treated barriers out of the way, but they didn’t. The barriers are not pinned so maintenance equipment can still get through.

A note on width limiters

Limiters are objects that have been installed within the trail prism. As such, they can increase risk of rider injury and management liability. Limiters MUST be clearly visible. Install them on a tangent, never on a curve. Control approach speed by tightening the trail alignment or other method. Insure that there is adequate time for the rider to see the object, comprehend the object, and react accordingly. Apply reflective object markers if necessary.

Tires were placed as a filter at the entrance to these trails to provide an immediate indication of the difficulty. Good entrance management sets expectations and increases rider safety and enjoyment. It would be preferable to have the filters fit aesthetically with the landscape, but that is not always possible.

Entrance management gone awry…. This was a creative attempt to close a road to full-size vehicles and limit use to ATVs and OHMs. While it's been effective and is still in place, it is aesthetically displeasing, there is no signing or reflective markers, and it's the type of structure that could provide an unwanted "challenge" to an irritated operator of a full-size vehicle.

Tip, Trick or Trap?

Tip: Before designing or installing any gate or limiter, be sure to check for compliance with accessibility requirements

From the front, this tank trap just looks like a mound of dirt that could invite challenge…

…but riders launching themselves over that mound would be looking at a face plant in a vertical wall. These structures have caused serious injuries to riders.

A tank trap is a structure commonly used as entrance management to close or restrict motorized access to roads or trails. It is constructed by digging a hole and using the excavated material to build up a berm in front of the hole. Often called "Kelly humps," the combination of the hole and berm can create a formidable structure that can be 12 to 15 feet deep. There has been much debate on the use of tank traps. On the one hand, they do provide a visual barrier to indicate that the road or trail is closed. On the other hand, for OHV riders looking for challenge, a tank trap can look inviting and attract unwanted use. Just a mound of dirt does not effectively communicate a closure. Unintentional use on poorly located or poorly signed tank traps can result in severe injuries or death. Tank traps can be especially hazardous if the road or trail is closed in the summer to motorized use, but open in the winter to over-snow use. In poor light or blinding snow, a snowmobiler can unknowingly ride into a tank trap.

Tip, Trick or Trap?

Trap: Poorly located, constructed, and signed tank traps are just that- TRAPS

They should not be used on or adjacent to an OHV trail or trail system

Barriers are another management tool used to control and direct where the riders can or can't go. Riders' eyes are constantly scanning for the open route and the best line through that route. It does not take much of a barrier to catch the riders' eyes and deter use. As such, a low, unobtrusive barrier can be just as effective as a large

Boulders make a great natural looking barrier when available. This installation is not complete since the trail that is being blocked has not been ripped and disguised with debris.

visually obtrusive barrier. A variety of materials can be used for barriers, including dirt, vegetation, logs, wooden rails or poles, rocks, steel, tires, hay bales, or treated timber. The choice of materials usually depends on local availability, price, architectural theme, or factors such as the risk of vandalism. The material selected can either send a strong visual message or a subtle one. Once a material is selected, it should be used throughout the project so that a consistent message is sent to the riders.

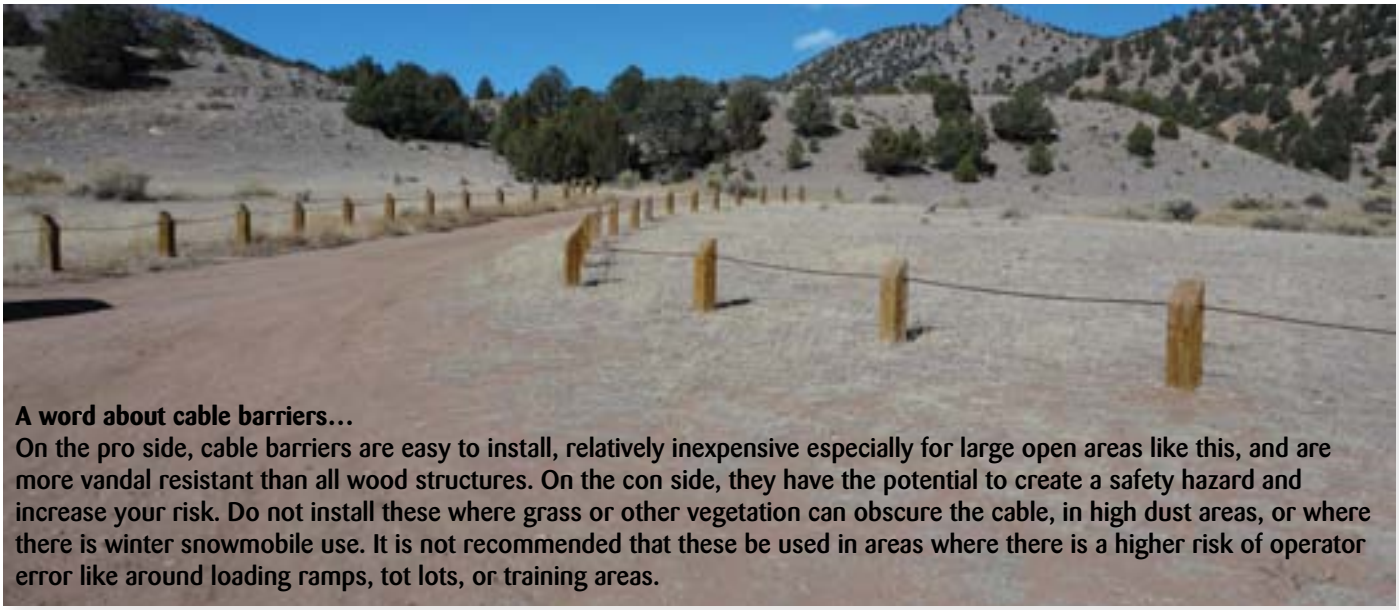
When used for closure or rehabilitation, the most effective installations include a sign behind the barrier saying "Area Closed" or "Trail Closed."

Hay or straw bales can make good barriers to control and direct the use. Their portability makes them good for short term uses like trail closures. Bales may need to be certified as weed-free.

These large tires make an effective barrier. Though not aesthetically pleasing, there was a local source of supply and the price was right: free.

With no other materials readily available and in an area prone to vandalism, these pipe barriers are a good choice.

The spruce budworm provided an ample supply of logs for these beautiful and effective barriers.



A word about cable barriers…
On the pro side, cable barriers are easy to install, relatively inexpensive especially for large open areas like this, and are more vandal resistant than all wood structures. On the con side, they have the potential to create a safety hazard and increase your risk. Do not install these where grass or other vegetation can obscure the cable, in high dust areas, or where there is winter snowmobile use. It is not recommended that these be used in areas where there is a higher risk of operator error like around loading ramps, tot lots, or training areas.

Like barriers, fences are used to control and direct the trail use. Materials used to construct fences are often metal, chain link, barbed wire, plain wire, treated timber, rail, split-rail, and log. Material selection is often dictated by local supply, price, or architectural theme. Once a material is selected, it should be used throughout the project so that a consistent message is sent to the riders. As with barriers, fences can add to (or distract from) the aesthetics of an area. They can provide a subtle guide or a strong constraint. Fencelines should also be shown on the trail map to aid in orientation and rider awareness.

One issue that often occurs is a trail paralleling a barbed wire fence. Many factors need to be considered when siting a trail parallel to this type of fence, including speed, traffic volume, tread width, and smoothness of the tread surface. Consider also the consequences of a rider losing control. If the tread is narrower and the surface is loose rock, the risk goes up and that should be reflected in the difficulty level assigned to the trail.

Though not pretty, a requirement for this OHV park was that riders be contained and chain link was the best way to accomplish that.

For resource protection, it was essential to keep cows and riders out of a sensitive drainage and the barbed-wire range fence achieved that.

Gates can be a good management tool, but their primary use is to control access and facilitate travel management. Gates are commonly used for seasonal closures, such as deer winter range or snow melt; to protect resources in cases such as after a natural disaster or other storm events; or as part of entrance management.

This beautiful Russell fence actually enhances the rider experience while providing protection for a sensitive grassland environment.

This classic chilcotin fence harmonizes with the landscape. The mountain pine beetle created a surplus of poles, so why not use them to help manage the use?

There has been much discussion about the effectiveness of gates. They can foster ill will because those with a key can go in, but others are restricted, so they are prone to vandalism. Gate effectiveness uses three of the 4Es. A gate is an engineering structure, but it needs to be supported by education and maybe some enforcement. Most people will respect a closure if they understand the reason behind it. Put up a sign explaining the closure and back that up with information on the trailhead kiosk, the map, website, and other media. Time and effort spent on education will be rewarded with compliance, user satisfaction, and reduced risk of vandalism.

Chains and braided cables are sometimes used as an inexpensive alternative to a gate. DO NOT DO THIS. Gates are visible structures and most have signs or reflective markers on them to increase their visibility,

but cables and chains hang low, are usually very thin, often poorly marked, and can be extremely hard to see in a storm or low light. They can be death traps, especially if the trail is also used in the winter by over-snow vehicles. Manage risk. Install the proper structures that will increase public safety and reduce liability.

Things to think about with gates:

- If possible, locate gates where vegetation or topography will inhibit bypassing.
- Use signing and education to inform riders as to why a gate is closed.
- Gates that are sometimes open or sometimes closed to manage access should have red and white retroreflective tape or object markers to increase their visibility. This is a simple step to help manage risk, and this protocol should be included in the project sign plan.
- Gates that are locked in the closed position should also be locked in the open position so that only management has control of the access.
- When gates are used for resource protection, ensure that they are opened in a timely manner when that protection is no longer needed. Similarly, when used for a seasonal closure, ensure they are opened on the date they should be opened.
- Gates should be fully closed or fully open and never in a partially open position. A partially open gate can be a serious safety hazard when there is limited visibility. Manage risk. Ensure that all gates have positive, functional latches or closure mechanisms.
- Work with human nature, not against it. If the complaint is that riders are leaving a range gate open, don't have a crude barbed wire gate closure that can shred expensive riding gloves and jerseys or is difficult to open and close. Use the 4Es. Improving engineering by installing a cam-lock gate closure device will increase compliance and facilitate OHV management.
- Never direct traffic around a locked gate without designating the side route as open, otherwise the public learns to ignore a locked gate.

A Closer Look...

On the gate below, the reflective red and white panel with diagonal stripes is called an object marker. They're available in several shapes, colors, and sizes; guidance for their use can be found in most sign handbooks and in the Manual on Uniform Traffic Control Devices (MUTCD).

Gates that are left in a closed position while the trail goes around them teach the public to ignore closed gates.

It is better to have a designated trail path when closing a gate to one use but opening it to another.

This trail is on an irrigation ditch access road. The innovative gate restricts trail access, but allows access for full-sized maintenance vehicles.

Here are two examples of using other structures as "gates" to control access.

Cattle guards are often installed for livestock management. There are two basic configurations: arched and on-grade. Arches can be a good choice in rocky terrain or where resources preclude excavation. Having a dog-leg in the trail alignment on each side of the cattle guard will control the speed of approach. The dogleg allows adequate sight distance but not enough distance to gain speed. On-grade structures can be easier to traverse, but they may require more frequent clean-out. A steel deck is far more durable than treated timber and a much better option.

All cattle guard installations should have a bypass gate to allow passage of equestrians, stock, pedestrians, or maintenance equipment. They can be very slippery when wet or icy. For rider safety and risk management, cattle guards should be installed on tangents, never on a curve, on the flattest grade possible, and level from side to side. Angled wings provide a margin of safety and allow room for transporting over-width materials or game.

Cattle guards are commercially available, but many agencies make their own. There is more science in design and rail spacing than one might think. Improper design such as too deep or too shallow trenches, sharp edges, slippery materials, too great an angle, etc., can pose a risk to both the cattle and the riders. Use caution when attempting to design a cattle guard.

This deck of this cattle guard has round steel tubing and a steel channel iron base. The strip of expanded metal down the center was intended to provide grip for motorcycles, but it is too narrow to be functional. The vertical wings are confining and provide no margin for error.

Above, this on-grade cattle guard has a 2"x 2" square tubing deck in an angle iron frame attached to a 2"x 12" treated timber base.

This arched cattle guard has an angle iron deck attached to a channel iron frame. Due to the forces exerted by tires on the deck ramp, it is essential that arched cattleguards are securely pinned to the ground.

