Guide to Sustainable Mountain Trails

Trail Assessment, Planning & Design Sketchbook

2007 Edition

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History of the Sketchbook

This *Guide to Sustainable Mountain Trails: Assessment, Planning & Design Sketchbook, 2007 Edition*, has its roots in the foundational policies and ethics of federal conservation and preservation land management agencies such as the United States Forest Service and the National Park Service, and in the spirit of nonprofit agency partnership support for land management agency stewardship initiatives.

The Colorado Outdoor Training Initiative (COTI), a partnership organization focused on building on-the-ground stewardship capacity by developing and delivering conservation leadership and skills training programs, inspired the synthesis of the *Sketchbook* from a variety of plans and sources into one resource. Pamela Packer, then executive director of COTI, first requested that Hugh Duffy of the National Park Service, present a field seminar at the Colorado State Trails Symposium in 2005 on mountain trail sustainability. Hugh enlisted Greg Seabloom and Danny Basch's help for this initial seminar, held at the Cal-Wood Nature Center near Boulder, Colorado.

The *Sketchbook* was revised for use during the 2006 field season with the Colorado Fourteeners Initiative's design assistants training, with Greg Seabloom enlisting John Giordanengo's help.

Also in 2006, the *Sketchbook* was submitted for consideration, and accepted, for a presentation at the 2006 National Trails Symposium held in Davenport, Iowa. The *Sketchbook* was presented as "art half" of "The Art and Science of Sustainable Mountain Trails." The "science half" of the presentation was made by a scientist from the U.S. Geologic Survey who is conducting and publishing research on recreation impacts. Scientific research has confirmed that sustainability principles implemented in Colorado for over twenty years reduce impacts to natural and cultural resources in the eastern United States (Marion, Jeffrey L., 2006).

Jeff Leisy, U.S. Forest Service project manager for the Continental Divide National Scenic Trail was enlisted in the fall of 2006 for his professional trail design experience comments as well as his patience and lessons learned examples for the 2007 Edition of the *Sketchbook*.

Colorado Chapter, American Society of Landscape Architects

During the summer of 2006, the *Sketchbook* was submitted for consideration for professional design awards through the Colorado Chapter of the American Society of Landscape Architects (CC ASLA). In the fall of 2006, the *Sketchbook* was awarded a *Merit Award* and a *Land Stewardship Designation* by CC ASLA. A *Merit Award* is intended to " … *highlight outstanding accomplishments in the design profession*." A *Land Stewardship Designation* is " … *meant to highlight projects that should be used as precedents for future projects by other landscape architects*." Both of these awards were in the Research & Communication category.

National Park Service & the 2007 edition

Recognizing the ability of the *Sketchbook* to assist park and regional office staff integrate mountain trail sustainability principles into general management plans, condition assessments, natural resource management plans, conservation assistance activities including cooperative trail planning, and the project design and compliance processes, the National Park Service, Transportation Management Program in Washington, D.C., has supported the production of the 2007 edition of the *Sketchbook*.

Continuing Stewardship Training Partnerships

COTI support for the *Sketchbook* has continued in 2007 with the current Executive Director Walt Horner and Training and Outreach Coordinator Liz Lowry, as COTI implements pilot training activities for assessment, planning and design training for sustainable mountain trails. The 2007 edition of the *Sketchbook* will be the pilot trainee manual, and a parallel instructor manual is being developed by a Curriculum Development Committee under the auspices of COTI for the 2007 field season. COTI is pleased to be associated with the National Park Service in the production of the 2007 edition of the *Sketchbook*.

Sketchbook Purpose & Target Audiences

The purpose of the *Sketchbook* is to inspire excellence in the assessment, planning, design, implementation and communication of sustainable mountain trail projects by presenting the "why's and how's" of successful projects in simplified form. Key to project success is customizing scientific and landscape architectural sustainability criteria to the project at hand across the trail project cycle as well as being patient during implementation.

The *Sketchbook* displays many examples of successful tools and techniques which will aid interdisciplinary trail teams in streamlining delivery of economical sustainable mountain trail projects while minimizing impact to natural and cultural resources and their intrinsic values.

The *Sketchbook* is organized into
- *Foundations of Mountain Trail Sustainability*
- *Fundamentals of Mountain Trail Sustainability*
- *Ensuring Mountain Trail Sustainability*
- *Patience Examples*
- *Room to Grow*
- *The Trail Ahead*

Key to successful projects include
- Utilizing a *Project Management Framework*
- Understanding the *Trail Project Cycle*
- Adopting a *Lessons Learned* technique
- *Pitfalls to Avoid*

The following round out a sustainable trails program
- *Stewardship Partnerships & Training*
- *Basic Design*
- *More Tools*

Target Audiences

The primary target audience of the *Sketchbook* is the nonprofit conservation community who is poised to partner with and support land management agencies with trail projects and their stewardship goals and initiatives.

Secondary target audiences of the *Sketchbook* include students, land management agency staff, young professionals, youth corps leaders, technical and non-technical trail advocates, professional associations and organizations, decision makers, as well as donors and granting organizations.

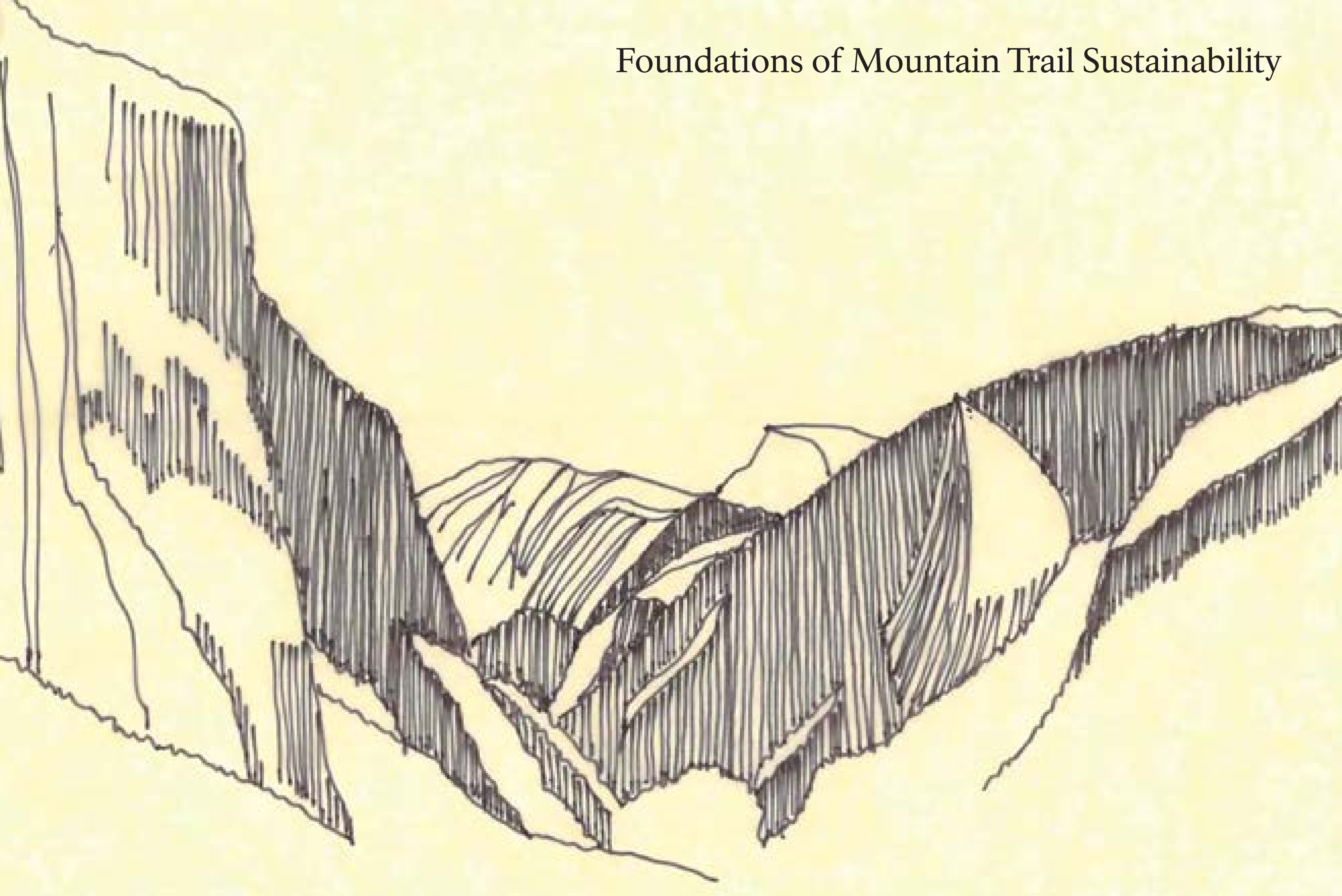
A combination of classroom and field activities, lessons and exercises ensure that trainees receive the balance they need to solve challenging on-the-ground trail design problems.

Above: Design assistants in training for the Colorado Fourteeners Initiative, summer 2006.

Left: Project Thailand students at University of Denver, November 2006.

Foundations

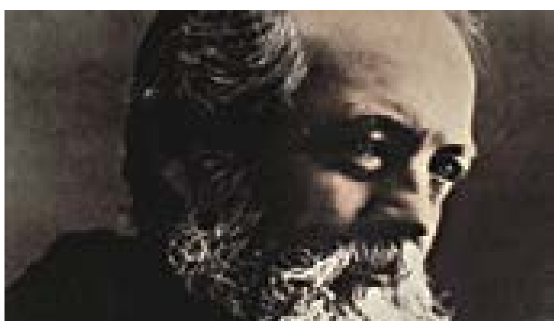
The variety of natural and cultural qualities of landscapes as well as the inspiration we draw from them is as infinite as the stars. A foundational component of mountain trail sustainability is to that care must be taken within established limits so as not to impact the natural and cultural resource values of protected landscapes while still providing appropriate recreational settings so that trail users are inspired and refreshed from a day on the trail.



The Olmsted Report

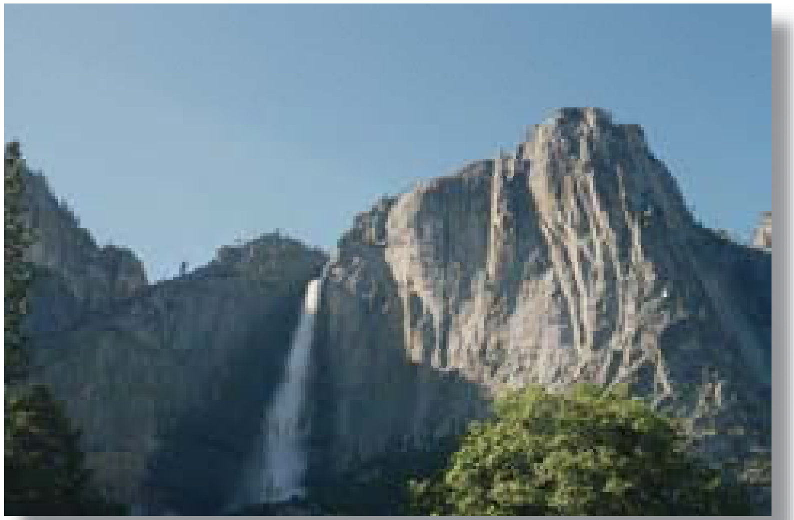
Having been declared a national trust by Abraham Lincoln in 1864, Yosemite was the first conservation area land in the United States set aside for its visual resource values. The publication of "The Olmsted Report" in 1865, which provided recommendations for the preservation of the naturally occurring scenery as well as visitor management strategies for Yosemite Valley and Mariposa Grove of Giant Sequoia trees, was a watershed event in the preservation community. The report no doubt influenced preservation and conservation initiatives of the late 19th and early 20th centuries. From the report:

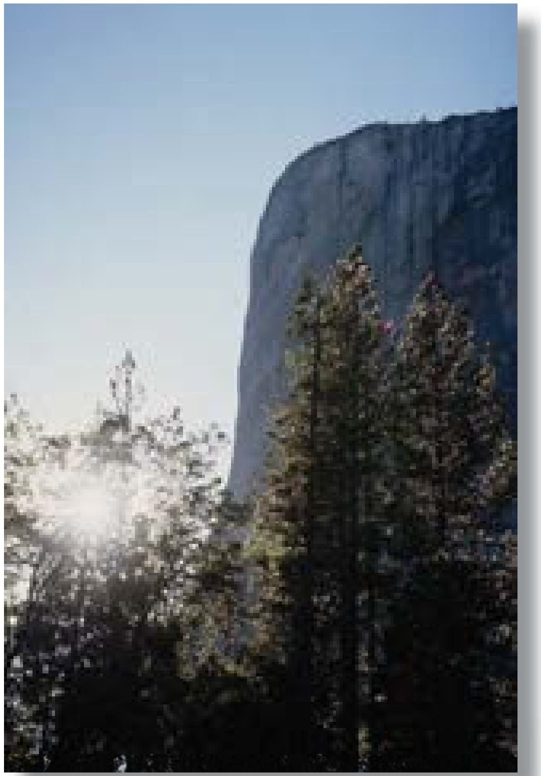
> *The first point to be kept in mind then is the preservation and maintenance as exactly as is possible of the natural scenery; the restriction, that is to say, within the narrowest limits consistent with the necessary accommodation of visitors, of all constructions and the prevention of all constructions markedly inharmonious with the scenery or which would unnecessarily obscure, distort or detract from the dignity of the scenery.*
>
> *Second; it is important that it should be remembered that in permitting the sacrifice of anything that would be of the slightest value to future visitors to the convenience, bad taste, playfulness, carelessness, or wanton destructiveness of present visitors, we probably yield in each case the interest of uncounted millions to the selfishness of a few individuals* (Yosemite Association, 1995).



Preservation and conservation of public lands is a complex endeavor, and many times significant effort goes into actually drawing lines on a map establishing conservation area boundaries. Interdisciplinary trail teams of today are wise to be mindful of this fact and take specific care to develop strategies that protect the very resources that public lands are set aside to protect. Recreationists of all types are relying on public land managers to develop projects that provide for safe and enjoyable access, while protecting sensitive natural and cultural resources and their intrinsic resource values.

Foundational principles of landscape architecture, the preservation of naturally occurring scenery and the restriction of development within narrow limits, still apply today. Too often, haste or improper planning and design lead to projects that are out of scale with their environment, or diminish the visual resource quality of naturally occurring landscape features. Every effort should be made to preserve landform and soil resources as these are the most foundational of natural and visual resources, lest impacts occur which detract from the natural setting of the area.





As much as our natural and cultural resources inspire us, so too, should our trailside improvements, so as to not detract from their settings or the reasons why land was set aside for enjoyment.

Opposite page. Yosemite Valley in Yosemite National Park has been the source of inspiration to the preservation, conservation and recreation communities for many years. Left, Frederick Law Olmsted.

No less important to citizens of our country today, are all open space lands possessing unique visual resource values, wetlands, habitat for native or rare plants and wildlife, and opportunities for passive recreation and solitude.

Not all Americans are able to visit the crown jewels of our National Park system. State governments, cities, counties, local governments and special districts all across the country provide conservation area lands for their citizens to enjoy. A mature understanding of the intrinsic resource values of a landscape, the reasons people visit and recreate upon public lands, as well as a mature mountain trails' sustainability ethic are required to ensure that wise decisions are made regarding the safe access to-, enjoyment of-, and stewardship of- our nation's public lands.

Policies of the American Society of Landscape Architects

The American Society of Landscape Architects is the primary professional organization representing landscape architects at the national level.

From the *ASLA Code of Environmental Ethics:*

> *Members of the American Society of Landscape Architects should make every effort within our sphere of influence to enhance, respect, and restore the life-sustaining integrity of the landscape for all living things.*

Landscape architects undergo a rigorous program of history, basic design, landscape design, ecology and plant materials, professional practice courses, and graphic communication, among others. Landscape architects are trained to facilitate formulation of the components of a project (site program), evaluate the potential uses of land (site selection), develop summaries of site opportunities and constraints (site analysis), and prescribe solutions (design). Landscape architects are also trained to understand the implications of safety, maintenance and long-term viability of land development and land stewardship projects.

Landscape Architecture

Frederick Law Olmsted is credited with the founding of the profession of landscape architecture with his proposed Greensward Plan for New York City's Central Park in 1858. For almost 150 years the profession of landscape architecture has commonly combined the application of artistic, scientific and design principles to land development or land stewardship projects with effective written and graphic communication.

Foundational to the practice of landscape architecture is the professional ethic to protect, respect, enhance or restore the intrinsic values of land, and to not degrade the intrinsic values of land. In one word, the profession of landscape architecture emphasizes land "stewardship."

The American Society of Landscape Architects has many policies which are intended to govern the practice of landscape architecture. Basing professional practice upon the code of ethics as well as other ASLA policies, landscape architects can provide leadership to land development and land stewardship projects which protect, respect, enhance and restore the intrinsic values of land. Land management agency staff, nonprofit agency staff and individual volunteers can all adopt and promote landscape architectural policies and ethics.

Other ASLA policy statements help characterize the practice of landscape architecture, as applicable to the stewardship of mountain trails and the sustainability ethic to minimize impact to public land natural and cultural resources and their associated intrinsic values, include:

- ASLA Research Policy, R 2001

  > *The American Society of Landscape Architects encourages the undertaking of high quality research in the discipline of landscape architecture. The Society encourages a range of research resulting in new tools, techniques, applications and emerging areas of professional practice, and an on-going accumulation of information and knowledge through inquiry on many levels, from the applied to the theoretical. The Society supports a multidisciplinary approach to research whereby the adaptation of concepts and methods from other disciplines strengthens the profession.*

- ASLA Environmental Sustainability Policy, R 2001

  > *The Society urges the employment of sustainable practices that balance stewardship to minimize environmental degradation and consumption with the need to provide a healthy, productive and meaningful life for all community residents such that the needs of future generations are not compromised.*

◆ ASLA Open Space Policy, R 2001

The American Society of Landscape Architects believes that the current rate of unprecedented growth and urbanization, whether in cities or in rural landscapes, create increased development pressures on remaining open space. Due to this pressure, it is imperative that the leadership at the federal, state and local level develop appropriate criteria and strategies for the preservation and protection of open space. Dedicated open space should be required as a component of all public and private development from small site-specific projects to regional land use plans. Each community should contain ample open space to meet the range of community needs, with particular attention to renewing local residents and sustaining natural systems in perpetuity.

◆ ASLA Wildlife Habitat Policy, R 2001

The American Society of Landscape Architects supports the stewardship of landscape resources upon which wildlife and humans depend by the protection of wildlife and wildlife habitats and the integration of the principles of land use planning and design with the principles of wildlife and wildlife habitat protection. The disciplines of land use planning and design and wildlife management apply similar principles to planning for the beneficial use of the land and mutually support an awareness of and appreciation for wildlife, wildlife habitat and their value to people. The Society therefore urges the identification and application of planning and design principles that promote the enhancement, protection and management of landscapes that support wildlife.

◆ ASLA Wetlands Policy, R 2001

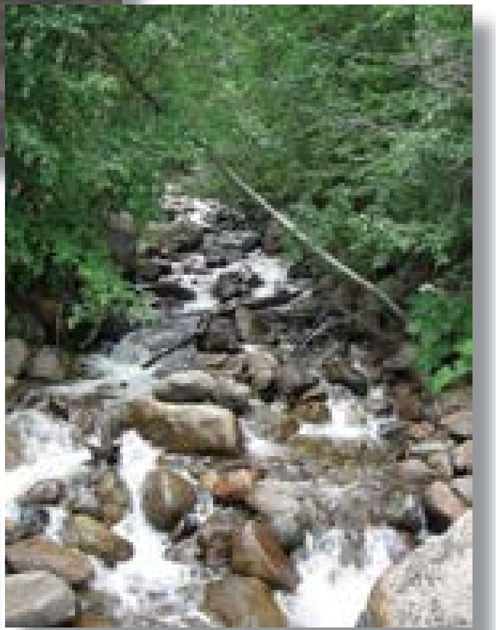
The American Society of Landscape Architects recognizes the critical and functional role of wetlands as essential to the quality of life and well being of the earth's ecological systems. The Society supports the immediate protection, conservation and enhancement of wetland resources. ...

◆ ASLA National Parks Policy, R 2001

The American Society of Landscape Architects believes that National Parks should preserve ecological processes and biological diversity, provide for re-creation of mind and body, serve as models of environmental quality and protect the significant natural and cultural heritage of the people. National Parks serve as outdoor classrooms for children, learning centers for adults, environmental barometers, repositories for the natural and cultural wealth of a nation, and are great reservoirs for scientific inquiry and focal points for adjacent economic development. The creation, expansion and professional management of a National Park System is critical to the well being of the populations and resources of this nation.

◆ ASLA Public Lands and Forests Policy, R 2001

The American Society of Landscape Architects believes that public lands should be retained, expanded and administered in a manner promoting multiple use while recognizing special issues inherent in wildlands and other sensitive environments. Stewardship of the public trust requires careful assessment to determine uses that are consistent with long-term sustainability. Managers are encouraged to render appropriate land use decisions which sustain natural systems, utilize best management practices for the development of extractive resources, and consolidate private lands with public lands to better protect habitat and / or increase aesthetic and recreational opportunities. The establishment of national monuments to set aside significant natural resources that lie within these lands is encouraged. Management and acquisition decisions should be made with effective public participation and broad public support.



◆ ASLA Visual Resources Policy, R 2001

The American Society of Landscape Architects believes that the character and condition of the nation's visual environment is as important as that of the nation's natural, historic and cultural resources. The visual landscape, both on private and public lands in rural and urban areas, reflects our national attitudes toward caring for the earth. It is a record visible to all, written on the face of the land, revealing our successes and failures in meeting our stewardship responsibilities. Every city, region and rural area in the nation should have a visual environment that shows respect for the landscape. Proper management of the visual environment can only be realized if there is an enlightened public and willing and committed government agencies.

◆ ASLA Water Quality and Conservation Policy, R 2001

The American Society of Landscape Architects urges the efficient use of available water supplies, equitable allocation of water resources, elimination of all forms of water pollution and land use that conserves and protects water resources and related ecosystems. The Society urges multi-functional integration of water resource facilities with natural ecosystems and human communities.

◆ ASLA Invasive Species Policy, 2003

The American Society of Landscape Architects recognizes that non-native invasive species are adversely impacting ecological functions and natural systems worldwide. These invasive species include plants, animals, and insects that naturalize and disrupt native ecosystems. Landscape architects are encouraged to use responsible design practices that sustain the local, regional ecosystem without introducing non-native invasive plant species.

Brea arvense,
Credit: Al Schneider

Land Stewardship & Inspiration

Throughout history, humankind has enjoyed the magnificence of land, nature and wilderness and occasionally recorded their thoughts in words or art. From ancient art to modern poetry, many have endeavored to capture their thoughts and feelings to pass on to subsequent generations. From the wonders and fears of our ancient ancestors through our current concern for the dwindling supply of open space and natural resources, land, nature and wilderness have influenced each successive society's outlook on the environment.

The American conservation movement has its roots in the Romantic era of writing and art of the 19th century. This is when writers and artists captured their thoughts of land, nature and wilderness, and communicated them to the American public. This intellectual thrust influenced the establishment of Central Park, in New York City in the 1850's. The hallmark of Central Park is its foundational application of previously unpublished principles of landscape architecture combined with designing in combination with the naturally occurring topography to create passive recreation areas where visitors could enjoy relief from urban life by the contemplation of landscape scenes.

The *Olmsted Report* followed in 1865 with the recommendations for the management of Yosemite Valley and the Mariposa Grove of Giant Sequoia Trees, advocating development within the narrowest limits consistent with necessary accommodation of visitors.

Subsequently the U.S. Forest Service was established in the late 1800's with its guiding principles espoused by Gifford Pinchot of "The Greatest Good." This concept gave rise to the Forest Service's Multiple Use – Sustained Yield Act and National Forest Landscape Management Planning initiatives in the later 20th century.

Finally, in 1916, the National Park Service was established in the early 20th century with the *Organic Act*. The concept of leaving natural and cultural resources unimpaired for future generations is foundational to the NPS and has influenced the NPS since that time, culminating with the drafting of the NPS' *Guiding Principles of Sustainable Design* in 1993.

And while there have been many writers and many different attempts to describe a land stewardship ethic, the promise of nature and opportunity of wilderness throughout the 20th century, Aldo Leopold stands out as an eloquent and passionate voice. His *A Sand County Almanac*, originally published in 1949, is a classic piece of conservation literature.

In *A Sand County Almanac*, Leopold articulates his understanding of the relationship of plants and animals to the land, and their combined relationship to humans. In doing so, he gave voice to a then little known concept: Ecology. He stimulates his readers to understand these critical ecological relationships and to influence decisions based upon that understanding … guiding readers to a land stewardship ethic.

Aldo Leopold's Inspirational Legacy

Whether quoting Thoreau or the ancient prophets and philosophers, Aldo Leopold called out to critical thinkers to question then-current approaches to land conservation ethics. Leopold's thoughts are as inspirational to 21st century Americans as they were when written over 50 years ago for 20th century readers.

