PLANNING & MANAGING ENVIRONMENTALLY FRIENDLY

MOUNTAIN BIKE TRAILS

ECOLOGICAL IMPACTS • MANAGING FOR FUTURE GENERATIONS • RESOURCES

Dr. Pam Foti
Northern Arizona University

Dr. Dave White
Arizona State University

Grant Brodehl
M.A. Northern Arizona University

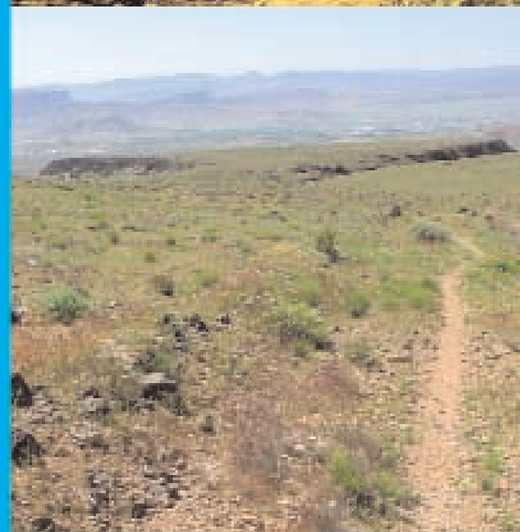
Troy Waskey
M.S. Candidate, Arizona State University

Elladee Brown
Professional Mountain Bike Consultant

If you are wondering…

- What are the ecological impacts of mountain biking?
- How do they compare with the ecological impacts of other popular trail uses?
- How can I sustainably manage mountain biking trails for future generations?
- What resources are available to assist my efforts?

This guidebook is for you.



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ASU College of Public Programs
ARIZONA STATE UNIVERSITY

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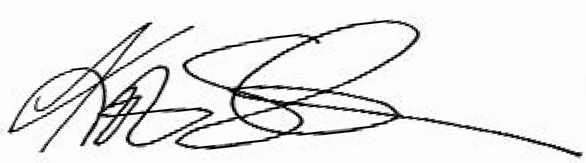
For millions of people, riding a mountain bike is a healthy way to enjoy our natural outdoor heritage. As more riders come to appreciate the recreational opportunities on public lands, land managers and policy makers are faced with an increasing demand for more bike trails.

At Shimano, we believe that decisions and policies determining recreational uses of public lands should be based on the best available applied science, research and professional natural resource management tenets. Only by applying these basics can the future demand for more mountain bike trails be met in ways that are environmentally sustainable and responsible. The unacceptable alternative is to have more riders and increased congestion on a shrinking number of trails.

Our working partnership with the U.S. Bureau of Land Management on behalf of recreational cycling and responsible resource use began in 1993 when Shimano became the first company in the bike industry to sign a formal agreement for this purpose with the agency. Previously through our fishing tackle division, the Shimano Sport Fisheries Initiative partnered with the BLM in the largest fish habitat restoration project in the U.S. on Lake Havasu, Arizona.

Dr. Pam Foti at NAU and Dr. Dave White from ASU came highly recommended as two of the best recreation ecologists in North America. Their professional association with the BLM brought us together as partners in comprehensive field research to determine the impacts of mountain bikes on the natural environment. Land managers and policy makers will now be able to apply the practical aspects and positive results of their research when making decisions about new and existing mountain bike trails.

We consider it a privilege to help sponsor research leading to a better understanding of how mountain bike trails can be planned and built for long term environmental sustainability. When people are able to experience wild places first hand, they develop a deep respect for our outdoor heritage. The information contained in the following pages shows how mountain bikes can continue to contribute to these positive experiences on public lands for millions of people today and tomorrow.



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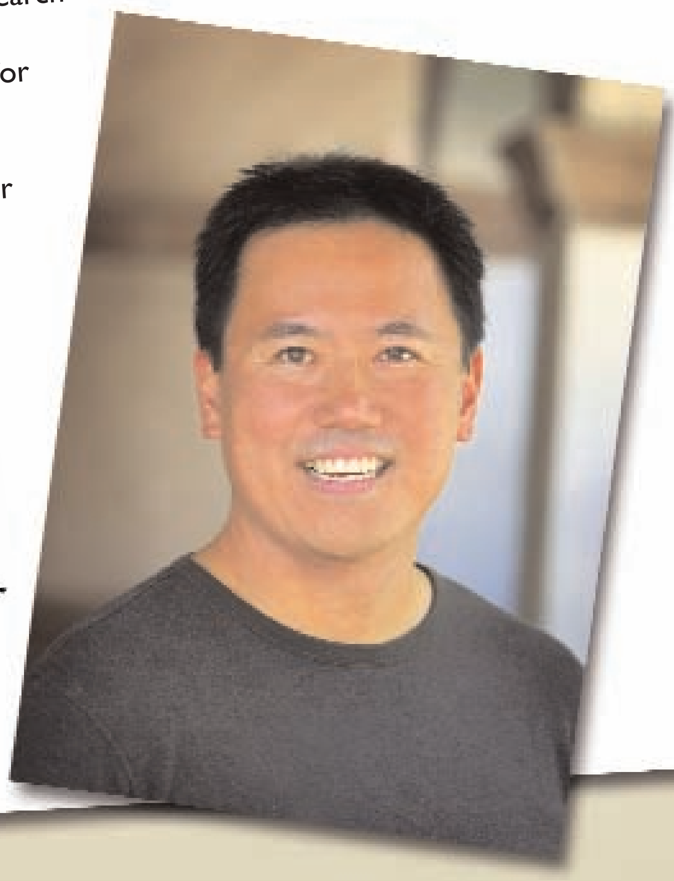

PREFACE

Mountain biking is an increasingly popular outdoor activity in North America, with tens of millions of participants. It provides important individual, social, environmental and economic benefits for its enthusiasts and their communities. However, the rapid expansion of mountain biking has led to concerns over the potential for undesirable social and ecological impacts to recreation environments. Management issues include safety of trail users, user conflict, crowding and possible resource degradation. To address these concerns, managers have used various approaches, from partnering with mountain biking organizations to provide education and information, to controversial regulatory approaches including closing trails to mountain bikers. Some trails may have been closed and permits for organized events denied based on the perception that mountain biking causes significant ecological impacts, and that those impacts are more substantial than impacts from other activities. Yet mountain biking ecological impacts have remained under-researched and no comprehensive body of knowledge on the subject exists.

Recreational use of any natural areas inevitably results in some degree of change. Managers must consider the ecological significance of these changes when making decisions regarding resource use. In the absence of sound scientific information, managers often apply the precautionary principle, choosing to take regulatory action to restrict use based on intuition, influence from advocacy groups, or studies of questionable scientific merit.

Clearly, further research was needed regarding the ecological impacts of mountain biking on recreation trails and how these impacts related to trail features, and use levels, in order for recreation managers to make informed and equitable decisions regarding sustainable land use. In 2003, the Arizona State Office of the U.S. **Bureau of Land Management** (BLM), **Shimano American Corporation, Arizona State University and Northern Arizona University** forged a cooperative conservation partnership to address this issue.

This team developed a research project designed to achieve three goals:

- To evaluate the physical impacts of mountain biking on recreation trails in multiple physical environments in the U.S. Southwest.
- To document relationships between impacts, use-related factors and environmental factors.
- To develop guidelines to contribute to "Best Management Practices" for trail resource management.

The study was intended to address gaps in the scientific understanding of recreation impacts, inform natural resource managers in the development of sustainable recreation environments, provide practical advice for sustainable riding for mountain biking enthusiasts and associations, and offer clear advice for policymakers. Designed as a multi-year phased project, the Southwest Mountain Bike Study included collaboration and peer review by leading recreation ecology researchers in North America. To ensure the practical relevance of the project, land managers, members of the mountain biking community and policy makers were consulted.

The project included two phases. The first phase was the development of a comprehensive state-of-knowledge review of published literature, research reports and agency monitoring data. This review was completed and documented in an unpublished thesis.

The second phase of the project was an empirical field study to determine the existence, extent and ecological significance of physical impacts from mountain biking on established recreation trails in multiple physical environments. The project included a preliminary assessment of **31 trails (185.31 miles)** in five different geographic regions in the Southwest. These trails were primarily distributed across Bureau of Land Management and USDA Forest Service lands; however mountain bike trails managed by a city, a county, and a state were also included. The Southwest Mountain Bike Study is explained in detail in the first section.

The results of the literature review identified a challenge – no common organizing spatial framework existed for recreation impact research. One of the unique features of this study was the introduction of Common Ecological Regions (CERs), as a spatial framework to allow comparison of the results of ecological impact studies for mountain biking. This tool, developed by nine U.S. federal earth science and resource management agencies to facilitate research co-operation, has the potential to allow researchers to generalize localized research for regions, an important next step in building a recreational impact knowledge base for North America. CERs are explained in the Southwest Mountain Bike Study section.

The results of the study provided baseline data for mountain bike impacts and suggestions as to where impact problem areas might occur. As with all recreation resource use, mountain biking has a footprint. However, the results indicate that specific impacts to mountain bike trails, width in particular, are similar or smaller than impacts to hiking or multiple-use trails, and appreciably smaller than impacts to equestrian or off-highway vehicle trails. The results are included in the Southwest Mountain Bike Study section.

The basic objective of wildland recreation management is to protect the integrity of the resource base while allowing appropriate wildland recreational access, such as mountain biking. This project was designed to complement "***Limits of Acceptable Change***," an "indicators and standards" based approach to land use planning and management within the federal sector. The guidebook was developed to add to recreation managers' "Best Practices". It offers specific information on how to construct and maintain mountain biking trails, which will allow sustainable mountain bike use. Eight assessment forms, with key variables identified, were developed to form the mountain bike physical impact assessment program, and can subsequently be used for ongoing monitoring of mountain bike trails. These forms can be found in the appendices.

Results from this study support the ecological sustainability of mountain biking while sounding a clear call to action for (**a**) user ethics to protect the right to ride on public lands and (**b**) managerial actions to design and mitigate mountain bike trails that were poorly designed or not constructed for mountain bike use.

The ***Resource User Responsibilities*** section of this guidebook addresses their responsibilities for sustainable mountain biking.

The ***Planning and Management Actions*** section deals with managerial actions. Two specific case studies are presented. The first, the LakeTahoe basin area, discusses the user-based approach to decision-making that the Lake Tahoe resource management team has adopted. While not without challenges, this approach has provided a high quality mountain biking experience for biking enthusiasts. Basically the argument presented is that mountain bike users' motivations and preferences must be considered at every stage of development of mountain bike trail planning.

The second case study reviews the ecological impacts of a specific mountain bike race. In March 2005, the team conducted a pre-race/post-race assessment at the 2005 NOVA-NORBA National Desert Classic, an annual event occurring at McDowell Mountain Regional Park in Arizona, which draws over 1,500 racers from across the globe. Although some insignificant trail widening was attributable to the race itself, the most recognizable ecological impact was due to the cutting of trailside vegetation to provide adequate passing lanes for racers.

While multiple trailing was also an issue, suggestions are offered as to how recreation managers might mitigate this ecological impact and save themselves the extra work that comes with trail rehabilitation.

Finally in this section, a review of the standards-based approach to wildland management is provided. Implementing an indicators and standards-based system to evaluate, monitor, and manage recreation impacts helps the manager to focus on the quality of the resource in order to prevent conditions from deteriorating over time.

Ultimately, the decisions that managers make will have as much effect on the ecological viability of trails as will the type of use and the environment. Manager action—or inaction—will greatly influence the sustainability of mountain biking.

The **Implications for Resource Managers** section, offers specific as well as broad recommendations to keep in mind when designing, constructing and maintaining mountain bike trails, based upon study results.

In the conclusion we state that, when properly managed, mountain biking is an appropriate and ecologically sustainable use for recreational trails in these five CERs. We can now provide clear advice and suggestions as to how to enhance "best management practices" for recreational trail managers and policy makers in designing, building and managing mountain bike trails in these five specific regions. We also look to the future. With the use of Common Ecological Regions (CERs) as a spatial framework to allow comparison of research results, our study can be replicated in other areas of the U.S. and Canada, which could lead to recommendations for improving specific mountain bike management practices in these additional regions.

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Dear Reader,

As part of the Department of the Interior, the Bureau of Land Management is responsible for the administration of over 250 million acres of publicly owned land, located primarily in the western U.S. Our responsibilities include maintaining the health, diversity, and productivity of these public lands in perpetuity for the use and enjoyment of Americans. Naturally, we are interested in maximizing the benefits citizens gain from recreational activities on these lands. To carry out our mandate, we must understand the ecological effects of various recreational pursuits. With this knowledge, we can then develop tools to manage public land use sustainably.

As a relatively new recreational activity now enjoyed by tens of millions, it's critical that mountain biking is well understood by land managers and policy makers in terms of its impact on the ecological and social environment. This document is meant to be an assistive tool. It complements existing strategies, such as the Bureau of Land Management's (BLM) National Mountain Bicycling Strategic Action Plan (November 2002), adding to our lessons learned in the field.

Field research, such as the project described in this guidebook, can provide managers and policy makers with specific information, especially with respect to construction, maintenance, user education and messaging, that will allow sustainable mountain bike use on recreation trails.

This guidebook can be used to assist in successfully planning, designing, and constructing mountain bike trail systems, while keeping in mind that user issues must be addressed at every stage of development. It's important to understand what constitutes a high quality mountain biking experience and what benefits motivate mountain bikers if we are building a sustainable mountain bike trail system. It also provides necessary information for deciding among recreation and trail uses for any given site. The Lake Tahoe Basin case study is just one example of how recreation managers are successfully incorporating a user-based approach into planning for sustainable trail management. Responsible planning calls for inclusion of outside ideas. At the very core of this research design was the use of outside expertise and labor to collect data for planning and designing trails.

Northern Arizona University and Arizona State University both have an academic focus on the scientific approach. This research project used this method to develop a 'Limits of Acceptable Change' format to assess a trail system's physical environmental condition. This construct includes monitoring criteria, indicators, standards and thresholds. By establishing such a format, we have the ability to develop a comprehensive inventory of trail conditions. From this baseline, we can accurately monitor changes occurring from mountain bike use. By defining the scientific data necessary we, as managers, can now obtain the information needed to continue making sound decisions regarding sustainable mountain biking within our jurisdictions.

By combining user preferences and a standards-based approach for measuring impacts, we have a good starting point. Through establishing long-term relationships with bicycle manufacturers like Shimano, agencies can better understand biking trends and the emerging technologies that respond to them. As we gain understanding of these trends, we can better relate to the needs and desires of the user and find sustainable environmental solutions.

Our influence doesn't have to end there. Through the use of consistent messaging on trails, we can also affect user knowledge and behavior. This guidebook encourages adoption of outdoor user ethics as outlined in "Leave No Trace, Tread Lightly!," and the International Mountain Bicycling Association's "Rules of the Trail" for all mountain biking programs, especially those geared for youth and new riders. It provides the factual data needed to develop interpretive material along trails to emphasize the relationship between resource protection and responsible mountain biking.

A manager is constantly challenged with anticipating what opportunities the mountain biking public might need, expect, or desire in the future. One of our goals to meet this emerging issue is to provide a variety of mountain biking experiences and opportunities. Through this research partnership, BLM has established a relationship with the scientific community to better understand existing research and initiate new research as needed to help predict and accommodate change. Much of the data collected and resulting findings will already apply to other management situations. But if it doesn't apply, the research methodology is purposely designed for each of us to use in our local environs. We can all contribute to the effective and sustained management of mountain biking trail systems by deploying both the findings and the tools to advance this knowledge database. In doing so, we can scientifically and factually determine and describe impacts specific to our area, thereby assisting in the design and implementation of sustainable mountain biking opportunities and trail systems.

Don Applegate
Recreation Program Lead, Arizona
Bureau of Land Management

THE SOUTHWEST MOUNTAIN BIKE STUDY

Executive Summary

Since mountain biking began thirty years ago, it has grown exponentially, leading to concern about possible undesirable ecological impacts on trails and other recreational environments. While it is generally understood and accepted that any recreational use of natural areas will result in some degree of change to the condition of the resource, managers must weigh the ecological importance of these changes, along with community reaction to them, when making their decisions regarding use. However, no well developed body of research exists on the environmental impacts of off-road cycling, or the connections between these impacts and physical aspects of the recreational environment. Without this empirical evidence, mountain bike impacts on recreational lands are simply unknown. This makes it particularly difficult for recreational lands policy makers and managers to make informed decisions regarding the establishment and management of sustainable mountain bike trails on public lands.