Treated poles were used for this single-track cattleguard. The wood will provide a better grip than a steel deck, but note that this cattleguard in installed on a curve. Though slight, it is enough of a curve for a motorcycle with muddy tires to slide.

Need more? Learn more here...

Alaska Trails Training Modules: Mike Shields: *Slope Structures and Trail Stability,Trail Drainage: Structures and Hydrology, Trail Treadway Structures*

Best Maintenance Practices, Maine Motorized Trail Construction and Maintenance Manual, Bureau of Parks & Lands, Off-Road Division, May 2011

Locating Your Trail Bridge for Longevity, USDA Forest Service, Technology & Development Program, 1023-2808P-MTDC, June, 2010

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Manual on Uniform Traffic Control Devices (MUTCD), http://mutcd.fhwa.dot.gov

Natural Surface Trails by Design, Troy Scott Parker, Natureshape, 2004

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Water Harvesting from Low-Standard Rural Roads, Bill Zeedyk, 2012

Wetland Trail Design and Construction, USDA Forest Service, Technology and Development Program, 0123-2833-MTDC, September 2001

A Look Back...

Here are some of the elements discussed in this chapter:

- Always start with the best location for the trail and be forced into utilizing a structure. Structures should be the last option, not the first, since good trail location will minimize the need for them. Structures are time consuming and expensive to build, maintain, and eventually replace.
- A principle element in achieving a durable trail is managing water. Structures help accomplish that by moving water off the trail, under the trail, across the trail, or away from the trail.
- When trying to drain water off a trail, use the grade and alignment to help you. Locate the structure where there is a break in the grade or in a curve where the natural superelevation will help turn and drain the water in the direction of the curve. Allow the water to run in its original direction as much as possible.
- The critical vehicle or design vehicle may not be the OHV using the trail, but the trail dozer or other equipment needed to maintain the trail
- Using entrance management to restrict or define difficulty level access may preclude future trail maintenance or management options
- Many structures require engineering calculations and design. Don't cut costs by short-cutting this step. Manage liability and risk by doing it right the first time.
- Any time that manmade structures are incorporated into a project, the potential risk to public safety goes up and the risk of liability goes up
- Structures require regular inspection and maintenance. The cost and personnel to perform these tasks must be built into the O&M program.
- The longevity of most structures depends on use type, use level, soil type, climate, proper design, proper installation, and proper maintenance. Failure to adequately assess and address any one of these elements may lead to structure failure.

Chapter Eight
Tools in the Toolbox: Equipment

Wear All Your Gear All the Time

To develop an effective O&M program, amassing materials, supplies, tools, vehicles, and equipment is a must. For the field technicians, this is where the fun starts, and they would probably term this chapter "Toys in the Toy Box" since equipment is what puts the trail on the ground and keeps it there. For the program managers, equipment poses a multitude of questions with not-so-easy answers, including what needs to be bought and when?; how will it be paid for?; where will it be stored and how will it be moved around?; and who will operate, maintain, and repair it?

Often two pieces of equipment are more efficient than just one.

Heavy Equipment

Here are some thoughts regarding heavy equipment:

- There isn't one do-all machine; it usually takes a combination of equipment to accomplish all of the necessary tasks.
- Program managers should identify equipment needed for the short term (construction) and equipment needed for the long term (operation and maintenance).
- Managers should examine options to borrow, rent, or contract the equipment for the short term.
- Program managers should only buy the equipment they know they will need, not what they think they might need.
- In most cases, managers should not buy equipment that is wider than the intended trail widths.
- Equipment is just a tool that is useless and potentially detrimental without a skilled operator who has the finesse, vision, and experience to create a great trail and maintain it as a great trail.
- Trail construction takes a different skill set than road construction, so there can be challenges in trying to train a road builder to be a trail builder.

- Trails are a narrow path on steep, rocky, irregular, and often soft ground. Any machine can quickly go sideways and the operator must instantly know what to do. All operators must be trained. Don't trade expensive, but experienced operators for inexpensive, but inexperienced operators to try to save money. It could be a costly decision.
- As a minimum, managers should ensure that other personnel are on site in the vicinity of equipment operation. On technical terrain, spotters should be working with each piece of equipment.

There are five main performance categories for heavy equipment: loaders, haulers, pushers, diggers, and other. Some equipment like dozers are purpose-built to perform as pushers, while others, like excavators and skid steers, have the ability to perform well as loaders, haulers, and diggers.

Dozers come in all shapes and sizes, but trail work usually requires only two sizes of dozers. Trail dozers have a track width of less than 50" and full-sized dozers are everything over 50" wide. Mechanized trail building is 10 times faster and cheaper than building by hand, and trail dozers are purpose-built for trail building. Though small in size, they are powerful and versatile with a six-way blade and draw bar with rippers. A variety of attachments are available, and they can grub a stump or move a large boulder. One advantage they have is that they can maneuver easily within the tighter confines of a trail corridor and minimize environmental impacts. The full sized dozers are great for anything which requires a larger foot print than can be accomplished by the trail dozer.

A dozer can push through a rock pile like this and some of the rocks may roll down the hill. An excavator can create a bed for the rocks and carefully place each one. Rocks like this can be used to support the trail tread or used as anchors or chokes for the trail which will enhance the trail's aesthetics and the rider experience.

A Closer Look...

Building trails is not about plowing dirt. In fact, most times the objective is to minimize the amount of dirt movement and retain as many natural features as possible. More important than the size and type of equipment is the skill, motivation, and finesse of the operators. Trail planners and designers can have a great vision and a great design, but it's the operators who put it on the ground and keep it maintained. They can turn a great design into a great trail; a mediocre design into a great trail; or a great design into a poor trail.

A 6-way blade makes short work of trails on steeper ground.

With traction, power, durability, versatility, and maneuverability, a trail dozer is an excellent piece of equipment.

Mechanized equipment is faster and cheaper than building by hand.

There are a lot of jokes about the "baby" dozer, but it all comes down to selecting the right tool for the job.

Excavators are diggers and loaders. They are extremely versatile pieces of equipment because they can construct tread, dig holes, dig ditches, pluck rocks or stumps out of the ground, and drag debris in or scatter debris out of the trail corridor. Most have a two-way blade, but some even have six-way blades for efficient grading and shaping. Having a thumb on the bucket increases the machine's versatility.

With a large selection of excavators in the rental market, it is easy to match the best sized machine to the job; two to look for are mini-excavators and full-sized excavators. It's hard to beat the versatility and finesse of a mini-excavator, which is less than 50" in track width. Many have adjustable-width tracks, a zero clearance cab, and a bucket with a thumb for handy plucking and placing.

A bucket with a thumb is great for grabbing material and placing it strategically without a lot of ground disturbance. The versatility of a mini-excavator makes it a good choice for finesse or finish work.

The ability to work on steep slopes, scatter debris and reach down to remove woody debris from the embankment area is an advantage.

These are great for building narrow treads, digging ditches and drainage structures.

The operator is digging a hole to plant a boulder for a road-to-trail conversion.

Full-sized excavators are handy for constructing wider trails, closure and rehab, road-to-trail conversion, and facility construction. Often, the ideal equipment combination is a trail dozer and a mini-excavator working together.

A clamshell bucket is also very handy for plucking trees, stumps, or rocks. This one has a built-in grizzly that allows dirt and smaller rocks to fall through.

This excavator is rehabbing old hillclimb trails. It is scarifying the trail, installing waterbars in a herringbone pattern, and strategically placing logs that divert water and deter riders.

Need more reach? Not a problem as this excavator places a blanket of energy dissipaters in this drainage.

Equipped with a 6-way blade, this excavator is a versatile trail making machine.

Small size, fast walking speed, and a host of attachments give skid steers great versatility and make them ideal companions with other equipment to accomplish a wide range of tasks. They can be pushers, diggers, loaders, and haulers. One advantage they have is that they are readily available at most rental stores. Mini-skid steers are commonly called walk behinds because there is no operator cab or seat post. These small machines are maneuverable and have many of the same attachments as their big brothers. The common name is a misnomer since most have a platform for the operator to stand on. They don't have the force of a trail dozer, but they can work well for light excavation on flatter ground or finish work. Many have a six-way blade that helps them cut into shallow sidehills with soft soils. The auger attachment is handy for sign or barrier posts, but a slow walking speed does not make them efficient for widely scattered installations.

Whether used as loaders or haulers, skid steers are versatile trail-sized equipment. Because they are tracked with low center of gravity and good braking ability, they are far more stable and safer as a tow vehicle than an ATV or ROV.

The wide range of attachments for skid steers makes them useful for a variety of tasks. This bucket attachment with a fixed thumb works well for placing these barrier rocks.

This flail or mulching attachment makes quick work out of clearing brush and small trees as it pulverizes logs and woody debris on the ground.

If one thumb is good, two has to be better. A clamshell bucket can hold material with odd shapes and sizes.

Though most are equipped with either a blade or a bucket, mini skid-steers have a huge assortment of handy attachments and they are often available at local rental stores.

A tractor with a backhoe attachment can be very handy to load and haul material and to dig holes for barriers, fence posts, and sign posts. Thus they fall into the loader, hauler, and digger categories. Four wheel drive is recommended for most trail applications. Their fast walking speed gives them an advantage over mini-excavators or dozers with backhoe attachments when work is scattered over a wide area. Their three-point hitch and power take-off (PTO) allow for a wide range of power attachments from box blades to mowers.

The clamshell bucket on this backhoe adds to the machine's versatility. It can scoop, load, back blade, pluck, place, and chop.

The backhoe attachment can increase the versitility of a tractor.

Trail dozers, mini-excavators and mini-skid steers are commonly used to build single-track trails. Motorcycle riders have always coveted sweet single tracks, but when it comes to a designed trail, the issues have always been how to build it and then maintain it. Riders will volunteer to build the trail and do. But it is a slow, laborious process and few volunteers can or will return day after day. Purists will say that the only good single track is hand-built single track because it is more natural. When done properly, it is pretty hard to tell a hand-built trail from a machine-built trail. It all comes down to the skill, vision, and conscientiousness of the operator. After some time, compaction and displacement will cause roots and rocks to show on the surface; the sides will

Whether on the machine or off, the control panel moves with the operator. This not only can increase operator safety, it allows the operator to always be in the perfect vantage point to control and finesse the machine.

Like its big brothers, the mini-dozer has brute force power, yet the agility to finesse. Note the big 6-way blade and pointed blade tips. These are great for digging out stumps and boulders if it's desired to have those features come out.

Tip, Trick or Trap?

Tip: Equipment is useless if it doesn't work or breaks down when you need it

Keep all equipment clean and serviceable, do daily maintenance and inspection, and perform all scheduled preventive maintenance.

revegetate; trees will have fallen and been bucked out to a narrow width; and forest litter will make it look like it's been there forever. What is the big difference? With equipment, the production rate is much higher and the cost of construction is much lower. There are now machines that have been purpose-built for single-track trail construction and maintenance. Find more information about these machines at greatohvtrails.com.

This single track trail was constructed with a mini-excavator and a good operator. It is narrow and has a beautiful flow, notice the roots appearing in the tread through compaction.

Tip, Trick or Trap?

Trick: Riders usually make the best operators

It can be easier to teach a rider how to be an operator than to teach a seasoned heavy equipment operator how to build a trail. Riders know the flow, can understand the vision, and can do a test ride to see and feel how well they did.

Rock crushers fit into the "other" category. There is usually a need for crushed rock on most trail projects. If a trail has sections of loose cobble rock, scree, lava, river rock, or glacial till and if those sections are not consistent with the intended difficulty level of the trail, crushing that rock in place can provide a more rideable and stable trail tread. Rock crusher attachments are available for skid steers, excavators, and some trail dozers. Grinders and pulverizers are available for loaders and other equipment. If there is a source of suitable rock, a portable crusher can be brought in and set up on site. The crushed rock is then loaded into dumpers and hauled to the work site.

This manual-feed crusher attachment reduces cobble size rock in place. The smaller, angular rock resists displacement and will provide a more solid, durable trail tread.

If there is a source of suitable rock, a portable crusher can be set up onsite. The crushed rock is then loaded into dumpers and hauled to the work site.

Rock, aggregate, and good quality soil are a great resource for check dams, bridge abutments, drains, headwalls, energy dissipaters, or trail hardening. The issue is getting the material from the source to the site. One solution is a motorized toter or dumper. They come in all shapes and sizes and some are even self-loading. Because they need to fit on the trail and traverse rough terrain, they can have a slow walking speed and relatively low carrying capacity. If there is a lot of material to be moved for any distance, several dumpers may be needed.