> *A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise.*
>
> *… stability depends upon integrity …*
>
> *Conservation is a state of harmony between men and land.*
>
> *Recreation development is a job not of building roads into lovely country, but of building receptivity into the still unlovely human mind.*

Stewardship

The essence of effective stewardship is the understanding that resources are not one generation's to wholly deplete, but to leave available for future generations; and that decisions made today must be based upon sound principles and with the understanding of implications of that decision on future generations. Practicing effective stewardship can be as simple a concept as resolving to turn off unused lights when leaving a room, or to implement a decision to not drive a car but walk or take transit instead. Effective stewardship is parallel to the ethic of sustainability, and applies to decisions affecting sustainability mountain trails as easily as it applies to fossil fuel consumption.

Land Management Agency (Public) Role

Land management agencies are obligated by law, policy or agency directive to provide effective stewardship of the natural and cultural resources and their associated intrinsic values under their management.

Conservation Nonprofit Agency (Private) Role

Nonprofit agencies commonly have missions similar to land management agency missions and tend to be more focused on educational, interpretive, research or fund raising activities in support of land management agency missions. Many nonprofit agencies have long-term relationships with land management agencies. Nonprofit agencies differ from land management agencies in they commonly can mobilize qualified volunteers to help carry out individual tasks or provide training associated with a land management agency's mission.

Partnerships

A partnership can be defined as a relationship between individuals or groups that is characterized by mutual cooperation and responsibility, as for the achievement of a specified goal. A hallmark public / private stewardship partnership is the Appalachian Trail Conservancy's partnership with the National Park Service and the U.S. Forest Service to manage the Appalachian National Scenic Trail. This partnership has inspired many other public / private partnerships, including indirectly inspiring the Colorado Outdoor Training Initiative, as well as the soon-to-be-created Outdoor Stewardship Institute, a program under the auspices of Volunteers for Outdoor Colorado.

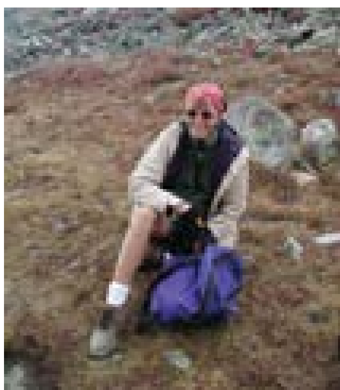
Colorado Outdoor Training Initiative

Mission: *The Colorado Outdoor Training Initiative mission is to enhance Colorado's public as well as protected lands by providing conservation leadership and land stewardship skills training in partnership support to Colorado's public land management agencies.*

COTI's Guiding Principles

- *Public lands are historic and valued parts of the Rocky Mountain lifestyle. Partnerships between agencies and volunteer organizations enhance the value of those lands.*
- *A limited source of skilled agency and volunteer conservation crew leaders and project managers hinder project planning and implementation.*
- *Creating a culture that integrates and expands volunteer and nonprofit agency stewardship projects alleviates demand on agency resources.*
- *Federal, state and local agencies, public and private organizations, and specialized user groups are committed to developing a statewide leadership and skill straining program.*

Stewardship Partnerships & Training. Providing agency staff and volunteer training opportunities streamlines the delivery of sustainable trail projects while increasing achievement of land management agency stewardship goals.



Inputs

- Typical Inputs
- Foundation Documents

Tools & Techniques

- Typical Tools & Techniques
- Lessons Learned Technique
- Trail Project Cycle Tool

Outputs

- Typical Summary Package Outputs
- Draft for Review; Final

Typical Inputs

- Foundation Documents
- Stakeholder Analysis
- Popular Literature (More Tools)
- Aerial Photos, Annotated Aerial Photos
- Maps, Annotated Maps
- Data Bases
- Pitfalls to Avoid / Lessons Learned

Foundation Documents

- Organic Act / Legislation
- Agency Mission / Management Policies & Guidelines / Related Plans
- Local / State / Federal Environmental Regulations

Typical Tools & Techniques

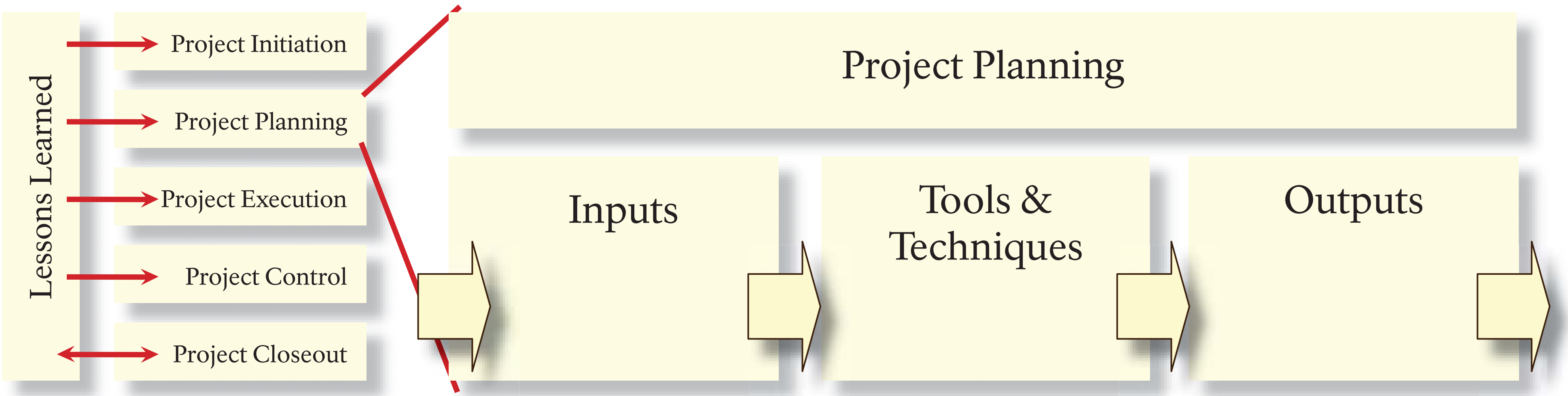
- Assemble Interdisciplinary Trail Team
- Popular Trail Literature & Internet Search & More Tools
- Research / Science
- Field Work, i.e.: Field Notes, Design Notes, Thumbnail Sketches
- Drawings, Examples, Photo Collages, Photomontages
- GPS, GIS, Analytical Techniques
- Estimating Tools
- Choosing by Advantages Rating Process
- Stakeholder Analysis
- Charette Techniques
- Management Team Review
- Compliance Review

Typical Summary Package Outputs

- Purpose / Goals / Written Summary
- Plans Set
- Thumbnail Sketches / Drawings
- Stakeholder Summary
- Photographs, Collages
- Lessons Learned Summary
- Trail Management Techniques
- Actions Sequences
- Checklists

Customizing tools and techniques that apply to "most projects, most of the time" will increase achievement of sustainability on mountain trail projects.

Lessons Learned Technique



Project Planning Process Areas

The Project Management Institute (PMI) recognizes 5 process areas where interrelated project activities task place. PMI does not advocate a linear project process, but rather a process based upon inter-relationships between the project process groups inputs, tools and techniques and outputs.

Shown is the *Project Planning* process area schematic as defined by PMI. Outputs from *Project Initiation* would be inputs to *Project Planning*, and outputs from *Project Planning* are inputs to *Project Execution*, *Project Control* and *Project Closeout*.

PMI encourages the application of a lessons learned technique to activities throughout the project cycle. Outputs from each project process areas are typically inputs to other project process areas. Tools and techniques are applied to project situations to determine the best course of action. Lessons learned from each process can be utilized as inputs in subsequent processes, either with a positive connotation, i.e.: this worked, do it again; or a negative connotation, i.e.: this didn't work, don't do this again, try another tool or technique.

Project Closeout in the *PMI PMBOK Guide to Project Management, 3rd Edition* specifically addresses lessons learned as part of the closeout process to be incorporated into the project archive files, and to be used as an input into subsequent project process areas or projects.

Short of having an archive of existing hard-copy project data, interdisciplinary trail teams can review similar existing projects in the area, such as roadway projects or other development projects. As an example, if cut slopes on a road project are not healing quickly in an area proximate to your project with similar soil types, you can deduce that backslopes on your trail project will also not heal quickly. Overall attention to lessons learned from other trail projects will ensure that your projects continue to approach higher percentages of success and sustainability.

Trail Project Cycle Tool

Partnerships with conservation nonprofit agencies are required, now more than ever, to ensure continued success of recreational trails on public lands.

All cogs in the trail project cycle would benefit from such support!

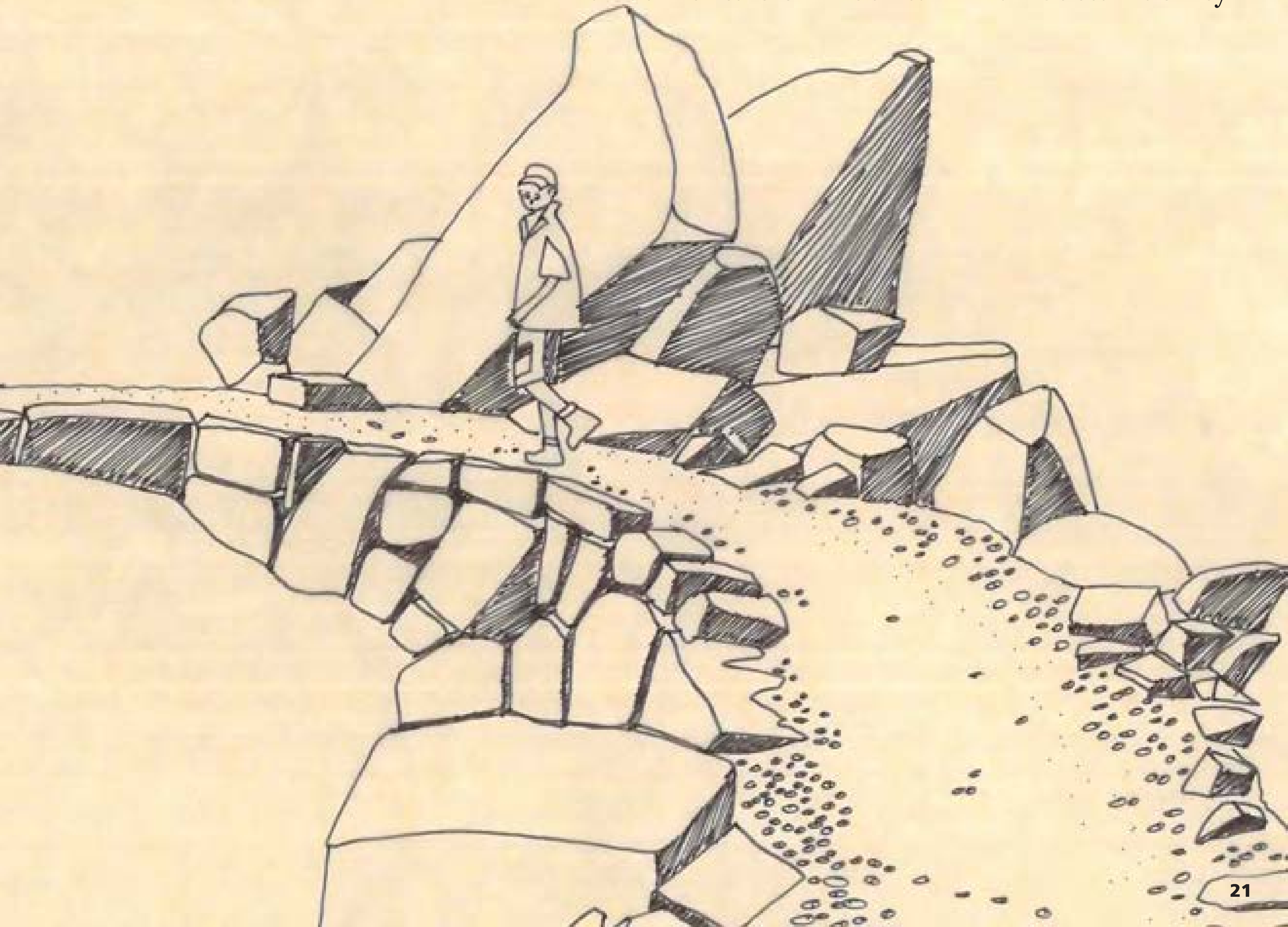
Inspiration. These photographs convey the trail tradition established by trail crews at Rocky Mountain National Park, Colorado. As evidenced by the preservation of natural scenes, combined with minimum impact to natural and cultural resources through development within narrow limits, these trail examples are an inspiration to all park visitors!

Appropriate Settings for Recreation & Inspiration

Sustainable mountain trails provide the appropriate setting for non-impacting contemplative recreational activities, provide the setting for the establishment, restoration or strengthening of relationships, provide the opportunity for lessons about resource stewardship and protection of our natural and cultural resource heritage, and inspire the human spirit.

- Who could not delight in these environments or be awed by these naturally occurring scenes?
- Whose relationships could not benefit from time spent having a sack lunch on a mountain trail?
- In one of the best equipped classrooms, who could not learn about alpine environments or traditional use of the land?
- Who could not be inspired and refreshed by the infinite variety of nature and give pause to their restless souls?

Although hard work and significant investment of time and materials may be required, it is possible to implement trails that do not impact resource values. Please join us in our journey towards improved protection of natural and cultural resources and increased visitor satisfaction and safety!



Mountain Trail Sustainability

The concept of mountain trail sustainability presumes that mountain trail projects should not unnecessarily impact natural (especially soil resources), cultural or visual resource values, but should be developed within narrow limits consistent with allowing safe and enjoyable recreation passage. It is based upon paramount criteria of optimum profile grade relative to prevailing cross slopes (a.k.a.: fall line – the steepest line across a contour). Subordinate criteria to consider include cross slope, aspect (compass orientation), elevation, and viewsheds as well as soil types, ecosystem types, climate and geographic context.

Interdisciplinary Trail Team

For over 50 years, interdisciplinary trail teams have been assigned to trail projects. The National Park Service's *Construction of Trails* and the Parks Canada *Trails Manual* both describe this foundational ethic. The education, skills and values of both the landscape architect and civil engineer are equally vital to the interdisciplinary trail (assessment, planning, design or implementation) team. Other specialists such as naturalists or field personnel bring important skills and values to the team, including ecologists for restoration projects.

> ***Mountain Trail Sustainability***
>
> *Sustainability of backcountry trail corridors is defined as the ability of the travel surface to support current and anticipated appropriate uses with minimal impact to the adjoining natural systems and cultural resources. Sustainable trails have negligible soil loss or movement and allow the naturally occurring plant systems to inhabit the area, while allowing for the occasional pruning and removal of plants necessary to build and maintain the trail. If well-designed, built, and maintained, a sustainable trail minimizes braiding, seasonal muddiness and erosion. It should not normally affect natural fauna adversely nor require re-routing and major maintenance over long periods of time.*
> – National Park Service Natural Resource Management Reference Manual # 77, 2006.

Protection of Natural & Cultural Resources

The *Trails Manual* recognizes the importance of the protection of resources these ways:

> *The protection of the environment is (also) of major importance; if environmental quality is seriously affected the very attributes that have made areas attractive for development in the first place may be lost. Effort should be made to ensure that trails fit their environment as harmoniously as possible so that ecological processes and environmental character are not significantly altered.*
>
> *The carrying capacity of an area is the amount of use by man that the area can withstand without undue environmental degradation. … The task of the [interdisciplinary trail team] development team is to plan, build and manage the trail so that the carrying capacity of its environment is not exceeded. … Detrimental impact of trail use upon the environment is directly affected by type of trail activity and how intensively the trail is used.* – Parks Canada, 1978.

As soil is the substrate for most terrestrial plant and animal life, protection of soil resources from human-caused erosion is the most foundational ethic of mountain trail sustainability.

Areas where soil unnecessarily or excessively erodes, as well as areas where eroded soils are deposited, too often testify to poorly established trails, influencing additional impacts, less than optimum recreational experiences and increased life cycle costs.

Introduction or spreading of non-native plant species along improperly implemented mountain trail corridors are common impacts and can usually be prevented or avoided. Careful attention to sustainability criteria and customization of landscape architectural tools and techniques across the trail project cycle will prevent or avoid unnecessary soil resource impacts.

Optimum Prevailing Cross Slope Ranges & Trail Profile Grades

There is a limited prevailing cross slope range and optimum trail profile grade combination which yield the most sustainable mountain trail corridor. Multiple project's experience along Colorado's front range indicates that sustainable mountain trails not only have good maintenance programs in place, but they also have trail gentle to moderate profile grades (elevation change along the trail center line) and that are less than ¼ of the prevailing cross slope in the immediate section of trail.

Due to topographic variation, the optimum profile grade along a length of trail will vary, with steeper topography being able to sustain a steeper optimum profile grade. This suggests a 2.5% optimum profile grade in 10% cross slope areas, 5% in 20%, 10% in 40%, and 12% maximum profile grade in 48% cross slope areas or greater. Experienced interdisciplinary trail teams realize that 8% is an optimum trail profile grade in most frontcountry areas. See page 51 for a recommended design solutions hierarchy for sustainability.

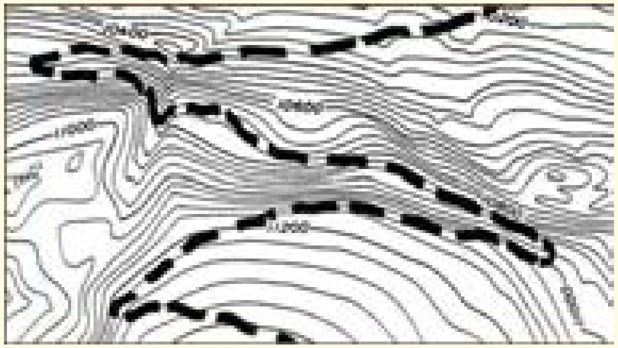
Natural surface trails in prevailing cross slope areas of less than 20% usually require drainage improvements, a.k.a.: armoring, because they do not drain quickly. Natural surface trails in prevailing cross slope areas exceeding 70% require significant investments, again armoring, which correspondingly could be considered unsustainable.

Prevailing cross slopes between 20% and 70% provide the best combination of cross slope for drainage with the commonly preferred trail profile grades near 10% to allow proper drainage across or off a trail surface without undue erosion.

Trail profile grades > 12% in most prevailing cross slopes and soil types are prone to erosion. These trail profile grades also need to consider the effect of moisture (frost, rain, ice and snow), aspect, season of use, and level of use on user comfort and safety. Diligent efforts can usually avoid using these profile grades in frontcountry areas! Conscious decision-making when utilizing steeper profile grades, understanding anticipated costs as well as the probability of required armoring, is recommended.

This preferred prevailing cross slope location provides for equestrian uses while protecting important natural resources at Steamboat Lake State Park, Colorado.

The concept of mountain trail sustainability was first published in 1991 in the Colorado State Trails Newsletter and later in the NPS' Resource Management Guideline "NPS-77" that same year.



Gently climbing trail profile grades located on gentle to moderate prevailing cross slopes and predominantly coarse soils will yield the most sustainable mountain trail corridor.

Mountain goats from the Mount Evans herd are a common source of interest for hikers on popular Greys and Torreys Peaks, both 14,000-foot-plus (14er) peaks west of Denver, Colorado.

Happy hikers on Green Ranch, Golden Gate Canyon State Park. Discovery of a landscape's intrinsic resource values is a source of long-lasting memories, as with this scout troop on their first 5-mile hike.

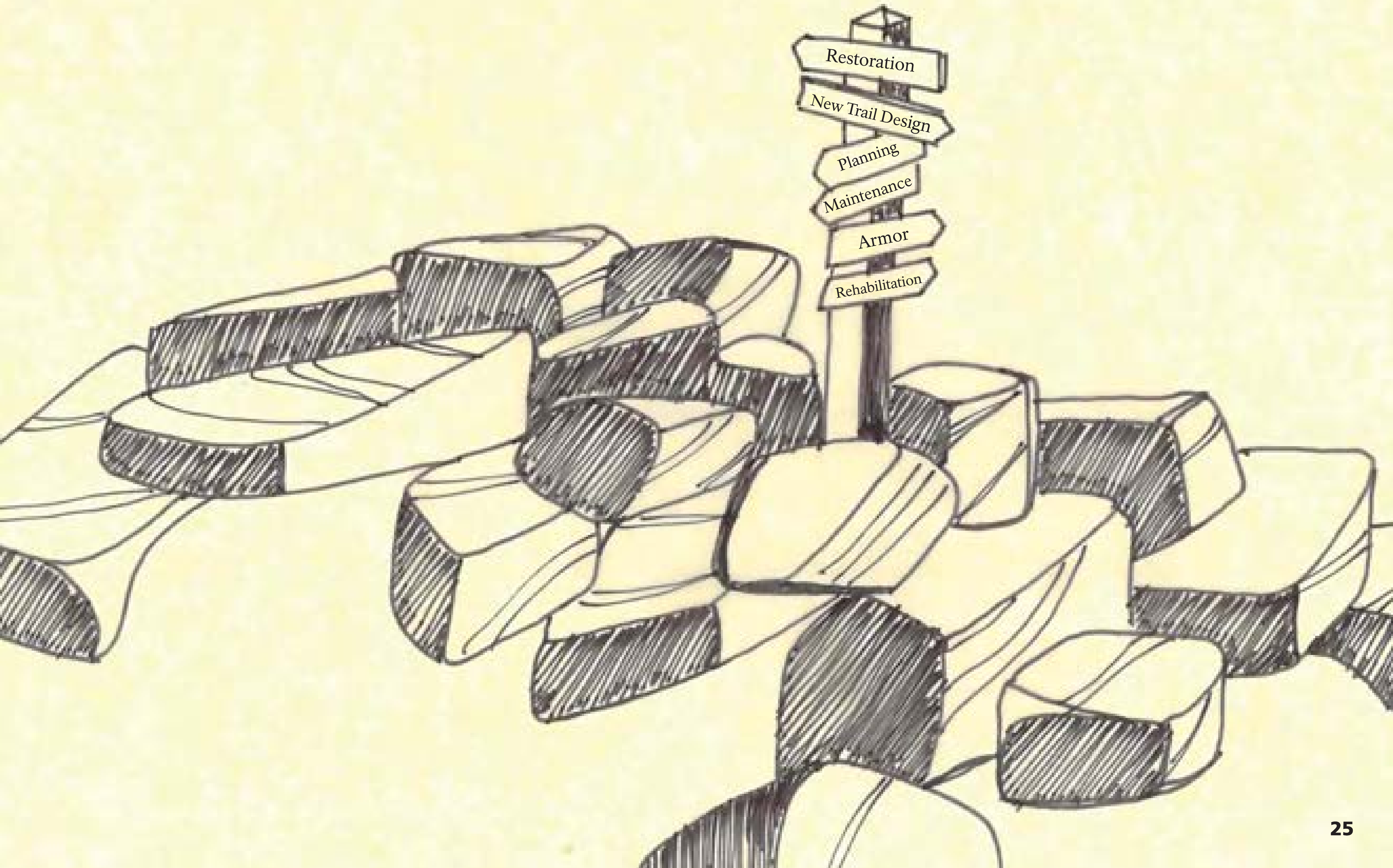
Long Distance Hiking. Our nation's long distance trails are seeing ever more use, i.e.: these young hikers on the Appalachian Trail.

Opportunities for equestrian activities abound on public lands. Larger clearing zones and more stable treads are required to prevent resource impacts.

Natural areas are the setting for many activities, including weddings.

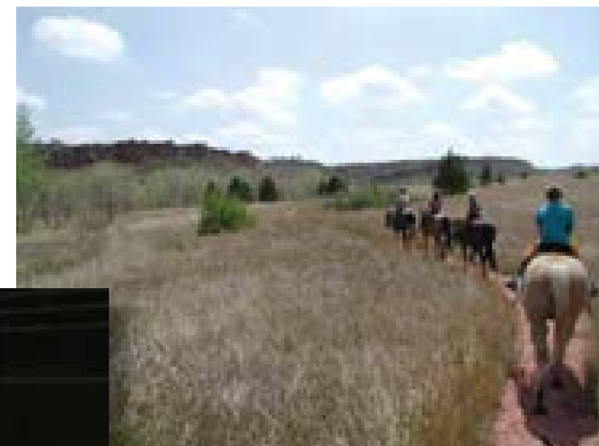
Mountain bicycle use of public lands is increasing, especially near urban areas. Comprehensive strategies need to be developed which accommodate this use. Trails that are planned, designed and implemented according to mountain bicycle criteria can be sustainable and non-impacting to natural and cultural resource values while also providing visitor satisfaction.

Trail Sustainability Assessment



Sustainability Criteria. Sustainability assessment techniques must be customized to specific physical sustainability criteria as well as the anticipated user type, volume of use and frequency of use with an understanding of the recreational reasons that trail users visit public lands.

Shoulder season uses along Colorado's front range needs to be accounted for, as over-snow hiking is common and affects trail sustainability.



Inputs

- Typical Inputs
- Foundation Documents
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Recreation Accessibility Potential Rating Tool
- Trail Corridor Assessment Tool
- Travel Surface Assessment Tool
- Review

Outputs

- DRAFT Trail Sustainability Assessment Package for Review
  - Purpose
  - Goals
  - Trail Sustainability Annotated Plan
  - Trail Corridor Assessment Rating
  - Travel Surface Sustainability Rating
  - Recreation Accessibility Rating
  - Trail Management Techniques
  - Checklists
  - Lessons Learned Summary
- FINAL Trail Sustainability Assessment Package

Scenes such as this draw people to the mountains of Colorado. Conducting mountain trail projects which are sustainable will communicate to visitors wise land stewardship principles. Assessing mountain trails according to sustainability criteria is the recommended first step in that process.