Beginning in 2003, our team of stakeholders collaborated to address this lack of scientific knowledge. We decided to undertake primary research to study the relationships between the ecological impacts of mountain biking and trail features.

Using **Common Ecological Regions** (CERs) as a spatial framework to allow comparative analysis of maximum trail incision and width at varying degrees of slopes, the team conducted a survey of 185 miles of mountain bike trails within five regions in the U.S. Southwest. These recreational trails were primarily managed by the Bureau of Land Management and the USDA Forest Service, but they also included city and state-managed trails. Physical impacts on mountain bike trails were measured using a well-accepted, multi-parameter, point-sampling procedure.

Results indicate that CER has a major effect on trail width and maximum incision. As well, trail slope significantly affects maximum trail incision. The Arizona/New Mexico Mountains region sustained the greatest trail width and depth, possibly because of environmental features including sparse vegetation and soils susceptible to erosion, high level of use, or user activities. Maximum incision and slope were highly correlated in three of the five CERs.

The results of the research study indicate that specific impacts to mountain bike trails, width in particular, are similar or smaller than impacts to hiking or multiple-use trails, and appreciably smaller than impacts to equestrian or off-highway vehicle trails. These findings support other research that has been conducted in the field.

With these results, we can state that, appropriately managed, mountain biking can be a sustainable use for recreational trails in these five CERs. As well, we can now provide clear advice and suggestions to improve "best management practices" for recreational trail managers and policy makers in designing, building and managing mountain bike trails in these five specific regions. With the spatial framework we have established to allow comparison, research could be expanded beyond the five regions identified to other areas of the U.S. and Canada, thereby developing specific mountain bike management practices for these additional regions.

Introduction

As a recreational activity, mountain biking or off-road cycling continues to gain popularity throughout North America. In 2003, authors of the National Survey on Recreation and the Environment estimated that **45.2 million people**, or close to **21% of the American public**, mountain biked on backcountry roads, trails, or cross country at least once in the twelve months prior to the survey. Perhaps this is not surprising, as the survey identified general bicycling as the second most popular recreational activity on land in the United States.

Drawn by the significant individual benefits of exercise, technical challenge, the outdoor experience and bonding with friends and family, Americans embraced the sport with vigor. As well as individual and social benefits, there are significant environmental and economic benefits associated with the sport. Cyclists are attracted by the primeval beauty of wild country and want to continue to experience what they love. Interest in trail development has helped to preserve many natural areas, benefiting the environment and stimulating local and regional economies. One study by Fix and Loomis in 1997 estimated that mountain bikers in Moab, Utah generated a consumer surplus value of **$200 per trip**, or between **$8.4 million** and **$8.7 million** for the region each year.

As off-road riding in recreational environments quickly grew in popularity, concern arose over the potential for adverse ecological and social impacts. Recreational resource managers became increasingly concerned about conflict between users, resource deterioration, overcrowding and safety issues. Yet efforts to study both the social and ecological impacts of mountain biking lagged far behind the development of the activity itself. Faced with a practical need to deal with existing social and potential ecological challenges, public land managers used a variety of strategies, from spatial or temporal zoning, to strict regulations and often total trail closure to mountain biking. Some of these more restrictive management decisions, if not supported by empirical evidence, could be construed as being inequitable among different users of the resource.

However, if public land managers lack reliable scientific explanations of ecological impacts on trails, they will frequently rely on the "precautionary principle"; that is, impose regulations which restrict use based on their own intuition, public opinion, the views of anti-use lobbyists, or available studies which do not meet scientific criteria, with the mistaken justification that this protects the resource. A 1997 national study of U.S. State Park Directors found that, while just over two-thirds of these Directors believed that mountain biking was causing problematic resource degradation in their parks, fewer than 13% of the park systems had actually conducted fieldwork to quantify the problem, or identify it as anything more than a perception. Another study suggests that public land managers attribute trail degradation to mountain biking without being able to determine whether it was mountain biking, or another use, that was causing the damage.

Any recreational use of natural areas will unavoidably end in some level of impact to the resource. It is the size and ecological significance of this change, along with community acceptance, that managers must consider when making their decisions. As resource impacts caused by mountain biking are under-researched, and limited scientific knowledge of inter-relationships exists, it is evident that further research is required to inform public land managers. Armed with this information, they can make sound and equitable decisions regarding the resource, and construct sustainable recreational trails that will support mountain biking.

In order to minimize, manage or even prevent resource impacts, the relationships among the main causal factors and their important effects must be understood. Some key factors affecting trail impacts are known. They include the extent, timing and other use-related issues; ecological attributes, including soil composition and vegetation, and physical aspects of the trail such as trail design, slope and alignment. However, quantitative, published studies explaining the relationships among these variables are few. As well, the discipline of recreation ecology, or the study of ecological impacts, required a specific framework that could be used to organize and compare study results.

To address these areas of deficiency, one goal of this study was to investigate the influence of trail slope and ecology on two common indicators of erosion and compaction – trail width and maximum trail depth – for well-traveled mountain bike trails in the southwest United States, an understudied area. As a measurement tool, the study team proposes using Common Ecological Regions (CER), a recently created framework that classifies and maps regions based on common biologic, geologic, topographic, soil, aquatic and land use characteristics.

Recreation Ecology and the Early Development of Mountain Bike Research

Hailing back to E.P. Meinecke's 1928 work, The Effects of Excessive Tourist Travel on California Redwood Parks, recreation ecology has grown to include a core group of researchers, academics and land managers committed to understanding the ecological impacts of outdoor recreation. Ecological impact research relies on gaining the information required to understand the relationships among key causal factors and their effects in order to prevent, or at least alleviate them. As federal land management agencies funded studies aimed at improving management practices in the 1960s and 1970s, recreation ecology became well established.

Recreation ecologists have primarily studied the environmental costs of two popular recreation features, campsites and trails, in both backcountry and semi-remote front country locations.

With respect to trails, initial design and construction cause the greatest ecological impact to recreation resources. However, trail construction is generally considered to be socially acceptable, as the benefits to the individual and to the community are viewed to be greater than the environmental costs. Most trail impact research focuses on either environmental impacts or user-related issues. Environmental impacts are subdivided into either gradual changes that occur over time, or sudden impacts that are the result of catastrophic environmental events. Environmental impacts are further sub-divided into those affecting soil, vegetation, water and wildlife. Visitor or user factors include frequency, type of use and user behavior. Recreation ecology and its existing research provide a solid framework from which to study mountain biking impacts.

It is generally accepted that mountain biking began about thirty years ago in Marin County, California (Mountain Bike Hall of Fame). Single-speed bikes were modified for off-road use, utilizing balloon tires, a high clearance frame and flat headset. These creations were termed "Clunkers". Yet national and international interest was not sparked until the 1980s, when the cycling industry's technological advances in materials, components and designs made this form of cycling accessible to a wider audience. Specialized Bicycle Components developed the first mass produced mountain bike in 1981, called the Stumpjumper. Bicycle Retailer and Industry News reported that, by 1999, mountain bikes accounted for one-half unit sales and one third of all gross revenue for U.S. bicycle retailers.

However, magazine articles began to appear in the 1980s, negatively influencing public opinion about the presumed effects of mountain biking on recreational environments and wildlands. Sensationalized headlines from that era, such as "Backcountry Bicycling: Sport or Spoil-Sport?", "The Mountain Bicycle: Friend or Foe?" and "Vicious Cycles?" illustrate this trend.

Ultimately researchers began to study the social and environmental impacts of off-road cycling in the late 1980s and 1990s. They studied mountain biker demographics, predilections and insights; social conflict among users and management strategies. However, the ecological impacts of mountain biking remained poorly documented as concrete information was almost entirely non-existent. While Cessford presented observations in his 1995 summary of mountain biking literature, he based his conclusions on results from other forms of recreational use. In fact, he and other researchers stated that available research at that time could not reveal whether mountain biking made a greater or lesser impact than hiking. Other researchers conducting experimental or quasi-experimental studies concluded that trail features were as important as use in predicting erosion; that trail conditions affected erosion and that there were no appreciable differences between mountain biking and hiking for the variables studied.

From existing studies, it appeared that the scale of ecological impacts credited to mountain biking were comparable to those of hiking, and less than those of either equestrian or motorized trail use. Soil structure, slope and environmental factors can often be as important as use in producing effects such as soil loss. With proper management, compaction and vegetation loss to trail peripheries can be minimized. Muddy and wet conditions and steep uphill or downhill slopes that can cause spinning tires or skidding pose the greatest risk factors for potential damage caused by mountain bikes. However, as mountain bikers often prefer technical challenge in their riding, it can be difficult to manage a balance.

These studies, while offering an incomplete picture, provided an indication of what the team might find in the field. A brief summary of the literature review is presented in Appendix 1, page 42.

Methodology: Determining a Spatial Framework: CERs

Common ecological regions, or CERs, comprise a spatial framework developed as a cooperative effort among nine U.S. federal earth science and resource management agencies, including the Bureau of Land Management, U.S. Forest Service (USFS), U.S. Fish and Wildlife Service, and National Park Service. Based on similarities in biotic, abiotic, terrestrial and aquatic environmental features, these CERs are an amalgamation of three preliminary, single-agency mapped sets of geographic regions. However, these often-conflicting methods of classification discouraged the comparison of data amongst agencies and regions. With the advent of CERs, researchers have greater ability to widely share their results and draw regional-scale conclusions from local studies. Individual agency soil maps and other geographic structures may still be used under the overarching CER framework to achieve specific agency goals or meet identified needs.

We selected trails from the five following CERs in the southwest United States
(U.S. Environmental Protection Agency, 2005):

- **Arizona Strip BLM Lands (AZ) in the Sonoran Basin and Range:**
The Sonoran Basin and Range is home to several low mountain ranges jutting up through wide desert basins. Palo verde, cacti (including the giant saguaro), shrub-steppe, oak-juniper woodlands, and ponderosa pine are found at successively higher elevations in this hot and dry CER, where large tracts of federally managed lands exist.

- **Coconino National Forest (AZ) in the Arizona/New Mexico Mountains:**
The Arizona/New Mexico Mountains are lower in elevation than surrounding mountainous ecological regions. Chaparral, oak-pinyon-juniper woodlands and vast ponderosa pine forests exist at successively higher elevations in this warm and dry CER. Douglas fir, fir, and spruce forests are present in isolated pockets at the highest elevations.

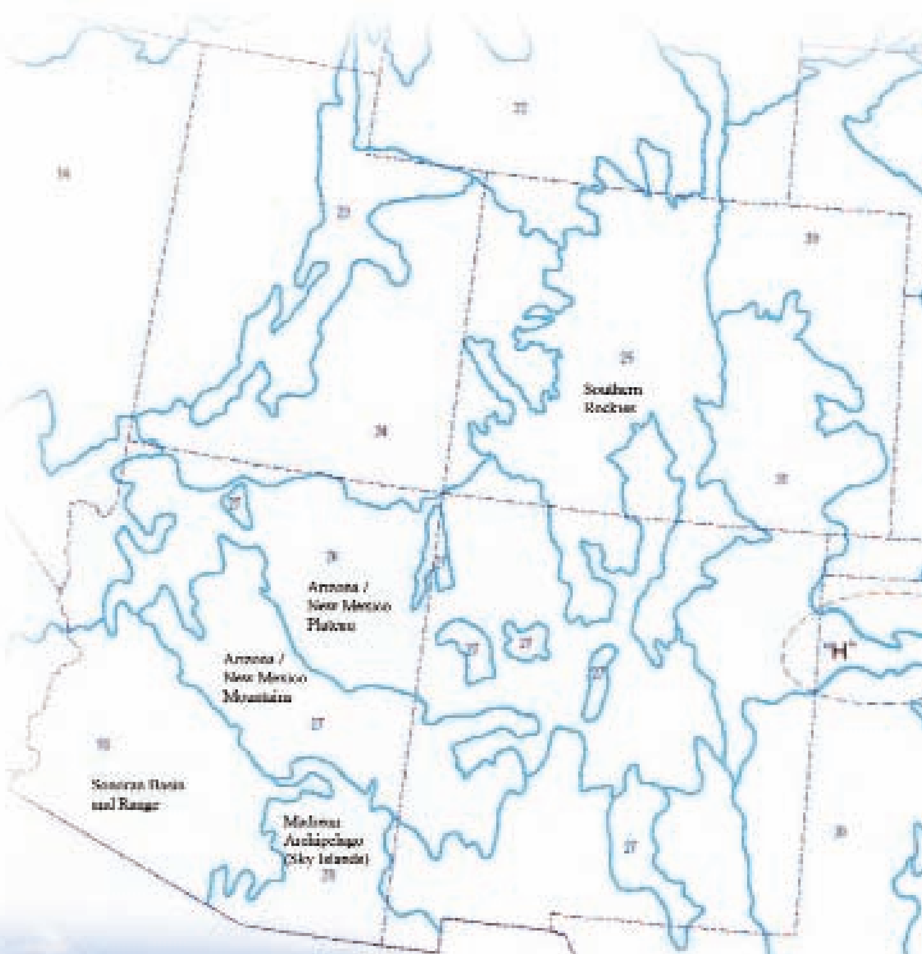
- **Red Cliffs Desert Reserve (UT) in the Colorado Plateau:**
The Colorado Plateau is composed of numerous mesas, buttes, sidewalls and cliffs. Saltbrush and greasewood are common in the hot and dry low elevations of this CER, while pinyon-juniper woodlands dominate the higher elevations.

- **Dixie National Forest (UT) in the Wasatch and Uinta Mountains:**
  The jagged Wasatch and Uinta Mountains are interspersed with valleys and plateaus. Chaparral, oak-pinyon-juniper woodlands and aspen are present at middle elevations, while pine, spruce, fir, and alpine vegetation abound at higher elevations.

- **The San Isabel National Forest (CO) in the Southern Rockies:**
  The Southern Rockies ecological region, the eastern extent of the study, is one of the most mountainous CERs in the United States. Low and mid elevation grasses, shrubs and oak-juniper woodlands quickly give way to coniferous forests and alpine meadows.

Map of CERs Studied

While variability in biotic and abiotic elements exists within ecological regions, the CER spatial framework allows segmentation of the region and provides context for interpreting environmental research results.



Selecting Trails

The sample trails were chosen from a comprehensive list of system trails identified by recreation managers and mountain bike and trail associations. Our goal was to select trails that offered typical conditions in that region, even though our results could not, without further research, be extrapolated to the region as a whole. In order to isolate the impacts associated with mountain biking in multiple-use environments, we included in the study only those trails where mountain biking was the dominant activity, based on expert opinion and trail evidence. Ultimately, we narrowed our sample to **31** trails totaling **185.31 miles**. Three of those trails were designed specifically for mountain bike riders.

The majority of mountain bike trails assessed for physical impacts in the study were classified as follows:

1. Included in agency trail systems
2. Usually user constructed with no clarity regarding the original trail design
3. Received some type of on-going maintenance.

The study used an applied research approach, as opposed to an experimental design, and, as such, all data collection was completed in the field on currently used mountain bike trails.

The following tables are a summary of trail descriptors for the 31 mountain bike trails included in the mountain bike physical assessment program.

The descriptors include land management agencies, trail regions, types of trails, dominant trail vegetation, water presence, dominant soil type, mountain bike dominance, trail length and trail characteristics.