Tip, Trick or Trap?

Trick: Effective grooming: lighter is better

With any drag, making several light cutting passes is more effective than one heavy cutting pass. This produces a better product with less wear on the equipment.

A flexible pasture drag is great for smoothing a newly constructed trail and removing woody debris.

Drags are pull-behind grooming tools that are used in both construction and maintenance. The best drag or combinations of drags is often found by trial and error on a specific site. The choice of implement depends on many factors such as the task at hand, soil type, trail width and alignment, use type, and required maintenance frequency. There are five main types: flexible drags, rigid drags, rock rakes, box blades, and other.

This flexible drag has been modified with a heavier square tubing draw bar and rear channel iron. These work well in soft or disturbed soils, but not in compacted trails where displacement has occurred.

Flexible drags are pasture drags or tine harrows that are made from a draw bar and flexible steel web with steel tines on one side of the web. They can be flipped over when traversing rocky trail sections so the tines don't unearth more rocks. With the tines down, they smooth the trail tread, remove small rocks, and collect woody debris. As the debris collects under the drag, the operator must sporadically stop, flip the drag over, and clean it out. They are great for dressing up a newly constructed or reconstructed trail. Flexible drags are effective in loose soils, but not effective in compacted soils since they have limited weight and cutting ability. Being flexible, they are also not effective in smoothing out a heavily moguled trail since material is removed from both the humps and the dips.

Flexible drags can be modified in many ways, including replacing the round draw bar with a piece of channel iron or square tubing for more weight and cutting action. A piece of channel iron can also be added to the rear for more rigidity, weight, and cutting and smoothing action.

A downside of flexible drags is that they are always on the ground. They work well for construction since everything needs to be groomed, but not for maintenance where one section of trail may need grooming, but not the next section.

Rigid drags, the second type of drag, are long, rigid, and usually have cutting blades in a variety of configurations similar to a snowmobile trail groomer. Some rigid drags have cutting blades with adjustable angles and heights and most have rear wheels that can raise the whole implement off the ground for easy transport. Rigid drags will work in compacted soils to cut and fill moguls and to smooth out the trail tread. They are heavy and if they are allowed to cut too much, the weight can tax the transmission of the tow vehicle. Being long and low, they are

This rigid drag has non-adjustable angle iron cutting blades that are designed to cut the edges and fill the center of the trail.

A rigid drag works well in non-cohesive soils that mogul out quickly. This crew uses a rigid drag followed by two rock rakes.

not very maneuverable and they usually don't work well in super tight trails, but in open country they can be quite effective.

This sliding comb rake can reach out and retrieve material that is normally unrecovered and wasted in berms.

Rock rakes, the third type of drag, have a steel bar with spring steel curved tines bolted to them. Their name is misleading since the equipment is a rake, but not necessarily intended to only rake rocks off the trail. They have either electric motors or electric and hydraulic motors so that both the height and the angle of the comb are adjustable. Most have a u-joint coupler, a handlebar-mounted control box, and a safety breakaway wiring harness. The tines will wear out but they are replaceable. These are the most effective grooming tools on the market and will work in soft soils, compacted soils, and moguls. The small tines have a large psi so they have a powerful cutting action. The adjustable comb allows the operator to direct where the material goes.

The rock rake can cut material from the edges and drift it into the center. Combs are available in different widths. At full tilt, this fixed comb extends past the width of the ATV to retrieve berms.

With the comb off the ground, these are easy to back up, turn around, or avoid sections that don't need grooming like rock gardens.

This fixed-comb rock rake has hydraulic rams which have proven durability in dusty conditions. The steel tines are replaceable. Which ones wear out first? The outer ones since most trails are cupped by the forces of compaction and displacement.

Most vendors make two models of rock rakes. One has a fixed comb where the comb rotates on a fixed axis, and the other has a sliding comb that not only rotates, but extends out from one side to the other. The advantage of the sliding comb model is that it can retrieve berms that have built up along the sides of the trail. Their downsides are that they are heavier, have a higher center of gravity that may not work well on superelevated curves, and are considerably more expensive. A fixed comb model can also retrieve berms if there is enough clearing width to allow the tow vehicle and the groomer to straddle the berm. For most routine maintenance, the fixed comb groomer is both effective and a better value.

Box blades have ripper teeth inside the box, which shapes and compacts the material.

This disc and tire combination is being used on sandy trails. Due to its length, this unit would not work well with a tight curvilinear alignment.

Box blades, the fourth type of drag, attach to the three-point hitch of a tractor and are very common in track and arena grooming. Most have a set of ripper teeth mounted inside the box and the teeth can be down or up. The box shapes and compacts the ripped-up material. They are available in a variety of widths down to 4 feet and can work in a variety of soils. Unless

the tractor is equipped with a float mechanism, a box blade will not work well on undulating or moguled trails. Other potential pitfalls are that they tend to cut a trench; the operator cannot drift material from one side of the trail to the other; and it is difficult to reach out and bring in berms.

The last type of drag is for everything else from bed springs to discs to tires. There are a lot of implements commercially available, or the trail team members can get creative and fabricate their own. They shouldn't be afraid to experiment until they find the implement or combination of implements that work the best for their situation.

Compaction equipment compresses soil or rock particles into a denser mass that increases durability and bearing strength. It is essential for the stability of large embankments. It's an important element in the installation of structures such as for the packing material behind retaining walls, bedding culverts, and foundations for bridge abutments. The desired density is best achieved when material is placed and compacted in shallow layers. A compacted trail surface, whether native surface or crushed rock, will retain its shape far longer than a non-compacted tread because it resists the forces of displacement.

A huge assortment of compaction equipment is available, including tampers, plates, and rollers that are either hand operated, self-propelled, or attached to other equipment. Vibratory rollers will compact better and deeper than non-vibratory rollers. Even without specialized equipment, some degree of compaction will occur just by running whatever equipment and vehicles are on site over the full width of the trail.

This sheepsfoot roller attachment behind a trail dozer doesn't vibrate, but it does a good job of compaction when there are favorable soil moisture conditions.

Tip, Trick or Trap?

Tip: You cannot roll out pie crust in a bowl

Do not use compaction equipment on a trail that has a concave or convex shape. The entire tread surface must be uniform from side to side and the soil density must be uniform or only the high points and dense points will receive compactive effort.

this tandem-drum walk behind vibratory roller is labor-intensive, but it produces a well-compacted product.

Moist soil will compact better than dry soil, so try to time compaction operations during periods of favorable moisture content.

These handy vibratory plates will not exert the same compactive effort as a smooth drum roller, but they do a good job smoothing and compacting the surface of the tread. One advantage of compaction attachments is that they can be raised by the equipment to avoid root or rock sections.

This trail size ride-on vibratory roller beats a walk-behind any day, however for safe operation, the tread surface must be relatively smooth and level from side to side. These will not work well with protruding roots or rocks.

A wide range of trailers are useful to haul equipment, materials, and supplies. There is not one do-all trailer and most O&M programs have a fleet of highway trailers and off-highway trailers. Highway trailers are usually full-sized flatbed trailers designed to haul equipment or utility trailers designed to haul materials. Off-highway trailers can help bring materials, equipment, and supplies to a trail work site. They can be pulled by ATVs, ROVs, or skid steers. The trail team members should heed towing capabilities of the tow vehicle before loading up a trailer. Uneven terrain and steep grades add to the challenge of towing off highway so exceeding the tolerances can be risky.

Without road access, it can be a challenge getting materials and supplies into a trail worksite. Trailers in a variety of configurations can be a big help.

Flatbed trailers with a built-in ramp like this are great for hauling OHVs, drags, materials, and supplies.

Tip, Trick or Trap?

Tip: Properly secure all equipment and materials

Never transport equipment that isn't tied down securely even for short distances

Tip, Trick or Trap?

Trap: Bigger equipment isn't always better

Although trails can be constructed with equipment that is wider than the intended trail width with care and some extra work, they cannot be maintained with equipment wider than the trail

Rubber tracks are flexible and have no grousers. With a low PSI and a careful operator, this machine can walk over hand placed trail armoring stones without breaking or displacing them.

A Closer Look…

How to Approach Equipment

It takes hand, foot, and eye coordination to be an operator and intense concentration to make the machine do what the operator wants it to do. The operator's focus is on safely and efficiently accomplishing those tasks, and not necessarily what is going on around him. It is dangerous to come within 20' of a machine being operated unless directed to do so by the operator. Workers should not assume an operator has seen them approach or they will put themselves at risk.

A good trick is the Stick Method. When approaching equipment, even from the front, pick up a good-sized stick (a lath or roll of flagging will also work). If you are unable to get the attention of the operator, throw the stick over the cab or beside the cab at the eye height of the operator. An astute operator will immediately stop to figure out where that came from. Once you have the attention of the operator, wait for a signal that it is okay to approach. A good operator will lower the blade or the bucket to the ground, throttle down, and take his hands off the control levers.

Equipment Drive Characteristics

Steel Track	Rubber Track	Tires
Durable	Durable on dirt, but a lot of sharp rocks will eat them up	Durable
Low PSI due to high ground contact area	Low PSI due to high ground contact area	Higher PSI due to lower ground contact area
Excellent traction in dirt and mud	Good traction in dirt and mud	Poor traction in dirt and mud
Poor traction on rocks	Better traction on rocks	Poor traction on rocks
Will not slip off in uneven terrain, but they can bind up when clogged with debris	Can slip off in uneven terrain	Potential to break the bead or puncture sidewalls in uneven terrain
Higher potential ground impact	Lower potential ground impact	Higher potential ground impact
Better on steeper grades	Good on steeper grades	Poor on steeper grades, better suited on flat grades
Smooth ride	Smoother ride	Bouncy ride
Highest potential to break or dislodge roots and rocks	Lower potential to break or dislodge roots and rocks	Lowest potential to break or dislodge roots and rocks
Steel grousers can damage bridge decks and other structures	Much less potential for structure damage	Much less potential for structure damage

	Dozers	Excavators
Functions	Push, sidecast, rip, back blade; good for construction and maintenance	Dig, pluck, place, load, scatter; limited push and back-blade; good for const., finish work, local maint.
Material Handling	Push, sidecast	Pluck and strategically place
Brushing	Unable to remove debris from embankment area on steeper ground	Able to remove debris from embankment on any slope
Cut slopes	Unable to shape steeper cutslopes	Able to shape any cutslope
Maneuverability	Needs flatter area to turn around. Locking tracks increase ground disturbance	Only needs enough clearance to swing cab to change direction
Stability	Low center of gravity helps stability but stability affected by rocky or slippery slopes	Higher center of gravity can hinder stability but ability to use boom to stabilize on rocky or slippery slopes
Compaction	Excellent embankment compaction by track-splitting or optional mechanical roller	Can use boom to compact embankments or use optional mechanical roller
Slash and Debris	Clears debris deposited in mound or ball	Able to scatter debris on any slope
Objects	Can roll objects but creates ground impacts outside trail prism	Can reach, grab, place objects while staying in trail prism
Digging	Good for trenches and large holes	Good for ditches, post, barriers

Hand and Mechanized Tools

No trail can be constructed by heavy equipment alone. Hand tools do the clearing, pruning, root cutting, structure assembly, and the final finesse work to make it all look pretty. Three common mistakes that are made when purchasing tools are: 1) not buying a good variety of tools like shovels, Pulaskis, and McLeods; 2) not buying enough of each tool; and 3) not buying or renting the right specialty tools (like drills, augers, and rock hammers) that make tough tasks easier. Each tool has a purpose and not having the right mix of tools can make a task much more difficult. Building a single-track trail with just shovels is a waste of time and energy. Tools have a tough life and often a short life as they get misplaced, broken, dulled, and misused.

Camaraderie is important with any crew, but this group is working too closely together for safety. There should be a minimum of 6' between workers. It is a good example of the use of hardhats and the number of tools that are needed for a work crew.

It can be challenging just getting the tools and gear to the work site. From L to R, chainsaws, brush cutters, shovels, McLeods, pulaskis, and loppers.

The following paragraphs describe some of the most common hand tools for trails.

Pulaskis are one of the most essential trail tools because they can cut, chop, dig, and pry.