Trail Sustainability Assessment Tools

Just one afternoon thunderstorm produced this damage to the (old) Mule Deer Trail at Golden Gate Canyon State Park, Colorado, in 2002.

Conducting an assessment particular to natural surface trail sustainability for your project area will help agency managers put perspective on their trail program needs.

Focused on fulfilling a need to communicate natural surface mountain trail sustainability issues, the tools used in Lakewood City Regional Parks (Hayden Green Mountain Regional Park and Bear Creek Lake Regional Park) have proven successful in helping portray individual trail corridor sustainability as well as area-wide sustainability. It is another tool that can be used by interdisciplinary trail teams to communicate issues of sustainability. Just two people can assess from seven to ten miles per day using this method.

Trail sustainability assessment is a two-step process: 1) Trail Corridor Sustainability Questionnaire Rating Tool, and 2) Trail Surface Sustainability Rating Tool. Trail corridors rated as sustainable can be assessed for trail surface sustainability. Trail corridors not rated as sustainable will eventually be abandoned and restored to natural conditions through the new trail design or restoration planning processes. See boxes on page 29.

Conducting trail sustainability assessments of an individual trail or an area-wide system may help support professional efforts to improve trail sustainability. They will help you quantify your needs for presentation to agency decision makers or funding or grant organizations, as well as to engage a nonprofit agency or individual volunteer's interest.

Trail corridors that start at appropriate origins, utilize appropriate corridor and intermediary control points, have appropriate profile grades located on appropriate prevailing cross slopes, and end at appropriate destinations have the most opportunity to be sustainable while economizing investment of time and materials over the life cycle of the project.

Recreation Accessibility Potential Rating Tool

High	Three or four season use 0-20% cross slope grades, gentle profile grades (< 5% average) Complementary trailhead facilities
Medium	Two season use 0-20% cross slope grades, gentle profile grades (< 5% average) Complementary trailhead facilities
Low	Single season use Steeper than 20% cross slope grades Moderate profile grades (> 5%) Non-complementary trailhead facilities

Trail Corridor Sustainability Questionnaire Rating Tool

Answering the following questions will assist the trail team in determining trail corridor sustainability:

Meets trail's established purpose?	Y / N ?
Originates at appropriate location?	Y / N ?
Destination at appropriate location?	Y / N ?
Allows appropriate uses?	Y / N ?
Appropriate corridor control points?	Y / N ?
Scenic viewpoints taken advantage of?	Y / N ?
Interpretive opportunities taken advantage of?	Y / N ?
Protects natural resources?	Y / N ?
Protects cultural resources?	Y / N ?
Nonprofit agency or individual volunteer support	Y / N ?

Trail Corridor Sustainability Rating Tool

S+	Sustainable corridor; sustainable travel surface (approximately 85%), trail kept in good condition with seasonal maintenance, adopted by nonprofit agency or maintenance program in place
S	Sustainable corridor, sustainable travel surface (approximately 85%), needs maintenance and some armor improvements
S-	Sustainable corridor Some unsustainable topography or surfaces needs rehabilitation and / or some armor improvements, new structures and / or short reroutes
U	Unsustainable
A	Abandonment recommended
R	Restoration recommended

A trail surface sustainability assessment taken at 100-foot stations along an existing trail's center line and then tabulated in a matrix will yield insights into the decision making process across the maintenance, rehabilitation and armor design spectrum. Interdisciplinary trail teams are encouraged to customize these criteria to their specific project.

Recreation accessibility many times is considered after a trail is implemented and oftentimes cannot be upgraded economically. Planning for recreation accessibility in advance of implementation can be a more economical approach. Assessing a trail corridor alternative for recreation accessibility potential is easily accomplished when using the Recreation Accessibility Potential Rating Tool. Frontcountry areas, near visitor facilities, are the best candidates for recreation accessible routes. See box on page 28.

Travel Surface Sustainability Rating Tool

Station (civil engineering notation)	1+00
Aspect	W SW S SE E NE N NW
Sustainable soil substrate	Y / N ?
Prevailing cross slopes 20% - 70%	Y / N ?
Average profile grades < 8% (frontcountry areas)	Y / N ?
Profile grade < 1/4 prevailing cross slope grades	Y / N ?

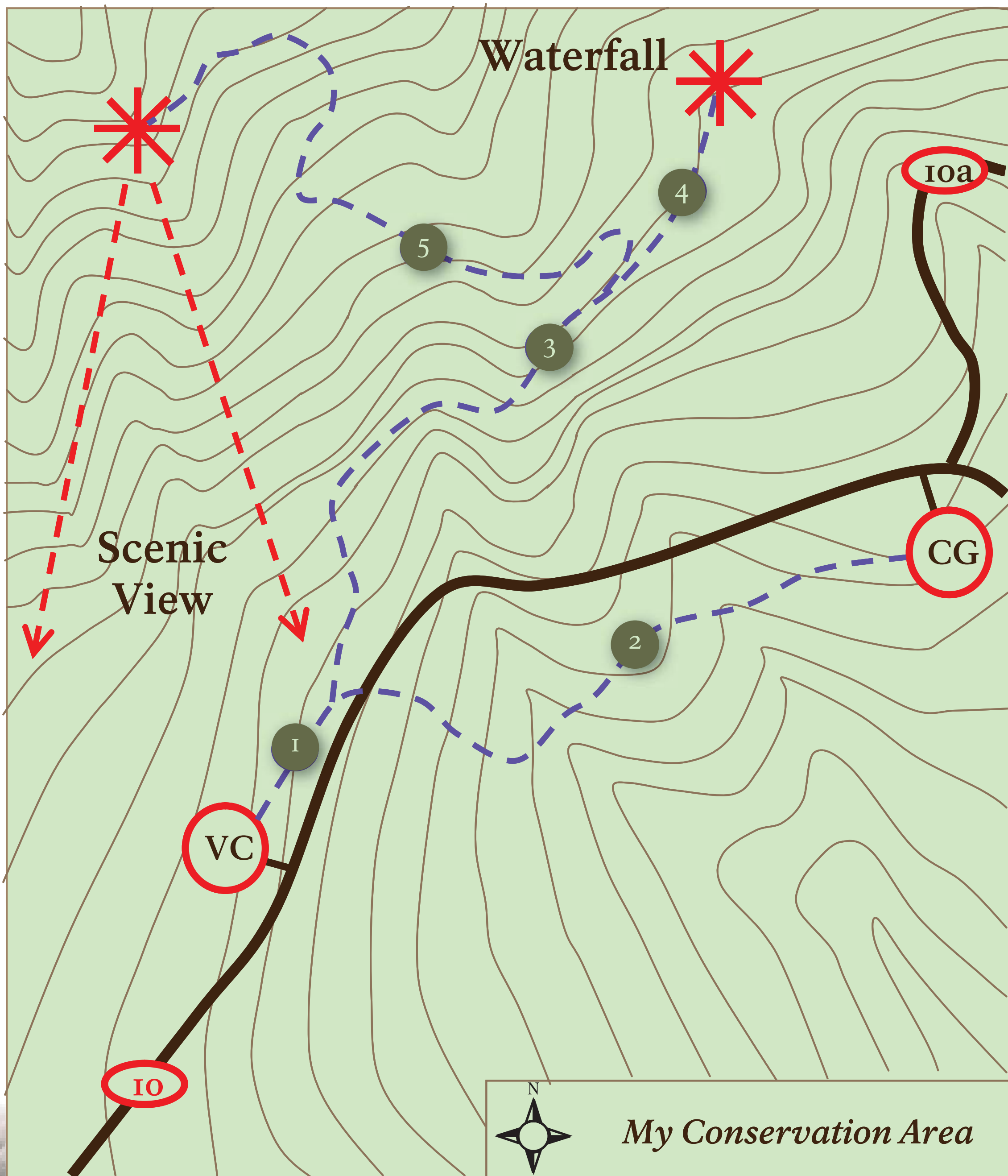
Appropriate

What is appropriate for a specific project? Identifying .....

- Geographic context
- Land management agency policies
- Distance from trailhead
- Specific single user groups or multiple user groups
- Plan or project goals
- Stakeholder interests

..... all contribute to the appropriateness for each project.

Trail Sustainability Assessment – Annotated Plan



In this example area, trails developed over a period of time without the benefit of professional planning or design services. No guidelines were applied. Trails have been heavily used, and the season of use has increased substantially from summer use to shoulder season through summer through shoulder season with some intermittent winter use. Some of the trail segments go straight uphill.

Trail Segment 1 leaves the Visitor Center in an apparently acceptable location.

Trail Segment 2 crosses County Road 10 at an unsafe location, and leaves County Road 10 quickly, a common mistake, and goes straight downhill for an extended distance.

Trail Segment 3 has several sustainable locations, but other locations go straight uphill, thereby being an unsustainable condition.

Trail Segment 4 approaches the waterfall (a prominent landscape feature in this area) from the side, contradicting a design principle when determining trail location.

Trail Segment 5 has some sustainable locations, but goes straight uphill in other locations, thereby being an unsustainable condition.

If corridor control points are missed, corridors can rarely be rated as sustainable and caution should be exercised before investing time and materials in maintenance, rehabilitation or armor activities.

Sustainability Assessment – Field Notes Example

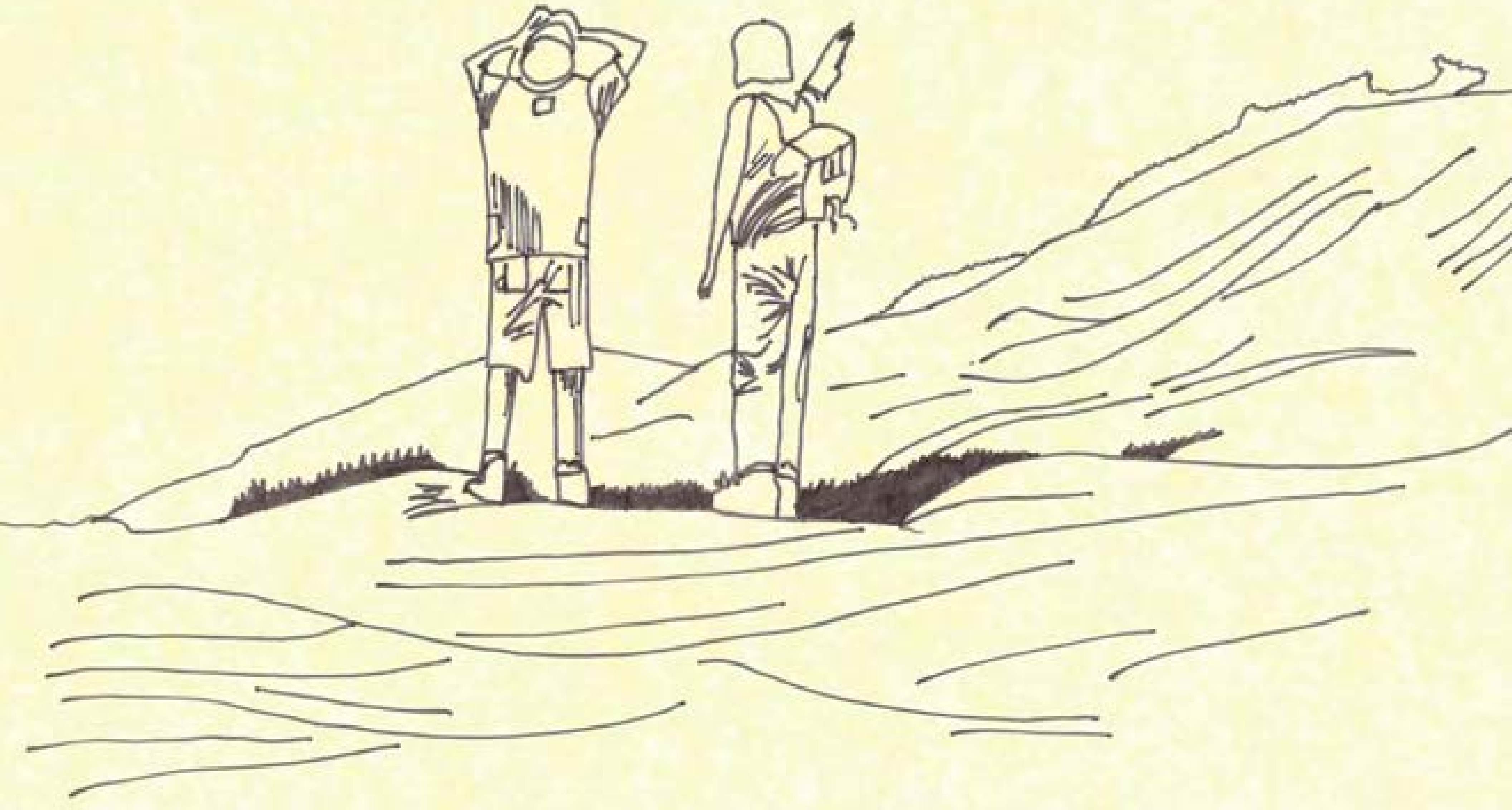
Original Design Year? _____			Original Design Standard? _____				Nonprofit Partnership in Place? Y / N?		
Station	Prevailing Cross Slope Grade (%)	Trail Profile Grade (%)	Aspect	Soils	Backslope	Tread Width	Surface Materials	Rating	Assessment Notes, Natural and Cultural Resource Impacts?
0+00	0%		E	Silt	OK	2'-7"	Cupped	S	Perform *As Needed Activities*
		1%							
1+00	0%		E	Stone	OK	2'-9"	Cupped	S	Perform *As Needed Activities*
		10%							
2+00	25%		SE	Coarse	OK	3'	Cupped	S	Perform *As Needed Activities*
		10%							
3+00	40%		SE	Silt	Eroded	3'	Outsloped	S-	Perform *Regular Basis Activities*
		0%							
4+00	25%		SE	Organic	Eroded	3'-9"	Outsloped	S-	Perform *Regular Basis Activities*, excessive erosion occurring
		4%							
5+00	15%		E	Coarse	OK	3'-5"	Outsloped	S	Perform *Regular Basis Activities*
		12%							
6+00	10%		E	Coarse	OK	3'	Cupped	S	Perform *As Needed Activities*

Prevailing cross slope and trail profile grade readings taken with a clinometer, while also recording additional sustainability notes, will assist the interdisciplinary trail team in assessing trail corridors or surfaces for planned activities. Readings are recommended for each 100-foot station.

The higher the percentages of unsustainable soils, excessive cross slopes or steep trail profile grades, the more likely it is the corridor should be simply maintained, rehabilitated, armored or relocated to more sustainable sites. If over 50% of a corridor is unsustainable, it is likely that the entire corridor needs to be abandoned, restored, and then a new corridor relocated to better soils or prevailing cross slope locations. Armor improvements (sometimes just minor spot improvements) will almost always be required to keep a trail corridor and travel surface in sustainable condition.

Optimum prevailing cross slopes grades are evident for a multiple use trail connection.

Mount Bierstadt, west of Denver, Colorado



Planning. Including the conservation area management team is key to successful mountain trail planning.

This rock outcrop at Lory State Park will present a significant challenge to trail planners to find an easy-to-construct corridor.

Guidebooks and maps will help the interdisciplinary trail team develop recommendations for trail plans.

Good Planning

Good planning can avoid problems such as steep grades and erosion, which destroy sustainability.
– National Park Service Natural Resource Management Reference Manual # 77, 2006.

Soil types play a predominant role is sustainable trail corridor site selection.

Cultural resources such as home sites, mine shafts and Native American sites must be identified in the planning process.

Inputs

- Typical Inputs
- Outputs from Other Process Areas
- Stakeholder Analysis
- Aerial Photos, Maps, Data Bases
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Establish Background Information / Foundations
- Establish Plan Goals
- Establish Climate & Geographic Context
- Identify Ecosystem Type
- Identify Rare Species & Habitat
- Physical Planning Tools
- Trail Profile Calculations
- Off-Site Connections & Network Analyses
- Optimum Trail Corridor Identification
- Compare Existing Corridors to Optimum Corridors
- Corridor Implementation Actions Sequence
- Develop Corridor Framework By Assembling Individual Corridor Plans
- Management Team Review
- Compliance Review

Outputs

- DRAFT Mountain Trail Plan Package for Review
  - Purpose
  - Goals
  - Sustainability Assessment Summary
  - Base Map
  - Landscape Characteristics Summary
  - Annotated Site Analysis
  - Corridor Control Points
  - Corridor Framework
  - Trail Management Techniques
  - Actions Sequences
  - Checklists
  - Lessons Learned Summary
- FINAL Mountain Trail Plan Package

National Park Service Organic Act

The purpose of the National Park Service is "*... to promote and regulate the use of the Federal areas known as national parks ... which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.*"

Other land management agencies have similar documents guiding their mission.

Aspen trees provide habitat for a variety of birds and mammals, and are naturally striking in their appearance, and as such must be accounted for in the trail plan.

A mountain trail plan is a fundamental tool land managers use to coordinate existing and proposed trail activities with agency initiatives and policies and serves as a guide for land managers in their decisions regarding the location, funding, and implementation of trails under their jurisdiction. A common intent of trail plans is to standardize and systematize the management of trails. Trail plans can also be used for the coordination of trail projects across agency boundaries where neighboring agencies have mutual goals.

A plan is best developed by an interdisciplinary trail team of resource and design professionals. The trail plan will identify where and when trail activities will occur and what uses will be allowed. The plan may include both short-range (up to 5 years) and long-range goals (up to 50 years). Updates to plans can address the long-range goals identified in the original plan.

A professional trail planning process will involve all stakeholders who might have an interest in the project: the public, agency resource professionals, and neighboring land management agencies.

During development of a plan, many issues will come up and be addressed by the team which can adequately respond to situations as they arise. The land manager is then presented with a professional plan which addresses the issues that will face the design team.

Implicit in mountain trails planning is the understanding that different user groups will have different corridor needs. Also, visitation must be analyzed to ensure appropriate solutions are developed.

Including a trail sustainability assessment summary of existing trails as an input into the plan ensures that their condition as well as their fitness for continued inclusion in the trail system in their current condition is considered over the life of the plan.

This corral on the historic Green Ranch property lies in a saddle, a corridor control point, and is the focus of several planned trails at Golden Gate Canyon State Park, Colorado.

Climate

Understanding and describing climatic influences in a climate summary helps the interdisciplinary trail team establish a baseline of information from which trailside decisions can be made. Example climate summary:

> *A semi-dry, continental climate characterizes the Roxborough State Park vicinity. Summers are long, hot and relatively dry. Winters are short, cold and dry. Average rainfall is considered slight (approximately 15 inches), with evaporation high. Most precipitation is uniformly distributed from April to October. Mean air temperatures decrease as elevations increase, along with increases in precipitation also as elevations rise. Winter precipitation falls as snow and persists, especially on north-facing slopes. Wind is common, predominantly from the northwest, and is strongest in spring and fall …*
>
> *Average spring temperatures vary from 30d F to 60d F; Average summer temperatures vary from 50d F to 80d F; Average fall temperatures vary from 30d F to 60d F; and Average winter temperatures vary from 20d F to 40d F. Frost occurs in the winter months, and extends to a depth of approximately 2 feet, and deeper on north-facing slopes.*
>
> *… During summer months, soils are dry and can be dusty.*

Shoulder season use, in the spring and fall, must be considered when implementing trail projects. Warm weather along Colorado's front range draws visitors to Mt. Sherman near Fairplay, Colorado.

Boundary Constraints

Starting a trail project with an accurate boundary and property survey in hand, especially if your unit adjoins private land, ensures an understanding of boundary locations and easement opportunities or constraints. A property survey might yield some insights into the challenge being faced while also exposing opportunities for easements or other creative solutions. Undertaking a trail project without an accurate survey can create legal problems. Be sure to request and obtain written permission to scout trails on private lands before venturing afoot.

Easements & Off-Site Connections

Obtaining an easement across private land within your park boundary, or negotiating with an adjacent landowner for an easement is a preferred way of assembling trail corridors. Large expense can sometimes be avoided when using this method of trail establishment. Easements are best determined and negotiated by experienced professionals. Easements can easily be a constraint if there are specific activities allowable or precluded by the language of the easement.

Your area's neighbors may have trail projects in place or planned which may affect where you do or don't develop trails. Consultation is wise to ensure compatibility with your neighbor's plans.

Good Fences …

"Good fences make good neighbors" is a paradigm that applies to trail planning and design. It can be said that "good off-site connections make good neighbors."

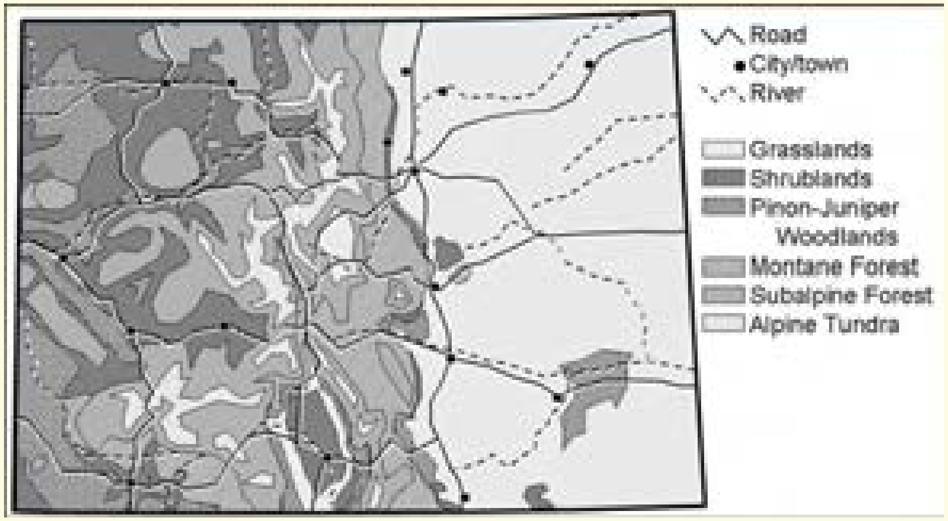
… Make Good Neighbors

Geographic Context

Establishing the geographic context for your area assists in putting the unit in proper perspective with neighboring and regional public lands and corresponding recreation opportunities. Example geographic context summary:

> *Roxborough State Park is located just 15 miles southwest of Denver, Colorado, at the ecotone between the Grasslands and Montane Forest ecosystems along Colorado's front range. Elevations above sea level vary from approximately 6,000 feet to approximately 7,200 feet.*
>
> *… It is in this zone that the eastern plains of Colorado give rise to the rugged mountains for which Colorado is famous. Here travelers across the eastern plains of Colorado have encountered a series of formations which would give a glimpse of the formidability of the Rocky Mountains. First encountered would be the Dakota formation (commonly known as the Hogback), a prominent rock outcrop which appears intermittently along Colorado's front range from Pueblo to Fort Collins. Moving further west into this landscape, visitors to this landscape encounter the Lyons formation, then the Fountain formation, then the foothills of Colorado's front range.*
>
> *… The Morrison formation, apparent as a ridge in other areas along Colorado's front range, is a valley former at Roxborough. For all of recorded history, these formations have yielded little towards the feeble strength of man.*
>
> *… Willow Creek drains part of the southern portion of the park. Little Willow Creek drains part of the northern portion of the park. Additional minor drainages and gulches drain western or eastern portions of the park. All of the drainages are part of the larger South Platte River basin.*
>
> *… The most prominent mountain peak in the park is Carpenter Peak, rising above the eastern plains to approximately 7,125 feet in elevation above sea level. From Carpenter Peak, one has a nearly panoramic view towards Mount Evans to the west, Longs Peak towards the north, the city of Denver and Colorado's eastern plains towards the east, and front range foothills towards the south.*
>
> *… Putting the topography of Roxborough in the context of the Rocky Mountains of Colorado will assist park managers in developing trails appropriate to the setting of Roxborough State Park. Colorado is famous for 13,000-foot and 14,000-foot-high peaks accessible only by very rugged trails or scramble routes. Roxborough's relatively low elevations, combined with its relative proximity to a large population center and the expected high volume of frontcountry users – gives rise to the premise that trails in this area that provide the most gentle profile grades would provide the most benefit to the widest variety of trail user types.*

The Denver-metro area is 15 miles distant from Roxborough State Park, Colorado.



Colorado Ecosystems
Based upon *"Distribution of Ecosystem Types in the Southern Rocky Mountain Region"* from *"From Grassland to Glacier"* by Cornelia Fleischer Mutel and John C. Frederick.

From the 3,300-foot high plains in eastern Colorado to the 14,000-foot-plus summits of its high peaks, Colorado displays a vast variety of ecosystems. Extensive grasslands, evergreen forests, and expanses of alpine tundra cover the state, each providing trail users with rich and diverse recreational experiences.

Understanding the natural characteristics of Colorado's ecosystems, especially within your land management area, will help you to plan and design trails that function well with each ecosystems' natural characteristics.

A basic understanding of vegetation will help interdisciplinary trail teams identify ecosystem types. This will provide an understanding of associated soil types, moisture levels, and habitat concerns. All of these factors will give the trail planner information towards proper trail location and alignment, and are important to understand for trail restoration projects.