LAND MANAGEMENT AGENCIES

Agency	Trails	% of Study
BLM	3	9.7%
City	1	3.2%
County	6	19.4%
State	4	12.9%
USFS	17	54.8%

TRAIL REGIONS

Region	Trails	%
Arizona Strip BLM(UT)	2	6.5%
Conconino National Forest (AZ) Peaks	4	12.9%
Conconino National Forest (AZ) Red Rocks	6	19.4%
Dixie National Forest (UT)	4	12.9%
Phoenix (AZ)	7	22.6%
Red Cliffs Desert Reserve (UT)	1	3.2%
San Isabel National Forest (CO)	1	3.2%
Tucson (AZ)	6	19.4%

TYPE OF TRAIL

	N	%
System Trail	3	9.7%
Social Trail	20	64.5%
On-Going Maintenance	15	48.4%
Agency Constructed	7	22.5%
User Constructed	11	35.5%
Designed for Mtn Bikes	12	38.7%

TRAIL LENGTH

	N	%
1-3 Miles	11	35.5%
3-5 Miles	5	16.1%
5-10 Miles	12	38.7%
10-20 Miles	2	6.5%
20+ Miles	1	3.2%

DOMINANT TRAIL VEGETATION

	N	%
Alpine	3	9.7%
Pinyon/Juniper	9	29.0%
Ponderosa Pine	6	19.4%
Short Desert Shrub	8	25.8%
Tall Desert Shrub	5	16.1%

DOMINANT SOIL TYPE ALONG TRAIL

	N	%
Loam	18	58.1%
Sand	13	41.9%

WATER PRESENCE ALONG TRAIL

	N	%
Lake	2	6.5%
Potholes	1	3.2%
Spring	1	3.2%
Stream	4	12.9%
NONE	17	54.8%

MOUNTAIN BIKE DOMINANCE FOR TRAIL ACTIVITY

	N	%
Expert/Literature	21	67.7%
Trail Evidence	23	74.2%

MOUNTAIN BIKE TRAIL CHARACTERISTICS

	N	%
Total Upgrades	17	54.8%

OTHER RECREATION

Climbing	1	3.2%
Hiking	21	67.7%
Equestrian	15	48.4%
Camping	7	22.6%
ATV/OHV Use	6	19.4%
Shooting	1	3.2%

OTHER USES

Ranger	3	9.7%
Timber	3	9.7%
Wildlife	4	12.9%
Water	2	6.5%

Implementation

To collect trail width and maximum trail depth data, we used a point-measurement method commonly applied in trail impact studies. Using a bicycle wheel measuring computer to identify sampling points at regularly spaced intervals (805 m or one-half mile) along the trail from a random start point near the trailhead, our technicians took systematic measurements of the trail width, maximum trail depth and slope, rutting, multiple trailing, and vegetation damage. They also identified and similarly measured unique locations, such as grades, sharp curves, stream crossings, open areas, trail junctions, and unsanctioned, off-trail routes. While research has shown that intervals of less than 100 m provide the best accuracy for common trail impact assessments, to provide greater balance between accuracy and efficiency for the fieldwork, we chose the larger interval measurement scheme. While this poses a possible limitation in terms of accuracy, it allows us the opportunity to include a larger sample of trails over a greater geographic area.

Each site was located using global positioning technology (GPS), and technicians captured site images with digital cameras. Using visually obvious disturbances such as alterations in vegetation cover, height and composition as a guide, we defined the trail boundary as the area where the vast majority, or over ninety percent of trail use, occurred. We placed temporary stakes at the boundaries of the trail, thus establishing a transect perpendicular to the trail tread. To measure trail width, we measured in inches (to the nearest inch) the distance between the trail boundary points. The Maximum trail incision (MIC) was measured by stretching a nylon cord tightly between the bases of the stakes and taking the maximum depth from the cord to the trail surface in inches to the nearest quarter inch. Qualitative data, including the presence or absence of litter, graffiti, human waste, vandalism, damage to sensitive vegetation and archaeological sites were also noted by the field technicians. The data were collected between May 2003 and March 2005, entered into an online database (Miscrosoft Access 2003) managed by the Bureau of Land Management, and analyzed using SPSS.

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FIELD EQUIPMENT

- ✓ Mountain Bike
- ✓ Data Forms
- ✓ Global Positioning System (GPS)
- ✓ Cyclocomputer
- ✓ Digital Camera
- ✓ Extra Batteries (AA, AAA)
- ✓ Pens/Pencils
- ✓ Map of the Area
- ✓ 100 Ft. Measuring Tape
- ✓ Brunton Pocket Transit
- ✓ 10 Tent Stakes
- ✓ First Aid Kit
- ✓ Cell Phone
- ✓ Food
- ✓ Water
- ✓ Jacket
- ✓ Data Collection Box

Forms and Data Collection Variables

The mountain bike physical impact assessment program included a variety of assessment forms, each with their own distinct variables. Eight forms were developed to facilitate data collection and assessment for specific areas of mountain bike impact. (To review the forms, please see Appendix 2). For example, a Trail Descriptor Form was devised to collect basic information about each trail. The remaining forms included: Trail Interval Form (data collected each 1/2 mile on any trails assessed); Off Trail Impact Form; Open Area Impact Form; Grade Impact Form; Curve Impact Form; Streambank Impact Form and Trail Junction Impact Form. Specific impact information for each trail was then collected and recorded, using the forms indicated.

Trail Descriptor Information	31
Trail Intervals (each 1/2 mile)	378
Off Trail Impacts	19
Grade Impacts	13
Curve Impacts	22
Streambank Impacts	73
Trail Junction Analysis	105

A variety of site variables were included on each form to assess potential mountain bike impacts.

These variables were a combination of ecological impact considerations and recreation impact considerations. The variables used in the study were standard recreation ecology variables employed in similar studies for backcountry and dispersed campsite monitoring, day user trail monitoring, and ATV/OHV monitoring.

In addition, data were collected to assess evidence of "other" recreation activity uses on the mountain bike trails.

The ecological impact variables included in the study were: multiple trailing, trail rutting, trail erosion (gully or sheet), as well as a variety of human caused vegetative impacts (trees, shrubs, grasses and forbs, and cactus), tree root exposure, crypto biotic soil impacts, and delicate rock formation impacts. The basic recreation impact variables included evidence of campfires, litter, human waste, and site vandalism.

Finally, evidence of other recreation activities on the trails was recorded for hiking, equestrian use, ATV/OHV use, shooting, camping, and climbing.

Evidence of Other Recreation Use on the Trails

In terms of other recreation activities on the mountain bike trails, it was found that hiking was the most significant activity across all assessment forms, ranging from 84.2% (open areas) to 31.8% (curve assessments).

Open areas exhibited a small incidence of camping (26.3%). Streambank crossings indicated some evidence of equestrian use (28.8%).

Study Results

Including all common five ecological regions, data from 378 point measurements were collected, representing 185.31 miles of mountain bike trails. The largest majority of these trails were managed by the U.S. Forest Service; the remaining trails were managed by a county parks and recreation agency; a state government agency; the BLM and a city government. Mountain biking was the primary activity on all of these trails; three of these trails were actually built for mountain biking.

This table indicates the number and type of assessment forms that were completed for the entire study.

MOUNTAIN BIKE STUDY: NUMBER OF ASSESSMENTS ALONG THE TRAIL

	N
Trail Intervals	378
Off Trail Impacts	106
Open Area Impacts	19
Grade Impacts	13
Streambed Impacts	73
Trail Junctions	105

The following table provides an overall trail impact rating for all trails.

TRAIL IMPACT RATING

	N	%
Extremely Impacted	1	3.2%
Heavily Impacted	3	9.7%
Moderately Impacted	13	41.9%
Slightly Impacted	5	16.1%
Unimpacted	9	29.0%

Note: 45.1% (N=14) of the trails were either slightly impacted or unimpacted

Trail interval widths and depths on and off trail, average trail width, depth and maximums across mountain bike assessments, as well as an off-trail use assessment, are provided below:

TRAIL INTERVAL WIDTHS (N=378)

	N	%
1-1.5 Feet	53	14.0%
1.6-2.0 Feet	94	24.9%
2.1-2.5 Feet	82	21.7%
2.6-3.0 Feet	39	10.3%
3.1-4.0 Feet	42	11.1%
4.1-5.0 Feet	23	6.1%
5.1-6.0 Feet	14	3.7%
Above 6.0 Feet	24	6.3%
Mean in Feet	2.45	
Maximum in Feet	9.5	

TRAIL INTERVAL DEPTHS (N=378)

	N	%
1-2 Inches		%
3-5 Inches		%
Above 6 Inches		%
Mean in Inches	1.7	
Maximum in Inches	12.0	

OFF TRAIL USE ASSESSMENT (N=106)

	N	%
Recent Use	83	78.3%
Frequent Ue	56	52.8%

OFF TRAIL DEPTH (N=106)

	N	%
1-2 Inches	87	82.1%
3-5 Inches	6	5.7%
Above 6 Inches	2	1.9%
Mean in Inches	1.4	
Maximum in Inches	12.0	

OFF TRAIL WIDTH (N=106)

	N	%
1-1.5 Feet	7	6.6%
1.6-2.0 Feet	18	17.0%
2.1-2.5 Feet	21	19.8%
2.6-3.0 Feet	13	12.3%
3.1-4.0 Feet	15	14.2%
4.1-5.0 Feet	9	8.5%
5.1-6.0 Feet	5	4.7%
Above 6.0 Feet	17	16.0%
Mean in Feet	5.8	
Maximum in Feet	75.6	

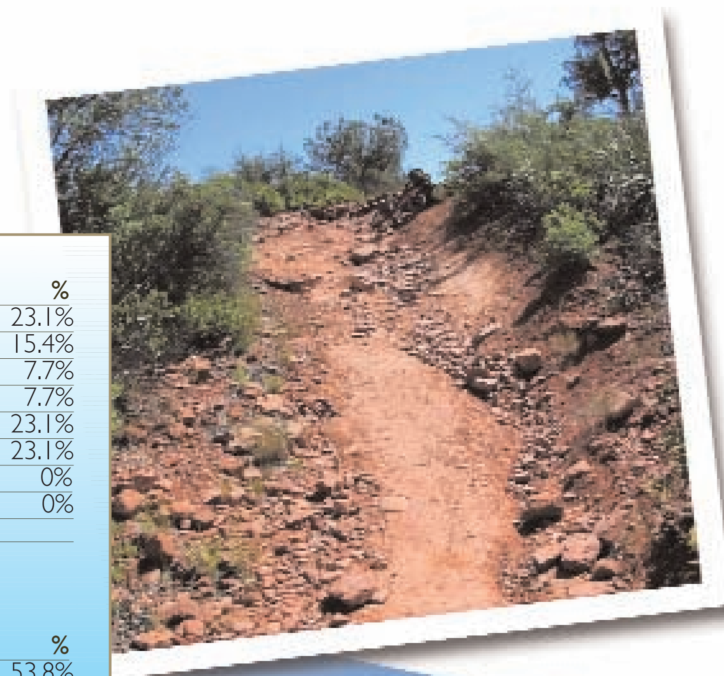
AVERAGE TRAIL WIDTH, DEPTH AND MAXIMUMS ACROSS MOUNTAIN BIKE ASSESSMENTS

	Intervals (378)	Off Trail (106)	Grades (13)		Curves (22)			Streambanks (73)	
			Top	Bottom	Top	Mid	Bottom	Entry	Exit
Mean Width (ft)	2.45	5.8	4.1	2.8	2.1	2.8	2.4	1.9	2.9
Max Width (ft)	9.5	75.6	14.7	4.6	5.1	7.4	5.1	15.9	18.9
Mean Depth (in)	1.7	1.4	2.8	2.3	1.2	1.2	1.3	1.5	1.5
Max Depth (in)	10.0	12.0	8.0	5.0	2.0	5.0	4.0	8.0	5.0

The results of the remaining assessment forms included in the mountain bike physical impact assessment program follow.

OPEN AREA SIZE AND TRAIL PRESENCE (N=19)

	N	%
SIZE		
1 Acre	9	47.4%
2-3 Acres	8	42.1%
4-5 Acres	2	10.5%
Open Areas w/Trails	10	52.6%



GRADE WIDTH (N=13)

TOP	N	%	BOTTOM	N	%
1-1.5 Feet	2	15.4%		3	23.1%
1.6-2.0 Feet	1	7.7%		2	15.4%
2.1-2.5 Feet	1	7.7%		1	7.7%
2.6-3.0 Feet	0	0%		1	7.7%
3.1-4.0 Feet	6	46.2%		3	23.1%
4.1-5.0 Feet	1	7.7%		3	23.1%
5.1-6.0 Feet	0	0%		0	0%
Above 6.0 Feet	2	15.4%		0	0%
Mean in Feet	4.1			2.8	
Maximum in Feet	14.7			4.6	

GRADE DEPTH (N=13)

TOP	N	%	BOTTOM	N	%
1-2 Inches	6	46.2%		7	53.8%
3-5 Inches	6	46.2%		6	46.2%
Above 6 Inches	1	7.7%		0	0%
Mean in Inches	2.8			2.3	
Maximum in Inches	8.0			5.0	

CURVE WIDTH (N=22)

BEGIN	N	%	MID	N	%	END	N	%
< 1 Foot	3	13.6%		3	13.6%		3	13.6%
1-1.9 Feet	12	54.5%		2	9.1%		6	27.3%
2-2.9 Feet	2	9.1%		8	36.4%		9	40.9%
3-3.9 Feet	4	18.2%		6	27.3%		1	4.5%
> 3 Feet	1	4.5%		3	13.6%		3	13.6%
Mean in Feet	2.1			2.8			2.4	
Maximum in Feet	5.1			7.4			5.1	

CURVE DEPTH (N=22)

BEGIN	N	%	MID	N	%	END	N	%
0 Inches	4	18.2%		7	31.8%		6	27.3%
1 Inch	12	54.5%		12	54.5%		11	50.0%
2 Inches	6	27.3%		1	4.5%		2	9.1%
>2 Inches	0	0%		2	9.1%		3	13.6%
Mean in Inches	1.2			1.2			1.3	
Max in Inches	2.0			5.0			4.0	

STREAMBANK WIDTH (N=73)

ENTRY	N	%	EXIT	N	%
< 1 Foot	2	2.7%		1	1.4%
1.1- 1.9 Feet	22	30.1%		24	32.9%
2.0 - 2.9 Feet	26	35.6%		26	35.6%
3.0 - 3.9 Feet	11	15.1%		11	15.1%
> 3 Feet	12	16.4%		11	15.1%
Mean in Feet	1.9			2.9	
Maximum in Feet	15.9			18.9	

STREAMBANK DEPTH (N=73)

ENTRY	N	%	EXIT	N	%
0 Inches	5	6.8%		5	6.8%
1 Inch	48	65.8%		43	58.9%
2 Inches	13	17.8%		13	17.8%
>2 Inches	7	9.6%		12	16.4%
Mean in Inches	1.5			1.5	
Max in Inches	8.0			5.0	

The tables below illustrate the number of sample points in three slope categories (>5% slope, 5% to 10% slope and > 10% slope) for trails in each of the 5 common ecological regions studied, and the average slope for each of the common ecological regions studied.

Number of sample points in three slope categories across five common ecological regions

COMMON ECOLOGICAL REGIONS	TRAIL SLOPE			TOTAL NUMBER SAMPLE POINTS
	> 5%	5% to 10%	> 10%	
Colorado Plateaus	9	21	7	37
Wasatch and Uinta Mountains	16	19	19	54
Southern Rockies	15	25	12	52
Arizona/New Mexico Mountains	26	25	25	76
Sonoran Basin and Range	52	22	26	100
Total	**118**	**112**	**89**	**319**

Note: x2 = 25.35, df = 8, p = .001

Taken and adapted from White, D.D., Waskey, M.T., Brodehl, G.P., and Foti, P.E. (in press). A comparative study of impacts to mountain bike trails in five common ecological regions of the southwestern U.S. Journal of Park and Recreation Administration. P.29.

COMMON ECOLOGICAL REGIONS	MEAN SLOPE
Colorado Plateaus	6.6%
Wasatch and Uinta Mountains	7.98%
Southern Rockies	6.68%
Arizona/New Mexico Mountains	8.31%
Sonoran Basin and Range	7.03%
Mean: All 5 Common Ecological Regions	**7.06%**

Taken and adapted from White, D.D., Waskey, M.T., Brodehl, G.P., and Foti, P.E. (in press). A comparative study of impacts to mountain bike trails in five common ecological regions of the southwestern U.S. Journal of Park and Recreation Administration. P. 16.

Multiple trailing was the primary ecological impact associated with stream crossings and trail junctions. At the interval and curve sites, the most commonly occurring indicator was damage to trailside grasses and forbs. As shown by the ***Mountain Bike Assessment Forms and Critical Impacts*** table.