McLeods are the second most essential trail tools. They combine a hoe and a rake and are great for chopping, moving dirt around, raking out rocks, and shaping the tread, rolling dips, or lead-off ditches.

Chainsaws, with a variety of chain and bar configurations, are essential for cutting trees, logs, brush, and trimming posts, barriers, and other wooden structures.

Loppers are great for pruning small limbs and cutting roots out of the cut bank or trail tread.

A good quality folding saw makes cleaner and closer cuts than a chainsaw and is very handy for final touch-up pruning. Adjustable pole pruners are great for trimming long droopy limbs and they're much safer and faster than using a ladder or standing on top of a vehicle.

Gas-powered brush cutters and hedge trimmers are great for removing or cutting back underbrush, both in construction and maintenance. Hedge trimmers come in either standard or pole units. They are good for keeping new growth from side vegetation from creeping into the trail in places where the tread is already established. Brush cutters come with a variety of implements from blades to nylon string. Choose the correct implement for the largest growth which needs to be cut.

In a deciduous forest, leaves can be a nuisance. Leaf blowers can remove leaves from the work site or blow leaves back onto cut or fill slopes to provide a natural appearance and to protect them from exposure to the elements. Blowers are also handy for removing dirt from bridge decks and other structures.

Spade shovels are indispensable for digging holes, moving dirt, prying out rocks, and cutting roots.

Bow rakes or smaller landscape rakes smooth out the surface and remove small rocks and woody debris. They are great for final shaping and finish work.

It is always amazing how many rocks there are in the exact place a hole needs to be made. Rock bars and tamping bars help to break up or dislodge rocks. A tamping bar is pointed on one end and has a small flat plate on the other, so it can be used for digging and compacting.

The pulaski is an essential trail tool.

McLeods are also essential trail tools.

Chainsaws are an essential trail tool for several functions besides tree removal.

Leaf blowers can move away nuisance leaves in a deciduous forest.

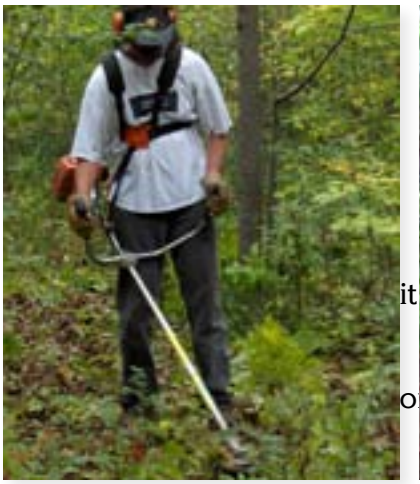
Depending on soil type and time of year, post hole diggers and power augers can be great for digging holes for sign posts and barriers.

Gas powered augers save time and hands for sign post or fence installation.

Portable air compressors are essential because there is always a need for compressed air. Tires go flat, filters need to be cleaned, dirt needs to be blown off parts or personnel, air tools can be more powerful than hand tools, and the list goes on. An industrial-grade air compressor is an essential component in the shop, shop truck, or field staging area. Some heavier equipment offers a compressor as an accessory and this is usually a worthwhile option to consider. Having the ability to use pneumatic drills, rock splitters, and compactors can save a lot of manual labor and is more efficient.

Portable generators are another essential tool because there is always a need to power lights, tools, battery charging stations, etc.

Sometimes, just the tip of a rock needs to be moved out of the way, not the whole rock. And sometimes seems that rocks are anchored to the other side of the world. In those situations, having a pneumatic, gas, electric rock hammer or drill is both safer and faster than ordinary hand tools.



Brush cutters are great for clearing underbrush from a single-track trail.

Pneumatic rock splitters clear away stubborn rocks in the tread.

Many of the wooden structures require the drilling of holes for bolts or drift pins. This can be a tough task that requires electric- or gasoline-powered drills and long drill bits.

Equipment and tools break. Being able to weld on site with a portable welder can save on down-time and expensive trips to a repair shop.

Equipment will also get stuck or find its way into a precarious position. Having a winch suddenly becomes an essential item in these situations. When ordering equipment, it is usually wise to purchase a winch if it's an available option. Chainsaw winches, come-alongs, and OHV winches can be invaluable in moving rocks or logs and in placing bridge stringers, puncheon, and other structures.

Equipment can find its way into precarious positions.

Drills and bits are invaluable for on-site structure assesmbly.

The list can go on forever, but some other tools worth mentioning include the following:

- pick mattock
- hazel hoe or adze
- mallet
- sledge hammer
- hand seeder
- fence stretcher
- fiberglass marker installer and removal tools
- T-post driver
- pop rivet tools
- complete mechanics tool sets (both standard and metric)
- cordless drill and drivers
- hand saws
- corded or cordless circular saws
- A tool bag is great for everything else:
  - a drill and driver with spare battery and bits
  - sockets and wrenches for whatever size hardware is being used on the project
  - an assortment of hardware
  - an assortment of decals
  - a fencing tool
  - torpedo level to make sure the signs and posts are straight
  - 25' tape measure
  - notebook and pencil
  - hammer
  - scrench saw tool
  - ear plugs
  - 4-way screwdriver
  - pliers

Tip, Trick or Trap?

Trick: Want to be ready for just about anything?

When reviewing a project site, consider carrying:
tool bag
pulaski
McLeod
folding pruner
loppers
hand axe
lath or stakes
flagging

A Second Look...

Personal Protective Equipment (PPE): PPE includes gloves, hardhats, chaps, hearing protection, eye protection, boots (or steel toe boots), long-sleeved shirts, long pants, etc. For equipment, PPE includes the seat belt. Whatever personal protective gear is needed, HAVE IT and WEAR IT.

Did we mention the #1 function of hand tools?

A Look Back...

Here are some of the elements discussed in this chapter:

- There isn't one do-all piece of heavy equipment; it usually takes a combination of equipment to accomplish all of the tasks
- Identify equipment needs for the short term and long term
- Rent or contract short-term equipment
- In most cases, do not buy equipment that is wider than the intended trail widths, especially for maintenance
- Tracked equipment has better traction and less ground impact than wheeled equipment Steel tracks have more traction, but potentially more ground impact than rubber tracks
- Keep all equipment and tools clean, serviceable, and properly maintained
- Equipment is useless without a skilled operator who has the finesse, vision, and experience to create a great trail
- It can be easier to teach a rider how to be an equipment operator than to teach a seasoned heavy equipment operator how to build a trail
- Buy a full variety of hand tools and buy lots of them
- Whether operating equipment, working around equipment, or using hand tools, always have and wear appropriate PPE
- Ensure that all equipment and materials are properly secured during transport
- Never approach a piece of moving equipment unless directed to do so by the operator

Chapter Nine

Tools in the Toolbox: Communicating with the Public

If Not You, Who?

The foundation of this book is the effective application of the 4Es; and the basic premise of the second "E," Education, is that educated riders are responsible riders. Most agencies don't have the personnel or funding to have staff in the field when the riders are recreating, but it is essential that management communicate with the riders and that the riders understand that communication. If management team members don't effectively tell the public where they should be riding and how they should be acting, the team can't be disappointed when riders go where the team doesn't want them to go and do what the team doesn't want them to do.

Communication can occur through non-personal media, including signing, trail maps, websites, and social media. It can also occur through personal contact, including through agency staff, contracted site hosts, or volunteer trail ambassador programs.

Signing

Signing gives the rider key information about the site, rules, orientation, education, and safety. By clearly conveying these messages, management can better control and direct the use, maximize rider safety, and minimize agency risk. But signing does more than just convey a message, it conveys an image and an expectation: this site is professionally managed. Visitors will respond to that image with increased respect and compliance.

These signs are getting illegible; the lower ones look like an afterthought. What image are you sending to the public when using these signs? How is the public supposed to obey the signing?

Here are some key points on signing:

- Have a sign plan. This ensures consistency with sizes, shapes, colors, messages, placement, and decal application protocols.
- Signing must be clear, concise, and effective. Follow the Keep It Simple (KIS) principle.
- Trails are like miniature roads and should be signed in the same manner as roads.
- Ensure that signing on the ground agrees with the information on the map or other handouts and media (website, downloadable maps, downloadable GPS data, etc.).
- When first entering a trailhead, signing will give visitors their first impression of the site, its management, and its maintenance. Make it a good and lasting impression.
- Provide the information that is essential for the rider to know.
- During project development, the importance of signing is often overlooked and its cost is often underestimated. Signing costs can be significant and need to be factored into the project budget to ensure quality signs and signing.

Tip, Trick or Trap?

Tip: Entrance management components

- Trail marker
- Travel management sign
- Vehicle width limiter
- Difficulty filter (if necessary)
- Closure or restriction sign (if necessary)

A sign plan can be very detailed and provide site-specific data on sign location, sign type, and message. Or it can be a programmatic sign plan which identifies typical signing scenarios for a project area and provides guidance on what signs would be appropriate in each of those scenarios. This provides consistency by ensuring that similar scenarios have similar signing. In each

scenario, the plan discusses the signs that are needed and their function. It provides guidance on the sign shapes, sizes, colors, messages, letter sizes, reflectivity, materials, decal placement protocols, and sign installation protocols.

Other benefits of a sign plan include:

- Identifies a sign theme that is consistent with the architectural theme and landscape setting for the project site.
- Helps ensure that the proper sign types are used in a given scenario.
- Minimizes sign clutter and maximizes sign efficiency.
- Provides all personnel with the same vision.
- Allows managers to budget for sign needs according to the vision.
- Allows volunteers to install and maintain the signs according to the vision.
- Over time, management and personnel will change, and a sign plan will maintain continuity and consistency through these changes.

Here, a low-volume spur road has been blocked where it continues on a single-track conversion. The motorcycle is parked in what is now a dead-end road with no cross traffic. There is nothing to Yield to, so why have a Yield sign?

There are eight key elements in effective signing (need, simplicity, clarity, quality, consistency, placement, monitoring, and maintenance) and having a plan helps address all of them.

These signs are simple and easy to read.

These signs have too much information and the important information like trail number and direction are not at the top where they should be. Agency and funding decals, if needed, should be at the bottom of the marker. Riders will not stop long enough to read or comprehend this data.

1. Need

Determine the reason for a sign or if a sign is necessary.

- Are there other options instead of signs? Can the hazard be eliminated or mitigated? Can the trail be realigned or relocated to eliminate the hazard? It's easier to put up a sign than to physically correct the problem, but this may not be the best long-term solution.
- If a sign is needed, choose the appropriate sign from the sign plan.

Having a plan helps avoid sign clutter like this. Though the information may be important, no rider is going to stop to read this barrage of signage. All of this could be put on one well-designed large sign.

Tip, Trick or Trap?

Tip: More signs do not equal more effectiveness


What do these signs mean? Riders cannot be compliant if they are confused by the message.

2. Simplicity
- Keep it simple and avoid clutter.
- The public spends very little time reading signs, so make them count.
- Use enough signs, but avoid over-signing.

The sign at left is too simple. Caution of what? The sign at right explains what the Caution is.

3. Clarity
- Use clear, concise messages.
- Will the rider understand the intent of the sign?
- Whenever possible, use symbols rather than words.

4. Quality
- Use durable materials that are vandal-resistant.
- Make sure the sign is taped to protect it from UV light or snow shear.
- Use professional letters and templates.
- Make the sign messages appropriate and professional.
- Check, re-check, then check again for correct spelling.
- The sign and the installation should be neat, legible, straight, and professional looking.
- The public respects quality, but quality does not necessarily equate to expensive.

While any sign may be better than no sign, what message is being given to the riders with this poor quality sign installation?

Why did management accept and pay for these poor quality signs? People respect quality. If management doesn't care, why should the riders care?

These signs may be inexpensive, but they do not meet size, shape, color, or mounting standards. The paper stop sign is illegible. All of this only increases tort claim risk and decreases agency image.

The better image? The home-made sign on the left was definitely inexpensive, but the sign on the right is far more professional and effective.

Both of these motorcycle crossing warning signs are on the same trail system. Neither meet size, shape, color, mounting, or reflectivity guidelines. This, plus the lack of consistency, increases risk.

5. Consistency
- Do all of the signs meet shape, color, reflectivity, and message standards?
- Are similar hazards and situations signed identically?
- Is the signing consistent with that of other OHV trail systems in your area, state, or province?

6. Placement
This is perhaps the most critical and abused element. Most OHV trail signs are viewed from a moving vehicle, so signs need to be sized and placed where they are readily visible.