Seven major ecosystem types can be found in Colorado. Organizing and summarizing the following foundational information for each ecosystem will help interdisciplinary trail teams understand implications of trailside actions.

- Range & Elevation: approximate location of ecosystem in terms of the geography of Colorado
- Common Soils: soil texture types for each ecosystem
- Common Vegetation: general vegetation types (i.e.: grasses, forbs, shrubs) and some common species
- Vegetation – Soil Type Indicators: information on identifying soil types based on vegetation
- Trail Considerations: trail planning information specific to that ecosystem type

Colorado's Grasslands transition to the Montane Forest ecosystem along Colorado's front range, symbolic of two of the seven major ecosystem types in Colorado.

Grasslands

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Eastern Colorado plains, blends into foothills Shrublands and Montane Forests. Less than 5,600 feet elevation.	Deep organic clay and silt soils, frost free more than 150 days per year. Occasionally soils are coarse, sandy or cobbly.	Grasses and forbs, some shrubs. Common weed species include Cheatgrass, Thistles and Knapweeds.	Pockets of shrubland may exist on north-facing cool slopes. This indicates higher soil moisture retention and later season snowmelt.	◆ Difficult soils for natural surface trail solutions are common due to high potential for erosion and mud. ◆ Gentle profile grades recommended. ◆ Trail location on south-facing slopes is beneficial (dry), and a more sustainable location than on north-facing slopes. ◆ Armor improvements may be required. ◆ Prevalence of weeds in these ecosystems may spread into trail corridors. ◆ Lack of tall vegetation helps to speed drying of muddy trails. ◆ Excellent opportunities for trail restoration.

The West Valley Trail at Lory State Park near Fort Collins, Colorado is in the transition from the Grasslands to the Montane Forest Ecosystem.

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Interspersed in intermountain basins. 7,300 feet – 10,000 feet elevation.	Deep and fine-textured. Wet meadows may have large amounts of accumulated organic matter.	Dry meadows: grasses and forbs. Shrubby Cinquefoil is common. Wet meadows: sedges, rushes, Willow, Bog Birch, Shrubby Cinquefoil and forbs.	Mountain Greasslands and Meadows are interspersed throughout the Montane Forest and Subalpine Forest Ecosystems. Wet meadows are dominated by sedges and rushes, not grasses.	◆ Wet meadows usually require armor improvements. ◆ Gentle profile grades recommended. ◆ Management issues such as with trail braiding, widening or short-cutting may arise. ◆ Meadows offer excellent opportunities for memorable visitor experiences, including changes of scenery and wildlife viewing. ◆ Prevalence of weeds in these ecosystems may spread into trail corridors. ◆ Restoration is generally quickly accomplished.

The Green Ranch Property at Golden Gate Canyon State Park offers spectacular views towards the south, including Mt. Evans. Trails here will be designed to not impact these Mountain Meadows.

Riparian

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Corridors along rivers, streams, and moist valleys, interspersed statewide. Elevation variable.	Variable in depth and texture with high moisture levels (may be seasonal).	Lowland: Cottonwood Trees, shrubs (Wild Plum, Hawthorn, Currant, Wild Rose, Snowberry, Willow) and Salt Cedar (western slope invasive). Mountain: Alder, Cottonwood, Willow, Birch, Colorado Blue Spruce and White Fir.	Riparian ecosystems are interspersed throughout Colorado. Rushes and sedges can be an indicator of deep, fine-textured, wet soils.	◆ Biologists can add expertise for the interdisciplinary trail team to consider. ◆ Use careful design when designing trails which cross riparian areas. ◆ Gentle profile grades recommended. ◆ Armor improvements may be required. ◆ In mountain riparian areas, frost-free season is usually shorter than surrounding hillsides and ridges due to cold air drainage. This results in late season snowpack and potentially muddy trails in the early hiking season. ◆ Riparian areas have rich biodiversity, so trails can be a disturbance to important wildlife habitats. ◆ Riparian areas offer excellent opportunities for memorable visitor experiences, including changes of scenery and wildlife viewing.

Riparian areas offer many recreational opportunities yet require much care when creating trails near them or across them.

Shrublands offer unique trail opportunities. They are usually very suitable for trails.

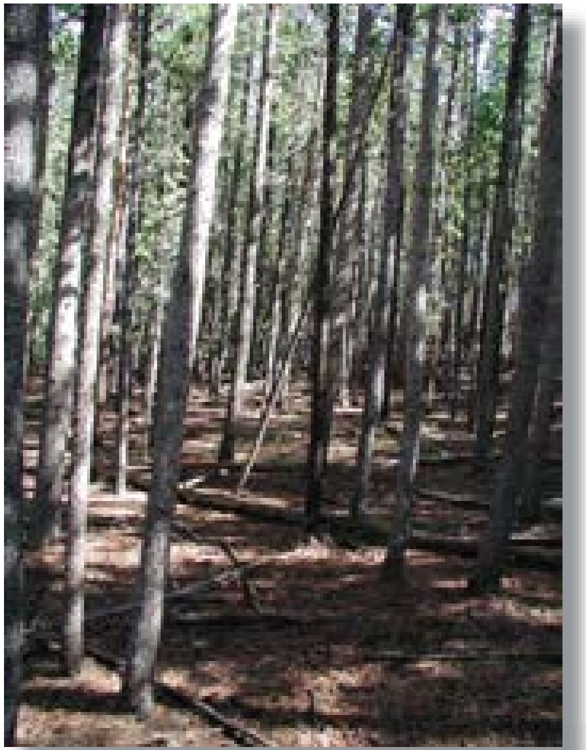
Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Interspersed throughout foothill and mountain regions and the Colorado Plateau. 5,500 feet – 10,000 feet elevation.	Semidesert regions: clay, silt, or sand. Sagebrush regions: deep, fine-grained (clay and silt). Mountain and foothill regions: well-drained, coarse-textured to rocky and / or sand.	Semidesert regions: Greasewood, Shadescale, Four-winged Saltbush, Rabbitbrush, Winterfat and Big Sagebrush. Sagebrush regions: Big Sagebrush. Mountain and foothill regions: Gambel Oak, Mountain Mahogany, Skunkbrush, Serviceberry, Antelope Bitterbrush, Wild Rose and Currants.	Pockets of Shrubland may be found on north-facing cool slopes in grassland areas. This typically indicates higher soil moisture retention and later season snowmelt.	◆ Shrublands are typically a sustainable location for trail corridors due to their commonly coarse, well-draining soils. ◆ Gentle to moderate profile grades recommended. ◆ Open views of surrounding landscapes are common in Shrubland ecosystems.

Pinon-Juniper Woodlands

Pinon-Juniper Woodlands offer spectacular forms and spatial variety for the trail user to enjoy, and are usually very suitable for trails.

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Western and southern Colorado, southern part of eastern foothills, southeast plains (patch). 4,800 feet – 8,200 feet elevation.	Typically are coarse (sandy / gravelly), but can be fine-textured (clay).	Pinon Pine, Rocky Mountain Juniper, One-Seed Juniper (> 7,600' in southern Colorado) and a variety of shrub species (similar to Shrublands).	Pinon Pine is more tolerant of cold, thus it dominates stands at higher elevations. Conversely, Juniper is more drought-tolerant and dominates stands at lower elevations and dry sites.	◆ Prevalence of sandy / gravelly soils (coarse) in Pinon-Juniper woodlands is a sustainable characteristic of these ecosystems. ◆ Gentle to moderate profile grades recommended. ◆ Pinon-Juniper Woodlands provide for a complex variety of foreground, middleground and background viewsheds, significantly increasing variety for trail users.

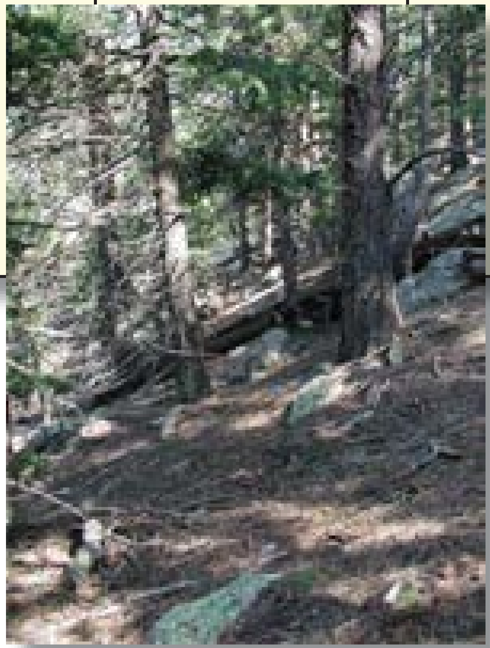
Montane forests provide richness and diversity to the landscape.



Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
Throughout mountainous regions of Colorado. 5,500 feet – 9,000 feet elevation.	Coarse (sandy), rocky, can be fine-textured.	Ponderosa Pine, Douglas-fir, Rocky Mountain Juniper, Aspen and Lodgepole Pine.	Pine species and Juniper are more dominant on dry sites and slopes. Douglas-fir and Aspen typically occupy cool, moist sites.	◆ Soils are typically good for locating sustainable trail corridors. ◆ Gentle to moderate profile grades recommended.

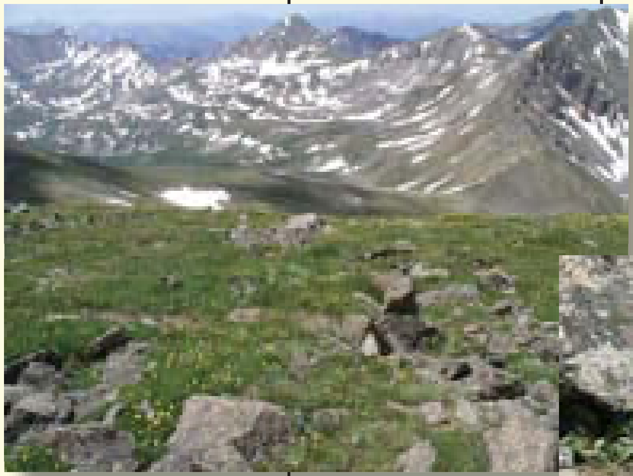
Subalpine Forests

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
9,000 feet to tree line or approximately ~11,500 feet – 12,000 feet elevation.	Coarse (sandy), rocky, can be fine-textured.	Aspen, Lodgepole Pine, Limber Pine, Bristlecone Pine, Engelmann Spruce and Subalpine Fir.	Pine species are more dominant on warm, dry sites.	◆ Late-season snowpack can keep trails hidden into early summer, creating muddy conditions. ◆ Thick layers of organic material may have accumulated in some sites. ◆ Soils are typically good for locating sustainable trail corridors. ◆ Gentle to moderate trail profile grades recommended. ◆ Subalpine Forests provide for more varied views, similar to foreground, middleground and background views offered in the Pinon-Juniper Woodlands, but from higher elevations.



Subalpine Forests offer abundant trail opportunities, providing more enclosed experiences for trail users.

Range & Elevation	Common Soils	Common Vegetation	Vegetation - Soil Type Indicators	Trail Considerations
High mountain ridge tops and peaks. Greater than 11,500 feet elevation.	Coarse soils, can be fine-textured in low-lying wet areas or wet mountain ranges (San Juan Mountains).	Cushion plants, forbs, grasses, sedges and low shrubs (at lower elevations).	Lush alpine meadows can have fine-textured soils and remain wet well into the summer. Vegetation height is a good indicator of soil moisture (taller plants usually equate to higher soil moisture levels).	◆ Gentle profile grades recommended. ◆ Seasonal snowpack can last well into the summer (observe over several seasons), creating muddy conditions. ◆ Improvements which mitigate sometimes continuous snowmelt are recommended. ◆ Alpine plants are slow to establish and grow in disturbed areas. Limit trail activities to the trail surface. ◆ Waterbars are discouraged due to the potential for sediment build up over neighboring alpine plants. If waterbars are needed, drain into talus or Willows. ◆ Few physical barriers exist above timberline to prevent trail short cutting. ◆ Scree fields are best avoided. ◆ Talus fields are difficult sites to implement trails, but provide a sustainable trail surface. ◆ Restoration is difficult due to short growing season and harsh growing conditions.



Environments of an extremely fragile character (i.e.: marshy and alpine areas) require special attention in order to protect their sensitive natural uniqueness. Thus it is essential that the delicate balance be maintained between maximizing hiking opportunities and the environmental carrying capacity of the ecosystem. Overuse can destroy the natural environment, which is an essential segment of the hiking experience. – William G. King, 1984.

Rare Species & Habitats

Protection of rare species is a foundational goal of many land management agencies. Protecting rare plants is easy but bringing them back is very difficult! Natural ecosystems support a diverse and fascinating flora. Some plant species may be endemic (known from nowhere else in the world) though wide-spread, while others are found only in microclimates of a single mountain range. Some rare plants may be part of very isolated populations, found infrequently in similar habitats around the world.

What Makes a Plant Rare?

Knowledge of what makes a rare plant “rare” can be used to help protect it. Rare plants, like other rare species, are specialists and as such have very specific habitat requirements. Several variables interact to create the unique habitats required by rare plants including soil texture, hydrology, soil chemistry, elevation, associated vegetation, aspect and snow pack.

Where the correct habitat exists, a rare plant can in fact be represented by thousands of individuals. The key point to remember is that the number of suitable habitats is often limited, and most rare plants occur in much lower numbers and / or in few populations scattered across the region. In contrast, a generalist plant such as Alpine avens (Geum rossii), can occur by the tens-of-thousands in a specific area, and can be found on several continents.

According to a 1995 report by the Colorado Natural Heritage Program which gathered data from 6 peaks in the Sawatch Range of Colorado, concentrating hiker impact along a single well-planned trail is preferred over a maze of unplanned social trails, in order to protect rare plant populations. By encouraging hikers to stay on established routes, you can prevent trampling of vegetation, including rare plants.

Rare species are especially a concern for new trail alignment and implementation which may jeopardize known populations of rare plants or animals, or the habitats of these species (even though no species may be currently present). Knowledge of existing populations of rare plant is also important for restoration crews to be aware of in order to avoid disturbance while sourcing native materials (i.e.: rocks, logs), removing transplants and collecting seeds.

Consult the compliance documents for your plan or project for complete information on rare species and habitats.

The dwarf columbine is just one of the 100’s of rare plants that land management agencies work to protect in all ecosystems. When implementing trail projects, small measures can be taken to successfully protect rare plant populations on the project site. The fate of rare plants could be in your hands.
Aquilegia saximontana, credit: U.S.D.A., Gary A. Monroe.

Aspect

Aspect is the compass orientation of a particular parcel of land. Aspect affects trailside decisions in that obviously, one would want a cross-country ski trail on north-facing slopes, as these slopes will tend to hold snow, for longer periods of time. For anticipated year-round multiple-use trails use, southeast, south or southwest slopes would offer the best opportunity for soils to dry out after rains or snowfall. See table on page 52.

Elevation

Elevation affects trailside decisions in that higher, more inaccessible trails will likely have less use, and will be used by more accomplished users. Elevation is also a significant factor in precipitation rates in Colorado. Lower elevation trails can be expected to have more use, with more novice users. Trail standards which are customized to specific uses, locations, distances from trailheads and elevation change from trailheads will ensure appropriate solutions for the intended uses. See table on page 52.

Extent of Impact

The average extent of impact widths for proposed trails can be determined by applying the trail width guideline for the project at hand to the prevailing cross slopes. For example, a 24" wide trail on a 40% cross slope will impact approximately 36" of horizontal width. The interdisciplinary trail team can visualize if the trail will unduly impact resources by walking the proposed trail corridor with the extent of impact in mind.

Trail Profile Calculations

Mathematical calculations will assist the trail team in determining feasibility of varying trail profile grades for a corridor, including length of trail and required improvements. See page 53.

Corridor Control Points

Key, appropriate origins, destinations and corridor control points must be established to ensure that the corridor will work in design and can be studied further in the compliance process. It is incumbent upon the interdisciplinary trail team to recommend alternative origins or destinations if existing facilities are in inappropriate locations. Corridor control points are locations which the corridor must utilize or avoid in order for the corridor to be considered sustainable. They can be either functional or aesthetic control points. Functional control points are features such as impenetrable rock outcrops, stream crossings, or archaeological sites where entry is not permitted. Switchback locations are usually corridor control points. Aesthetic control points are landscape features that attract trail users. These include landscape features such as overlook areas, high points, interesting water features or an ecological zone of interest.

Applying planning guidelines such as optimum trail profile grades as well as prevailing cross slope ranges and studying a potential corridor with consideration to functional and aesthetic control points is the basis of planning sustainable trails. Intermediary control points, those where flexibility is allowed, may be looked at during design.

Optimum Corridors

The optimum corridor starts at appropriate origins, utilizes appropriate corridor functional and aesthetic control points, and terminates at appropriate destinations. The optimum corridor also considers boundary constraints, adjacent corridor locations, easements and off-site connections. When the optimum corridor is compared to existing trails, the percentage of the existing corridor that is sustainable, as well as degree of impact in that corridor, will assist the interdisciplinary trail team in determining appropriate actions such as new trail design, maintenance, rehabilitation, armor or restoration.

Multiple corridors are easily assembled into area-wide plans.

Optimum Soils for Sustainability

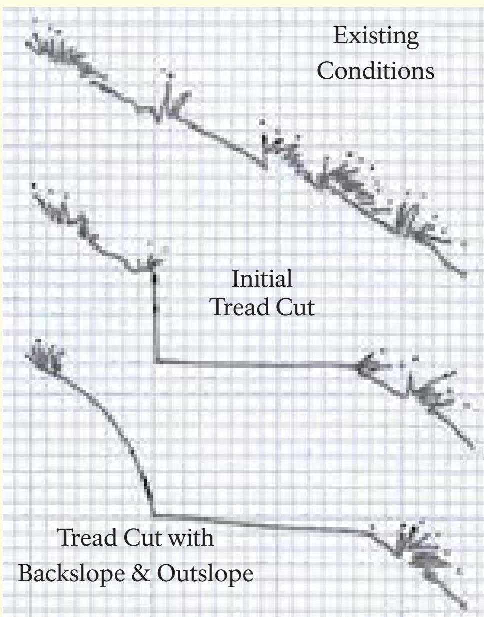
Soils result from the mechanical or chemical breakdown of rock substrates, and can be classified as coarse (cobbles, gravels, sands) and fine (silts and clays). Coarse soils offer the best setting for trails, and usually coincide with preferred prevailing cross slope ranges. Fine soils usually coincide with unfavorable or unsustainable prevailing cross slope ranges. Organic matter is present in both coarse and fine soil conditions, and on the one hand needs be removed during trail implementation as it prevents soil from binding together well and contributes to muddy conditions upon decomposition, while on the other hand encourages revegetation during restoration activities. Optimum soils for natural surface trails are predominantly coarse soils, with some small amount of fines mixed in to act as a binding material. Optimum soil types are often referred to as "mineral soils." See table on page 52.

Soils Comparison Matrix

	Coarse Soils	Silts	Clays
Trail Considerations	Coarse soils leaves large pore spaces for water to drain through soil. Fractured particle shapes ensures a firm and stable trail surface. Occasionally, sandy soils can be too loose if there is not enough binding material (i.e.: small amounts of clay and / or silt) present.	Silt does not leave enough pore space for water to seep through soil, and erodes easily.	Clay does not have enough pore space for water to drain through, and holds water in soil, creating long-lasting mud. Clay soils have high potential for erosion because water runs over it, not draining through it, and small particles of clay are carried away easily by wind and water.
Particle Size	Large	Medium – Small	Small
Erosive Potential	Low – Moderate	Moderate – High	High
Drainage Capability	Excellent	Poor – Moderate	Poor
Organic Content	On Surface Only	Moderate – High	High
Restoration Potential	Difficult	Good	Good

Recommended Design Solutions Hierarchy for Sustainability					
	Distance from Trailhead	Optimum Trail Profile Grades	Optimum Prevailing Cross Slopes (%)	Tread Width	Natural Surface versus Armor Improvements (%)
Recreation Accessible	Not Defined	< 5%	0 – 20%	36” minimum	Low % / High %
Mountain Trails					
Frontcountry	X < 3 – 5 miles	0% – 8%	20% – 40%	24” – 60”	~ 85% / 15%
Middlecountry	3 – 5 < X > 7 miles	0% – 12%	20% – 60%	24” – 48”	~ 60% / 40%
Backcountry	X > 7 miles	0% – 15%	20% – 70%	24” – 36”	~ 15% / 85%
Ascent Routes	Any Distance	15% < X > 100%	> 60%	NA	Low %
Scramble Routes	Any Distance	15% < X > 100%	> 60%	NA	Low %
Technical Climbing Routes	Any Distance	NA	NA	NA	Low %

Extent of Impact Tool



Most trails will impact 1.5 to 2 times the trail tread width.

Design Solutions Hierarchy

Trail use is more substantial closer to trailheads, with use tapering off as distance from trailheads increases, usually corresponding to day use activities. Interdisciplinary trail teams are encouraged to customize their plans and projects to their specific physical and social context. “Frontcountry” can be generically defined as up to 3 to 5 miles from the trailhead, “middlecountry” can be generically defined as 3 to 5 to 7 miles from the trailhead, and “backcountry” can be generically defined as over 7 miles from the trailhead. Investment in trailside improvements will likely increase the further the project is from the trailhead.

Build it …

Correspondingly, trail use almost always goes up over time. “Build it and they will come” is more than a catchy baseball cliché. Project criteria which take this into account will more likely result in trails which are more sustainable.

… And They Will Come

Table A. Opportunity for Trail Sustainability – Prevailing Cross Slope (%) & Aspect

Prevailing Cross Slope (%)	West (W)	Southwest (SW)	South (S)	Southeast (SE)	East (E)	Northeast (NE)	North (N)	Northwest (NW)
0 – 20%	Good	Good	Good	Good	Good	Poor	Poor	Poor
20 – 40%	Excellent!	Excellent!	Excellent!	Excellent!	Excellent!	Poor	Poor	Poor
40 – 60%	Very Good	Very Good	Very Good	Very Good	Very Good	Poor	Poor	Poor
60 – 70%	Good	Good	Good	Good	Good	Poor	Poor	Poor
70% +	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor

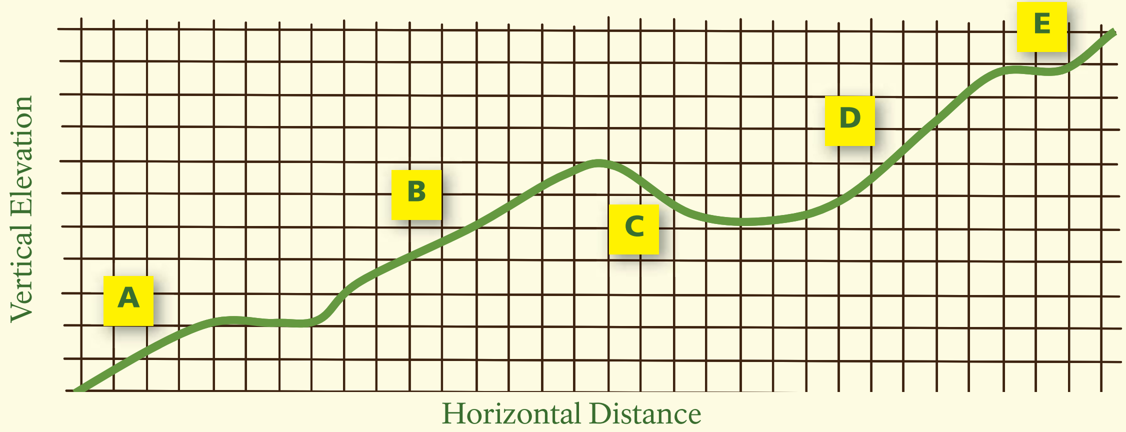
Table B. Opportunity for Trail Sustainability – Prevailing Cross Slope (%) & Soils

Prevailing Cross Slope (%)	Coarse Soils	Silts	Clays
0 – 20%	Good	Poor	Poor
20 – 40%	Excellent!	Good	Poor
40 – 60%	Excellent!	Good	Poor
60 – 70%	Good	Poor	Poor
70% +	Poor	Poor	Poor

Table C. Opportunity for Trail Sustainability – Elevation & Aspect

Elevation	West (W)	Southwest (SW)	South (S)	Southeast (SE)	East (E)	Northeast (NE)	North (N)	Northwest (NW)
3,300 – 7,000’	Excellent!	Excellent!	Excellent!	Excellent!	Excellent!	Good	Good	Good
7,000 – 9,000’	Very Good	Excellent!	Excellent!	Excellent!	Very Good	Good	Good	Good
9,000 – 10,000’	Good	Very Good	Very Good	Very Good	Good	Poor	Poor	Poor
10,000 – 11,500’	Poor	Good	Good	Good	Poor	Poor	Poor	Poor
> 11,500’	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor

Several profile grades calculated out over the anticipated total vertical gain will portray how many horizontal linear feet of trail would be required at each profile grade. Be sure to account for reversals in elevation between corridor control points, not just the raw vertical distance gain. In the case of alternative #2, A, B C, D and E must be added together to determine the combined vertical gain. Alternative #1, a "no-action" alternative, could be further studied and compared to alternatives # 2 and #3 in the design and compliance processes.