MOUNTAIN BIKE ASSESSMENT FORMS AND CRITICAL IMPACTS

Trail Intervals (N=378)	Off Trail Impacts (N=106)	Open Area Impacts (N=19)	Grade Impacts (N=13)	Curve Impacts (N=22)	Streambank Impacts (N=73)
Grass/Forb Damage **(41.8%)**	Grass/Forb Damage **(65.1%)**	Multiple Trails **(52.6%)**	Erosion **(92.3%)**	Grass/Forb Damage **(36.4%)**	Multiple Trails **(46.6)**
	Shrub Damage **(30.2%)**	Cryptobiotic Soil Impacts **(36.8%)**	Root Exposure **(46.2%)**	Shrub Damage **(31.8%)**	
	Multiple Trails **(39.6%)**	Litter **(52.6%)**	Grass/Forb Damage **(38.5%)**		
			Rutting **(30.8%)**		
			Shrub Damage **(30.8%)**		

The table below identifies by assessment form, the critical variables which were most commonly associated with mountain bike impacts at a level that would indicate either continued assessment or site mitigation.

CRITICAL VARIABLES BY ASSESSMENT FORM

	Trail Intervals (N=378)		Off Trail (N=106)		Open Areas (N=19)		Grades (N=13)		Curves (N=22)		Streambanks (N=73)Entry		Streambanks Exit	
Multiple Trails	52	13.8%	42	39.6%	11	52.6%	3	23.1%	4	18.2%	34	46.6%		
Rutting	49	13.0%	13	12.3%	NA		4	30.8%	2	9.1%	3	4.1%	8	11.0%
Erosion	74	19.6%	23	21.7%	NA		12	92.3%	5	22.7%	19	26.0%	16	21.9%
Shrub Damage	57	15.1%	32	30.2%	NA		4	30.8%	7	31.8%	16	21.9%		
Grass/Forb Damage	158	41.8%	69	65.1%	NA		5	38.5%	8	36.4%	17	23.3%		
Cactus Damage	2	0.5%	7	6.6%	NA		0		0		0			
Tree Damage	14	3.7%	16	15.1%	NA		3	23.1%	0		6	8.2%		
Rock Impacts	14	3.7%	1	0.9%	1	5.3%	2	15.4%	4	18.2%	10	13.7%		
Crypto Impacts	13	3.4%	24	22.6%	7	36.8%	0		1	4.5%	7	9.6%		
Root Exposure	78	20.6%	5	4.7%			6	46.2%	3	13.6	12	16.4%		
Campfires	7	1.9%	7	6.6%	6	31.6%	0		0		0			
Litter	34	9.0%	6	5.7%	10	52.6%	0		2	9.1%	7	9.6%		
Human Waste	2	0.2%	1	0.9%	0		0		0		0			
Vandalism	8	2.1%	1	0.9%	2	10.5%	0		0		0			
Hiking Evidence	151	39.9%	80	75.5%	16	84.2%	2	15.4%	7	31.8%	54	74%		
Equestrian Evidence	53	14.0%	3	2.8%	3	15.8%	2	15.4%	3	13.6%	21	28.8%		
ATV/OHV Evidence	30	7.9%	3	2.8%	2	10.5%	0		0		1	1.4%		
Shooting Evidence	1	0.3%	0		0		0		0		0			
Camping Evidence	2	0.5%	5	4.7%	5	26.3%	0		0		0			
Climbing Evidence	0		0		1	5.3%	0		0		0			

Analysis of Results

Data analysis yielded two statistically significant trends. Firstly, trail width varied—sometimes greatly—among the CERs. The average trail width for the Arizona/New Mexico Mountains was 46 inches. This is greater than the trail width averages for all other CERs, which range from a low of 25 inches in the Southern Rocky Mountains to a high of 30 inches in the Sonoran Basin and Range. Multiple analyses of variance indicated that CER was a main factor in both trail width and maximum trail depth.

As indicated, the average trail width for the Arizona/New Mexico Mountains was much greater than the range of trail width averages for all other CERs. One explanation for this disparity is that the dominant vegetation for most trail segments in the Arizona/New Mexico Mountains were open pinyon-juniper and ponderosa pine woodlands, and the soil was mostly sandy-loam to loam. Not surprisingly, trails tended to be widest in areas of heavy use where few environmental constraints were present. This combination of open vegetation and a more easily eroded soil may not prevent trail widening like the rocky soils and cacti of the Sonoran Basin and Range or the dense forests of the Southern Rockies and Wasatch and Uinta Mountains.


BRIAN HEAD, UT

Another explanation, focusing on use rather than environmental factors, recognizes that the trail segments studied in the Arizona/New Mexico Mountains region are located in the Coconino National Forest near Sedona and Flagstaff, Arizona. This area is popular among local residents for day hiking, and it is likely that heavy use and user behavior contributed to increased width. Open areas and meadows were sometimes ecologically impacted by multiple trailing and the trampling of cryptobiotic crust, a fragile soil-stabilizing and enriching matrix that prepares many desert soils for successive vegetation.

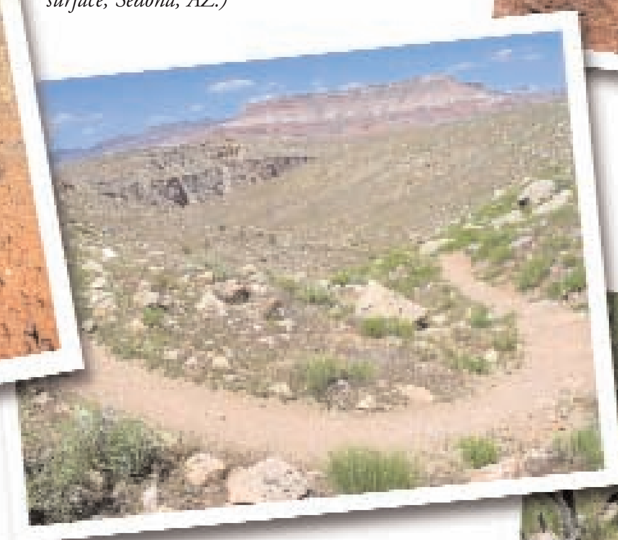
Cyptobiotic soil crust (black, uneven surface; Sedona, AZ.)

Often, the vegetation in these sensitive areas offers little resistance to the off-trail riding that can inhibit the development of an ecosystem. In these cases, recreation managers may want to consider signing open areas with messages that strongly encourage staying on the trail, and/or creating barriers to off-trail travel.

Second, trail slope was found to be a pivotal factor for potential impacts to soil and vegetation on recreational trails. Slopes greater than 12% were strongly correlated with higher degradation of soil and vegetation. The average maximum trail depth for slopes of less than 5% (1.14 inches) was found to be significantly lower than the averages for slopes between 5% and 10% (1.61 inches) and slopes greater than 10% (1.76). It appears that as slope increases, so generally does the maximum trail width and depth, although this conclusion could not be established statistically.

Multiple trailing was also the primary ecological impact associated with stream crossings and trail junctions. Often the entry/exit points were unclear at wide washes, leading to many different paths climbing into and out of the streambed.

Extreme example of a junction of two trails that are heavily impacted from user trampling. Note that cacti are the only survivors at this junction. (Sedona, AZ)



Representative curve. Note the entry and exit straight sections are slightly more narrow than the middle of the curve. Vegetation is often trampled as a result of this widening. (Hurricane, UT)

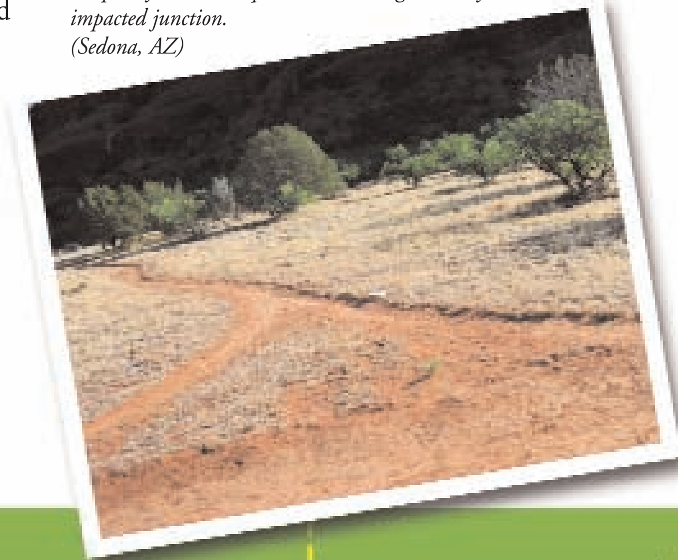
Triangular shaped trail junction. (Flagstaff, AZ)

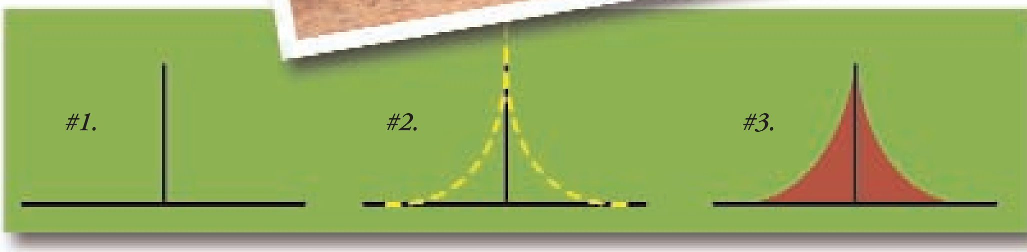
At numerous junctions, curvilinear paths often cut through ninety-degree intersections, eventually widening the junction from a "T" shape to a wide triangle. Interestingly, existing signs are usually located at junctions and may not provide enough advanced warning for riders traveling at faster speeds than for other trails users. Improved signage and reinforcing junctions may alleviate this ecological impact.

This may be an indication of some riders' inability to navigate increasingly steeper grades and/or inadequate trail drainage. In either case, recreation managers should help riders find an early line and ensure that grades are adequately designed to shed rather than funnel water. These actions will also help reduce other ecological impacts common to grades, including root exposure, damage to trailside vegetation, rutting and erosion.

As outlined, at the interval and curve sites, the most commonly occurring indicator was damage to trailside grasses and forbs. While this ecological impact denotes trail widening, it may also be related to riders being poorly matched to the trail and unable to control their bike over obstacles or along route changes. There is no question that riders who cannot control their bikes are more damaging to the environment than riders who are in control. Educating riders on proper technique and providing caution signs prior to technical sections discourage this trampling and widening.

Main trail runs left to right at the base of the image and has two trails connecting to the same spur trail. the triangular patch will likely be trampled completely with subsequent use, creating a heavily impacted junction.
(Sedona, AZ)



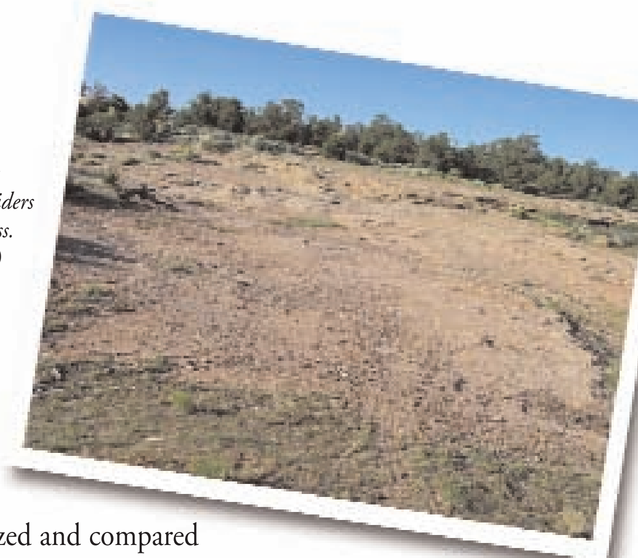


The images on this simplified graph depict:
#1. A normal "T-shaped" junction.
#2. Multiple trails created by mountain bide riders and other users cutting the junction. (shown by the dotted lines).
#3. The triangular shaped destruction of vegetation at the junction.

The average and median trail widths (32 inches/ 26 inches) and average and median maximum trail depths (1.48 inches/1.00 inches) for our entire data set provide results comparable to other studies.

Our findings indicate that the frequency of off-trail activity was the greatest cause of concern. We noted 106 off-trail routes over 185 miles of trails. This ecological impact is the largest threat to mountain biking access to our public lands. Public land managers should be discouraging additional trail creation through specific actions because this practice results in unnecessary ecological impacts and will negatively affect the image of the sport.

Open area where mountain bike riders have trailed across.
(Hurricane, UT)



Although results of this study cannot be extrapolated for these five regions as a whole, by using the common ecological regions as a framework, we are working towards the development of a complete knowledge base of impact conditions throughout these regions. According to the U.S. Environmental Protection Agency, the CER framework is now available to be downloaded as a GIS layer. Further research based on this framework can be analyzed and compared with existing work to ultimately allow some generalizations regarding specific relationships among causes of ecological impact and related factors, as well as specific impacts in varying geographic regions. This will strengthen the entire field of recreation impact research by broadening the applicability of results.

Conclusion from the Southwest Study

The primary focus of the mountain bike physical impact assessment study was to determine the existence, extent and ecological significance of physical impacts from mountain biking on established recreation trails in multiple physical environments with a focus on the Southwest. The project included a preliminary assessment of 31 trails (185.31 miles) which were distributed across Bureau of Land Management and USDA Forest Service lands, as well as city, county and state mountain bike trails. In terms of regions, the project trails were distributed across the following resource areas: Arizona (desert, Pinon Juniper and Ponderosa Pine); Utah (desert shrub, Pinon Juniper and high mountain forests) and Colorado (sub-alpine and high forest). The dominant vegetative regions in the study were short desert shrub communities (25.8%; < 3 feet in height) and Pinyon/Juniper associations (29%). A variety of impact assessments were completed as part of the study including, as follows: random trail intervals (n = 378); off trail impact assessments (n = 106); open area impact assessments (n = 19); grade impact assessments (n = 13); streambank impact assessments (n = 73) and trail junction assessments (n = 105).

Trail Descriptor Conclusions

While the trails for this study were distributed over city, state, county and federal agencies, over half of the trails were managed by the USDA Forest Service, indicating the most common mountain bike trail provider in the Southwest. It is important to note that the Forest Service is, by mandate, a multiple use agency; thus trails used in this study are, in all probability, subject to impacts from other recreation activities. This is despite the fact that trails selected for the study were dominant in mountain biking activity according to experts and trail evidence.

In most cases, the trails included in the study were established as a user-created social trail and then incorporated into the agency's trail system. The trail distribution was bi-modal in terms of length; trails were either short (1 – 3 miles) or moderate in length (5 – 10 miles). While about half of the trails received some type of on-going maintenance and upgrades, 35.5% of the trails were user-created and only 38.7% were actually designed for mountain bike use. This has significant implications for appropriate impact management due to the possibility of poor trail construction from the beginning.

> If mountain biking is documented as being a major impacting activity on a particular trail, one of the first considerations should be whether or not the trail was, in fact, designed for mountain bike use. ***A basic foundation of wildland recreation management is the provision by the agency of an appropriate activity trail or platform.***

The majority of the trails in the study had no water present along the trail and had a loam soil base. While there were few other non-recreational resource uses noted along the trails (such as range, timber, etc.), there was evidence of other recreational users, especially hikers. Most of the trails received a "moderately impacted" rating for overall impacts; however, it is important to note that 45.1% of the trails were either slightly impacted or not impacted. In all cases, only 12.9% of the trails were considered to be either extremely or heavily impacted. In considering these results, it is quite interesting to note that 87% of the trails are impacted at a level that is acceptable for any recreational activities. The exception to this statement would be in the case where the trail is inappropriate for use due to the presence of special resources, such as threatened or endangered species, or has special designation, such as wilderness.

Trail Assessment Conclusions

The ***Critical Variables by Assessment Form***, shown on page 23, provides a good overview of impacts related to mountain biking based upon particular assessment sites (trails). Several statements can be made based on the results of the table, as follows:

1. Grades appear to be areas of high impact related to mountain biking. High incidence variables included trail erosion, root exposure, grass/forb damage, shrub damage and trail rutting.

2. Open areas were most impacted by mountain bike use due to multiple trailing, user litter and cryptobiotic soil (soil crust) impacts.

3. Off trail activity is a significant component of mountain bike impacts. For the 31 trails studied (185.31 miles), there were 106 off trail impacts noted. Site impacts associated with off trail use included multiple trailing, shrub damage and grass/forb damage.