Install signs where the riders would expect to see them (generally on the right-hand shoulder of the trail, not up in a tree). This is where drivers and riders have been programmed to look for them. Occasionally, due to alignment or vegetation, a sign may be more visible if placed on the left side of the road or trail. Riders' eyes constantly scan the trail to pick the best line, but they aren't scanning trees and bushes looking for signs, so place the signs where the riders' scan will pick them up.
- Avoid placing signs in shadows or where vegetation may obscure them.
- Place the sign enough in advance of the hazard to allow sufficient time for the rider to see it, read it, comprehend it, and react to it. This is called the Perceive, Identify, Emotion, Volition (PIEV) time. The minimum sight distance for a warning sign should be 175 feet.
- The intent is to have professional looking signs, so all signs and posts should be as level or perpendicular as possible.
- When signing, assume that the rider is a beginner, unfamiliar with the trail, and there is poor light and visibility.

This trail is approaching a paved county road, but the Yield sign was placed behind a rock fence support.

This reassurance arrow stuck up in a tree is not visible nor effective.

Even in poor light, this well-placed reassurance marker is clearly visible.

Effective signing is critical with one-way trails. This Wrong Way sign is poorly placed and is barely visible from the trail junction.

The sun has faded this Stop Ahead symbol to the point where it no longer meets color or retroreflectivity standards. In addition, the Stop sign is missing entirely.

Bullets beget bullets. Regular monitoring is essential to maintaining quality and effective signing.

On a mixed use road, it is essential that the public be warned of the mixed traffic. Someone has removed the OHV symbol and it needs to be replaced in a timely manner.

7. Monitoring

- Monitor the condition of the signs and supports on a regular basis.
- Check color, reflectivity, placement, and overall effectiveness of the sign.
- Review the signing under a variety of light and weather conditions.
- Use an outsider or someone unfamiliar with your trails and signs to objectively judge the effectiveness of the signing.
- Don't be afraid to take down signs. More signs are needed early in a new program to educate the public, but may not be needed in three to five years.
- An annual evaluation is suggested. Evaluate the following:
  - Are signs visible?
  - Are signs missing?
  - Are the existing signs in good condition?
  - Are the signs in compliance with the current standards?
  - Are any signs no longer necessary or appropriate?
  - Are messages appropriate or accurate?
  - Are new signs compatible with existing installations?
  - Based on accident reports or near misses, are engineering studies required to determine additional signage to alleviate a safety concern?
  - Have signs been evaluated at night to determine their overall effectiveness and retroreflectivity?

8. Maintenance

- Repair or replace signs as needed to maintain quality appearance and function.
- Keep vegetation pruned back so the signs are visible.
- Bullet holes invite more bullet holes.
- Warning and regulatory signs must be in-place and legible.

The reassurance marker lying on the ground is almost useless.

The forest is a dynamic environment. Inspection and maintenance personnel must be conscious of changes that can alter the effectiveness of the signing.

Types of Signs. When signing, it is important to use the right type of sign in the right situation.

Administrative

Recreation Site

Visitor Information

Travel Management

Trail


Warning

Regulatory

Cooperator

Program Area

Administrative signs generally identify who has jurisdiction of the site. Examples include Federal, State, Provincial, County, City, and Private property.

Recreation site signs identify the name of the site. Examples include trailhead, staging area, campground, and OHV park.

Visitor information signs relay rules, etiquette, information, education, and interpretation. Examples include: kiosks, map boards, and Required to Ride signs.

Travel management signs identify who can or can't use the route or area and any restrictions on use. Examples include: trail users allowed on routes, trail users restricted from routes, and seasons or dates trails are open and closed.

Trail signs include: trail junction markers, reassurance markers, destination (guide) signs, points of interest signs, and information signs (Use It, but Don't Abuse It; Stay on Trail or Stay Home; Please Stay on the Trail, the Future of This Trail Depends on You).

Warning signs warn of a potential hazard or unusual condition. They are diamond-shaped with reflective black on yellow or black on orange. Examples include: Intersection Ahead, Gate Ahead, Stop Ahead, and Yield Ahead.

Regulatory signs inform the users of traffic laws or regulations. Except for stop and yield signs, they are rectangular-shaped with reflective black on white. Examples include: Trail or Area Closed, Trail or Area Restricted, Stop, Yield, One Way, and Do Not Enter.

Cooperator signs recognize trail stewards, key volunteer groups, or other partners.

Program Area signs include open area boundary signs, OHV park boundary signs, and other boundary signs.

Sign Colors. As per the Manual on Uniform Traffic Control Devices (MUTCD) and EM7100-15, signs should conform to the following standard colors.

Red is used only as a background color for Stop signs, Do Not Enter, and Wrong Way signs. Red is used as a legend color for Yield signs, parking prohibition signs, and the circular outline and diagonal bar prohibitory symbol.

Black is used as the background color on horizontal arrow One Way signs. Black is used as a message color on white, yellow, and orange signs.

White is used as the background color for most regulatory signs, except Stop signs. White is used for the legend and border on brown, green, blue, black, and red signs.

Orange is used as a background color for construction and maintenance signs.

Yellow is used as a background color for most warning signs unless orange is specified.

Brown is used as a background color for guide, information, and recreation signs.

Green is used as a background color for state and federal highway guide signs, milepost markers, and as a legend color with white background for permissive parking regulation signs.

Blue is used as a background color for information signs and related motorist services on state and federal highways.

Sign Shapes. As per the MUTCD and EM7100-15, signs for motorized trails should conform to the following standard shapes.

Tip, Trick or Trap?

Trap: More signs do not equal less risk

Keep signing simple and minimal. Warning signs especially should be used very judiciously. Tort claims have been lost because one hazard was signed, but another hazard wasn't. There can be less risk by adding "ride at your own risk" verbiage to the map, kiosk, and web messages than by putting up warning signs.

Image	Shape	Sign	Image	Shape	Sign
	Octagon	Stop		Rounded pentagon	County route
	Equilateral triangle	Yield		Crossbuck	Highway-rail grade crossing
	Circle	Highway-rail grade crossing (advance warning)		Diamond	Warning series
	Isosceles triangle	No Passing		Rectangle (and square)	Regulatory series Guide series Warning series Recreation symbols
	Pentagon	School advance warning		Trapezoid	Recreational and cultural interest area series National forest route

Letter and Symbol Sizes. For motorized trails, the minimum letter size is 2 inches using an ASA (American Standards Association) Series C font and the minimum symbol size is 12 inches. Consider the intent of the sign, rider speed, and viewing distance when determining appropriate letter sizes. A 2-inch letter is difficult to read from a moving vehicle or from any distance, but a 3-inch letter is quite legible.

Sign Sizes. The minimum size for warning and regulatory signs is 12 x 12 inches. Smaller signs should not be used unless the rationale is documented in the project file.

This regulatory sign prohibits OHV operation in this area. The letter size is too small and the sign is placed too far away from the trail to be legible. We can't get compliance if we don't effectively deliver the message.

Letter sizes are important since it doesn't serve you or your customers to have a sign that cannot be read. This sign is intended to be read from a moving vehicle. The Required to Ride sign is legible, but the Attention sign is not legible even from a stopped vehicle. The letter sizes should be bigger or this sign should go on a kiosk for stationary, close-up viewing.

The USDA Forest Service Sign and Poster Guidelines EM7100-15 is a recommended resource for roads and OHV trails. It contains a plethora of additional information on sign messages, abbreviations, number of lines per message, the use of arrows, letter size in relation to speed, sign substrates, etc.

Tip, Trick or Trap?

Trap: Use the word "safe" as a descriptor of the trails, facilities, or experiences. Safe is a relative term, it can't be guaranteed, and lawyer will use it against you in court.

Recommended Sign Guidance. For safety, durability, and professional appearance, the following general sign guidelines are recommended:

- Use retroreflective backgrounds on signs so they appear to be the same shape and color by night as by day. Even if there is no night riding, search and rescue operations frequently occur at night.
- Put a border on the signs.
- Order signs with rounded corners and pre-drilled holes for attachment.
- Mount signs on posts or markers, not on trees.
- Only one warning or regulatory sign should be mounted per post.
- All signs with decals, letters, or numbers can be covered with clear plastic tape that wraps over the top of the sign. This helps prevent snow shear; protects the sign and decals from UV decay; and protects the sign from damage by weather, wildlife, or vandalism. This protective sheeting can triple the life of the sign or marker.

At the time of final design or construction, a Sign List should be developed that lists all the signs and markers needed on a particular segment of trail. Once the signs are installed, GPS coordinates can be added so the Sign List and can serve as a complete sign inventory as well as a maintenance tool. This list aids in the correct assembly and installation of the signs.

Signs up to 18 x 18 inches should be attached to posts with 5/16 x1¼ inches hex head lag bolts with washers. Larger signs should be attached with 3/8 x 1½ inches hex head lag bolts with washers. For all signs that are near roads, trailheads, staging areas, campgrounds, or other areas with public access, consider vandal-resistant hardware. To avoid damage to the sign face and decals, the holes for these screws need to be pre-drilled and care should be taken not to over-tighten the bolts or screws.

For quality aesthetics in most forest settings, it is preferred to have signs with brown backs since they blend with the landscape better and look more natural. This is an advantage of using brown polyplate as a sign substrate. In an urban or industrial setting like an OHV park or MX track, other background colors may be more appropriate.

Things That Harm Signs. When selecting sign materials, there are several environmental factors to consider.

Wildlife. Porcupines eat wood signs, so avoid using wood if these animals are prevalent. Deer and elk will use signposts to rub the velvet off their antlers. A 4 x 4 inch wood post can be rubbed to a toothpick in a few years. Fiberglass or metal may be a better alternative.

Livestock. Cows will scratch themselves by rubbing on signs and can easily break a sign or deface it. Consider using thicker materials and be sure to cover the signs with clear overlaminate tape to increase durability.

Ultraviolet light. The sun's UV rays will fade colors, damage adhesives so decals peel and multi-layer signs delaminate, and bleach the resins out of fiberglass so it fades and rots. When possible, order materials that are UV stabilized. Cover all signs and markers with clear overlaminate tape.

Weather. Rain will eventually saturate wooded laminate signs like plywood. Heavy hail can cause sign sheeting or decals to peel. Snow shear is a tremendous force that can also peel away the sheeting or decals. Extend the life of your signs by using clear overlaminate tape.

In areas that are prone to high winds or tornados, consider using thicker substrates and heavier bolts to attach signs to posts. Be sure that signposts and markers are thoroughly imbedded in the ground. This can be difficult in hardpan or rocky ground so drilling may be needed to obtain an adequate depth.

Human exposure. Graffiti, bullet holes, or breakage can be a common problem in some locations. Having a clear overlaminate sheeting will aid in the removal of graffiti. Regular inspection and maintenance are needed to address other issues.

Common Mistakes. There are several common mistakes that all management teams make when considering what signing to use on their trails. The photos below highlight the mistakes and give suggested solutions.

Mistake: Improper sign and placement, plus the top of sign is illegible.

A poster stapled on a tree is not an adequate warning sign and a sign like this increases agency risk. A proper warning sign should be installed on a post on the right side of the trail. The trail difficulty should be indicated at the beginning of the trail, not midway through it.

Mistake: Improper sign size and sign clutter.

At this trail and road junction, the important sign is the Yield sign, yet it is the smallest sign. The Intersection Warning sign should be placed in advanced of the junction. The Speed Limit sign should be put in a location removed from the intersection.

Mistake: Mixing sign types.

Yield is a regulatory sign, but 2-Way Traffic is a really a caution message that should be on a warning sign. The intent was good, but the sign is confusing. On a two-way trail, someone always has to yield to another rider. This Yield sign should be removed and replaced with a standard 2-Way Traffic sign.

Mistake: The agency logo at the top.

Don't be offended, but riders really don't care or need to know who owns the trail. If desired, agency decals should be placed at the bottom of the marker. Keep in mind that every decal adds to the sign installation and maintenance cost. Trail identifiers would be helpful.

Mistake: Improper sign, and the sign is illegible

In most cases, any sign is better than no sign, but can riders read this hand-stenciled sign as they go by? The letter color blends into the sign background. Having standard shapes, colors, and messages increases signing effectiveness and decreases agency risk.