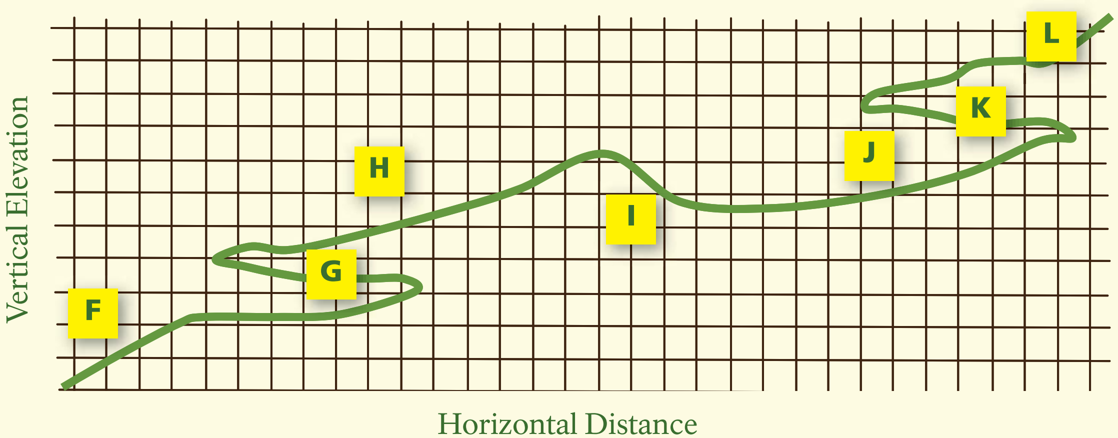
Trail Profile Alternative #2 – 7% Average Grade

Trail Profile Alternative #3

% grade = vertical difference / linear feet (l.f.)
.05 = F + G + H + I + J + K + L / l.f.
.05 = 1,500 / L
L = 30,000 linear feet of trail (5.68 miles)
5.68 x 1.25 = 7.1 miles (for flexibility in design)
4 switchbacks are also required

Trail Profile Alternative #2

% grade = vertical difference / linear feet (l.f.)
.07 = A + B + C + D + E / l.f.
.07 = 1,500 / L
L = 21,429 linear feet of trail (4.05 miles)
4.05 x 1.25 = 5.1 miles (for flexibility in design)



Trail Profile Alternative #3 – 5% Average Grade

Trail Profile Calculations

Calculating alternative average sustainable profile grades and comparing required investments and anticipated resource impacts ensures that corridor control points and high cost investments are located in permanent locations.

Choosing by Advantages

The National Park Services utilizes five standard factors when determining preferred alternatives during budgeting and schematic design

1. Protect park resources?
2. Provide educational and interpretive experiences?
3. Protect employee and public health, safety and welfare?
4. Improve management efficiency and sustainability?
5. Provide other advantages to the national park system?

By asking the question "How well does this alternative ____?" (meet each factor), assigning attributes of quantifiable difference between each alternative and subsequently a rating score, alternatives which meet non-monetary factors can be compared and a preferred alternative determined for further study and comparison in the design and compliance processes.

The amount of maintenance, rehabilitation, armor and restoration required under no-action alternative #1 could be compared to new trail design requirements of alternatives #2 and #3 on page 53. Initial costs and life cycle costs can both be determined and evaluated to help the interdisciplinary trail team and the management team make decisions on a recommended course of action.

Stakeholder Analysis

Stakeholders are those individuals or organizations that

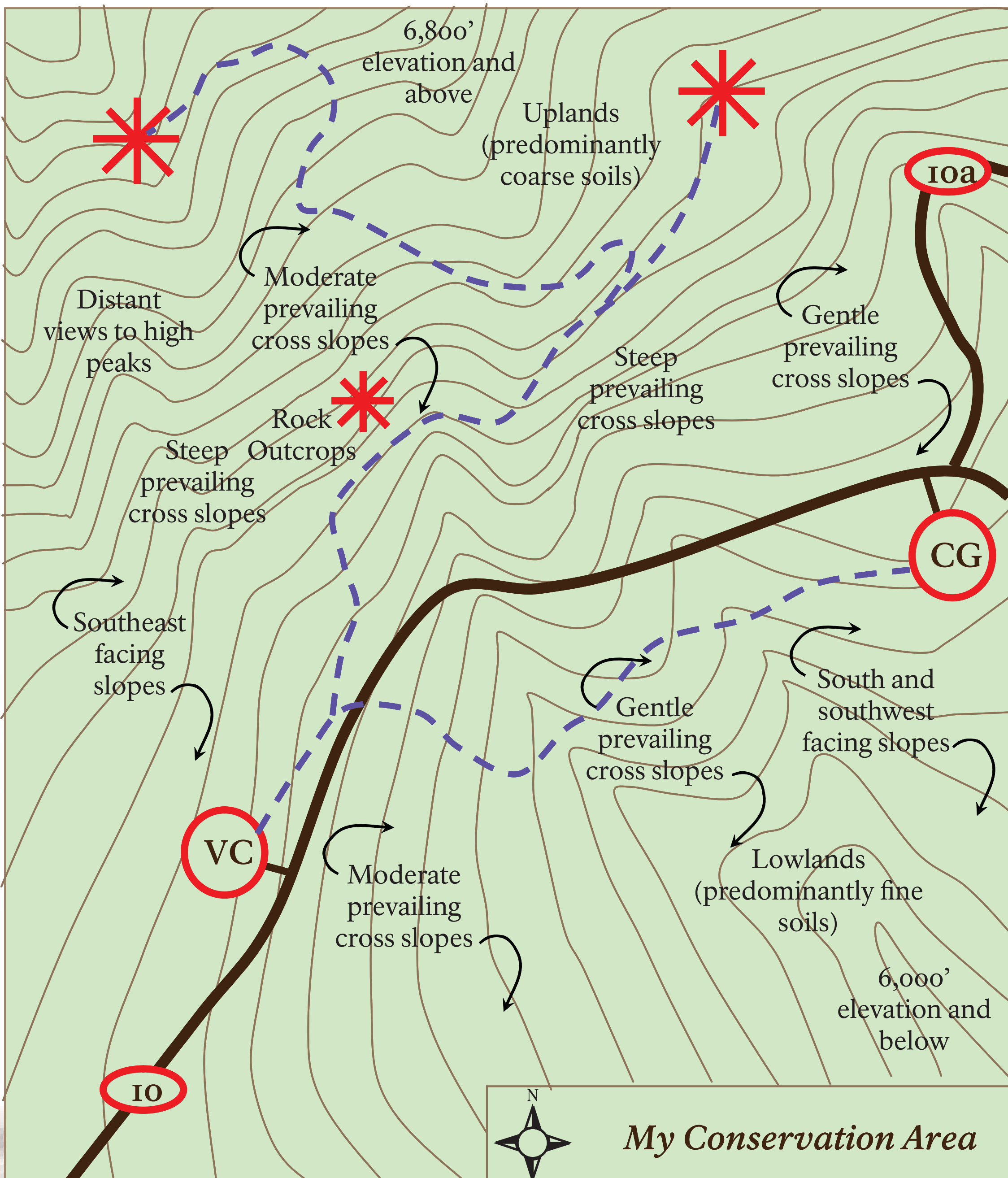
- have information about a project
- can influence the outcome of the project
- have an interest in the outcome of a project

For mountain trail projects, stakeholders typically include land management agency staff, including decision makers and resource staff personnel, user group representatives, nonprofit agencies, and donor and granting organizations. Stakeholders will likely comment on recommended actions during the compliance review process, so it is prudent to involve them from project initiation onward.

Stakeholders can participate in the establishment of the project purpose or goals, the development of sustainability criteria for the project, assessment or inventory techniques, and the establishment of destinations. Stakeholders might also have information for the interdisciplinary trail team to consider, i.e.: traditional routes or locations of snowpack in shoulder seasons. Stakeholders can conduct sustainability assessments, scout trails considered for plans, offer insights into trail corridor design, and help implement trails by leveraging funding or providing volunteers for implementation day projects.

Recommended Daily Requirements Per Mile of Trail Estimating Tool

Trail Worker	Assessment	Plan	Design	Implementation	Maintenance	Rehabilitation	Restoration / Armor
Trail Planner	1	1	NA	NA	NA	NA	NA
Trail Designer	1	NA	6 – 10	.25 – .5	NA	2 – 5	2 – 5
Trail Associate	0.25	1	3	3	1	1	1
Volunteer Crew Manager	0.05	0.05	3	3	1	1	1
Volunteer Crew Leader	0.05	0.05	3	25	3	1	1
Volunteer Crew Person	0.25	0.25	0.25	250	25	250	500
Day Labor Crew Leader	0.05	0.05	3	20	1	20	40
Day Labor Crew Person	0.25	0.25	3	250	8	250	500



Existing cross slope ranges are generally moderate. Approximately 55% of the property has cross slopes of 20 – 60%; approximately 15% over 60%; and approximately 40% of the parcel is in the less than 20% range.

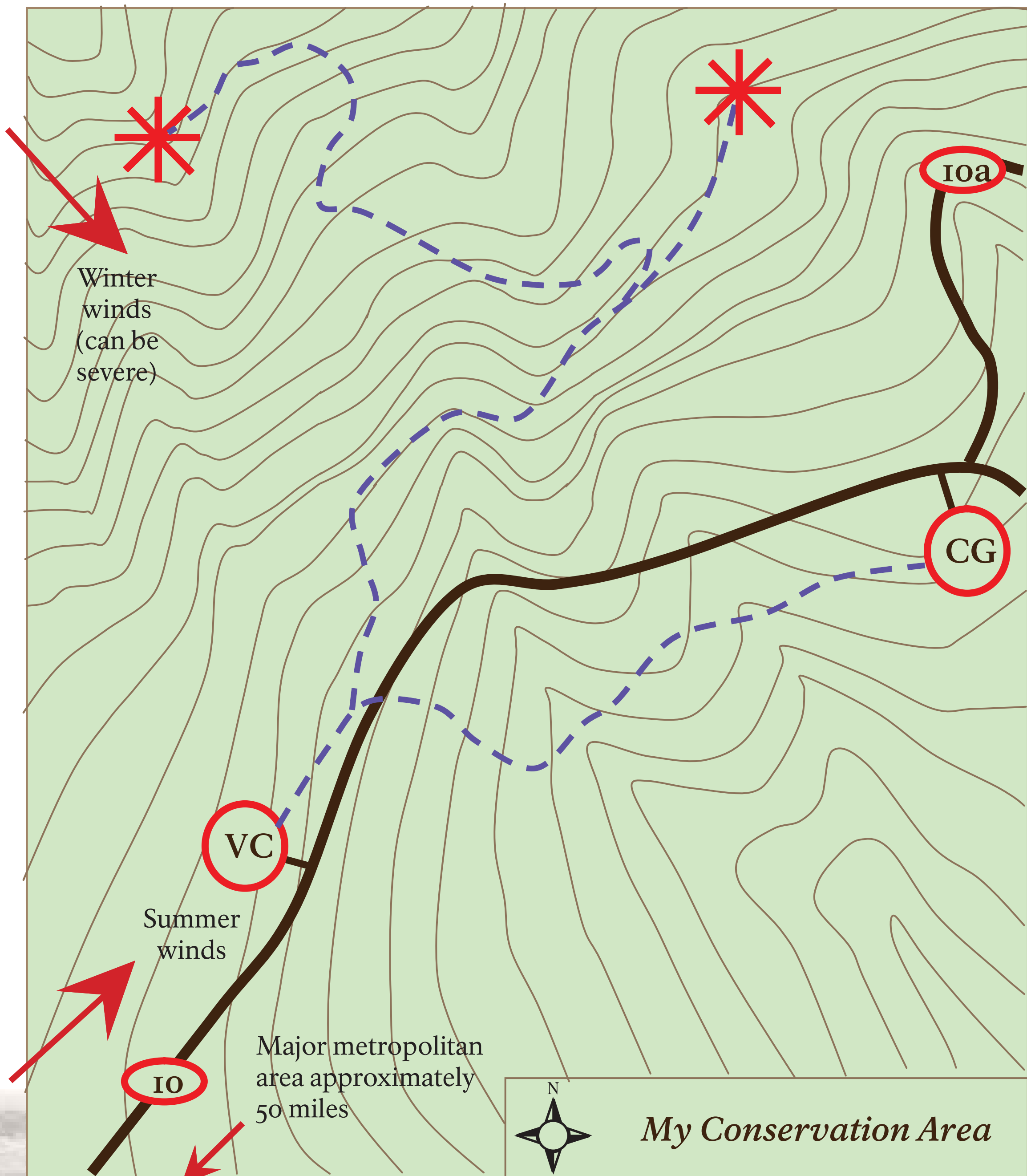
There are several rock outcrops on the property, a hazard, as they are fragile rocks and erode easily. Elevations are moderate, between 6,000 and 7,000 feet.

Approximately 60% of the parcel has an aspect of south, approximately 25% of the parcel has an aspect of east, and approximately 15% has an aspect of west. No land on this parcel has a north aspect.

Some of the open lands have substantial topsoil. The more upland slopes are have predominantly coarse soils. There are several intermittent streams on the parcel.

The eastern plains of Colorado extend as far as the eye can see east of the foothills of Colorado's front range. The prevailing cross slopes in the foreground are favorable for trail corridor locations.

Area-wide Base Map / Existing Conditions



Summary

This conservation area was acquired by a conservation nonprofit agency and transferred to a land management agency. It originally was a homestead and cows were run on this property, as there are many grassy openings. When the land was acquired, game and cattle trails were converted to trails. Currently a trail dead-ends at the waterfall, coming in from the side, offering an uninspiring view.

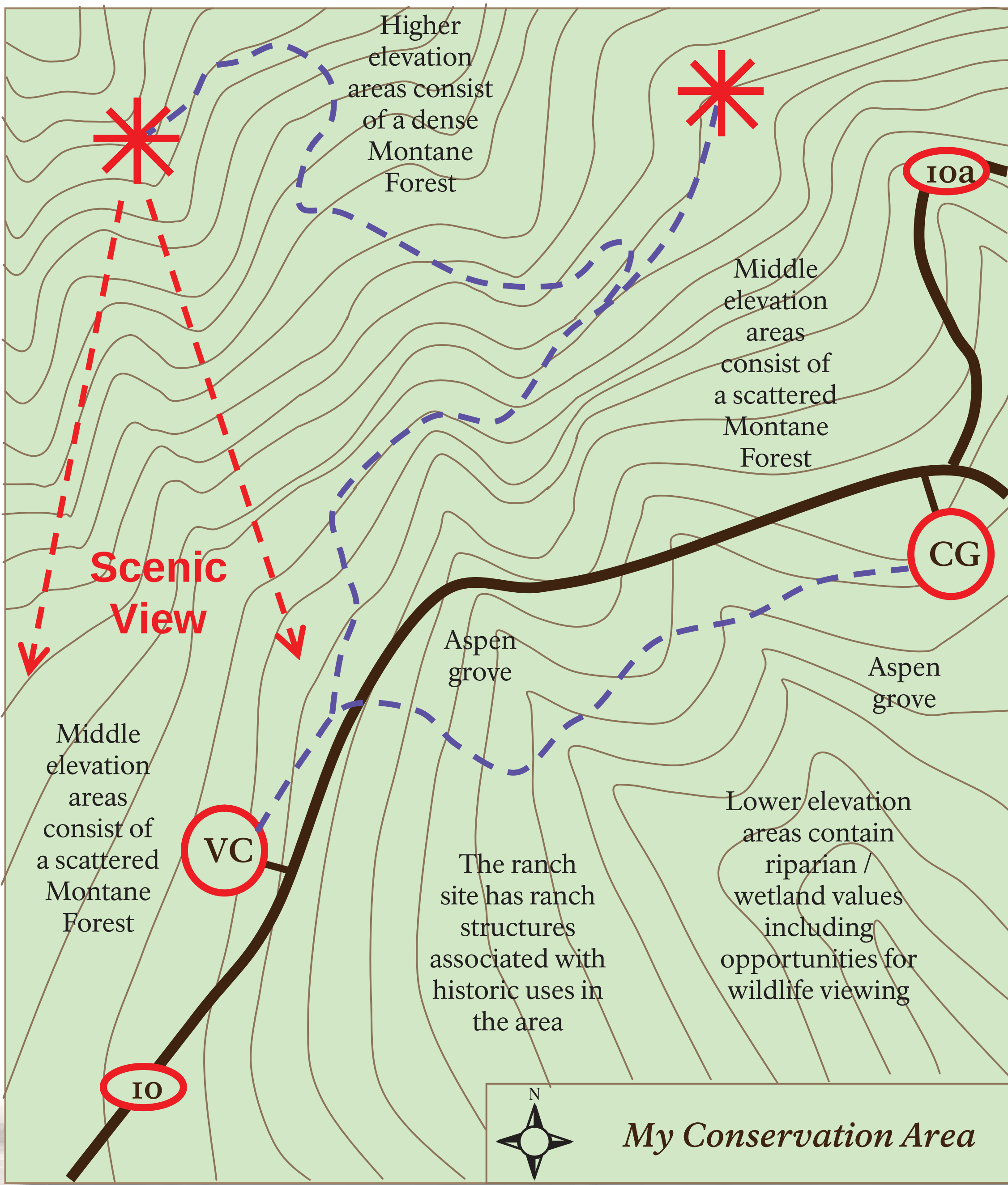
There is a scenic viewpoint which is taken advantage of.

Climate

Climate is semi-arid, with most moisture falling as snow from December through April totals 150 inches per year. Frequent summer thunderstorms occur, and can drop 1" of rain in just one hour. Frost depth is 40". Winds are from the northwest in winter and can be severe. Summer winds are predominantly from the southwest.

Geographic Context

This parcel is about 50 miles from major population areas, which invites year-round users. Local destination resorts publicize the area as a great place for weekend getaways and recreational activities. Now that the park has been open for several years, neighboring conservation land managers are also encouraging trail connections and increased trail use.



This parcel would be characterized as a Montane Forest and sits at the base of several mountains which rise to over 10,000'. There are several of Colorado's popular 13,000-foot peaks just a few miles away.

Ponderosa Pine is a dominant tree in this area, with scattered Aspen groves as well as scattered under story plants. Aspen groves host abundant wildlife and provide fall color viewing opportunities.

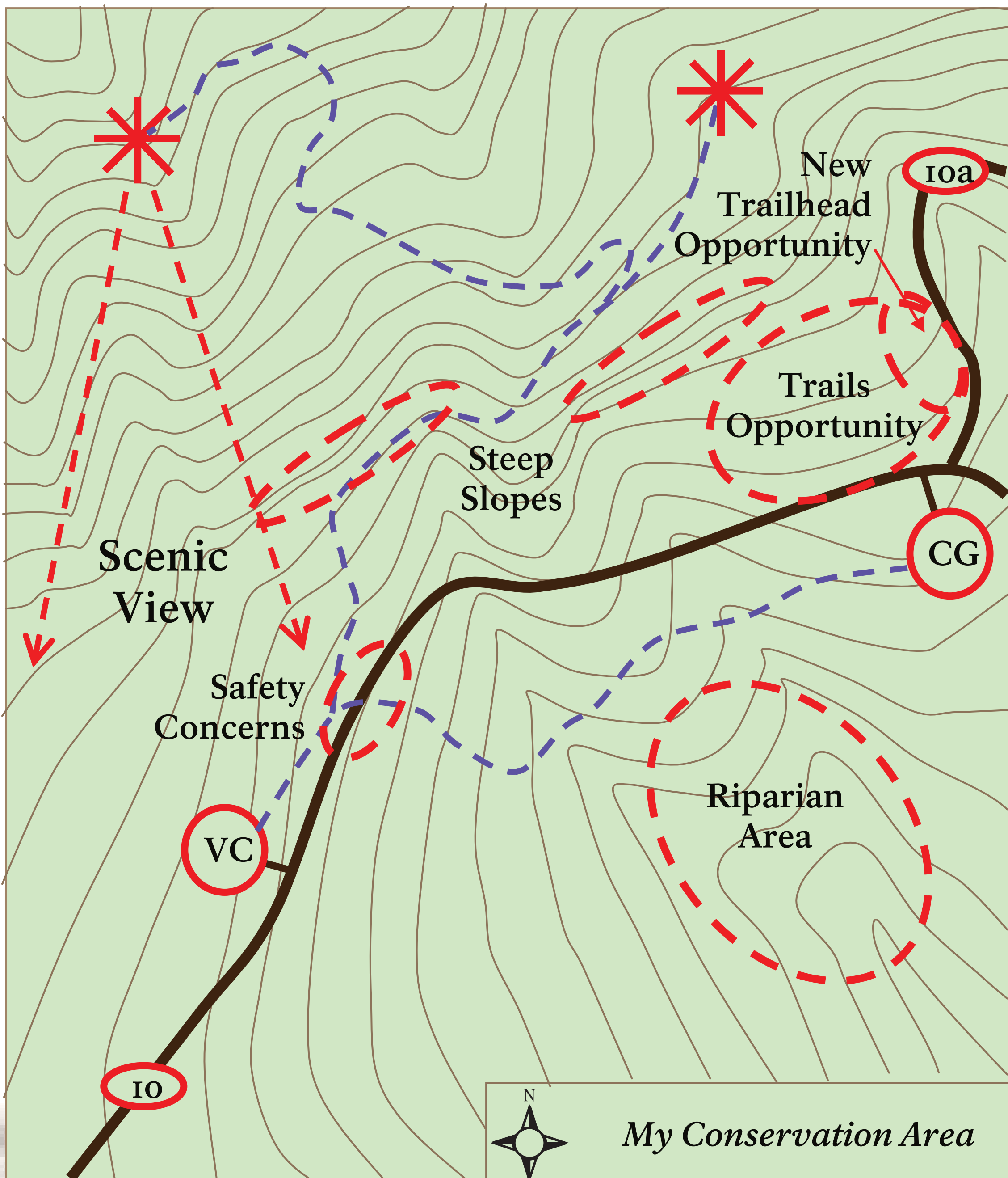
The Ponderosa Pine forest is mature, and park-like in nature, some stands are dense, some are scattered. It has not burned in over 100 years. On-site views are attractive due to the openness of some of the forest stands.

The landform is bold in nature but is dwarfed by the higher peaks nearby. Wetland values exist in the lower elevations of the site.

Off-site views are impressive, as the valley to the south is dramatic, with a clearly western flavor of hay fields and ranch roads.

Texture in the landscape is an important landscape characteristic to consider when planning mountain trails.

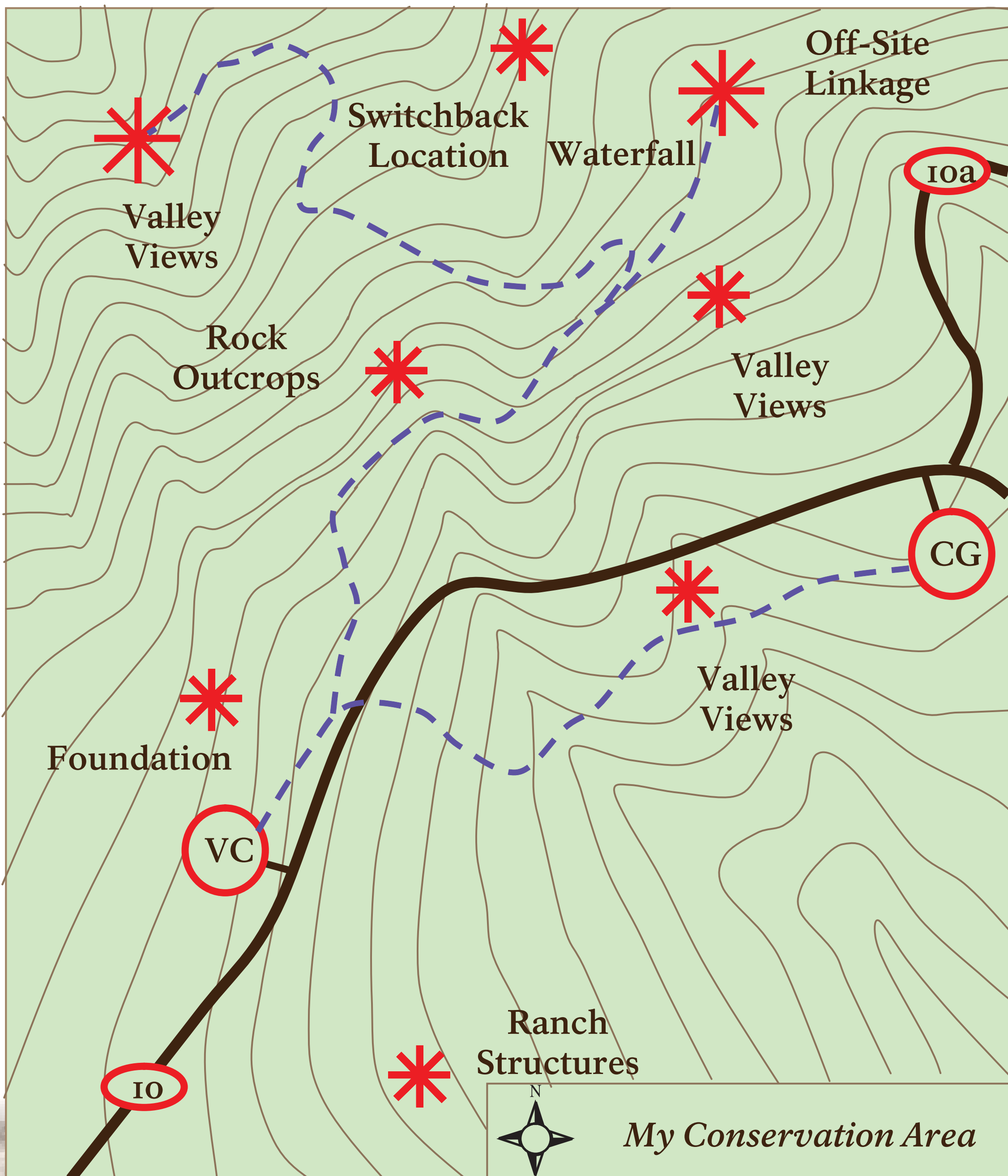
Annotated Area-wide Site Analysis



Summary

- Scenic views to the valleys and ranch lands below are to be capitalized upon.
- Steep slopes are to be avoided.
- County Road 10 is crossed in an unsafe location and the trail should be re-routed to a safer location.
- Neighboring land offers the opportunity for network linkages and there is a gentle slope where a new trailhead can be established.
- An opportunity exists to approach the waterfall from below, a more desirable observer location.
- Constraints, such as property boundaries, are not a concern in this project.