4. Curves appeared to be primarily impacted by shrub damage and grass/forb damage.

5. The major impacts related to streambanks are on the entry into the stream and the exit. In most cases, streambanks were impacted by multiple trails.

6. The randomly selected trail intervals were extremely useful in identifying impacts along the trail without "special" circumstances. The only variable which was marked by high incidence for the 378 trail intervals was damage to grass/forbs along the trail. While not a severely damaging factor, it is important to note that vegetative damage in recreation sites is often due to users increasing the size of the use footprint. In the case of mountain bikers, this is increasing the size of the trail.

7. Grade appears to be the most significant variable contributing to trail width and depth impacts, based on the data. Both the trail mean width and depth were higher than the assessment averages at the top of the grade. This may be an indication of users making last minute calls related to their route or their inability to navigate the grade. Off trail impacts also showed increased trail widths. However, in reviewing the data, this may have been influenced by some off trail impacts with extremely exaggerated widths (for example, 75.6 feet).

Based on these trail assessment conclusions, specific recommendations for resource managers are provided in the section, **Implications for Resource Managers and Policy Makers**.

Overall Conclusions

After many years in the field working specifically with recreation impacts in wildland areas of the Bureau of Land Management, National Park Service, and USDA Forest Service, we can firmly attest to the following statement: There is no such thing as a non-consumptive user. All site users leave behind their "footprint" of use.

Two major questions related to recreation activities that recreation ecologists wrestle with are: what are the impacts of the activity on the resource base, and how significant are these impacts to the health of the land? We know that outdoor recreation activities have signature impacts. For example, all of our fieldwork shows that day hikers, by and large, are "wanderers" who spread impacts along the trail. They are prone to social trailing, improper sanitary waste disposal, and littering. By comparison, backpackers tend to be "destination" users, who move along the trail toward their campsite where their impacts are concentrated. Typical campsite impacts from backpackers include barren core development, campfire impacts, social trailing around the site, and vegetative impacts to trees, shrubs, and grasses. Our most recent research found mountain bikers to be "destination" users. Once on the trail, mountain bikers tend to have few impacts beyond the footprint of the trail itself. The exceptions to this pattern are the off-trail and multiple trailing impacts noted in the previous section.

> Following our mountain bike research in the Southwest, we feel confident in asserting that mountain biking does not appear to be any more damaging to the environment than other trail-based recreation activities.
>
> There are, most certainly, recreation impacts associated with mountain bike use like all other recreation activities. However, we did not discover anything in our research related to mountain biking that would prevent site use within the confines of standard wildland recreation management.

Standard wildland recreation management relates to a rational managerial approach to ecological and social impacts on-site, and the corresponding loss to the resource base or user experience. The basic objective of wildland recreation management is to protect the integrity of the resource base while allowing, as appropriate, for wildland recreational access, such as mountain biking. This project was based on a standard approach to land use planning and management within the federal sector: the Limits of Acceptable Change. This is a "best management practice" for planning and managing site use within a rational structure. A standardized managerial approach will be discussed in further detail in the section entitled, **Planning and Management Actions**.

The field results of this study indicate that mountain biking is a sustainable trail activity given the following assumptions:

1. No special resources, such as threatened or endangered species are present on the site and the site has no special designation (such as wilderness);

2. The managing agency has provided a properly designed and constructed trail, route, or activity base for users; and

3. The ecological impacts related to the activity are inventoried, controlled with use standards, and monitored for change on a regular basis.

This study has provided baseline data for mountain bike impacts and suggestions as to where impact problem areas might occur. There was no clear indication in the results of the study that mountain biking was any more damaging to the resource base than other trail activities. In some cases, it could be argued that mountain biking was less impacting than other recreational trail uses, for example, equestrian, ATV/OHV and day user trails. The study results also seem to indicate that mountain bikers are destination riders and once they settle into the trail, their impacts only occasionally extend beyond the footprint of the trail.

We will add one final comment related to recreation impacts, mountain biking, and wildland sites. Without question, the most significant ecological impact that mountain bikers can leave on a site is the random development of spurious, unauthorized trails. If this impact is discontinued and the previously mentioned ecological impacts are managed and mitigated, we are well on our way to providing sustainable mountain bike trails. This issue is both a resource management and resource user challenge.

Natural features such as rocks help maintain a narrow trail and confine mountain bike riders. (Flagstaff, AZ)

Mountain Biker Responsibility for Sustainable Use: Elladee Brown

Elladee Brown is a former Canadian National Mountain Bike Champion and World Champion Silver Medalist in Downhill. In addition to having represented the Canadian National Mountain Bike team at the World Championships for eight consecutive years, she is also a Certified Canadian Mountain Bike Instructor and Coach, holding both the CMIC (Canadian Mountain Bike Instructor Certification) and NCCP (Canadian National Coaching Certification Program) designations.

Riding technique is an essential part of trail conservation—the way we ride is simply another way to protect our right to ride on public lands. Because mountain bikers are typically traveling at higher speeds than other trail users, extra attention to the handling of the bicycle and to the changing terrain are high priorities.

Before even getting out on the trails, riders must ensure that their bicycles are in good working order—without properly tuned brakes, the correct tire pressure and a functioning drive-train, a mountain biker can quickly become a rolling hazard.

Improper technique can, over time, deteriorate the trail. Mountain bike instructors the world over are aiming to create better, more technically sound riders, as the end result is a better experience for everyone. All other modes of mechanical transportation require a basic amount of skill and awareness - mountain biking is no exception.

Here are some key fundamental skills that, when practiced, greatly reduce the risk of rider error and/or premature trail wear.

The most important basic element of riding a mountain bike is maintaining what is called 'neutral position', which means having equal weight on both wheels at the same time, all of the time. Neutral position involves standing up on the pedals and remaining in a hovering posture above the seat. As the terrain changes, which it continuously does, riders shift their body weight fore and aft or side to side to maintain proper balance. A balanced position allows riders to react quickly to terrain features as well as to other users.

Looking ahead seems like an all-too-easy skill, but it's a difficult one to implement. Riders often focus only on what is directly in front of them - they forget to lift their heads to look farther ahead. The body follows the eyes—it's that simple. Experienced mountain bikers scan the terrain some 10-15 feet in front of them and slow down considerably in places where visibility is reduced and/or the trail tightens.

Eye movement is also critical for choosing the proper gear before a steep climb or descent. Looking ahead enables the rider to make the appropriate gear selection before approaching the climb. Attempting a climb in a gear that is too big will cause the rider to either fall over or step off the bike. Once this happens, there are now two impact points on the trail, both the bike tires and the footprint of the rider. By staying on the bike, impact points are minimized.

Sound climbing and descending techniques also depend on ground surface conditions and tire pressure. Lower tire pressure (30-35lbs for a 140lb rider) in loose rock and gravel will allow the tire to 'bite' into the ground more effectively, reducing skidding on descents and in corners. Tire pressure should be adjusted according to the rider's body weight—the lighter the rider, the less air needed. This small change makes a big difference in the overall feel of the bike.

Through corners, braking technique is the primary factor dictating whether the rider will actually 'ride' or 'slide' through a turn. Sliding should be avoided at all costs. It prematurely wears and widens the trail and can result in losing control of the bicycle. The onus is on the rider to *look ahead* and brake *before* the turn. The key to slowing down safely and in control involves lightly pumping, (i.e. 'modulating' or 'feathering') both brakes evenly with the index finger, while the other four digits remain gripped on the bar.

With regard to riding technique, the best conflict prevention and trail conservation efforts involve looking ahead, staying balanced and maintaining the overall upkeep of the bike. Every mountain biker needs to know that it is their responsibility to learn how to ride their bike correctly.

Of equal importance to acquiring the appropriate technical skills, riders must also gain stewardship skills. Sustainable recreational opportunities can only be maintained when mountain bikers respect and honor the *'rules of the trail'*. These are:

1. Never ride on closed trails.
2. Leave no trace.
3. Always maintain control of the bicycle.
4. Always yield to other users.
5. Don't scare the wildlife.
6. Always be prepared.

Unfortunately, there are the few 'renegades' who manage to tarnish the image of the sport through reckless behavior and complete disregard for the above rules. While it's unfortunate that these people receive any attention at all, it is important to notice that most off-road riders are actively involved in trail maintenance and relationship building with land managers and other user groups.

Similar to ski areas that list their accredited responsibility code on chairlift towers and lift tickets, designated mountain bike and multi-use areas are beginning to do the same.

> Ride don't slide,
> ride open trails only,
> always yield to other users,
> leave no trace,
> don't scare the wildlife,
> stay in control and plan ahead.

The goal is to get these messages across whenever the opportunity arises so that we never lose the incredible opportunity to ride on public lands!

PLANNING AND MANAGEMENT ACTIONS

Use is not the only factor that influences environmental impact on trails. The following case study discusses how a team approach and management decision-making that focuses on mountain bike users of the resource can be successful, even in a heavily used recreation setting where multiple recreation activities take place.

Case Study: Lake Tahoe Basin – A User-Based Approach to Management Planning

During the summer of 2005, armed with a more complete understanding of the ecological issues surrounding mountain biking, our team directed its attention to a place where mountain biking is extremely popular: the Lake Tahoe Basin. In this area, recreation managers from several agencies and local municipalities are working together to provide an exceptional mountain biking experience—often overcoming numerous roadblocks to success. Thus mountain biking in the Lake Tahoe Basin is an excellent case study with valuable lessons for recreation managers throughout the United States.

Our focus for this phase of our research was to understand stakeholder and visitor perceptions of mountain bike related impacts – both ecological and social – in the Lake Tahoe Basin. More specifically, we were interested in what lessons can be learned to inform sustainable trail management from studying stakeholder and visitor perceptions of social and ecological mountain bike related impacts in the Lake Tahoe Basin. Through group interviews with major local, state and federal recreation managers, as well as on-trail interviews with mountain bikers, we heard opinions on topics from illegal trail construction and the impacts of different recreation user groups to overuse, conflict and alternative management strategies.

LAKE TAHOE BASIN

A Recreation Destination

While sparkling water and sandy beaches are the most attractive summertime draw to the Lake Tahoe Basin, trail activities such as mountain biking, hiking, backpacking, wildlife viewing, camping and dirt biking are also popular with locals and visitors, especially when trails are adjacent to the urban amenities of communities such as South Lake Tahoe, California. While the Lake Tahoe Basin enjoys national and international acclaim, many of the mountain bikers that regularly use the trails surrounding Lake Tahoe come from California and Nevada. The Bay Area and Central Valley of California and nearby communities such as Reno are home to many avid riders that flock to Lake Tahoe, often hoping to rest from a busy work week or to avoid the heat.

Two Lake Tahoe Basin trails in particular beckon mountain bikers. One of the newest additions to the National Recreation Trails System is the Tahoe Rim Trail (TRT). This 165-mile trail, which also incorporates a segment of the Pacific Crest Trail, surrounds the entire lake, affording spectacular views of water, mountains and sky.

The Flume Trail, off the east shore of Lake Tahoe, offers the unparalleled riding experience sought by many locals and visitors. This moderately technical trail follows a sheer face in several sections that seems to drop off to the lake below. The Flume Trail is also popular because of its connectivity to the TRT and its accessibility for riders of various skill levels. These qualities, in addition to the expert design provided by Mountain Bike Hall of Fame inductee Max Jones and the Internal Mountain Bicycling Association, accentuate the overall riding experience provided by this 4.5 mile trail.

Introducing the Recreation Managers

The Tahoe Regional Planning Agency, USDA Forest Service Lake Tahoe Basin Management Unit, Tahoe Rim Trail Association and Nevada and California state parks, cities and counties work in conjunction to manage this delicate ecosystem and the recreation demands placed upon it.

The overarching agency in the area is the congressionally mandated Tahoe Regional Planning Agency. Although often on the receiving end of criticism, it has acted to guide development in a manner that protects the fragile ecosystem and seeks to improve the water clarity of Lake Tahoe.

Most mountain biking policies, however, are set by the Lake Tahoe Basin Management Unit, which manages roughly 70 percent of the land in the Lake Tahoe Basin. The Forest Service maintains a healthy relationship with the Tahoe Regional Planning Agency, the Tahoe Rim Trail Association and neighboring state parks such as Lake Tahoe-Nevada State Park.

Because of the popularity of the Flume Trail and the TRT, Lake Tahoe-Nevada State Park has become a haven for mountain biking. Thirteen of the 165 miles of the TRT travel through the park as does the entire Flume Trail. In dealing with these popular trails, park managers have taken a different approach to mountain biking management: they have focused on the preferences of their trail users. The feedback received has led to trails engineered with mountain biking in mind. These trails are maintained and patrolled by volunteer mountain bikers. Also, management strategies such as zoning (providing separate trails in congested areas for each major recreation group), alternating days for different recreation groups and educational efforts have been adopted to minimize conflict and ecological impacts.

As a non-profit entity and steward of the TRT, the Tahoe Rim Trail Association has an influential role in shaping policy and assisting the above agencies. It is responsible for coordinating volunteers, maintaining trail segments, and promoting and educating the public—all for a trail that winds through two states, six counties, a national forest and state park lands. Obviously, the Tahoe Rim Trail Association is an important link in this collaborative management setting.

Management Concerns

Despite the close working relationship between organizations and the proactive approach to trail construction and management, issues still remain. When questioned about the ecological and social impacts of mountain biking in the Lake Tahoe Basin, these organizations shared a variety of concerns. Ecologically, the protection of Lake Tahoe water quality is paramount. Unfortunately, much of the soil surrounding the lake is made up largely of decomposed granite. The "DG", as it is also known, is susceptible to cupping, rutting and washouts. Keeping this fragile ground from unnecessarily eroding is a difficult task, but critical for keeping additional sediment from reaching Lake Tahoe.

In the same vein, recreation managers seemed most concerned about the ecological impacts—especially erosion—from illegal trail construction and use. Downhill, off-trail travel became problematic a few years ago, especially on slopes falling out of the Basin. One county has even observed user-created trails in ski areas that have closed operations for the summer.

These new trails are identifiable after only a few rides and are nearly impossible to reclaim. Once in place, they may exist for several years even after "rogue" mountain bikers have abandoned the trail. While there has been cooperation to close these trails, these recreation managers fear an increase in off-trail activity as mountain bikers are beginning to appear with more "armor".

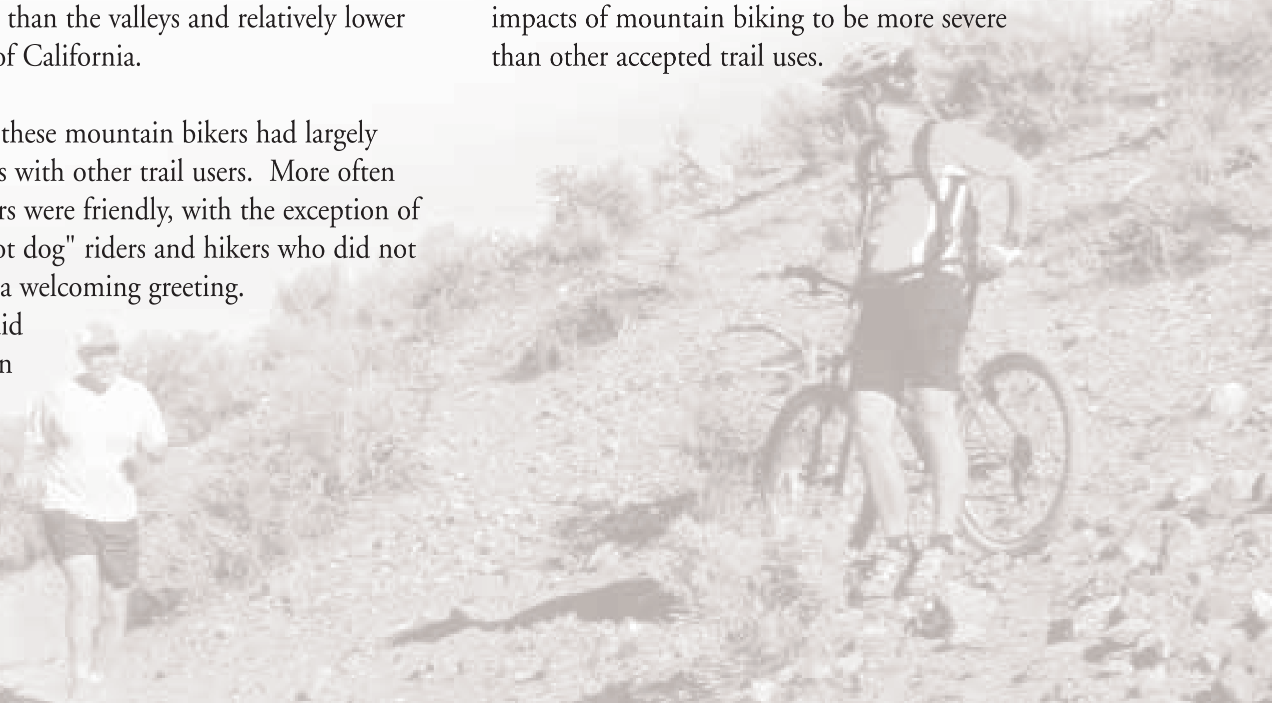
Overuse is another factor that Lake Tahoe Basin recreation managers suggest may unfavorably affect the local environment. At issue is carrying capacity—the level of use that a resource can handle before excessive degradation and social conflict occur. No one is quite sure how many mountain bikers, hikers, and horses these trails can bear before conditions become untenable. Are these recreation groups "loving the trails to death"?