Mistake: Improper size, shape, color, letter size, and reflectivity

The routed wood OHV Trail sign may be appropriate in some settings, but they are expensive and not as durable as other substrates. The Cattle Guard Ahead is being used as a warning sign but it does not meet proper sign guidelines for warning signs. A proper sign should be mounted on its own post on the right side of the trail.

Mistake: Improper size and placement of regulatory sign.

If a regulatory sign is really needed, then it is an important sign and it shouldn't be a 3"x 3" decal stuck at the bottom of a string of other decals. A standard Stop sign should be installed on its own post. Given that this is a primitive sand road, do riders really need to stop or would a Yield sign be more appropriate?

Mistake: Permanently mounted maintenance signs.

This is a good warning sign though it should be placed on the other side of the trail. The issue is that it is there all of the time. When riders see this sign, they will slow up and be cautious for a while, but if no activity is seen, they will roll the throttle back on and eventually ignore this sign altogether. A better sign would be a sandwich board that the maintenance crew temporarily places in the center of the trail segment being worked on. This is more work, but it's more effective.

Mistake: Conflicting messages.

Riders can't be compliant if we aren't clear in our communication.

Good ideas. There are also several good ideas for signing.

This sandwich board is easy to set up and it folds flat for easy transport. It is a good sign to use during reconstruction, maintenance, or if a trail needs to be temporarily closed for resource protection.

Signing trails and major road crossings can really help orient riders when they are staring at a map and wondering where they are. It can also help with search and rescue operations if they know a rider is near Trail X and Road 18.

Proactive management requires quick sign installations to inform riders and protect resources. A notice should also be posted on the trailhead kiosk and the trail website.

This sign alerting riders of hunting season is a great example of customer service. It could protect rider safety and it certainly gives riders a positive image of the managing agency.

People respect restrictions better when they understand the rationale behind them. People also like to understand the natural environment. This would be a good place to install a wild horse interpretive sign.

Trail Maps

As in signing, trail maps provide information, orientation, education, and safety messages. Riders may read the map information around the campfire or on the way home, but when first arriving on site, riders will make a beeline to the map so they can plan their route and start riding. The primary function of the map is orientation. As such, there are three critical factors: 1) the information on the map must match the signing on the ground; 2) the base map data must be recent enough to agree with the database used in most GPS units; and 3) maps must be available by handout or in a map box.

If there isn't staff, a host, or a volunteer available to hand out maps and education material, a map box is the next best thing. Think of that box as a way to personally hand a map to the customer.

Tip, Trick or Trap?

Tip: Trail junctions can often be congested with riders looking at maps or waiting for others in their group. This intersection ahead decal alerts riders that a junction is approaching so they have time to slow up and watch for traffic. NOTE: if there was a known hazard at the trail junction due to poor design or unusually high traffic volume, a 12"x 12" warning sign would be required. Notice how the even decal spacing increases the legibility of this marker. The Single Track No ATV decal is a good travel management reminder on this reassurance marker but a larger sign should be located at the trail entrance.

Though maps can easily be loaded onto mobile electronic devices, the paper map will never become obsolete because it can be wadded up and stuffed in a shirt or fanny pack; used when wet, muddy, or extremely dusty; and can survive a day of being bounced around on the trail.

A good, user-friendly trail map should have as many of the following elements as possible.

- The larger the scale, the better. 1 inch = 1 mile is good, but a larger scale allows more information to be displayed on the map and gives the rider a better sense of distance.
- Township, range, and section lines or UTMs (Universal Transverse Mercator) aid in navigation and orientation and are helpful for search and rescue operations. Most riders are GPS savvy and prefer maps with UTMs.
- US National Grid coordinates (previously US Military Grid) can be used in a GPS or as coordinates along the edges of a map, similar to

When the map shows the trail going to the left and the sign indicates the trail goes to the right, you have lost control of the riders. This can lead to concerns with rider safety and resource impacts not to mention arguments.

atlases so people with or without a GPS can find their location between the signs and the maps. Emergency response personnel can use the same coordinates in their system to easily find lost or injured recreationists.

- GPS coordinates for trailheads, campgrounds, shelters, or other key features also help riders orient and navigate.
- Topography contour lines or shaded relief. Riders tend to seek the trails with the most elevation change and will always go to the highest point on the trail system.
- The trails labeled by name or number with difficulty indicated by color or symbol and travel direction (one-way or two-way).
- Having the mileage between trail junctions is helpful in planning the day's ride and helps orient the riders as to the scale of the trail system.
- The allowable vehicle uses on each trail or all trails as well as allowed non-motorized uses. These can be shown with symbols on each trail, marked in the legend, or shown elsewhere on the map.
- All routes with indicators showing if they are open or closed to the designated uses. These aid in navigation and orientation. Access routes can be used when something goes wrong and riders need to find an alternate way back to the trailhead, or when there's a major breakdown and riders need to find the nearest vehicle access to retrieve a machine.

Where the heck are we? Why doesn't this agree with my GPS?

An empty map box is a lost opportunity for effective communication.

- Trailheads, campgrounds, shelters, viewpoints, play areas, interpretive sites, and other features or destinations identified.
- Key natural features labeled for orientation: mountains, lakes, major streams, etc.
- A good and complete legend.
- Access information from the nearest population center.
- A welcome section with brief information about the trail system.
- Emergency phone numbers, agency contact information, how to report a fire, websites, 24-hour hotlines, etc.
- Rules, restrictions, operator responsibilities, vehicle equipment requirements, seasonal closures, etc.
- Any fees to use the site.
- Hours of operation if day use only.
- Rider education, rider ethics, and safety information.
- Noxious weed information, important resource protection information for soils, plants, wildlife, fire, etc.
- Land ownership, wilderness areas, restricted areas, closed areas.
- A description of the key signs riders will encounter on the trail.
- A recreation opportunity guide (ROG). Some areas use ROGs to give the rider a brief description of what experience to expect on each trail, especially in relation to difficulty. What does a black diamond mean on this trail? The ROG will explain it.
- Camping and campfire information, group camping rules, firewood gathering rules, etc.

Websites and Social Media

The phrase "Know Before You Go" has never been easier to achieve. Most riders get maps, directions, weather, and other information from websites before they leave to go riding. Certainly, the cyber information era can be a blessing to management if management chooses to use it effectively. A website can have rules and regulations, downloadable maps, fee information, equipment and licensing information, current conditions, a volunteer page, links to weather and fire conditions, etc. The list of possibilities is almost endless.

A good website will be simple and easy to navigate. The general public should be able to locate the information easily on the site with a few simple clicks. Long pages where the public needs to scroll several times in order the find additional information usually causes important information to be missed. A higher number of shorter pages with a good menu or menu page is better.

Many maps are now geo-coded. This means a map can be downloaded to a smartphone or similar device. Map apps with the ability to read these maps use the internal GPS of the smartphone to track the rider's location on the downloaded map as the trails. The website should have both the maps and a list or link to possible apps which will work with the geo-coding on the map.

Social media is the number one way to reach younger people. Facebook, Twitter, and Instagram can get important messages to younger riders and get them out to your trails.

Agency Staff

Any manager's dream is to have the funding to have adequate staff who are conscientious, knowledgeable, professional, and customer service-oriented. However, as budgets tighten, that dream becomes less of a reality.

From the public's perspective, having personable agency staff on site provides:

- A sense that the agency cares about them and their activity.
- Face-to-face communication personalizies the agency and can breach the sometimes daunting impersonal wall of bureaucracy.
- A sense of increased security.
- An understanding of agency challenges that can potentially lead to increased volunteerism.
- Visible evidence that the site is actively managed.

Contracted Site Hosts

When there is inadequate agency staff, non-agency site hosts can help fill the gap and provide a valuable service. Site hosts must have the social skills to effectively handle a variety of situations and they must have a friendly customer-service attitude. Hosts must be trained and have dependable communication with management and law enforcement. Since hosts are more likely to be on-site when the riders are present, they can be especially beneficial on projects that include a change in rider ethics, rules, fees, and riding opportunities.

Other advantages can include:

- Increased "agency" visibility
- Increased rider education
- An increased sense of visitor security
- Increased compliance
- Decreased vandalism
- An increase and more effective collection of fees
- Increased public image and awareness of active management
- People prefer personal contacts over machines. Friendly customer service helps to provide for the riders' needs.

A neat professional looking host site and the key: a host with a smile

Volunteer Trail Ambassadors and Rangers

Except for fee collection, a volunteer trail ambassador program can have all of the same benefits of a site host. Ambassadors need to be able to ride, but like a host, the most important prerequisite is possessing good social skills. To be effective, a personal encounter must have a positive outcome, and that is determined by the skill and attitude of the ambassador (or host). Ambassadors must be trained and should have a probationary period of supervised encounters to ensure quality and positive outcomes.

Here are some considerations for trail ambassador programs:

- Ambassadors must have a designation, ride in pairs, wear PPE, have a check in and check out procedure, and have dependable communication with law enforcement or management.
- Ambassadors must recognize the line between education and enforcement. The role of an ambassador is strictly education. They do not do enforcement and usually do not collect fees.
- Sometimes personal ownership and commitment can lead to a vigilante attitude, which is neither positive nor productive. Management must weed out those people.
- Since ambassadors can roam the trails, they provide a wider agency presence that is outside of the trailhead.
- By riding the trails, they are providing monitoring and can report trees down, signs missing, off-trail use, erosion, invasive species, or other trail issues. This can be a huge value to management.

Volunteer Trail Ambassadors can perform many functions for the agency while out on the trail.

Trail Ambassadors provide peer to peer education, not enforcement.

- Since they are dressed like riders, they can apply effective peer pressure because riders will associate with and listen to other riders.
- Ambassadors can be trained to perform complimentary tech check inspections.
- Ambassadors can develop pride by being part of an elite group that provides an important function. Their positive attitude can stimulate volunteerism.
- Ambassadors can also serve as effective agency representatives at fairs, trade shows, sportsmen shows, professional OHV events, and other venues.

Volunteers can help staff educational booths at shows or events. They can also perform and educate peers regarding tech inspections, including sound measurement.

An effective OHV program communicates well with the public at all levels and ages.

A Second Look...

The Three Tools for Success: Almost every chapter has linked back to the Three Tools for Success: Provide for the Riders' Needs, Design for Sustainability, and Develop an Effective O & M Program. This chapter is all about developing and implementing that third tool. Communication opens doors by fostering trust and understanding. It provides a crucial personal or non-personal link between management and the riders to transfer essential information and education. When a person's actual recreation experience doesn't match his expected experience, the result is frustration and emotion that gets termed and categorized as user conflict. Management can influence those expectations by effectively communicating with and educating the public, especially prior to their arrival at the trailhead.

Need more? Learn more here...

ATV Braking Study, Sign Recognition Analysis and Validation, Final Report, Michigan Tech, Keweenaw Research Center, March 2014

Manual on Uniform Traffic Control Devices, U.S. Department of Transportation, Federal Highway Administration, May 2012, http://mutcd.fhwa.dot.gov/

Sign and Poster Guidelines for the Forest Service, EM7100-15, USDA Forest Service, October 2013

Central Oregon Combined OHV Operations (COHVOPS), http://www.fs.usda.gov/activity/deschutes/recreation/ohv

Coalition of Recreational Trail Users/Minnesota Department of Natural Resources, http://www.findthetrails.com

A Look Back...

Here are some of the elements discussed in this chapter:

- Educated riders are responsible riders. Communication provides that education.
- Non-personal communication includes signing, trail maps, and websites and social media
- Personal communication occurs through agency staff, contracted site hosts, and volunteer trail ambassadors and rangers
- If the management team members don't effectively tell the public where they should be riding or how they should be acting, the team can't be disappointed when riders go where they don't want them to go or do what they don't want them to do
- A sign plan helps to ensure consistent and effective signing while increasing rider safety and decreasing agency risk
- Eight key elements of signing: Need, Simplicity, Clarity, Quality, Consistency, Placement, Monitoring, and Maintenance
- Signing and mapping provide information, education, orientation, and safety messages.
- Three critical map factors:
  - The information on the map must match the signing on the ground.
  - The base map data must be recent enough to agree with the database used in most GPS units
  - Maps must be available for handout or in a map box
- Management should seize the opportunity to have current, complete, and accurate website data and links
- Agency staff can effectively deliver communication messages by being knowledgeable, conscientious, professional, and customer service-oriented
- Site hosts and trail ambassadors can be very valuable tools to augment agency staffing. They can increase agency visibility, education, compliance, and sense of public security.
- Site hosts and ambassadors must be trained, understand their roles, and have effective social skills to produce positive encounters under a variety of situations
- An effective OHV program communicates well with the public at all levels and ages

Chapter Ten

Tools in the Toolbox: Management

Noise isn't Cool to Those Who Make the Rules

This chapter covers general strategies and tools available to managers. Like the Great Trail Continuum, management has its own sub-continuum: implement, evaluate, make changes, re-evaluate. It never stops. If it does stop, management could fail, the project could fail, and the riders could lose another place to ride.