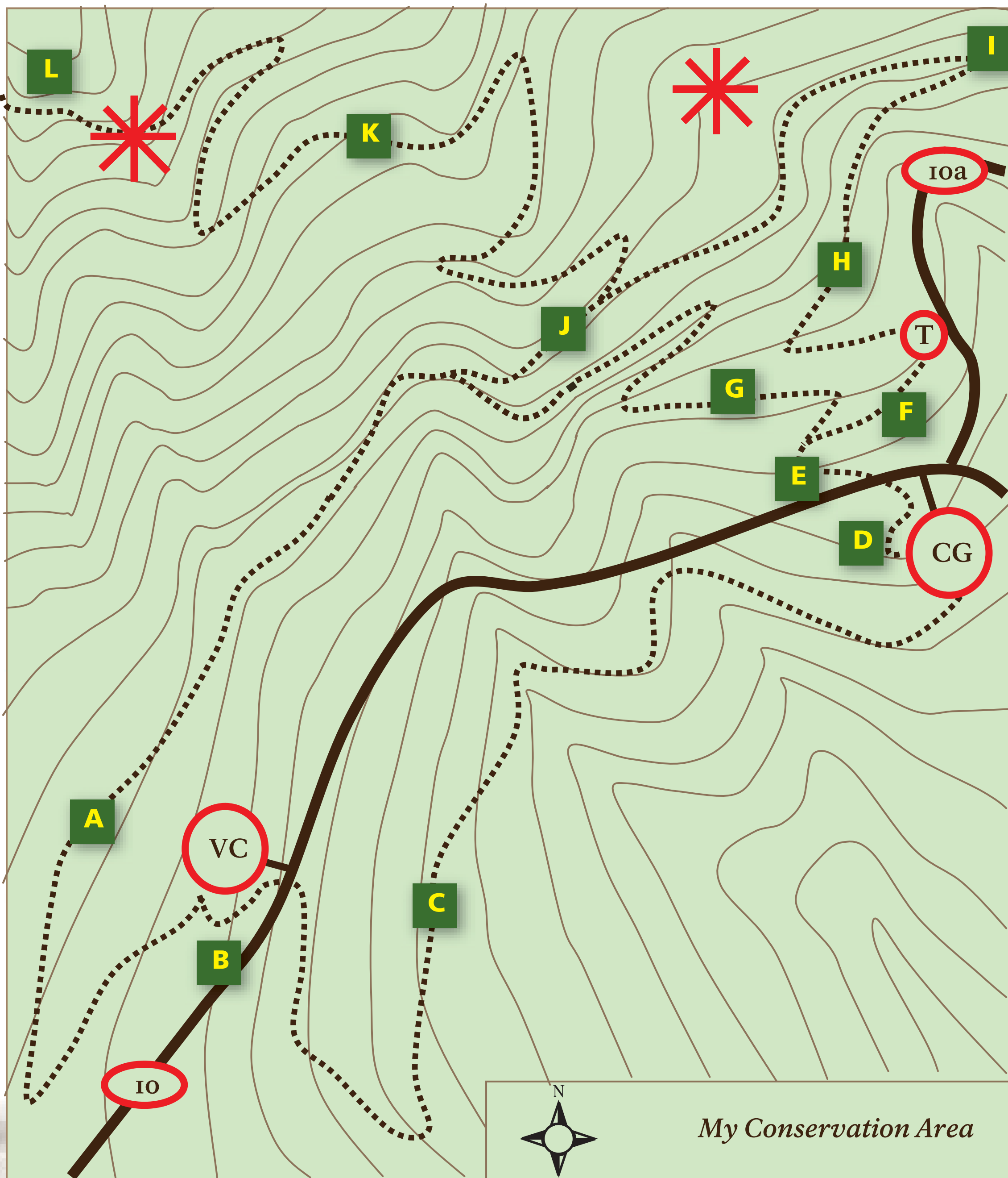
Nearly flat (< 20% prevailing cross slope) two-track ranch roads usually become muddy when converted to trails. They are inherently unsustainable.



Woodpecker snags or elk rubs may be desirable places to bring a trail. Scenic viewpoints have long been identified as desirable trail features to include along a trail. Cultural resource remnants, such as ranch structures and foundations may be desirable places to bring trail users. Rock outcrops, in this case, are corridor constraints, places to avoid. Off-site connections are key to successful network connections and increasing trails-related benefits.

Discovery of natural and cultural resource values strengthens the overall recreation experience, as is the case with this child and a woodpecker snag.

Mountain Trails Plan – Corridor C Summary



Trails that link appropriate origins and destinations with appropriate intermediary linkages form the basis of a mountain trail plan. Most of the identified corridor control points are accommodated in this plan.

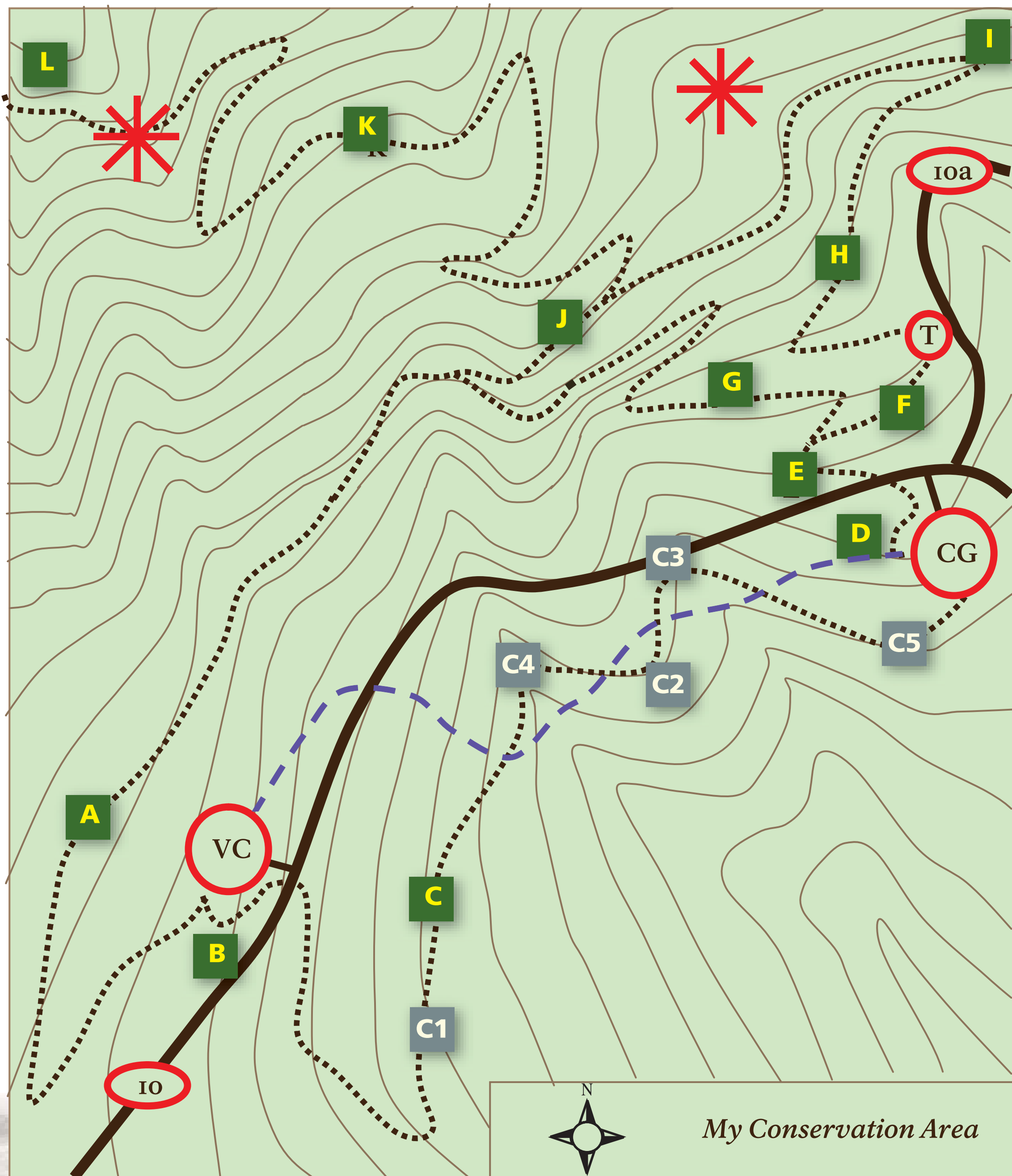
Establishing this plan allows resource professionals to have input into corridor locations, allowable uses, and potential resource impact determination.

Tabulating origins, destinations and linkages for each trail corridor, combined with describing the trail purpose, elevation gain, anticipated trail length, appropriate users types, and interpretive story opportunities yields the framework for the trail plan.

Corridor C (Example)

- Corridor C's origin is at County Road 10, traverses southeast to an appropriate switchback location, then heads north and northeast to its destination, the campground.
- The purpose of Corridor C is to provide multiple use access to the lower elevations of the park and to connect the visitor center and Corridor B with the campground.
- Natural characteristics of the predominant Ponderosa Pine forest as well as riparian features are to be preserved.
- The estimated length is 1.2 miles, with a vertical change of approximately 120 feet for an average profile grade of about 2%.
- Prevailing cross slopes are moderate.
- Appropriate uses are hiker and mountain bicyclist.
- Interpretive stories include cultural resource history, riparian values and forest ecology.

Corridor C Implementation Actions Sequence

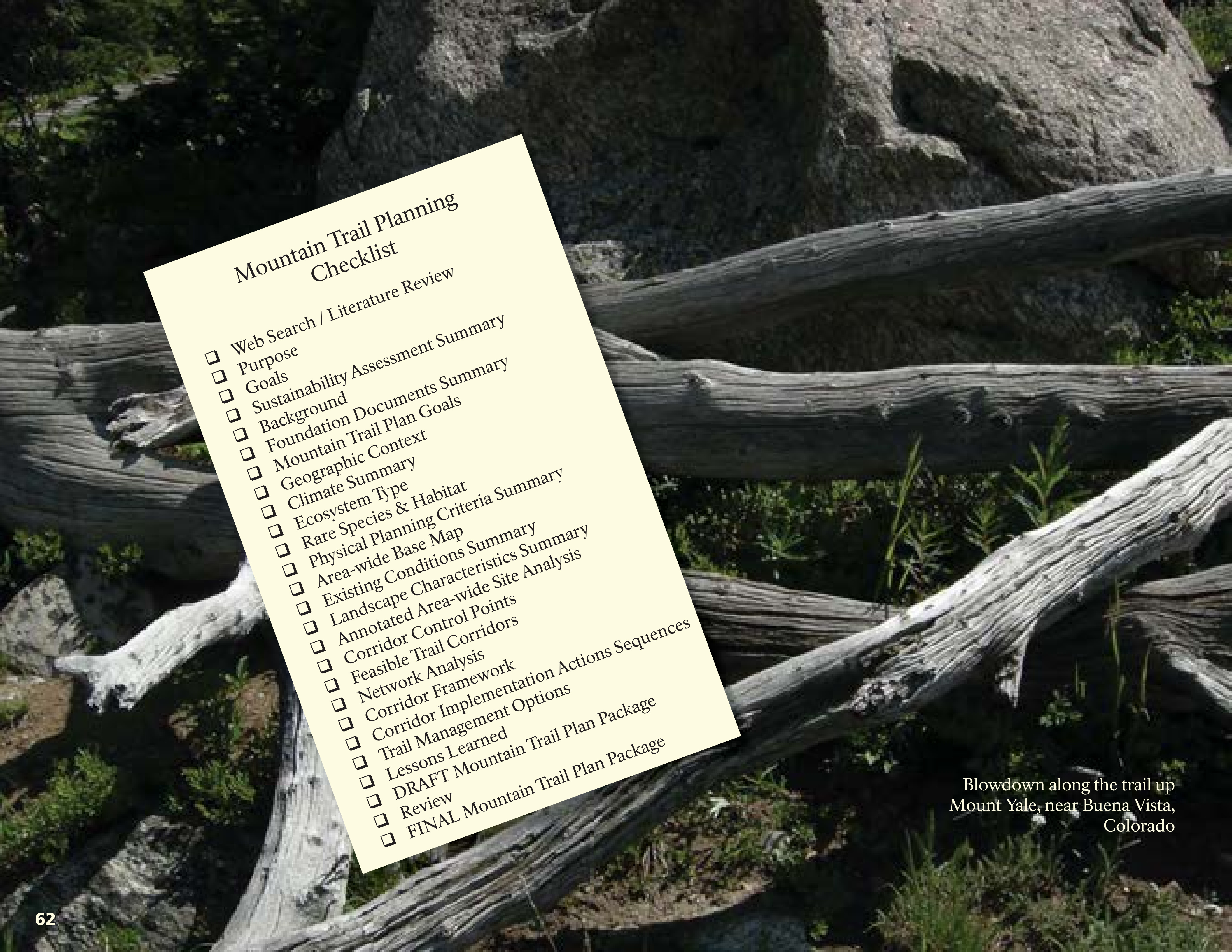


Patience is a virtue! Looking over a trails plan for trail needs, and prioritizing corridors and actions (C1, C2, C3, C4, C5) within sustainable corridors is a foundational ethic of sustainable mountain trails.

Outlining the needs of the priorities will yield insight into the appropriate crew skill level to carry out the task. Many times it makes sense to develop trails in a linear fashion, sometimes resources impacts or seasonal wildlife concerns may indicate the need to leap-frog some actions ahead of other segments.

Patience?

Knowing when trail corridors are unsustainable and must be relocated to sustainable sites, and having the patience to do so is the foundational sustainability ethic. Establishing a sustainable corridor and implementing it according to sustainable ethics is just the start of a long process. Spot improvements, maintenance, rehabilitation and some armoring are understood to be required in most corridors over long periods of time.



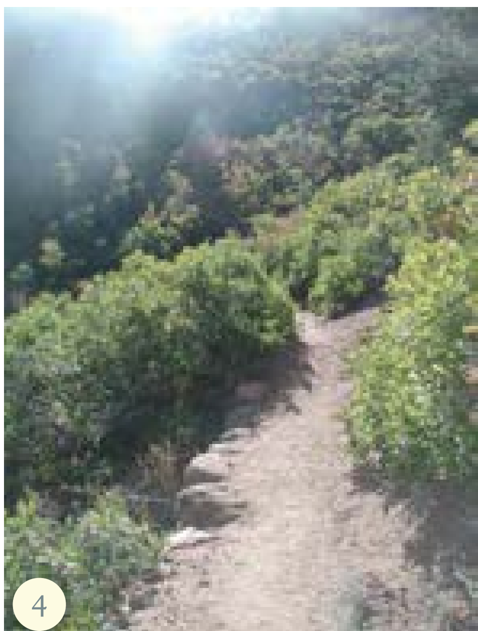
Mountain Trail Planning Checklist

- ❑ Web Search / Literature Review
- ❑ Purpose
- ❑ Goals
- ❑ Sustainability Assessment Summary
- ❑ Background
- ❑ Foundation Documents Summary
- ❑ Mountain Trail Plan Goals
- ❑ Geographic Context
- ❑ Climate Summary
- ❑ Ecosystem Type
- ❑ Rare Species & Habitat
- ❑ Physical Planning Criteria Summary
- ❑ Area-wide Base Map
- ❑ Existing Conditions Summary
- ❑ Landscape Characteristics Summary
- ❑ Annotated Area-wide Site Analysis
- ❑ Corridor Control Points
- ❑ Feasible Trail Corridors
- ❑ Network Analysis
- ❑ Corridor Framework
- ❑ Corridor Implementation Actions Sequences
- ❑ Trail Management Options
- ❑ Lessons Learned
- ❑ DRAFT Mountain Trail Plan Package
- ❑ Review
- ❑ FINAL Mountain Trail Plan Package

Blowdown along the trail up Mount Yale, near Buena Vista, Colorado

Basic Design

Carpenter Peak Trail, Roxborough State Park, Colorado



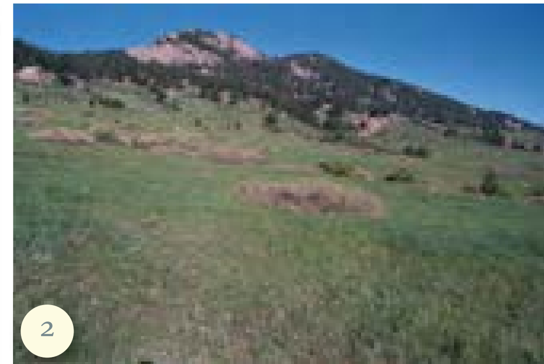
The Carpenter Peak Trail at Roxborough State Park, Colorado, was planned and implemented according to sustainability principles. The following basic design concepts are evident:

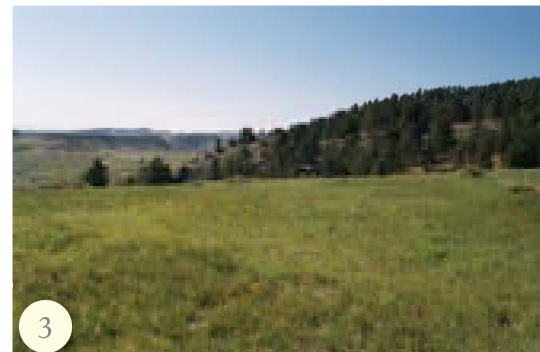
1. Seasonal color in the ground plane and curvilinear alignment create interest for the trail user as well as views of rock outcrops in the background
2. The form, line, color and texture of the trail matches the characteristic landscape qualities of the area
3. Foreshadowing of Carpenter Peak in the distance ... draws hikers upwards toward the peak
4. Atmospheric conditions create differing effects dependent upon time of day, moisture levels, and season or solar aspect
5. The Carpenter Peak Trail gently rises to reveal increasing observer superior position views of the "Red Rocks" Fountain Formation and Denver, Colorado in the distance

Characteristic Landscape Qualities

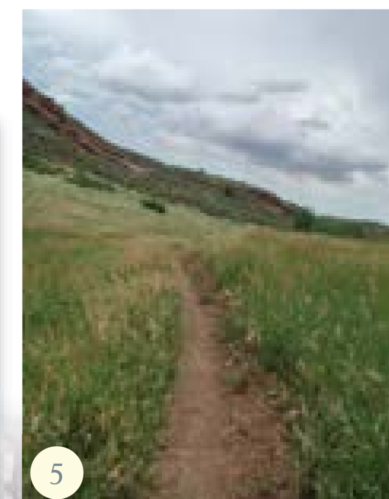
The most basic design inspiration for the interdisciplinary trail team is the naturally occurring form, line, color and texture of the characteristic landscape of the project area as evidenced by these photographs from Lory State Park, Colorado:

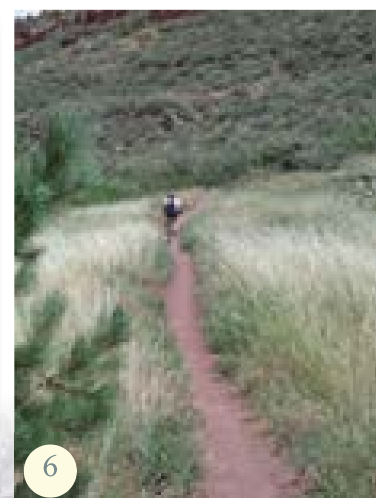
1. Continuously covered grasslands on gently prevailing cross slopes, scattered shrubs and dispersed Ponderosa Pine characterize where the plains meet the front range of Colorado
2. Arthur's Rock is the predominate topographic feature, rising above the surrounding grasslands and foothills
3. Expansive unimpaired natural scenes southward, northward and eastward inspire visitors
4. Trails gently rise and fall with the topography – lying lightly on the land – drawing their cues from the existing landscape forms and lines, without impact to existing shrub masses
5. The Dakota Hogback along the eastern edge of the park constrains the trail location, yet the trail still flows, rising and falling with the prevailing topography, offering unimpaired scenes for visitors to enjoy
6. Users of all types, hikers, mountain bicyclists and equestrians find the Valley Trails inspiring in their simplicity and subordination to the existing landscape





Valley Trails, Lory State Park, Colorado



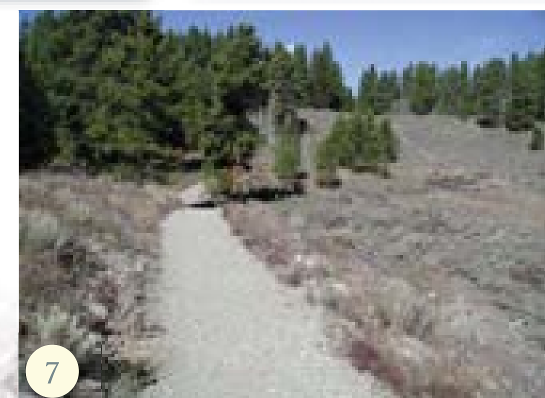


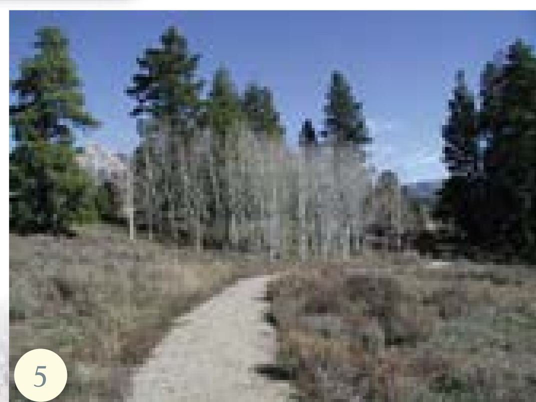
Design Principles

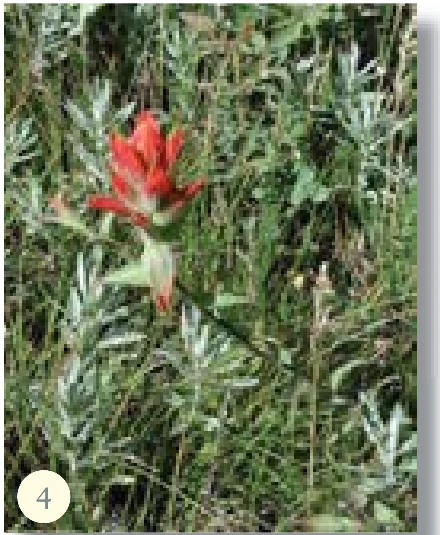
General design principles such as sequence, axis, and rhythm as well as design perception principles such as enclosure and openness, enframement and expanse, contrast and accent, dominance and codominance, harmony, variety and uniformity, convergence and divergence are all to be considered by the interdisciplinary trail team. The following are design principles incorporated into the Sunrise Vista Trail at Steamboat Lake State Park:

1. Leaving the Sunrise Vista Campground, the trail follows the Steamboat Lake shoreline ... what lurks?
2. Turning northward, trail users get their first glimpse of Hahn's Peak, a prominent peak in northwest Colorado
3. Then trail users are treated to an asymmetrically enframed view of Hahn's Peak
4. Soon, an expansive axial view – bisected by a curvilinear alignment – is framed by Aspen trees and Ponderosa Pine trees and Willows ….
5. Then a slight glimpse Hahn's Peak towards the north
6. Then finally a prominently framed view of Hahn's Peak to the north …
7. Before the Sunrise Vista trail turns into the forest for its journey towards the Steamboat Lake State Park visitor center

Sunrise Vista Trail, Steamboat Lake State Park, Colorado







Design Variables

Motion through the landscape, apparent light or darkness, atmospheric conditions, seasonal conditions, distance, observer position, scale and time would all be given consideration during design by the interdisciplinary trail team. A few design variables are displayed in these photographs:

1. Light and shadow play games with trail users, stimulating interest, creating new scenes, and movement throughout the landscape provides an infinite variety of scenes
2. Vivid and bold texture of this deciduous shrub is a short-lived sight
3. Cloud buildup above a mountain meadow subdues yet strengthens the presence of the meadow grasses and wildflowers
4. Close-up views of wildflowers are almost ephemeral to the trail user, sometimes lasting only a few days, but their presence is dramatic and memorable
5. Distant views of successive mountain ranges is screened by Lodgepole Pine tree branches creating an eerie appearance
6. Cloud cover is common on afternoons along Colorado's northern front range, with threatening summer thunderstorms common
7. Afternoon light shining through broken clouds creates light and shadow patterns that add interest to the scene

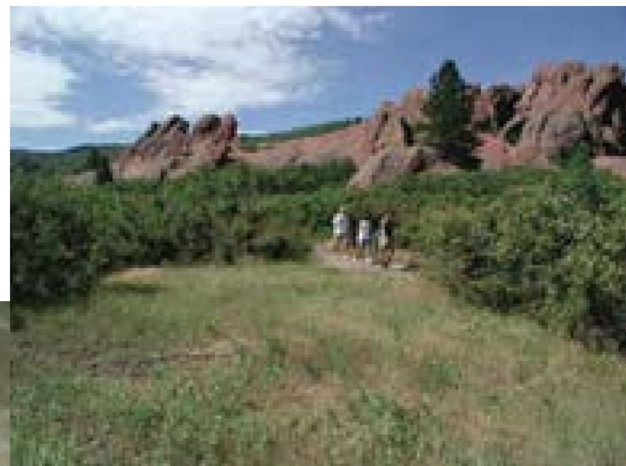
Green Ranch, Golden Gate Canyon State Park, Colorado

Fan Lake
Rocky Mountain National Park

This two-track road in Colorado's high country, like most old 4-wheel drive roads, will not support sustainable trail use and therefore should not be considered for new trail design. It is too steep and crosses the prevailing cross slope at too great an angle. Erosion gullies have already started to form.