Rider Responses

Complementing this management perspective, mountain bikers interviewed at the junction of the Flume Trail and a spur trail connecting to the TRT had much to say about their motives, experiences, and perceptions on the ecological and social impacts of mountain biking. Most came to ride the Flume Trail because of the recommendations of fellow bikers and almost all seemed enthralled with the scenic views of Lake Tahoe. Some even enjoyed exercising at higher elevations than the valleys and relatively lower coastal mountains of California.

During their rides, these mountain bikers had largely positive interactions with other trail users. More often than not, encounters were friendly, with the exception of a few impatient "hot dog" riders and hikers who did not respond in kind to a welcoming greeting. These encounters did not give rise to open conflict, but did leave some riders with a heightened perception of tension between trail users.

When questioned about the ecological impacts and the condition of the trails, there were no complaints. Everyone seemed impressed with the on-going maintenance and clearly displayed signage of the Flume Trail and TRT and none viewed the ecological impacts of mountain biking to be more severe than other accepted trail uses.



What's Working, What's Needed

If these riders' responses are any indication of the future of mountain biking in the Lake Tahoe Basin, it seems that these trails will only increase in popularity. However, it is also apparent that managers have implemented several strategies that they credit to their success in getting ahead of curve.

According to stakeholders in the Lake Tahoe Basin, two primary first steps must be taken to effectively manage the resource. These are to ascertain the current carrying capacity, or the amount of use the resource can withstand before reaching a point of ecological or social degradation, as well as to develop proper monitoring programs to assess ecological impacts and soil and water quality over time. One management option that can quickly be implemented to mitigate ecological impacts is proper trail construction. This has been shown in several studies, as well as on local trail sections of the TRT, to be the principal factor in protecting trails and preventing erosion. Trails designed specifically with the unique ecological impacts of mountain biking in mind are critical. Recreation managers are also watchful of any new user-created trails and are prepared to close them immediately.

Temporal zoning and alternate trail development have helped combat overuse and conflict. Supporting these efforts, several local governments and agencies, along with the Reno Gazette-Journal, have collaborated to enact the Know Before You Go program. This initiative has sought to standardize and adequately sign trailheads and provide trail users with the information that they might need for any hike or ride, such as trail distance, difficulty, views and facilities.

Regarding the future trends of mountain bike use, there is an increasing need to understand the motivations and needs of the most technical mountain bikers, whom recreation managers perceive to be the ones more inclined to travel off trail in search of greater challenges. Furthermore, research is needed to evaluate the long-term success of both temporal zoning and alternating trail development as ways to reduce conflict and disperse use. Continuing with endeavors such as these will likely prove vital to the ecological and social viability of mountain biking in the Lake Tahoe Basin.

In the end, the concerns and needs of these recreation managers are rightfully focused on the future instead of the present—one indication of a progressive planning approach. The satisfactory comments from mountain bikers support this conclusion and reaffirm that the strong inter-agency coordination, rider education and stewardship are promoting sustainability. Recreation managers in the Lake Tahoe Basin are poised to meet the challenges of tomorrow; in the meantime, they serve as excellent examples for all of us striving to accommodate mountain biking on our public lands.

The Influence of Recreation Managers in Mitigating Impacts of Mountain Bike Racing

Similar to our inventory in the Southwest, most ecological impact studies focus on the influence of both type of use and the natural environment. However, the policies and practices of recreation managers can also affect the condition of a trail, as can be seen in the case study discussed above. With this thought in mind, we also looked into the role that recreation managers have in mitigating the ecological impacts associated with mountain biking—this time in the context of racing.

In March 2005, we conducted a pre-race/post-race assessment at the 2005 NOVA-NORBA National Desert Classic. This annual event takes place at McDowell Mountain Regional Park just outside Phoenix, Arizona and draws over 1,500 racers from across the globe. Because of the intensity of this event, local recreation managers and volunteers had to prepare a suitable course for racing while also working to protect the trail from unnecessary ecological impact.

The most recognizable ecological impact attributed to preparation efforts was the cutting of trailside vegetation to provide adequate passing lanes for racers. Recreation managers took this action based upon the advice of race organizers.

Another factor leading to this decision was an abnormally high level of precipitation in the preceding two months that led to abundant vegetation growth. While it was apparent that some insignificant trail widening was attributable to mountain bike racing, the widest sections resulted from this cutting.

One of the other obvious ecological impacts at the Desert Classic was multiple trailing. Along certain trail sections, paths were created as some racers cut through the nearby vegetation because they were not able to maintain an adequate line or were eager to save time. Educational efforts, penalizing racers and flagging off these sections are examples of how recreation managers might mitigate this ecological impact and save themselves the headaches that come with trail rehabilitation.

In spite of these two examples, the Desert Classic was a success in terms of protecting the park's trails. We were unable to identify any other appreciable ecological impacts related to racing or management choices. Rather, on the day following the race we observed volunteers cleaning up the staging areas and removing litter and used water bottles from the trails—exemplifying the commitment of those hosting the Desert Classic to preserve the resources of McDowell Mountain Regional Park.

This brief glimpse into recreation management and racing is a lesson for us all. The decisions that managers make will have just as much effect on the ecological viability of trails as the type of use and environment. Their action—or inaction—will greatly influence the sustainability of mountain biking.

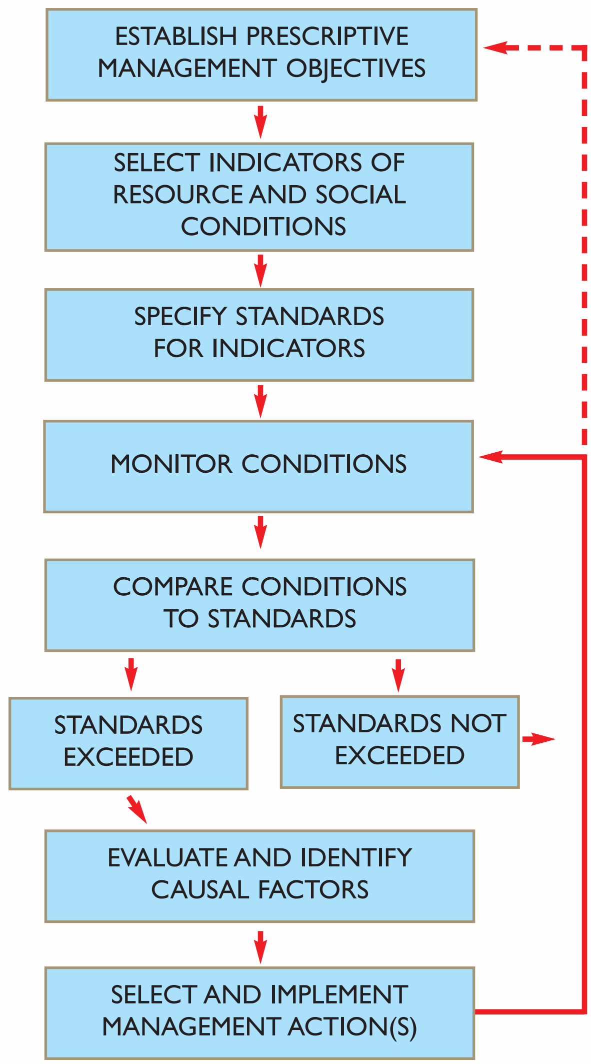
Multiple trailing. Note main route is at right and alternate route is at left, where some have ridden up on the bank, possibly because of higher speed. (Flagstaff, AZ)

Standards-Based Approach to Managing Recreational Impacts

In recent years, managers increasingly have adopted indicators and standards-based approaches to evaluate, monitor, and manage recreation impacts. These approaches involve identifying indicators – measurable variables that help define the quality of the resource – and standards – agreed-upon ranges of acceptable conditions. Several standards-based approaches have been adopted by resource agencies including the Bureau of Land Management, the USDA Forest Service and the National Park Service. The most common standards-based systems for recreation impacts are Limits of Acceptable Change (LAC), Visitor Experience and Resource Protection (VERP), and Visitor Impact Management (VIM). Although each of these systems has unique aspects, they share a common process. Standards-based systems require managers to:

1. Review or establish prescriptive management objectives for an area that are based on legislative mandates and agency policy.
2. Select key indicators of resource or social conditions. Indicators should be specific, objective, reliable, related to visitor use, sensitive to changing use, manageable, efficient to measure, and significant to the resource. Examples of indicators for mountain bike trails include tread width, maximum tread incision, or soil erosion.
3. Develop standards to specify the range of desired or acceptable conditions of each indicator. Well developed standards are quantitative, expressed as a probability, impact-oriented, and realistic.
4. Monitor conditions using accepted sampling and measurement techniques.
5. Compare existing conditions to standards and determine if conditions are within acceptable ranges of impact. If standards are within acceptable range, continue to monitor. If existing conditions are out of compliance with standards, evaluate and identify the causal or related factors that are contributing to the problems.
6. Select and implement appropriate management actions to maintain high-quality recreation resources and implement available strategies to address areas where standards may have been exceeded. Continue to monitor.

Contemporary Management Planning Frameworks such as LAC, VIM & VERP



Taken from Recreation Impacts and Management in Wilderness: A State-of-Knowledge Review by Yu-Fai Leung & Jeffrey L. Marion

Implementing an indicators and standards-based system to evaluate, monitor, and manage recreation impacts helps the manager to focus on the quality of the resource and prevents conditions from deteriorating over time.

Appendix 2, page 44, offers the series of assessment forms that constituted the mountain bike physical impact assessment program used in the Southwest Mountain Bike study.

IMPLICATIONS OF THE RESEARCH FOR MANAGERS AND POLICY MAKERS

Specific Recommendations for Resource Managers

The **Trail Assessment Conclusions** based upon physical impact results related to mountain biking in the Southwest study allow us to make some specific recommendations to resource managers, as follows:

- Grades appear to be areas of high concern for mountain biking. High incidence variables included trail erosion, root exposure, grass/forb damage, shrub damage and trail rutting. A recommendation to mountain bike trail managers would be to spend time and money ensuring appropriate trail construction on grades.
- Open areas were most impacted by mountain bike use due to multiple trailing, user litter and cryptobiotic soil (soil crust) impacts. In this case, trail managers may want to consider signing open areas to strongly encourage riders to stay on the trail. Since open areas are defined by their lack of impermeable vegetation, they are easily subject to user off trail activity. In addition, open areas are often crucial environments for the development of soil crusts and any off trail impacts are most likely to severely inhibit the growth of ecosystem components such as cryptobiotic soil.
- Off trail activity is a significant component of mountain bike impacts. For the 31 trails studied (185.31 miles), there were 106 off trail impacts noted - more than two per mile on average. Site impacts associated with off trail use included multiple trailing, shrub damage and grass/forb damage. Off-trail widths were also higher than in other areas, with a few extremely exaggerated widths being measured. Without question, the most significant impact that mountain bikers can leave on a site, and the most damaging to the presence of the activity on a site, is the random development of spurious, unauthorized trails. If this single impact were discontinued by participants in the activity, the other use impacts, when monitored and mitigated, would definitely lead to sustainable mountain bike trail use. Quite simply, off trail impacts are the result of inappropriate user behavior and should be stopped to avoid this unnecessary damage.
- Curves appeared to be primarily impacted by shrub damage and grass/forb damage. This is primarily related to the skill level of the rider and his/her ability to control the bike around a curve. For managers, vegetative impacts related to curves are best controlled by matching the rider to the appropriate trail or signing the trail to indicate the intensity of curve on the trail.
- The major impacts related to streambanks are on the entry into the stream and the exit. In most cases, streambanks were impacted by multiple trails. This can be mitigated by clarifying the trail footprint entering and exiting the streambank. In addition, in some cases, riders may need to be alerted to the upcoming streambank route via signage or trail cairns.
- The only variable which was marked by high incidence for the 378 trail intervals was damage to grass/forbs along the trail. While not a severely damaging factor, it is important to note that vegetative damage in recreation sites is often due to users increasing the size of the use footprint, or trail in this case. It is imperative that managers monitor mountain bike trail width to determine significant changes over time. Vegetative damage along the trail, such as grasses and forbs, may also be related to the user being poorly matched to the chosen trail. In this case, the rider may be unable to control his/her bike in the event of obstacles or route changes. There is no question that mountain bike riders who are not in control of their bikes are more damaging to the components of the ecosystem than riders who have control.
- Grade appears to be the most significant variable contributing to trail width and depth impacts. Both the trail mean width and depth were higher than the assessment averages at the top of the grade. This may be an indication of users making last minute calls related to their route or their inability to navigate the grade. In either case, managerial assistance may be needed to control impacts at the tops of grades and to assist riders in holding the trail.

> It's important that managers of mountain bike trails consider a system of "trail rating" to assist users in selecting a trail that meets the rider's skill level without damaging the ecological components of the trail.

Overall Recommendations for Resource Managers and Policy Makers

Undoubtedly, utilizing a standards-based system, as discussed in the previous section, is one of the best places to begin any effort to sustainably manage a mountain bike trail.

In addition to the specifics, resolve to include these broad recommendations from this guidebook in your mountain bike management efforts:

- Construct trails with mountain biking in mind. This includes designs that are thoughtful of both the technical needs of riders and sensitive areas of the environment such as wet and fragile soils.

- Be prepared to mitigate ecological impacts allied to specific locations along the trail such as steep slopes, curves, open areas, stream crossings and junctions. Remember to provide adequate drainage, a clearly defined trail and appropriate signage.

- Prevent proliferation of user-created trails by not incorporating them into your system, but rather rehabilitate them, if possible, back to their natural state. Also, develop enforcement mechanisms with "teeth" that will discourage this practice.

- If it is permissible under your agency's mandate, consider zoning and other strategies that separate the various user groups in high-use areas. These options may help reduce conflict and disperse ecological impacts.

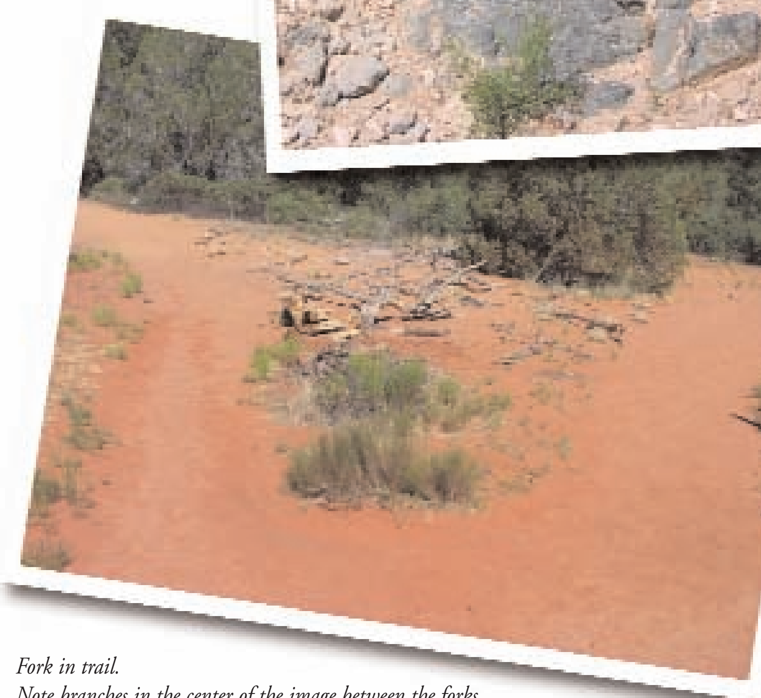
- Reach out to neighboring management agencies in your region and adopt consistent, unified statements on mountain biking.