Vegetation is your friend. Catastrophic events like this may necessitate changes in trail location or design.

Adaptive Management

The sub-continuum of implement, evaluate, make changes, and re-evaluate is called adaptive management. A trail is placed in a dynamic environment, and change of some type is inevitable. The need for trail changes should be anticipated in the planning process, and it is to the managers' advantage to include adaptive management verbiage in the initial environmental document.

There are several adaptive management tools available, including mitigations, restrictions, relocation, reconstruction, using existing infrastructure, entrance management and, when necessary, closure.

Catastrophic events can also create opportunities. This is a good time to step back and re-think this old road-to-trail conversion. A serpentine alignment would fit the landscape better and enhance the rider experience.

Closure Options

There are many closure options available to managers, each with a different focus and effect. Before any closure is implemented, ensure that there is sound justification, that there is an implementation and education plan utilizing the 4Es, and that the ramifications of the action are thoroughly examined. Riders will get displaced. Where will they go and what impacts will occur? Is there adequate personnel and funding for enforcement? Will the closure damage relationships with partners? For every action, there is an equal and opposite reaction. If a trail gets closed, there will be a reaction. Plan for it and be prepared to manage it.

Permanent Closure. To protect resource values or public safety, permanent closure is certainly a management tool. There are sensitive areas that need to be protected and there are non-sustainable trails that cannot be made sustainable. Closure is often seen as the easiest and cheapest management option. While it is the quickest option, it is often not the easiest or the cheapest in the long run. Displaced riders will need to go someplace. This could over-tax the few riding areas that are left, causing resource damage and conflicts.

A key point is, whenever possible, managers should not close something before opening something else of equal or greater mileage, quality, seat time, etc. When riders realize that they can still get from Point A to Point B or have a new higher-quality opportunity, compliance with the closure will significantly increase.

Sticking up a sign or a barrier to close a trail is not effective application of the 4Es. Engineering an effective closure should include a barrier, signing, and ripping and disguising of existing routes. Education regarding the rationale for the closure should be posted on the map, kiosk, websites, and other media as appropriate.

Emergency Closure. Management can implement an emergency closure any time there is extraordinary risk to public safety or resource protection. This could be due to an active forest fire, a severe weather event, or protection in the aftermath of those events.

Temporary Closure. A temporary closure is not recurring and can be used for maintenance, trail reconstruction, extreme fire danger, vegetation management activity, to protect the trails from damage when the trail treads are saturated, for range or livestock activities, for a special use permitted event, etc. When a change in trail use is not permanent and not recurring, it now becomes critical to successfully implement the 4Es. The word must quickly get out on the ground and in the media.

Temporal Restriction. A temporal restriction can be used to separate trail uses and users who are having difficulty being compatible with each other. An example could be that a trail is open for OHVs one week and open to hikers the next week. Here, the manager is placed in a position of conflict management and it will only be successful if: a) there is total agreement with all trail users that this is what they really want; b) if both or all trail groups are treated equally; c) if all share equally in the trail maintenance; d) if all groups commit to self-policing themselves; and e) if the 4Es are successfully implemented. This management option is an intermediate option between a trail being open to all groups and a trail being closed to one group. Most managers choose not to take this step because of the complexity of education and enforcement.

Tip, Trick or Trap?

Tip: With any closure or restriction, as the strength of the justification or rationale increases, compliance with the restriction increases.

This is a good example of closure tools; ripping, blocking, seeding, and signing. The Stay on Trail or Stay Home sign is a great sign, but it sends a confusing message here. Is the rider supposed to stay on the open trail or the closed trail?

This is a good example of a temporary closure. It would be better if the sign stated the reason for the closure to increase compliance.

Mitigations

Mitigation measures reduce the potential impact or the risk of impact. A seasonal closure is a mitigation measure to reduce the risk of impacts during a certain time period. Some resources like marshes, riparian areas, or subsurface cultural sites need to be avoided temporarily, but don't have to be avoided year-round. Mitigations can allow or restrict trail access while minimizing risk to a resource.

This seasonal closure is well signed with an explanation of the reason for the closure. However, if the trail is too wet for motorized use, is it really dry enough for equestrian and foot traffic?

Seasonal Closure. A seasonal closure is a recurring closure that regulates vehicle access. The three main uses are: 1) wildlife related, including big game winter range, fawning or calving season, and nesting season; 2) soil related, including closures during spring break-up or fall freeze-up; and 3) vehicle related, including closures to wheeled vehicles to allow access for over-snow vehicles. Any time there is a change in vehicle access, the effective use of the 4Es, especially education (signing, mapping, etc.), becomes more essential to ensure successful implementation.

A Forest Service resource specialist shows club members a sensitive plant population and explains why it has to be avoided.

Avoidance. When a sensitive resource is encountered, sometimes the easiest option is just to avoid going there. This usually simplifies the environmental analysis and minimizes risk to the resource. If the resource can't be avoided, use of design, structures, or other tools may provide adequate mitigation.

Monitoring. Sometimes monitoring can be used as a mitigation. A trail tread depth, for example, could just be monitored. When and if it gets down close to the depth of the resource, then trail hardening or structures could be implemented as additional mitigation.

Monitoring can be used to gain knowledge. Perhaps a sensitive or potentially sensitive bird decides to make a nest adjacent to an existing trail. Rather than implement avoidance, why did the bird choose to nest there and will the OHV trail negatively affect a bird which nested near its activity? These could be answered through monitoring if the manager and the resource specialist are comfortable with the risk.

A soil scientist measures changes in tread depth and width. This monitoring ceased after it was determined that recreation use had no effect.

One issue with monitoring is that there must be the budget, skilled personnel, and time for the personnel to perform the monitoring. When budgets get tight, monitoring is often the first thing to get put on hold. As personnel come and go, monitoring plans can sit on the shelf and fall through the cracks of implementation. In trail management and monitoring it is important that managers do what they say they are going to do in order to build trustful working relationships. That doesn't stop at planning, it follows through the whole Great Trail Continuum.

Interpretation. Sometimes, interpretation can be used as a mitigation measure. With interpretation comes potential risk to the site since people will be stopping and spending time there rather than riding through. But interpretation is education and that has value. The thought process is

that some risk will be accepted here, and by educating the public, there will be reduced risk elsewhere. Sometimes people will give more respect to a high quality area that has interpretation than to an area where they don't understand the value of the surroundings. Interpretation can be expensive, but it is a valuable tool and one that is not used often enough on OHV trail systems. Interpretation enhances the rider experience, extends the length of that experience, and can help protect the resource.

This mining site with cabins and equipment has been beautifully restored and interpreted. The public appreciates and respects quality and that equates to education, compliance, and reduced risk of vandalism. Riders can spend an hour here and significantly enrich their experience and increase the length of their recreation time.

High-quality interpretation of this old mine site is one of the things that makes the Paiute trail system so appealing. Note the attention to detail with the mining theme on the steel post matched with a brand on the wood post. WOW.

The public has a strong desire to learn about history and the natural environment. Including interpretation is one of those extra steps that adds the WOW factor and turns a good trail into a great trail.

Interpretation can also open the door for some creative partnership and funding opportunities.

Structures. Though structures are a design element, many structures are mitigations for issues brought up during the planning process. Bridges are a mitigation to help protect water quality. Barriers and fencing can be mitigations to help protect sensitive areas. Cattle guards help mitigate the range issue of gates being left open. Implementing structures like boardwalks and puncheons can allow access through or over sensitive areas while still protecting the resource. Trail hardening can be used to help protect subsurface resources. The use of those structures not only helps protect the resource, they can greatly enhance the quality of the riding experience. Structures help provide a win-win scenario.

This narrow cattleguard is being used for both range management and entrance management.

This sign is posted next to the narrow cattleguard pictured above.

Restrictions

Using restrictions is a form of adaptive management to protect both the resources and the riding experience. There are two forms of restrictions. Vehicle restrictions are restrictions regarding the actual machine. Equipment restrictions are restrictions on accessories or other equipment on the machines.

Vehicle Restrictions. Vehicles are most commonly restricted by their width or type. OHV trails which are open to vehicles 50 inches or less in width could allow OHMs, ATVs, and smaller ROVs on the trail. Trails can also be open to one or more designated machine types. Single-track trails are often restricted to OHMs only. And a combination of type and width restrictions can be used. Some 4WD-only designated trails have width restrictions to preclude modified rigs with excessive width.

Vehicle widths are restricted to: a) maintain narrow clearing width to enhance the trail experience; b) increase rider safety by limiting the size of a vehicle that may be encountered; c) protect a trail prism that wasn't built wide enough or may not have the durability to safely accommodate wider and heavier vehicles; and d) increase rider experience by providing more difficulty levels in the trail system. Many existing NEPA documents do not allow vehicles or a vehicle type which wasn't expressly analyzed in the document. Changing those documents could re-open the door to appeals and litigation.

This sign is a good example of an equipment restriction. In addition to having the information posted at the area, the information should also be available to people while they are planning their trip.

It is important to note that even though state or provincial laws may allow certain vehicles, trail managers usually have the option to be more restrictive when necessary and justified to protect resources or public safety. These messages are conveyed through the 4Es using effective entrance management structures and communicated to the riders before they get to the trail.

Equipment Restrictions. Restrictions which include items like requiring spark arresters, limiting sound emissions, requiring safety flags, and requiring fire tools on vehicles of a certain size like ROVs and 4WDs are examples of equipment restrictions. As with vehicle restrictions, land managers usually have the prerogative to be more restrictive than state or provincial laws allow when it is justifiable. The risk of fire is almost always raised as an issue, and sound can be an issue, so spark arresters and silencers are easy mitigations for these concerns. Safety flags are often required in dune areas to increase the visibility of approaching vehicles.

The trail tread is a valuable resource and the force of displacement acts on that resource. There is often discussion on whether the tire type should be restricted. Many people believe that more aggressive tires create greater displacement. However, as the U.S. Forest Service tire study has shown, the depth of the tread is not a factor in the amount of displacement on a trail. Knobby tires are designed to grip, not to tear or slip. They can be likened to golf shoe spikes which help keep feet from slipping across the surface and creating divots.

Tip, Trick or Trap?

Tip: Knobby tires can be like golf shoes, which provide traction without disturbing the ground.

Impacts from tires are caused more by the mentality of the rider than by the aggressiveness of the tire, so management effort is better spent on the 4Es to improve rider ethics and promote peer pressure than on enforcing a restriction. Tread Lightly!'s, "Use It but Don't Abuse It," and "Ride It, Don't Slide It" can be good education messages.

Relocation and New Construction

Relocation is a tool that can be used to avoid a sensitive resource or move a section of non-sustainable trail to a more suitable location and alignment. Too often, managers pour money into multiple bandages for a trail that cannot be fixed when it would be less expensive in the long term to relocate the trail. Relocation is a tool that can protect resources, enhance the rider experience, and increase rider safety.

Relocation, of course, involves new construction, which may require additional environmental review and documentation. Because of this, some managers do not consider relocation as an option. However, if the trail still goes from Point A to Point B and the effects of the relocation fall within the scope of effects analyzed in the environmental document, the relocation could still be meeting the intent

Tip, Trick or Trap?

Tip: Utilize as Many Tools as Possible.

Relocation is one of the most important, yet under-used tools to correct sustainability issues. Failure to use this tool can lead to over-use of another tool: closure.

of the original document and the process to implement the relocation could be relatively simple without opening the door to appeals and litigation. Adaptive management verbiage in the environmental document can facilitate the trail relocation process.

Reconstruction

Reconstruction can be used two ways: 1) to put a trail back into the condition it was in when it was first constructed (essentially performing backlog maintenance) and 2) to upgrade the original condition by re-grading; reshaping; and adding or improving structures, signing, facilities, and segments of trail.

This trail is in obvious need of reconstruction. The tread watershed is too big and too much water is draining at this point.