Topographic map study is essential to successful new trail design.

Field notes are an important field work technique used to document trailside decisions and communicate design intentions to trail crews.



The Willow Creek Trail at Roxborough State Park benefited from a clean palette and is a successful example of new trail design. It was built by park staff and volunteers and is kept in sustainable condition with seasonal maintenance.

Field work is best accomplished by 2 people, and with the appropriate tools including a clinometer and a 100-foot engineer's tape.

Inputs

- Typical Inputs
- Outputs from Other Process Areas
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Establish Design Goals
- Base Map
- Topographic Map Study
- Slope Analysis
- Landscape Feature Analysis
- Annotated Site Analysis
- Establish Intermediary Control Points
- Alignment Design
- ¼ Cross Slope Criteria
- Apply Basic Design Principles
- Network Analysis
- Management Team Review
- Compliance Review

Outputs

- DRAFT New Trail Design Package for Review
  - Written Summary
  - Thumbnail Sketches
  - Drawings
  - Base Map
  - Analysis Summaries
  - Trail Corridor Plan
  - Typical Section
  - Typical Details
  - Armor Options
  - Custom Details
  - Trail Management Techniques
  - Actions Sequences
  - Checklists
  - Cost Estimates
  - Specifications
  - Lessons Learned Summary
- FINAL New Trail Design Package

New trail design on the Colorado Trail near Breckenridge, Colorado resulted in this curvilinear alignment.

New Trail Design Vision

Probably the most crucial step in constructing a trail is to line out the entire path from start to finish. – Guy Arthur, 1975.

Design

Design and construction of trails is a complex combination of skills and should be accomplished by experts. Experience in trail design, construction, and management is essential for implementing projects that involve poor soils, complex topography, high levels of use (especially when stock animals are involved), and extensive improvements, such as surfacing or structures. Experience is also essential to design multiple use trail corridors to meet standards that allow safe use of the trail. For consultation, contact regional or support offices, the Denver Service Center, or parks with significant trail programs. Trail organizations may also provide assistance. In addition to consulting experts in trail design and construction, it is important to consult experts in resource disciplines, if these are not available in the park. Two of the most common problems of backcountry trails, deterioration through overuse of popular trails and the development of undesired routes at popular destinations, can be avoided by drawing on personnel or outside experts with trail design and management experience and by following commonly accepted standards of trail design after thorough field study. Observing proposed or existing routes through several seasons, including winter, will assist the planning team in determining the fitness of new corridors for trail development, as well as the level of improvement or rerouting required to achieve sustainability for rebuilt trails. There are a variety of factors necessary for a sustainable, low-impact trail. By carefully fitting the trail profile to the local topography, erosion will be minimized, thus increasing the durability and sustainability of the natural surfaces.

– National Park Service Natural Resource Management Reference Manual # 77, 2006.

New trail design is a creative endeavor, and especially so in mountain trail projects. It involves the processes of identifying and determining the appropriateness of alternative solutions on the ground to ensure that they are buildable. It also involves the process of specifically determining what trail experience is intended for the trail user. Experience is the best way to accumulate good trail design skills.

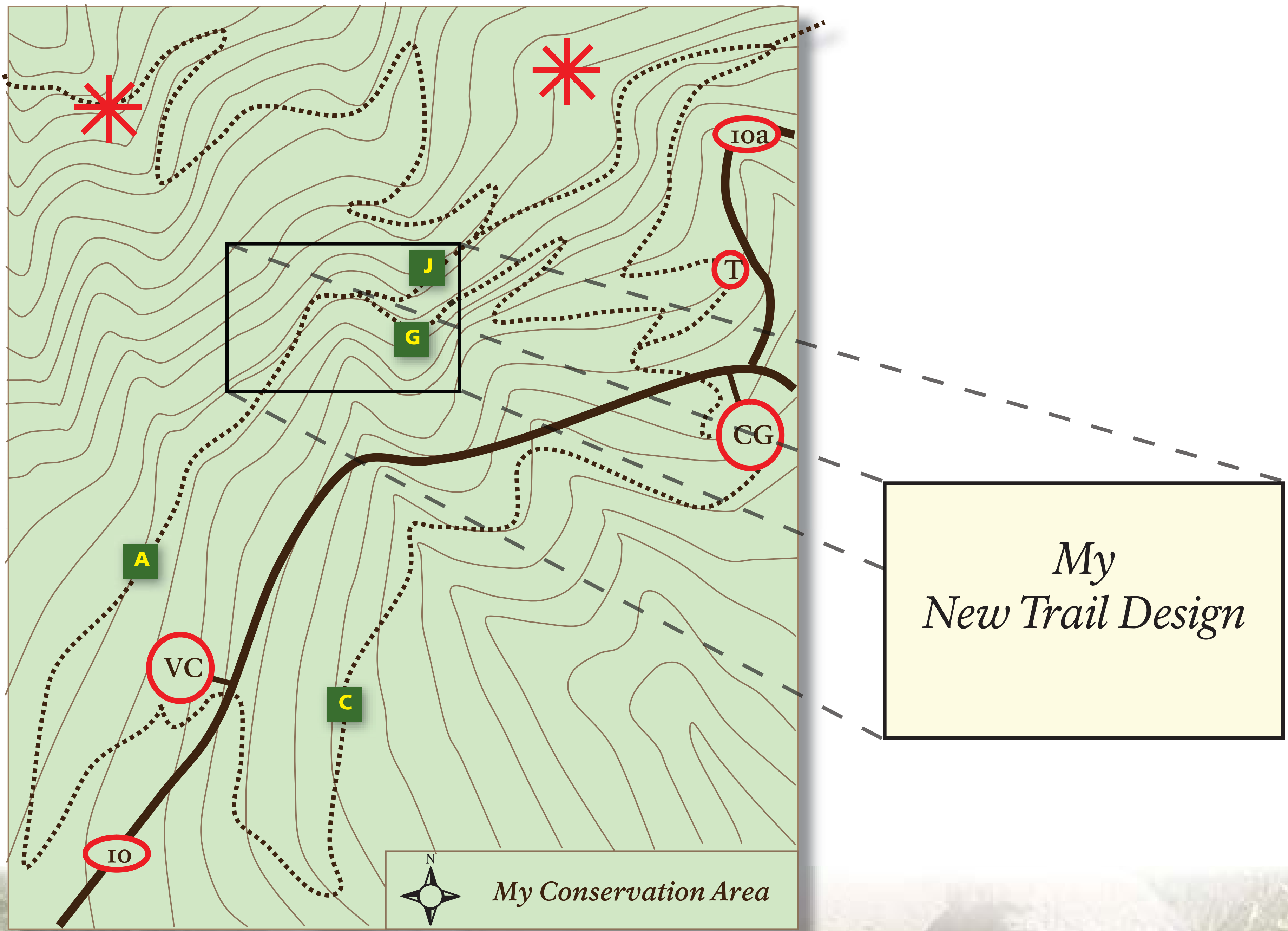
Design of multiple-use natural surface sustainable mountain trails must address the most stringent of the various design parameters. Hiking, equestrian, and mountain bicycling trails have very similar criteria, however equestrian uses have the most stringent criteria, that being the inside radius of a switchback.

Alignment Design Technique

Once the trail corridor has been established in a mountain trails plan, interdisciplinary trail teams must establish appropriate intermediary control points, develop the horizontal alignment and vertical alignments, stake the trail, and summarize the project for implementation.

Paramount to successfully developing horizontal and vertical alignments for the trail is an understanding of profile grades as well as physiology of the users of the trail. Construction staking defines the horizontal alignment of the trail. Many times, failure to accurately predict and describe the vertical alignment of the trail creates situations where impacts to resources occur because vertical grades are too steep for short sections of trails. It is therefore incumbent on construction crew leaders to ascertain design intent from the design notes and adjust the vertical alignment to the proper location during construction.

Many times not all acceptable solutions will exhibit the correct combination of prevailing cross slopes, predominant soils and acceptable profile grades. A balance of natural surface solutions and armor solutions must be achieved and designed into the project from the outset. See page 130 for more information on armor design.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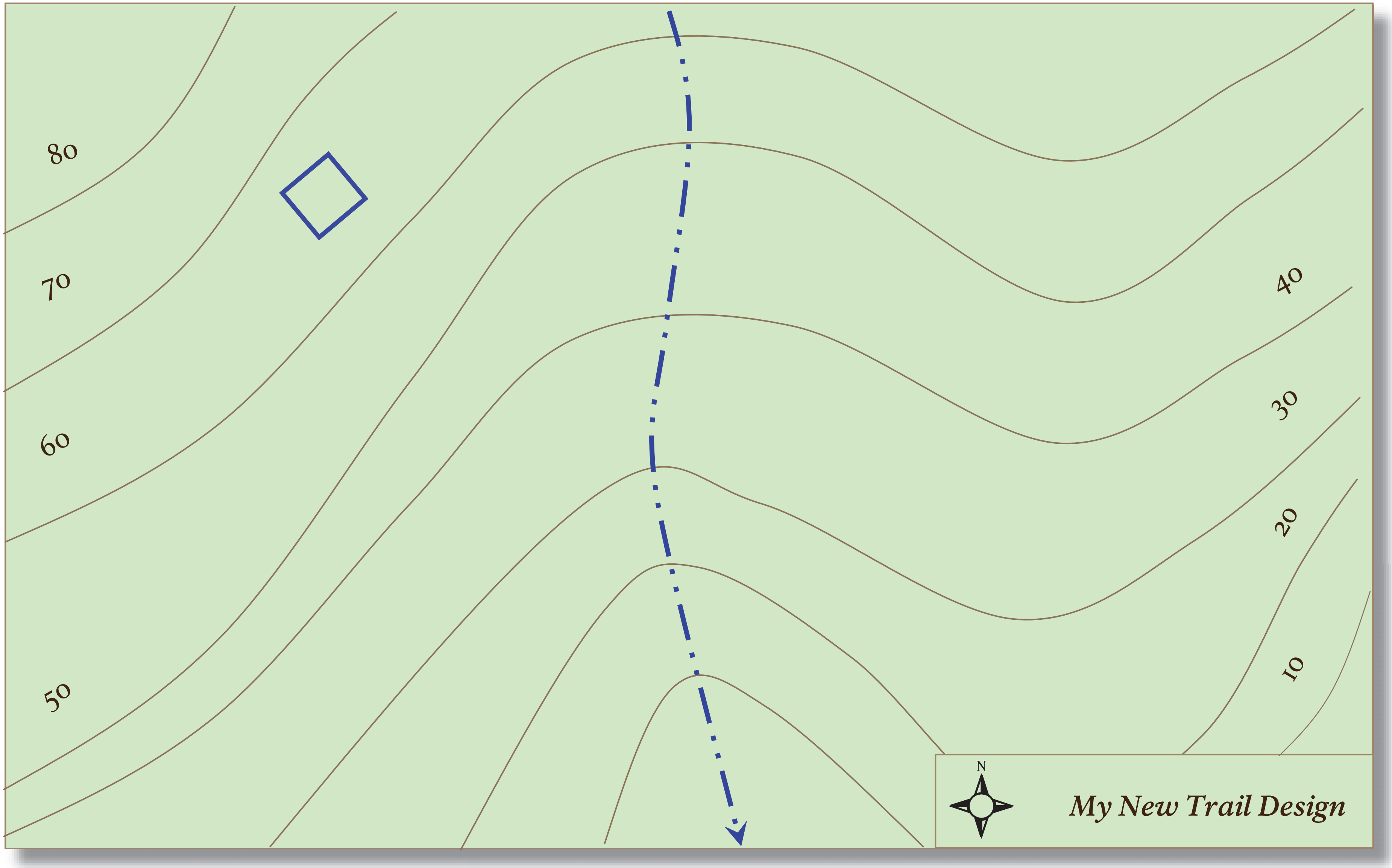
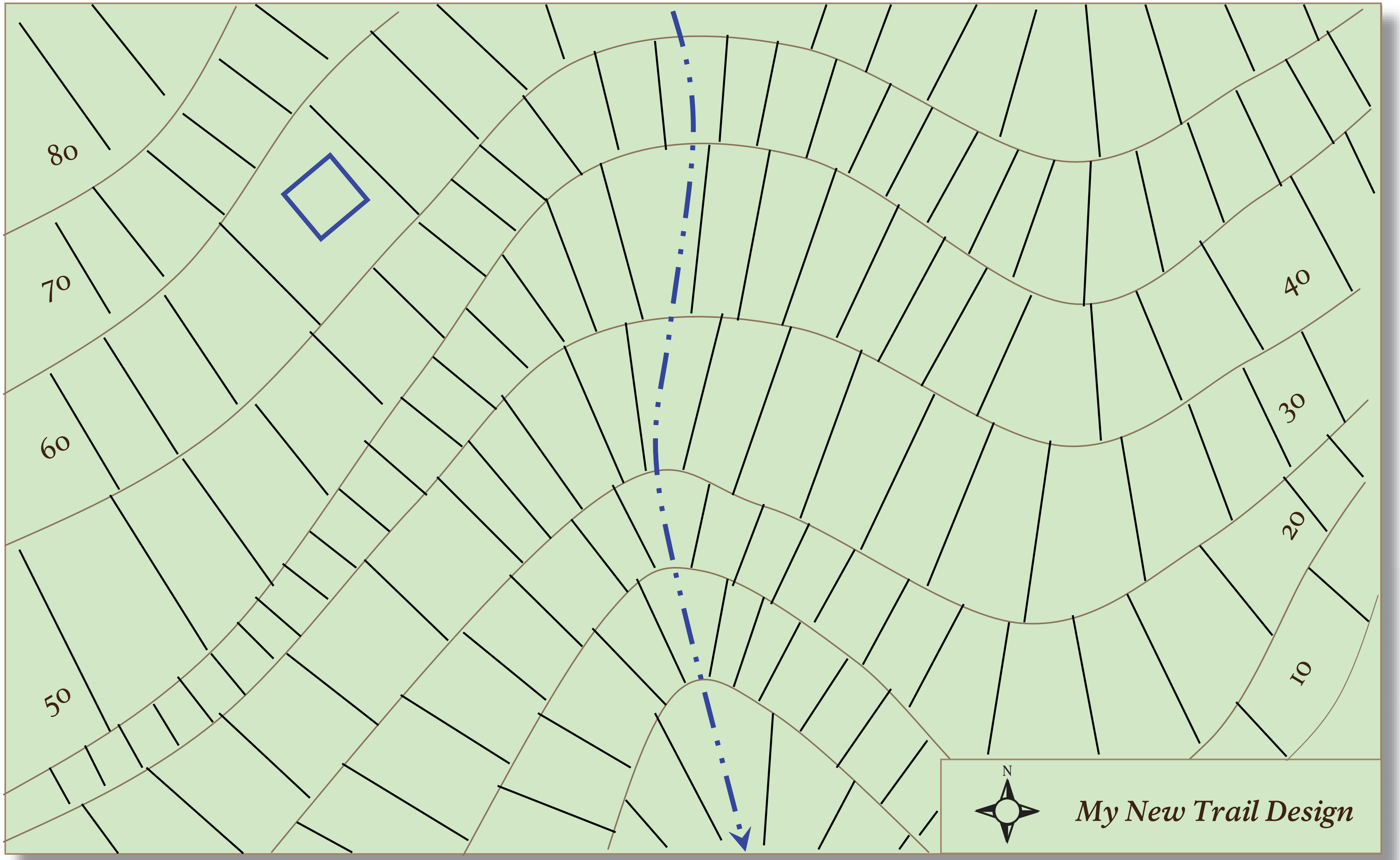
Example New Trail Design Outputs – Base Map / Existing Conditions Tool

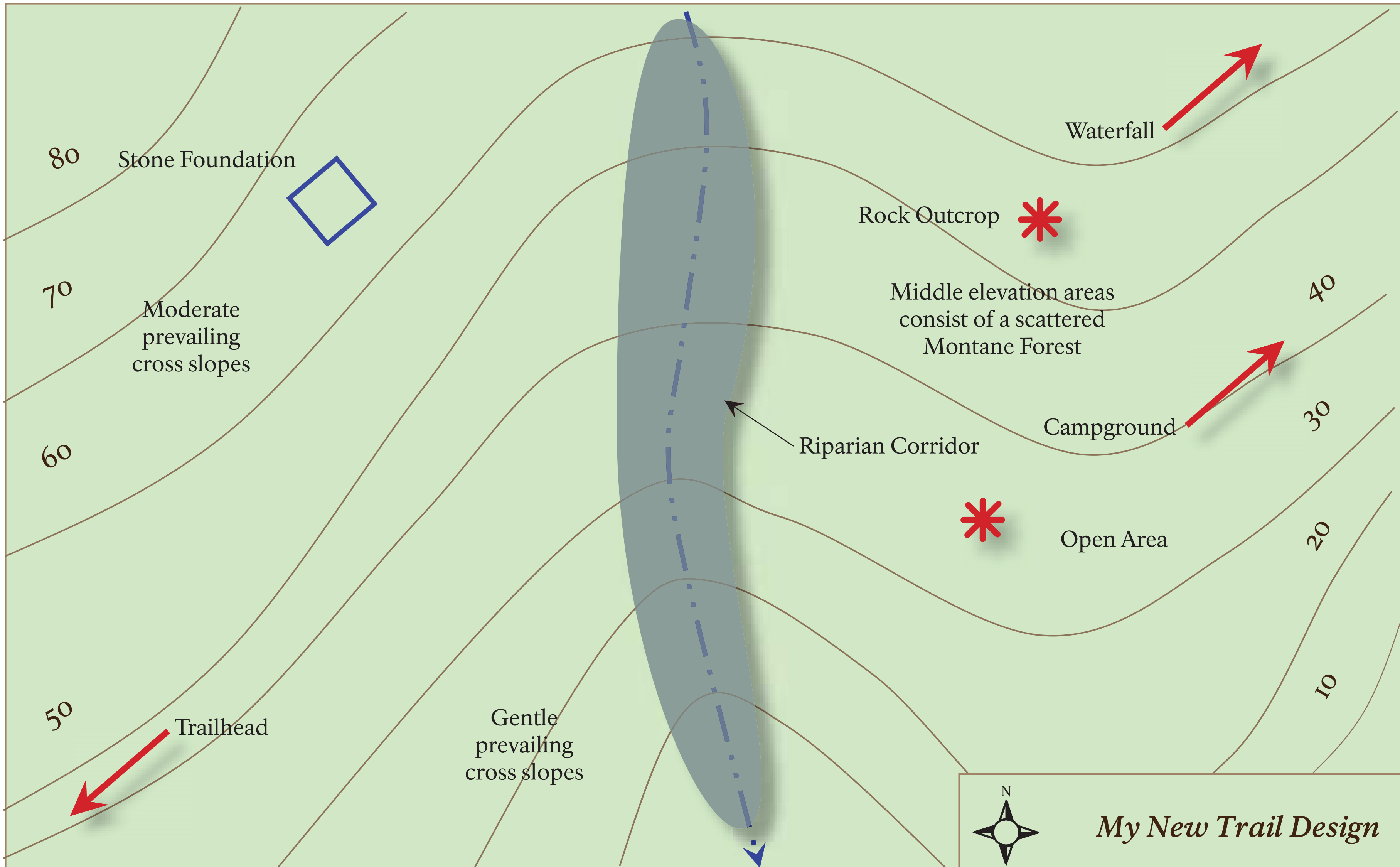


Creating a base map and mapping existing conditions enables the interdisciplinary trail team to record observations, share thoughts and exchange information.

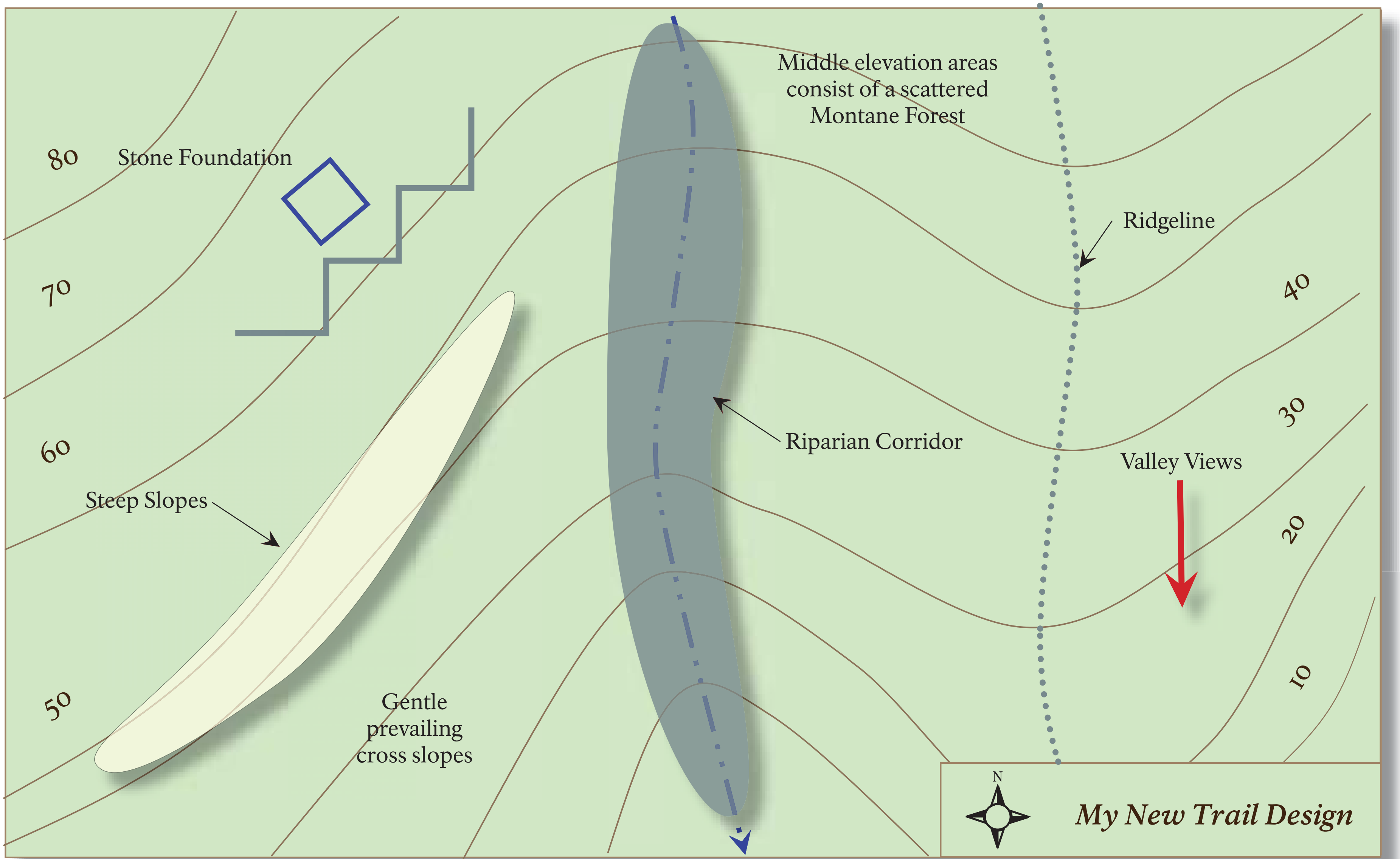


Slope analysis is the most fundamental landscape architectural site planning tool and will yield insights into the degree of modification required to fit a trail corridor to the ground. Steeper prevailing cross slopes require more investment of time and materials. Sometimes extensive armor improvements are required.