- Encourage responsible rider behavior by promoting outdoor ethics and providing information about sensitive natural resources.

- Offer mountain biking trails for riders of all technical abilities. This action will not only satisfy the needs of your constituents, but will also allow riders to progress in their mastery of mountain biking. Also, consider technical ratings for each trail.

- Promote proper riding technique and mountain bike maintenance as two ways to protect trails.

Steep grade with rocks left in place to slow runoff. (St. George, UT)



Fork in trail.
Note branches in the center of the image between the forks. They serve as an impediment to those who might cut through.
(Sedona, AZ)

CONCLUSION

Years ago, we recognized there were significant gaps in our scientific knowledge about the impacts of mountain bikes on the natural environment. In the absence of good research data, all opinions are valid because no one knows who is correct. Increasingly people are requiring more outdoor recreational opportunities on a finite base of public lands, and land managers and policy makers must have credible information in order to make responsible sustainable use decisions.

From this beginning a cooperative research project began to gather much needed information about the environmental impacts of mountain bikes, based on extensive field research. In addition to publishing this research in science journals, the primary goal was to make the information available to natural resource professionals, policy makers and interested parties so low impact environmentally sustainable mountain bike trails could be included in land use planning and policy.

Where trails and public lands have been closed to mountain bikes, the information contained here may make it possible to review the decision and find another alternative that serves the interests of environmental stewardship and the riding public.

We hope you find this book useful for these purposes. Please feel free to contact us if you require further information.

The extensive cooperation in this research effort between industry (Shimano), university researchers (Arizona State University and Northern Arizona University) and government (Bureau of Land Management) provides a model for resolving natural resource use problems. The team approach has helped us to obtain the best possible information before making important decisions.

We suggest that other groups, elected officials and land managers work together for a similar cooperative approach to resolving future issues over public land access, trails and recreational uses.

Our research partnership also confirms that there is still much work to be done in other regions. We are building on the efforts of others who have pioneered new ideas, and who continue to look for ways to improve. Our partnership really includes all of the people who enjoy riding a mountain bike in the back country and who want to continue to enjoy and appreciate wild places responsibly – leaving them as they found them.

History teaches that the best stewards of wild lands are those who come to value them from first hand experience and responsible use. Everyone who rides a mountain bike can make a positive difference for the future and reinforce the foundations of environmental stewardship by respecting other users, by riding responsibly and staying on the trails. The choice and the future of trail access is in your hands.

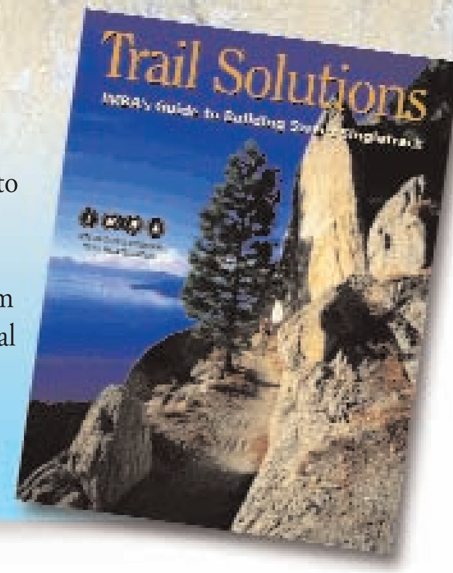
OTHER HELPFUL RESOURCES

The *Leave No Trace Center For Outdoor Ethics*, established in 1994, unites four federal land management agencies—the U.S. Forest Service, National Park Service, Bureau of Land Management and U.S. Fish and Wildlife Service—with manufacturers, outdoor retailers, user groups, educators, and individuals who share a commitment to maintain and protect our wildlands and natural areas for future enjoyment. The seven principles of *Leave No Trace* are important considerations for every mountain biking trip.

THE SEVEN PRINCIPLES OF LEAVE NO TRACE

1. Plan ahead and prepare
2. Travel on durable surfaces
3. Dispose of waste properly
4. Leave what you find
5. Minimize campfire impacts
6. Respect wildlife
7. Be considerate of other users

If you would like a booklet on mountain biking ethics from Leave No Trace, visit them online at http://www.LNT.org



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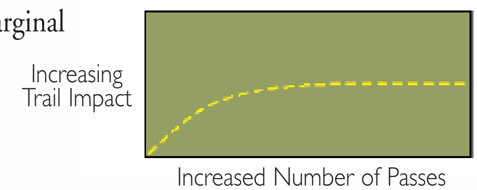
Appendix 1: Brief Literature Review

While physical impact studies did exist in the 1980s and early 1990s, few of them included mountain biking. In 1994, Montana State University earth and soil researchers subjected separate dry and wet trail plots to100 passes by a hiker, a horse, a motorcycle, and a mountain bike to determine runoff and sediment yield. The four uses did not significantly change runoff. Using this quasi-experimental approach, they determined that erosion from horseback riding was significantly greater than that from motorcycling, hiking or mountain biking. For all uses, erosion was more likely in wet conditions, indicating that proper trail drainage is critical in combating soil loss. At the same time, however, the researchers recognized that slope and soil texture are just as important as use in determining erosion or sediment yield. Thurston and Reader conducted a similarly designed study in 2001 to look at the separate effects of hiking and mountain biking on vegetation loss, species loss and soil exposure. They found no significant differences between the two uses for any of the three variables.

Water on trail promotes rutting and widening. (Brain Head, UT)

Similarly, University of Guelph botanists in Ontario passed hikers and mountain bikes up to 500 times over undisturbed plots. They were unable to identify a significant difference between the two uses concerning decreased vegetation density and diversity and increased soil exposure. Because it takes a small number of passes to create a new trail, however, they warned recreation managers to fight illegal trail construction and use.

A University of Wisconsin biologist conducted two studies in 1998. In the first, he determined that sediment yield and erosion caused by mountain biking was diminished by treating the surface with a nylon/polypropylene liner and covered with a substance made from recycled tires, as compared to the results from an untreated surface. In the second study, Bjorkman analyzed the first five seasons and 90,000 passes on two newly opened mountain biking trails. He found that the greatest changes in vegetation loss, soil compaction, and trail width and depth occurred within the first few thousand passes. Impacts were primarily located in the trail centerline and erosion and trail width were largest on slopes with a grade greater than or equal to 24 percent. Erosion was insignificant on lesser slopes. Additional use made a comparatively marginal contribution to the overall ecological impact on the trail.



Ecosystem researchers from Edith Cowan University in southwestern Australia examined recreation and racing trails for changes in soil compaction, erosion, trail width and vegetation cover over a period of one year. They found that steep slopes, curves, and sensitive soils were most susceptible to erosion, and that erosion and compaction were limited to on-trail only. Vegetation and trail width changes off-trail proved to be insignificant, although more pronounced under wet conditions. They recommend that recreation managers should avoid situating trails in locations prone to erosion, compaction, and widening, while working to provide technical features desired by mountain bikers.

Environmental researchers from the University of Tasmania compared the erosive effects of hikers and mountain bikers over 400 trail passes. They identified no significant difference between the two uses, but did note that the ecological impacts from mountain biking were focused more along the trail center whereas the ecological impacts from hiking were more dispersed. They discovered that erosion was greater on steep slopes and in wet soil conditions, and determined that erosion increased with skidding. This finding highlights the fact that rider technique and behavior can influence the level of ecological impact.

Appendix 2: Mountain Bike Physical Impact Analysis Dynamic Stream Impact Assessment MONITORING MANUAL & Mountain Bike Physical Impact Assessment Forms

This manual standardizes procedures for conducting a physical impact assessment of resource conditions on trails which are dominated by mountain biking.

MATERIALS:

- Digital Camera w/extra batteries
- Garmin E-Trek "Vista" or "Legend" GPS w/extra batteries
- 50 Foot Tape Measure
- 50 Feet of 1/16th inch braided Nylon String (Depth Measurement)
- Clinometer (for measuring grade degrees)
- Specialized "Turbo Elite Cyclocomputer"
- Compass
- 3 Tent Stakes (Depth Measurement - 2 to secure the nylon string and 1 to insert and measure the maximum trail tread depth)
- Trail Map or Description
- Clipboard or Writing Surface
- Monitoring Forms
- Pens/Pencils

1. All trails will have one *"Trail Descriptor Information"* form. This is an organizing form which describes the trail and summarizes the other impact analysis forms. This form is like the cover sheet on an impact analysis folder.

2. All trails will have an indeterminate number of *"Trail Interval Impact"* forms depending on the length of the trail. A Trail Interval Impact assessment will be completed after each 1/2 mile of trail. The 1/2 mile intervals will be tracked with a Specialized "Turbo Elite Cyclocomputer". Trail Interval Impacts ensures that on a completely unimpacted 10-mile mountain bike trail, a minimum of 18 impact assessments would occur. All of the other (following) impact assessment forms are based on assumptions related to potential impact areas for mountain biking and ensure that such potential impact areas are included in the study.

3. All "Off Trail Impacts" will receive an assessment. These are informal, visitor created side-trails off the main trail. Do not include formal trails, roads of any type, **extremely** faint trails or trails where it is OBVIOUS that one person may have gotten off trail but no OBVIOUS social trail is developing, or trails that have been **effectively** blocked off by managers. Informal trails are trails that visitors have created to access streams, scenic attraction features, camping areas, or other features, or they may be places where visitors have just gone off on their own!

4. Open areas (distinct meadow or lake areas in forested environments; or barren core flats in grassland/cacti environments) of 1 acre or more (1 acre = approximately 200 feet by 200 feet) will be assessed for impacts.

5. Steep grades which would require special riding and trail construction to avoid impacts will be assessed. The grade must be more than 20 degrees for at least 40 continuous feet to be assessed. A grade may be switchbacked.

6. Significant changes in the direction of travel will be assessed. Trail curves which are 140-180 degrees with a curve radius of 5-10 feet will be included in this assessment. (Do not include switchbacks on a downslope as a curve impact.)

7. All streambeds greater than 10 feet (flowing or dry) will be assessed for impacts.

Following a trail assessment, each trail will have a unique packet of assessments.

DEFINITIONS:

TRAIL BOUNDARY

The most pronounced outer boundary of visually obvious human disturbance created by trail use (NOT trail maintenance). You should observe changes in ground vegetation height, cover, composition, and a decrease or total loss of vegetative cover. The **TRAIL TREAD** receives >80% of the trail traffic. In selecting your trail tread, choose the most visually obvious boundary that could be replicated by another researcher.

Trail Width: a measurement of the trail treads with a tape measure. Measured in feet with one decimal.

Trail Depth: a measurement of the maximum trail depth within the trail tread. Stretch and secure the nylon string across the trail tread with 2 tent stakes. Position and insert the 3 tent stakes to measured the maximum incision from the string to the deepest portion of the trail tread. Measure to the surface of the tread's substrate, NOT the tops of rocks or the surface of mud puddles. Your objective is to record a measure that reflects the maximum amount of soil loss along the transect within the tread boundaries.

Trail Grade: use a clinometer to measure the degree of grade on the trail.

Mountain Bike Physical Impact Assessment Forms

Trail Descriptor Form
Trail Interval Form
Off Trail Impacts
Open Area Impacts
Grade Impacts
Curve Impacts
Streambed Impacts

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

TRAIL DESCRIPTOR INFORMATION

__________ **Region:** (1) Tucson (AZ) (2) Phoenix (AZ) (3) Sedona (AZ) (4) Flagstaff (AZ) (5) Red Cliffs Desert Reserve (UT) (6) AZ Strip BLM (UT) (7) Dixie NF (UT) (8) San Isabel NF (CO)

Trail Description: ____

____

____

____

____

____

__________ **Management Agency:** (1) BLM (2) USFS (3) NPS (4) State Agency (5)County (6) City (7) Non-Governmental Organization (8) Private

Number of Trail Users/year: ____

__________ On-Going Trail Maintenance: (1) Yes (2) No (3) No Information

__________ Presence of Trail Upgrades/Construction: (1) Yes (2) No

___ ___ ___ Trail ID (Region/Trail Number):

__________ Was this trail designed as a mountain biking trail? (1) Yes (2) No (3) Unsure

__________ Trail Construction: (1) Agency Constructed (2) User Constructed (3) Unknown

______ . __ Total Length of Trail Assessed (in miles w/1 decimal)

__________ DIFFERENCE in Elevation Gain or Loss over the course of the trail (feet)

__________ (Is this an uphill trail or a downhill trail?)

__________ Dominant Trail Vegetation: PP=Ponderosa Pine, PJ=Pinyon Juniper, TDS=Tall Desert Shrub, SDS=Short Desert Shrub, NR=Native Riparian, ER=Exotic Riparian, GR=Grasses, CA=Cacti, BA=Barren OTHER: ____

__________ Water Presence Along Trail: (1) spring (2) stream (3) potholes (4) none

Name of Primary Water Source: ____

__________ Dominant Soil Type along Trail: (1) Sand (2) Loam (3) Clay

__________ Based on agency/literature/expert input, is Mountain Biking the dominant activity? (1) Yes (2) No (3) Unsure

__________ Based on trail evidence, is Mountain Biking the dominant activity? (1) Yes (2) No (3) Unsure

Evidence of Other Recreation Activities on the Trail:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

Evidence of Other Multiple Use Activities along the Trail:

__________ Range (1) Yes (2) No

__________ Timber (1) Yes (2) No

__________ Wildlife (1) Yes (2) No

__________ Water (1) Yes (2) No

Trail Impact Analysis Overview:

__________ # of Trail Interval Sites (every 1/2 mile along length of trail)

__________ # of Off-Trail Impact Sites

__________ # of Open Area Impact Sites

__________ # of Grade Impact Sites

__________ # of Curve Impact Sites

__________ # of Streambed Impact Sites

__________ Evidence or Knowledge of Cultural Dwellings/Artifacts/Rock Art Present in Area?
(1) Yes (2) No (3) No Information Available

__________ **Overall Trail Impact Rating**

Extremely Impacted

Very high number of impacts noted on 3-4 of the 5 special impact analysis forms (Off Trail, Open Area, Grade, Curve, Streambed).

Heavily Impacted

High number of impacts noted on 2-3 of the 5 special impact analysis forms (Off Trail, Open Area, Grade, Curve, Streambed).

Moderately Impacted

Moderate number of impacts noted on 2-3 of the special impact analysis forms (Off Trail, Open Area, Grade, Curve, Streambed).

Slightly Impacted

Few number of impacts noted on 2-3 of the special impact analysis forms (Off Trail, Open Area, Grade, Curve, Streambed).

Unimpacted

Few number of impacts noted on 1-2 of the special impact analysis forms (Off Trail, Open Area, Grade, Curve, Streambed).