What is the lifespan of a trail? It depends on multiple factors like soil type, use level, type of use, climate, number and type of structures, etc. All trails require maintenance, but at some point, the trail may degrade to the point where routine maintenance will be inadequate to maintain the functionality of the trail. At that point, reconstruction, or heavy maintenance, is required.

Utilize Existing Infrastructure

There is usually a plethora of existing roads and trails but the goal should be not to maximize the use of existing infrastructure, but to examine what is available and creatively incorporate those sections that fit with the goals for the trail system. The key is variety in any form: scenic, tread surface, speed, tread width, destinations, vegetative, topographic, and interpretive opportunities, commercial access, etc. Providing an imaginative mix of experiences is what creates a quality trail or trail system. Trails are all about fun.

Structures. Utilizing or sharing existing structures is a great way to reduce project costs as well as reduce the number of structures on inventory. Sometimes, it requires creative solutions to use existing structures, but the benefits are worth the effort.

Natural Surface Roads. The use of roads can be seen as an expedient and low-cost way to provide trails. There can be many benefits, but there can also be many traps. Land managers have the option to use roads or not, and like existing structures, why not? The three main issues with roads are 1) the extent to which they are used, 2) the size of their tread watershed, and 3) the quality of the experiences they provide. If the road is being closed to mixed-use, consider using an existing road corridor and turning it into a trail rather than relying on the road as is.

It is important to remember that OHVs are not designed to be used on paved surfaces. When considering using roads as trails, only natural surface roads should be considered.

The opportunity to use this old railroad bridge as an OHV trail enhances the rider experience and saves project dollars. This could be a good place for some interpretation as well.

The outstanding visual quality of this site transforms the road experience from transportation to recreation. It's a road, but it's a WOW.

Use Natural Surface Roads as Trails. Roads are an existing infrastructure. Many state and provincial laws as well as agency regulations allow OHV use on roads, especially low standard or minimum maintenance roads. With roads, a key point to remember is that they can provide two types of experiences, transportation and recreation. The experience must match the riders' desired experience for the trail or it won't meet the riders' needs.

Convert Natural Surface Roads to Trails. Increasingly, roads are being closed to reduce road densities and reduce road maintenance costs. Often, this can present an opportunity to convert roads into trails. This is a good tool especially when options for creating new trails may be limited. There are many pitfalls of roads, including long sustained grades, infrequent drainage, and large watersheds; but when properly done, many roads can be converted into high-quality trails with high-quality experiences.

This road was closed and converted to a trail eight years ago. It was half-ripped and good entrance management was installed to restrict full-sized vehicles. Even in this dry environment, roads recover and revegetate very quickly once the use is off of them.

Convert Rails to Trails. Railroad grades can be too fast, too straight, and too boring, but this book is about WOW. What makes a great trail great? Traveling over a 150-year-old wooden trestle and looking 500 feet down through the ties to the river below or entering a dark tunnel. That is WOW. If there is an opportunity to incorporate that, seize it.

Trails. As in roads, there can be benefits and traps. Using existing trails can have the same issues as using roads: the extent to which they are used and the quality of the experiences they provide. Most existing trails were not designed, so primary concerns are their sustainability and whether they go where the planner needs them to go. Many user-created trails go up the hill whereas sustainable trails go across the hill, and the biggest trap that a manager can fall into is to assume that user-created trails meet the users' needs. Most do not.

Entrance Management

Entrance management is a tool that managers often overlook. Implementing effective entrance management:

- Provides rider education by indicating trail number, difficulty level, and allowed vehicles.
- Sets rider expectations through well-engineered barriers and filters.
- Reduces conflict by setting rider expectations.
- Sets the stage for enforcement by posting travel management signing and any pertinent restriction or closure signing.
- Increases rider safety by immediately indicating the skill level needed to negotiate the trail.
- Reduces impacts created by unskilled riders.
- Potentially reduces the number of riders on a trail, which can keep a marginal trail on the sustainable side of the fulcrum.

This user-created trail runs up the fall line, is non-sustainable, and is visually distasteful. Even if it could be made sustainable, it does not harmonize with the landscape and violates many principles of trail location by bisecting the meadow.

- Reduces or eliminates trail widening caused by over-width vehicle use.
- Increases the rider experience by maintaining the designed tread width, reducing the number of riders, and protecting challenge features.

These bollards and gate serve as width restrictons to keep larger vehicles from accessing the trail.

Tip, Trick or Trap?

Tip: Entrance management = Risk management

Every one of these items is an element of a great trail and of great trail management. Effective entrance management epitomizes the application of the 4Es; it helps ensure a quality recreation experience and reduces the managers' risk.

Administrative Tools

Below is a list of the management tools that can help build a successful program.

Partnerships. Having broad-based support for the project or program is imperative. Just like the Great Trail Continuum, the battle to have and keep OHV trails is never over. The stronger and broader the support base, the better it will survive attacks from critics over time. Time invested in strengthening and expanding partnerships is time well spent.

Donations. Having a broad base of partners can open the door for a wide variety of donated materials and supplies. Being in the position of asking for anything can be an awkward task, but vendors usually will not offer support without being asked. Managers who ask are usually surprised with the results. These donations not only help the program on the ground, but they serve as important sources for match contributions for grants.

Innovative Grants. Having partners helps secure grants, but having creative partnerships almost ensures grant success. Almost all resources benefit from having a well-managed, designated OHV trail system, so seek partners and grants from unlikely sources like the Nature Conservancy, Ducks Unlimited, the Rocky Mountain Elk Foundation, and Backcountry Horsemen, etc.

Volunteer Program. Having a lot of volunteer labor is another key to securing grants, especially if the labor comes from multiple volunteer sources. The organizing, training, and scheduling of volunteers takes a lot of time and energy, but again it is time well spent. Volunteers aren't free, but for building partners, grants, and a workforce, they are essential to any successful OHV program. Volunteer trail ambassadors can increase education, evaluation, peer pressure, and agency visibility. When it comes to maintenance, whatever work can be done by volunteers, should be done by volunteers. This will build support and ownership in the program. Volunteers are a key component in successfully implementing the 4Es. Like donations, volunteers usually don't step forward on their own, they need to be asked.

A local 4WD club conducts a trash clean-up day on public lands

External Relations and Politics. This would include anyone outside of the agency: dealers, local and regional clubs and associations, state or provincial OHV program and grant managers, community leaders, and stakeholders. Conducting a group or one-on-one field trip to the project presents a good forum to build and strengthen these relationships. Time spent here could lead to additional partners, grants, and volunteerism.

Kids listen intently to the instructor during a Family Fun Day Event.

Internal Relations and Politics. Dealing with internal politics can be far more challenging than external politics because of the day-to-day contact and interaction with co-workers. However, that effort is more than worth it when it comes down to gaining time commitments from essential personnel like resource specialists, obtaining labor from fire or smokejumper crews, or securing the fair share of a tight budget.

Permitted Activities. Permitted activities could include speed and non-speed events, jamborees or rallies, charity fundraisers, and special training or education events. There are many benefits to having permitted activities: clubs and the public enjoy them, so having them increases the external political connections and relations; clubs often rely on events as primary fundraisers; activities can stimulate interest, support, and volunteerism; they bring public and media exposure to the trail system that can help market the system and increase awareness of successful OHV management; they can provide an economic benefit to the community; and they can strengthen external relations and political connections.

Legislative Changes. Sometimes current laws are outdated or too restrictive to allow managers the flexibility they need to effectively manage the use. The only way to fix that is to work within the system to try to implement changes. Field trips with legislators, stakeholder group advocates, or state or provincial agency personnel can help show them the rationale for needed changes. Working with clubs and associations on these efforts can be well worth the time.

Tip, Trick or Trap?

Tip: Master the 3P's of Success:
Politics
Politics
Politics

Integrated Resource Management (IRM). IRM involves the coordination and cooperation between an OHV program and the activities of other resource entities within the agency: fire, other recreation, silviculture, range, law enforcement, engineering, wildlife, botany, cultural resources, etc. It takes effort to develop those internal relations and to get involved in the planning and execution of all of these other resource activities. But the trail is also a resource and the OHV program has or should have parity with any other program. Because trails are easy to traverse, they often get used as boundary lines for other activities, but those lines can affect the integrity of the trail and the quality of the trail experience. While a buffer strip usually isn't required, what is desirable is a mosaic that creates variety.

Here are some scenarios that could be avoided or minimized with IRM:
- The use of trails as skid trails or temporary roads.
- Having trails used as fire lines.

Due to good IRM, this trail is open and signed to protect public safety.

- Having trails used as timber unit or cut block boundaries.
- Having fencelines installed that cross the trail on steep grades or curves.
- Having sight lines and corridors opened up through vegetation management that can invite off-trail hillclimb use.
- Improper closure of temporary roads and skid trails that invite off-trail use.

A fenceline needed to be installed to keep livestock out of a stream to protect water quality, but there were limited places to cross this trail. This site was chosen after coordinating with range and the range permittee. Water, range, and recreation all benefitted by this cooperative effort.

And some benefits:
- Having advance notice of fire or timber harvest activities so trails can be signed and the public informed.
- Having pits and quarries shaped for use as play areas.
- Having a landing or other impacted site specifically located for future use as a trailhead or other site for OHV activity.
- Being able to relocate an undesirable trail or trail segment as a mitigation to avoid adverse impacts from the other activity.

Know the Customer. The demographics of the customer will change over time and managers can't provide for the riders' needs if they don't know who the riders are or where they are coming from. A short online survey or a registration box at the trailhead can give managers valuable information that can be used to better serve the customers and provide supportive data for grant requests and other reporting.

Tip, Trick or Trap?

Tip: Change is inevitable

As the demographics of your customers change, the configuration of your trails and facilities may need to change.

Volunteers are the heart of a successful OHV program.

Implement All of the 4Es

The 4Es: Engineering, Education, Enforcement, and Evaluation, have been mentioned several times in this chapter and throughout this book. Use them. Enough said.

Tip, Trick or Trap?

Tip: Utilize the 4E's:
- Engineering
- Education
- Enforcement
- Evaluation

For those with vertigo or fear of heights, this old railroad trestle may cause some trepidation. For the rest of us, this WOW experience is a great example of using existing infrastructure.

A Closer Look…

The fourth E of the 4Es, Evaluation, isn't just determining the success of a barrier or the effectiveness of erosion control measures. It includes zooming out and looking at the bigger picture: how is the program doing? In talking about building relationships with partners, stakeholders, and grantors, these people want value, efficiency, customer satisfaction, and resource protection. What do they see? Managers should put on their objective hat, go out to the project area on a weekend day, and look at their own program. Does it look professionally and successfully managed? Are the map boxes full, toilets clean, litter picked up, signs and posters neat and legible, smiles on the riders' faces, and tracks only where there should be tracks? No? Then the tasks of creating a successful OHV program and building internal and external relationships could be more difficult. Taking the time to zoom into the "on-the-ground" picture can help managers zoom out and better administer the big picture.

A Great Trail Requires Creating a Great OHV Program

Need more? Learn more here…

ATV Effects Study and Existing Trail Conditions, U.S. Forest Service San Dimas Technology Development Center and the Rocky Mountain Research Station in Moscow, ID, http://www.fs.fed.us/t-d/atv_trails_site/pdf/ATVEffectsStudy.pdf

A Look Back...

Here are some of the elements discussed in this chapter:

- A trail is imposed on a dynamic environment; therefore, the trail and its management must be dynamic, not static
- Like the Great Trail Continuum, management has its own sub-continuum that never stops: implement, evaluate, make changes, re-evaluate. This is called adaptive management.
- Having adaptive management verbiage in the initial environmental document can facilitate making necessary trail changes later
- Every trail requires maintenance, but at some point many will still degrade and require eventual reconstruction
- With any closure or restriction, as the strength of the justification or rationale increases, compliance increases
- Roads can provide two experiences: transportation and recreation. If the road is being used as a trail, the road experience must be equal to the desired trail experience.
- Relocation is one of the most important tools available to correct sustainability issues, yet it is the tool that is the most under-used
- Entrance management is an essential component of risk management
- Managers should not be afraid to step back and take an objective look at their program. Managers need to see what their customers are seeing.
- Few people have everything they need or know everything they need to know. Don't be afraid to ask for help.
- Politics is interwoven into everything, so master the 3Ps: Politics, Politics, Politics.
- As the demographics of the customers change, the configuration of the trails and facilities may need to change
- Great trails require having a great OHV program