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

TRAIL INTERVAL IMPACTS (Every 1/2 mile along length of trail)

2 ___ ___ __ Trail ID (Interval/Region/Trail Number, From Trail Descriptor Form):

__________ Trail Interval Number

__________ GPS Coordinates (UTM)

____

Digital Image Number(s) ____

__________ Trail Width (in feet w/1 decimal)

__________ Maximum Trail Depth (in inches)

__________ Trail Grade (in degrees - clinometer reading)

__________ Evidence of Trail Erosion: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Rutting (1) Yes (2) No

__________ Evidence of Multiple Trailing (1) Yes (2) No

__________ Other Impact Evidence: (1) Off-Trail Use (2) Open Area (3) Grade Area

__________ (4) Curve Area (5) Streambed Area

__________ Veg Cover % On-Trail: See Below

__________ Veg Cover % Off-Trail: See Below

__________ (1)0-5% (2)6-25% (3)26-50% (4)51-75% (5)76-95% (6)96-100%

Evidence of Other Recreational Activities on the Trail at Interval Site:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

Evidence of OTHER Recreational Impacts at Trail Interval:

__________ Campfire Evidence: (1) Yes (2) No

__________ Number of Campfires

__________ Presence of Litter: (1) Yes (2) No

__________ Number of Pieces of Litter
__________ Presence of Human Waste: (1) Yes (2) No
__________ Number of Human Waste Incidents
__________ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

TRAIL INTERVAL VEGETATIVE ASSESSMENT:
__________ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
__________ Number of Grass/Forb Impacts
__________ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction (1) Yes (2) No
__________ Number of Cactus Impacts
__________ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
__________ Number of Shrub Impacts
__________ Evidence of Tree Human-Caused Breakage or Destruction: (1) Yes (2) No
__________ Number of Tree Impacts
__________ Evidence of Tree Root Exposure: (1) Yes (2) No
__________ Number of Root Exposures

__________ Cryptobiotic Presence: (1) Yes (2) No
__________ Evidence of Cryptobiotic Impacts: (1) Yes (2) No
__________ Number of Crypto Impacts

__________ Evidence of Rock Formation Impact: (1) Yes (2) No
__________ Number of Rock Formation Impacts
__________ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No
__________ Number of Vandalism/Graffiti Impacts
__________ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No
__________ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No
__________ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes: ____

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

OFF-TRAIL IMPACTS

3 ___ ___ __ Trail ID (OFF TRAIL/Region/Trail Number, From Trail Descriptor Form)

__________ Off Trail Impact Number

__________ GPS Coordinates (UTM)

____

Digital Image Number ____

Evidence of OTHER Recreational Activities on the Off-Trail Impact Site:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

__________ Level of Off-Trail Use: (1) frequently used (2) some use (3) not frequently used

__________ History of Off-Trail Use: (1) recently used (2) old use (3) unclear

______ . __ Trail Width ("OFF TRAIL" Trail) in feet w/1 decimal

__________ Maximum Trail Depth ("OFF TRAIL" Trail) in inches

__________ Trail Grade ("OFF TRAIL" Trail) (in degrees - clinometer reading)

__________ Evidence of Trail Erosion Off Trail: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Rutting Off Trail: (1) Yes (2) No

__________ Evidence of Multiple Trailing Off Trail: (1) Yes (2) No

__________ Vegetative Cover % OFF TRAIL IMPACT "On-Trail": See Below

__________ Vegetative Cover % OFF TRAIL IMPACT "Off-Trail": See Below

__________ (1)0-5% (2)6-25% (3)26-50% (4)51-75% (5)76-95% (6)96-100%

Other Impacts OFF TRAIL:

__________ Campfire Evidence: (1) Yes (2) No

__________ Number of Campfires

__________ Presence of Litter: (1) Yes (2) No

__________ Number of Pieces of Litter

__________ Presence of Human Waste: (1) Yes (2) No

_________ Number of Human Waste Incidents
_________ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

OFF TRAIL VEGETATIVE ASSESSMENT:
_________ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or
_________ Destruction OFF TRAIL: (1) Yes (2) No
_________ Number of Grass/Forb Impacts
_________ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction OFF TRIAL: (1) Yes (2) No
_________ Number of Cactus Impacts
_________ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction OFF TRAIL: (1) Yes (2) No
_________ Number of Shrub Impacts
_________ Evidence of Tree Human-Caused Breakage or Destruction OFF TRAIL: (1) Yes (2) No
_________ Number of Tree Impacts
_________ Evidence of Tree Root Exposure OFF TRAIL: (1) Yes (2) No
_________ Number of Root Exposures

_________ Cryptobiotic Presence: (1) Yes (2) No
_________ Evidence of Cryptobiotic Impacts: (1) Yes (2) No
_________ Number of Crypto Impacts

_________ Evidence of Rock Formation Impact: (1) Yes (2) No
_________ Number of Rock Formation Impacts
_________ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No
_________ Number of Vandalism/Graffiti Impacts
_________ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No
_________ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No
_________ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes: ____
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MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

OPEN AREA IMPACTS

4 ___ ___ __ Trail ID (OPEN AREA/Region/Trail Number, From Trail Descriptor Form)

__________ Open Area Impact Number

__________ GPS Coordinates (UTM)

____

__________ Approximate Size of the Open Area in Acres

__________ Evidence of Multiple Trailing in Open Area (1) Yes (2) No

__________ Number of Trails in Open Area

__________ Evidence of ANY Recreational Activities in the Open Area:

__________ Mountain Biking (1) Yes (2) No

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

Digital Image Number ____

__________ Other Impacts in Open Area:

__________ Campfire Evidence: (1) Yes (2) No

__________ Number of Campfires

__________ Presence of Litter: (1) Yes (2) No

__________ Number of Pieces of Litter

__________ Presence of Human Waste: (1) Yes (2) No

__________ Number of Human Waste Incidents

__________ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

OPEN AREA VEGETATIVE ASSESSMENT:

_________ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
_________ Number of Grass/Forb Impacts
_________ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
_________ Number of Cactus Impacts
_________ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
_________ Number of Shrub Impacts
_________ Evidence of Tree Human-Caused Breakage or Destruction: (1) Yes (2) No
_________ Number of Tree Impacts
_________ Evidence of Tree Root Exposure: (1) Yes (2) No
_________ Number of Root Exposures

_________ Cryptobiotic Presence: (1) Yes (2) No
_________ Evidence of Cryptobiotic Impacts: (1) Yes (2) No
_________ Number of Crypto Impacts
_________ Evidence of Rock Formation Impact: (1) Yes (2) No
_________ Number of Rock Formation Impacts
_________ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No
_________ Number of Vandalism/Graffiti Impacts
_________ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No
_________ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No
_________ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes/Observations: ____
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MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

______ ______ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

GRADE IMPACTS

5 ___ ___ __ Trail ID (OPEN AREA/Region/Trail Number, From Trail Descriptor Form)

__________ Open Area Impact Number

__________ GPS Coordinates (UTM)

____

______ . __ Total Length of Grade (in feet w/1 decimal) MUST BE 40 FEET

______ . __ Trail Width at Top of Grade (in feet w/1 decimal)

______ . __ Trail Width at Bottom of Grade (in feet w/1 decimal)

__________ Maximum Trail Depth at Top of Grade (in inches)

__________ Maximum Trail Depth at Bottom of Grade (in inches)

__________ Trail Grade (in degrees - clinometer reading) MUST BE >20 DEGREES

__________ Evidence of Trail Erosion on Grade: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Rutting on Grade: (1) Yes (2) No

__________ Switchbacks on Grade (1) Yes (2) No

__________ Evidence of Multiple Trailing on Grade (1) Yes (2) No

__________ Number of Trails on Grade

Evidence of OTHER Recreational Activities on the Grade:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

__________ Veg Cover % On-Trail:

__________ Veg Cover % Off-Trail:

__________ (1)0-5% (2)6-25% (3)26-50% (4)51-75% (5)76-95% (6)96-100%

Digital Image Number ____

Other Impacts on Grade:

__________ Campfire Evidence: (1) Yes (2) No

__________ Number of Campfires

__________ Presence of Litter: (1) Yes (2) No

__________ Number of Pieces of Litter

__________ Presence of Human Waste: (1) Yes (2) No

__________ Number of Human Waste Incidents

__________ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

GRADE VEGETATIVE ASSESSMENT:

__________ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No

__________ Number of Grass/Forb Impacts

__________ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No

Number of Cactus Impacts

__________ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No

__________ Number of Shrub Impacts

__________ Evidence of Tree Human-Caused Breakage or Destruction: (1) Yes (2) No

__________ Number of Tree Impacts

__________ Evidence of Tree Root Exposure: (1) Yes (2) No

__________ Number of Root Exposures

__________ Cryptobiotic Presence: (1) Yes (2) No

__________ Evidence of Cryptobiotic Impacts: (1) Yes (2) No

__________ Number of Crypto Impacts

__________ Evidence of Rock Formation Impact: (1) Yes (2) No

__________ Number of Rock Formation Impacts

__________ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No

__________ Number of Vandalism/Graffiti Impacts

__________ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No

__________ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No

__________ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes/Observations: ____

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

CURVE IMPACTS

6 ___ ___ __ Trail ID (CURVE/Region/Trail Number, From Trail Descriptor Form)

__________ Curve Impact Number

__________ GPS Coordinates (UTM)

____

______ . __ Trail Width at Beginning of Curve (in feet w/1 decimal)

______ . __ Trail Width at Midpoint of Curve (in feet w/1 decimal)

______ . __ Trail Width at End of Curve (in feet w/1 decimal)

__________ Maximum Trail Depth at Beginning of Curve (in inches)

__________ Maximum Trail Depth at Midpoint of Curve (in inches)

__________ Maximum Trail Depth at End of Curve (in inches)

__________ Trail Grade (in degrees)

__________ Evidence of Trail Erosion: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Rutting (1) Yes (2) No

__________ Evidence of Multiple Trailing on Curve (1) Yes (2) No

Evidence of OTHER Recreational Activities on the Curve:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

__________ Veg Cover % On-Trail:

__________ Veg Cover % Off-Trail:

__________ (1)0-5% (2)6-25% (3)26-50% (4)51-75% (5)76-95% (6)96-100%

Digital Image Number ____

__________ Other Impacts on the Curve:

__________ Campfire Evidence: (1) Yes (2) No

__________ Number of Campfires

__________ Presence of Litter: (1) Yes (2) No
__________ Number of Pieces of Litter
__________ Presence of Human Waste: (1) Yes (2) No
__________ Number of Human Waste Incidents
__________ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

CURVE VEGETATIVE ASSESSMENT:

__________ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
__________ Number of Grass/Forb Impacts
__________ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
__________ Number of Cactus Impacts
__________ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
__________ Number of Shrub Impacts
__________ Evidence of Tree Human-Caused Breakage or Destruction: (1) Yes (2) No
__________ Number of Tree Impacts
__________ Evidence of Tree Root Exposure: (1) Yes (2) No
__________ Number of Root Exposures

__________ Cryptobiotic Presence: (1) Yes (2) No
__________ Evidence of Cryptobiotic Impacts: (1) Yes (2) No
__________ Number of Crypto Impacts
__________ Evidence of Rock Formation Impact: (1) Yes (2) No
__________ Number of Rock Formation Impacts
__________ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No
__________ Number of Vandalism/Graffiti Impacts
__________ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No
__________ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No
__________ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes/Observations:____

MOUNTAIN BIKE PHYSICAL IMPACT ASSESSMENT FORM

(June 23, 2003; Revised March, 2004; Revised May 10, 2004)

_____ _____ Data Collector (initials)

___/___/___ Date (month/day/year) of Trail Inventory

STREAMBED IMPACTS

7 ___ ___ ___ Trail ID (STREAMBED Region/Trail Number, From Trail Descriptor Form)

__________ Streambed Impact Number

Was there water in the streambed: (1) Yes (2) No

__________ GPS Coordinates (UTM)

____

______ . __ Trail Width at Streambank Entry (in feet w/1 decimal)

______ . __ Trail Width at Streambank Exit (in feet w/1 decimal)

______ . __ Maximum Trail Depth at Streambank Entry (in inches)

__________ Maximum Trail Depth at Streambank Exit (in inches)

__________ Evidence of Trail Erosion at Streambank Entry: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Erosion at Streambank Exit: (1) Yes (2) No

__________ Type of Erosion: (1) Gully (2) Sheet

__________ Evidence of Trail Rutting at Streambank Entry (1) Yes (2) No

__________ Evidence of Trail Rutting at Streambank Exit (1) Yes (2) No

__________ Evidence of Multiple Trailing across Streambank (1) Yes (2) No

Evidence of OTHER Recreational Activities at the Streambed Crossing:

__________ Hiking (1) Yes (2) No

__________ Equestrian Use (1) Yes (2) No

__________ ATV/OHV Use (1) Yes (2) No

__________ Shooting (shell evidence) (1) Yes (2) No

__________ Camping (1) Yes (2) No

__________ Climbing (1) Yes (2) No

__________ Other (1) Yes (2) No

__________ Vegetative Cover % On-Trail:

__________ Vegetative Cover % Off-Trail:

__________ (1)0-5% (2)6-25% (3)26-50% (4)51-75% (5)76-95% (6)96-100%

Digital Image Number ____

______ Other Impacts at Streambank Site:
______ Campfire Evidence: (1) Yes (2) No
______ Number of Campfires
______ Presence of Litter: (1) Yes (2) No
______ Number of Pieces of Litter
______ Presence of Human Waste: (1) Yes (2) No
______ Number of Human Waste Incidents
______ Human Waste Indicators: (1) Fecal Matter/(2) Toilet Paper/(3) Cathole

STREAMBANK SITE VEGETATIVE ASSESSMENT:

______ Evidence of Grass/Forb Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
______ Number of Grass/Forb Impacts
______ Evidence of Cactus Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
______ Number of Cactus Impacts
______ Evidence of Shrub Human-Caused Trampling, Breakage, or Destruction: (1) Yes (2) No
______ Number of Shrub Impacts
______ Evidence of Tree Human-Caused Breakage or Destruction: (1) Yes (2) No
______ Number of Tree Impacts
______ Evidence of Tree Root Exposure: (1) Yes (2) No
______ Number of Root Exposures

______ Cryptobiotic Presence: (1) Yes (2) No
______ Evidence of Cryptobiotic Impacts: (1) Yes (2) No
______ Number of Crypto Impacts
______ Evidence of Rock Formation Impact: (1) Yes (2) No
______ Number of Rock Formation Impacts
______ Evidence of Vandalism or Graffiti On-Site: (1) Yes (2) No
______ Number of Vandalism/Graffiti Impacts
______ Cultural Dwellings/Artifacts/Rock Art Presence in Area (1) Yes (2) No
______ Impacts to Cultural Dwellings/Artifacts/Rock Art (1) Yes (2) No
______ Number of Impacts to Cultural Dwellings/Artifacts/Rock Art

Field Notes/Observations:____

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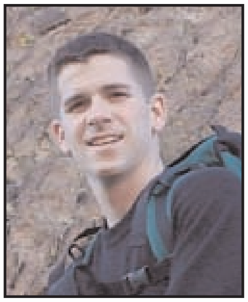
Dr. Pam Foti

Dr. Pam Foti is the Chair of the Department of Geography, Planning and Recreation at Northern Arizona University. In addition to training future recreation managers in the classroom and in the field, Pam has researched the ecological impacts of recreation in popular locations throughout the southwest United States, including Grand Canyon National Park and Zion National Park. Her broad experience also covers several user groups including day hikers, backcountry/overnight hikers, campers, horseback riders, ATV/OHV users and now mountain bikers.

Dr. Dave White

Dr. Dave White is an assistant professor in the School of Community Resources and Development at Arizona State University. His research on the social and ecological impacts of natural resource recreation and visitor experience has taken him to places like Yosemite National Park and Canyon de Chelly National Monument. Dave also has experience working with various agencies and groups including the Bureau of Land Management, USDA Forest Service, National Park Service, Arizona State Parks and the National Science Foundation.



Grant Brodehl M.A.,
Northern Arizona University

Troy Waskey M.S. Candidate,
Arizona State University

Research Team L to R:

- *Don Applegate, Recreation Program Lead, U.S. Department of the Interior, Bureau of Land Management, Arizona State Office.*
- *Pam Foti, Ph.D., Northern Arizona University*
- *Grant Brodehl, M.A., Northern Arizona University*
- *Dave White, Ph.D., Arizona State University*
- *Elladee Brown, professional mountain bike consultant*
- *Michael Caulkins, graduate student at Arizona State University*
- *Phil Morlock, Director, Environmental Affairs, Shimano American Corporation*

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For Additional Information Contact:

Phil Morlock
Director, Environmental Affairs
Shimano American Corporation/Shimano Canada Ltd.
PO Box 10
Whitney, Ontario, Canada K0J 2M0
Email: pmorlock@shimano.com

Dave D. White, Ph.D.
Arizona State University
School of Community Resources and Development
411 North Central Avenue, Ste. 550
Phoenix, AZ 85004-0690
Email: dave.white@asu.edu

Don Applegate
Recreation Program Lead, U.S. Department of the Interior
Bureau of Land Management, Arizona State Office
222 North Central Avenue
Phoenix, AZ 85004
Email: Don_Applegate@blm.gov

Pam Foti, Ph.D.
Professor and Chair
Department of Geography, Planning and Recreation
Northern Arizona University
PO Box 15016
Flagstaff, AZ 86011
Email: Pam.Foti@NAU.EDU

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