Landscape Feature Analysis Tool

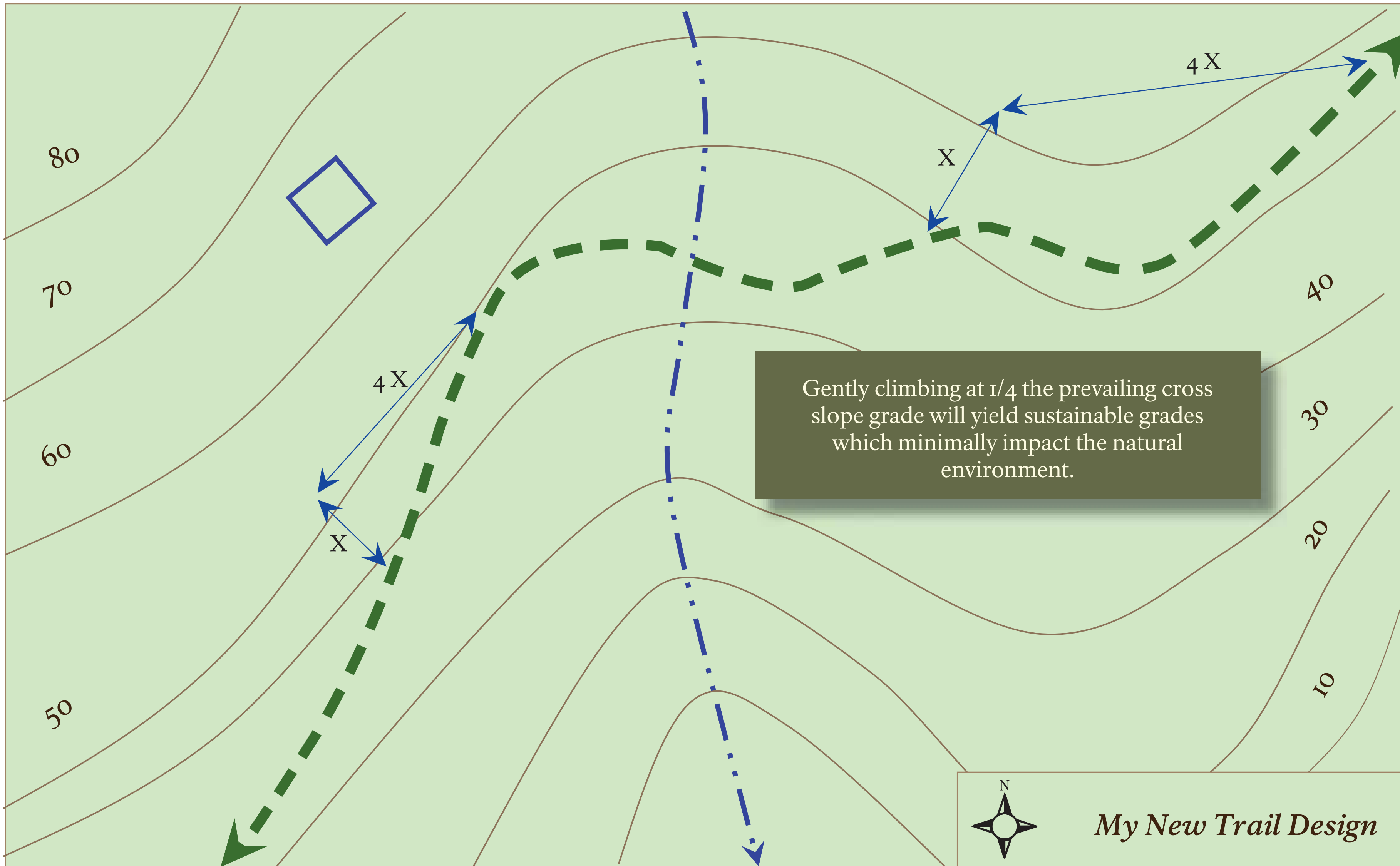


Landscape feature analysis records landscape features that are pertinent to the design at hand. Open areas may allow views, or on the contrary, may provide views to undesirable areas. Rock outcrops may be areas to avoid with a trail for novice hikers, and foundations may attract illegal artifact gathering.

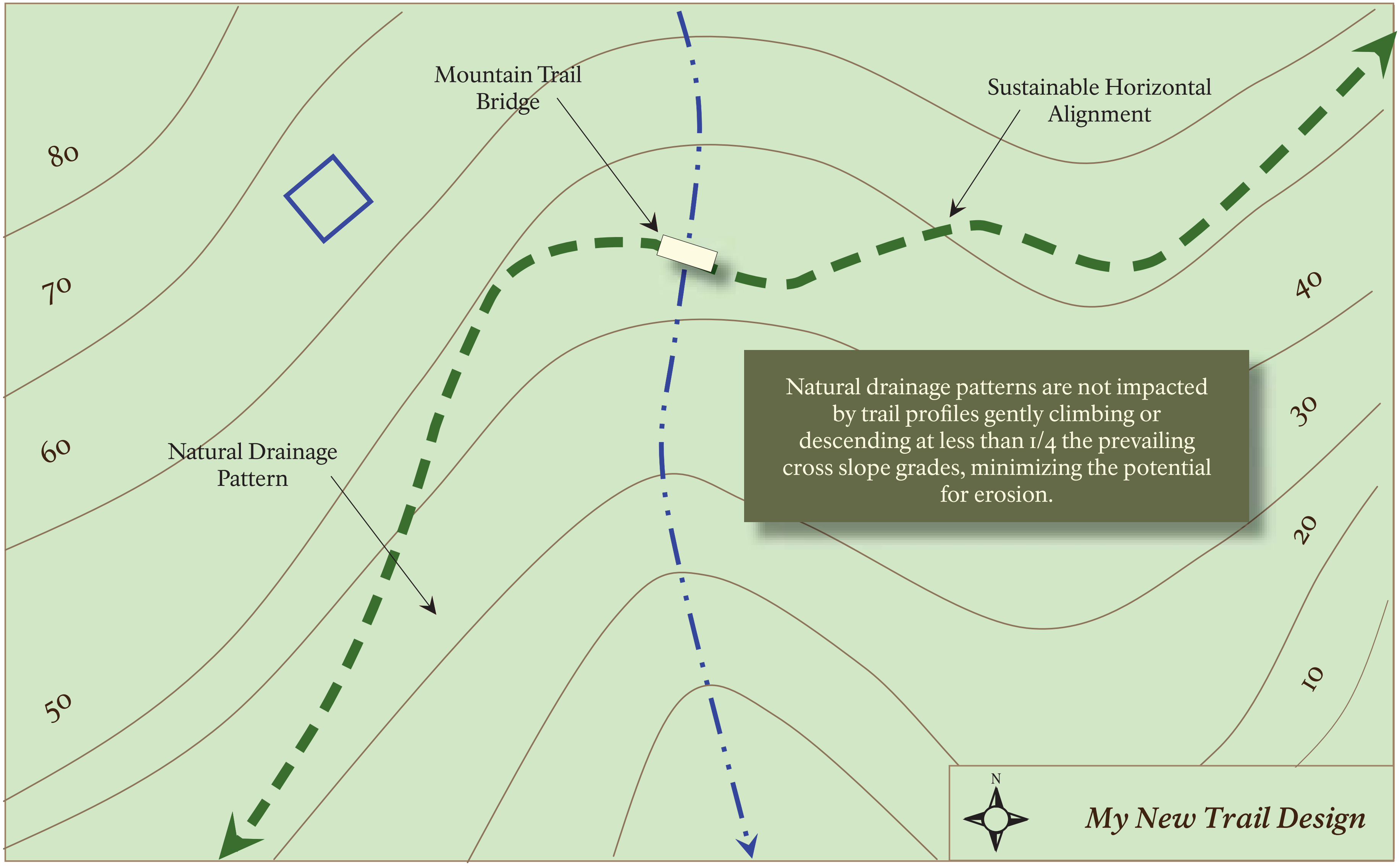


An annotated site analysis is a synthesis of the previous studies. It is used for communication of site opportunities (i.e.: valley views) and constraints (i.e.: steep slopes, stone foundation to avoid) amongst the interdisciplinary trail team and stakeholders. It is a powerful tool for management team and compliance review.

1/4 Prevailing Cross Slope Criteria Tool

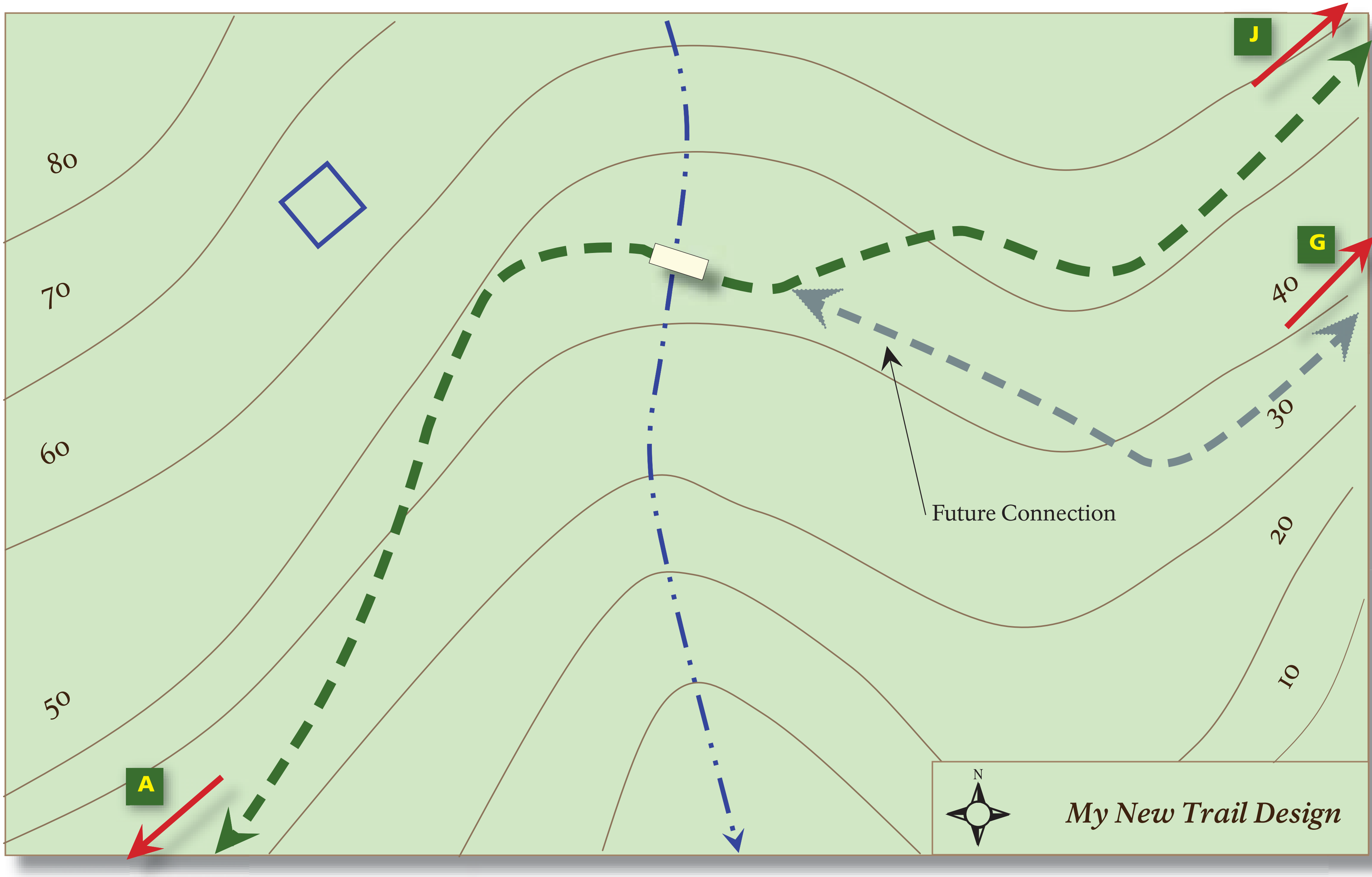


Using a pair of engineering dividers or a map tool from topographic map software, the interdisciplinary trail team can layout trail alignments on the base map by first measuring the prevailing cross slope (X) and extending out four times (4 X) parallel to the contour.



Sustainable trail design is built upon sufficient field work which investigates all opportunities for natural surface trails which obliquely, yet gently, cross contours while climbing or descending. Corridor control points and other significant investments, such as bridges, are located in permanent locations. Intermediary control points connect corridor control points.

Sustainable trail corridors, like the one in the sketch plan above, will minimally impact the natural processes of the area. Recreational use will not likely impact natural resources as much as natural processes (rainfall, runoff, snowmelt runoff, and wind) will after initial impact is created by human traffic, in any form.



Once one corridor's alignment is confirmed, the interdisciplinary trail team must study future connections to ensure that future opportunities are not precluded by decisions made for the current project. This ensures sustainability of the trail network, not just one trail corridor.

New Trail Design – Design Notes Example

Station	Cross Slope % (Left)	Cross Slope % (Right)	Trail Profile Grade (%)	Azimuth	Soils	New Trail Design Notes
0+00	0%	0%		108d	Good	Begin Clearing D, Begin Tread Cut 1, Width = 36 inches.
			3%			
1+00	0%	10%		120d	Good	Install Trail Drains A on downhill side at 1+40, 1+75 at low points.
			8%			Note: Good source of stone in this area, uphill from the trail.
2+00	35%	40%		125d	Good	Begin Tread Cut 2 at 3+75.
			12%			
3+00	30%	35%		120d	Good	3+50 Begin Retaining Stone Wall (2' H X 10' L).
			7%			
4+00	45%	55%		120d	Good	Begin Tread Cut 3 at 4+00.
			6%			
5+00	45%	50%		125d	Good	Install barriers 1 and educational signage 2 for the restoration area.
			7%			

Tread Cut Options	Prevailing Cross Slope (%)
1	0 – 20%
2	20 – 40%
3	40 – 60%
4	60 – 70%
5	> 70%
6	Crowned Trail
7	Tread Cut with Ditch

	On-Trail Management Options - see p. 133.
1	Barriers
2	Educational Signage
3	Directional Signage
4	One-Way Routes
5	Clockwise / Counterclockwise Routing

Corridor Clearing Options	Height (H)	Width (W)
A	8 Feet	6 Feet
B	8 Feet	8 Feet
C	10 Feet	6 Feet
D	10 Feet	8 Feet
E	10 Feet	10 Feet

	Trail Drainage Options
A	Trail Drain
B	Swale Crossing
C	Paved Dip / Stone Paving
D	Stepping Stones
E	Stone Waterbar
F	Stone Drains

	Mountain Trail Bridge Options - see p. 99.
1	Simple Foot Log
2	Log with Handrail
3	Foot Traffic Only
4	Multiple Use
5	Boardwalk

New Trail Design Checklist

- ❑ Web Search / Literature Review / More Tools
- ❑ Sustainability Assessment Summary
- ❑ Mountain Trail Plan Summary
- ❑ Distance From Trailhead
- ❑ Corridor Base Map
- ❑ Existing Conditions Summary
- ❑ Characteristic Landscape Qualities Summary
- ❑ Slope Analysis
- ❑ Trail Profile Grade Calculations
- ❑ Annotated Site-Specific Site Analysis
- ❑ Intermediary Control Points
- ❑ Action Sequences
- ❑ Trail Management Options
- ❑ Lessons Learned
- ❑ DRAFT New Trail Design Package
- ❑ Review
- ❑ FINAL New Trail Design Package

Cherry Creek
Castlewood Canyon State Park
near Franktown, Colorado

Native seed collection is a common practice that provides locally adapted plants for revegetation efforts.

Transplanting plugs is a common grassland and alpine restoration technique.

Barriers are an effective way to stop unwanted trail use. This buck and rail barrier at Lory State Park was moved many times to newly restored areas as new trails were developed.

Educational signage is an effective way to keep users off of restored areas. “Closed for Restoration” is an effective message on such signs.

Inputs

- Typical Inputs
- Outputs from Other Process Areas
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Web Search / Literature Review / Science Review
- Establish Restoration Goals
- Site-Specific Site Analysis
- Microclimate Analysis
- Estimating Techniques
- 4-Step Restoration Design Strategies
  1. Closure Strategy
  2. Stabilization Strategy
  3. Revegetation Strategy
  4. Monitoring & Evaluation Strategies
- Compliance Review
- Funding Strategy
- Management Team Review
- Compliance Review

Outputs

- DRAFT Restoration Planning Package for Review
  - Written Summary
  - Plan Drawings
  - Typical Sections
  - Typical Details
  - Custom Details
  - Cost Estimates
  - Materials List
  - Labor Estimates
  - Specifications
  - Trail Management Techniques
  - Actions Sequences
  - Checklists
  - Lessons Learned Summary
- FINAL Restoration Planning Package
- FINAL New Trail Design Package

Accomplishing restoration activities parallel to new trail design activities communicates a sense of responsibility towards resource stewardship.

Restoration of impacted areas is a required component of trail closure and relocation projects to restore impacted areas to a healthy condition. By developing restoration planning activities for abandoned or impacted trails on a parallel schedule with new trail design, users benefit from reduced confusion, increased landscape aesthetics, and well managed natural resources.

In areas where multiple social trails exist, closing and restoring those trails helps protect natural resources by

- Reducing habitat fragmentation
- Maintaining adequate soil moisture levels on site necessary to support natural plant communities
- Creating a self-sustaining plant community that will protect the restored site from excessive soil erosion and provide wildlife habitat

Well defined trails prevent off-trail impacts such as soil compaction. Unplanned social trails often experience high rates of soil erosion. The result is often trail braiding, trail widening, and deep erosion gullies (up to 4 feet deep and 80 feet wide in some areas of Colorado's alpine ecosystem). Mere closure of these areas is often not adequate to promote natural revegetation to occur.

Restoration activities create conditions that hasten the recovery process leading to a self-sustaining plant community in disturbed areas.

Restoration of impacted sites helps create a self-sustaining plant community that has the ability to withstand a wide range of environmental variability. As such, a practitioner does not attempt to recreate a plant community with one set of treatments but rather works to determine an adequate level of treatments necessary to start the impacted area on a natural path to recovery.

Ecological Restoration

Restoration has been defined as the practice of re-establishing natural ecosystem processes responsible for that ecosystem's form and function, including major biotic and abiotic components, on lands where these forces have been interrupted. When land managers take direct action to restore a site, this is referred to as active restoration. Passive restoration relies on management policy and other indirect options as a means of restoring the desired condition. For social trails that have experienced minor impacts, the site could be restored passively, by merely closing the social trail, providing an alternative trail, and installing barriers and educational signage.

The damage on many public lands in Colorado is often to a higher level of impact, requiring active restoration to achieve conservation goals. Complete loss of native soil and vegetation, and disruption of hydrologic patterns is all too frequent and regrettable. Cognizance to potential impacts of inappropriate trails throughout the trail project cycle and applying lessons learned at the completion of each project or phase will prevent avoidable impacts.

In a healthy Ponderosa Pine ecosystem a diversity of wildflowers and grasses flourish, providing cover and food for a host of insects, birds, and mammals. Blue penstemons and yellow western wallflower provide hikers with a great treat in summer!

Why Restoration?

In most trail projects, a common goal is to reduce the number of social trails that exist in the area. However, creation of a sustainable trail is yet another disturbance to the landscape. In order to mitigate this disturbance, and reduce the overall effect of trails on the landscape, land managers are obligated to restore all closed trails to a state that sustains a cover of native vegetation and reduces erosion.

It is difficult to appreciate the value of an ecosystem until land managers attempt to restore impacted areas to natural conditions. In fact, many citizens demand restoration be part of natural resource projects and dedicate their time as volunteers to implement restoration projects. Restoring social trails to natural processes and conditions can improve water drainage patterns, rebuild the contour of the slope, reduce habitat fragmentation, and create a self-sustaining plant community.

Funding Strategy

Grant funds are available for restoration activities from local and national foundations as well as government agencies. Many trails grant programs also provide funding for restoration activities associated with trail implementation projects. Volunteer labor is a great way to provide stewardship opportunities for the public, and a great way to match grant funds.

Cost estimates for restoration vary depending on the level and extent of disturbance, desired restoration goals, and whether or not volunteers are utilized to complete the project.

Goals

Restoration goals often include stabilizing slopes, recreating a natural plant community, and achieving visual closure of social trails. Besides the conservation goals associated with restoration projects, a common social goal is to maintain landscape aesthetics. This is especially important in federally designated wilderness areas and other sites where management goals are established to enhance the quality of the recreational experience. An additional goal may be to facilitate research aimed at improving the understanding of restoration ecology or the practice of restoration.

Overriding goals for restoration projects include
- Determine the extent and level of damage
- Determine the appropriate levels and types of restoration treatments to apply
- Calculate time estimates and material requirements for completing the project
- Prioritize restoration work items and sections to ensure that work will be completed according to project goals and timelines
- Establish a system for monitoring effectiveness of treatments. This usually includes before and after photos, but may also include monitoring transects and / or plots

Restoration Planning

Field work is necessary to determine labor and material requirements of the restoration project. Breaking down each project into individual restoration sites facilitates site-specific designs. The sites often correspond to a distinct social trail, a lengthy braid of a given trail, a unique plant community (i.e.: a riparian area), or other unique feature of a specific trail.

Before developing detailed restoration notes, it may be helpful to walk the entire project or segment to become familiar with all the types of disturbance and to list and map what on-site resources are available, such as Willows, salvageable topsoil, downed timber, and stone.

Restoration Planning Tools & Techniques

- Assign priorities to each work item.
- Take pre-project photographs and describe their location and what they are depicting.
- Develop a site naming convention that is easy to interpret by implementation crews.
- Record the grade and aspect at a frequency (i.e.: every 100-foot station) that meets site requirements and research needs.
- The plant community should be noted at a frequency that meets site needs and research needs. This information is useful to characterize the site and provide a suggested list of plants available for crews during revegetation efforts. Plant species should be listed in order of abundance or dominance in each section (based on general observation).
- General information about soil conditions (i.e.: level of erosion, soil compaction, loss of topsoil, general soil type) should be recorded if possible.

Prioritizing Restoration Treatments

Prioritizing restoration treatments and sections within a project allows the interdisciplinary trail team to more effectively allocate limited resources. Several factors are considered when assigning priorities to work sites and work stations within a site:

- The level of disturbance
- Whether the site continue to degrade if no action is taken
- Visibility of the site from nearby trails
- Available monetary and material resources
- The goals of the land management agency

Items left to passive restoration are best monitored over time to determine if additional restoration is needed at a later date to achieve management goals. Coordination with the trail design team is necessary to determine which restoration sites and sections should be prioritized for completion during the concurrent project season. These project level priorities are based on available resources, coordination of site resources (i.e.: turf transplants and topsoil generated from new trail construction), and land management goals.

Customizing field work and field notes particular to the restoration planning process will assist volunteers with restoration implementation activities which will help restore natural conditions and processes to the landscape.

Volunteerism & Restoration Projects

Restoration treatments are well suited to nonprofit agencies and / or individual volunteers whose mission is compatible with restoration ecology. Restoration projects usually are repetitive in nature and usually can be accomplished by novices while still achieving high quality results. Highly trained staff should be responsible for doing the most difficult restoration work, while volunteers are employed to complete revegetation work, check dams, and other less-technical restoration work when appropriate. Seed collection and seeding, which takes place in the fall, can usually be completed by volunteers led by trained staff.

The Willow Creek Trail provides a recreational respite for urban and suburban visitors to Roxborough State Park, Colorado. This location was an impacted area which has now been restored.

Restoration Implementation

Restoration implementation generally occurs at the same time as new trail implementation. Before restoration activities are implemented, it is best if the project manager coordinates with field staff to ensure that salvaged topsoil and vegetation resources from trail implementation are made available for restoration. The timing and amount of these resources are crucial to minimizing restoration efforts and maximizing results.

The restoration planning summary package is put together after the project is designed, the site conditions are adequately analyzed and characterized, and labor and material requirements are determined. The goal of the plan is to provide an understanding of the level of restoration to be accomplished on the site, as well as a schedule for completion. To develop an effective restoration plan

- Address existing land management goals and objectives
- Provide an introductory project summary
- List materials to use, especially if non-standard
- Explain how the plan mitigates legislated wilderness or other special management concerns
- List species of concern that will be protected by the project
- Summarize labor and material needs
- Include baseline (i.e.: pre-project) photographs
- Describe the restoration techniques to be employed
- Include a general site description for each restoration site on the project
- Develop actions plan sequences and actions notes sequences, their timing and assign responsibility for each action

4-Step Restoration Planning Strategies

The following four steps to successful restoration will assist land management agencies and interdisciplinary trail teams in achieving project success.

1. Closure Strategy

As long as users continue to use restored areas, erosion control and revegetation goals will be hindered. Physical structures, such as barriers and debris disguise, in conjunction with educational signage are necessary to keep hikers off of a restored area.

2. Stabilization Strategy

Stabilization of eroding social trails is often achieved by installing check steps, wattles or stone retaining walls. Diverting water off the trail, by means of outsloping, stone waterbars, and trail drains, is another way to reduce erosion. Installing erosion matting, especially associated with seeding, is another way to control erosion. Physical structures and erosion matting are only short-term means of controlling erosion. Within 1-5 years many erosion control structures will become full. If adequate vegetation cover is not achieved in this time frame erosion will continue between erosion control structures and many structures will begin to deteriorate. Erosion control matting is also subject to rapid deterioration (2-3 years), and adequate vegetation cover must be achieved in this time period to control erosion over the long-term. Regardless of the techniques used, adequate vegetation cover is the only means to achieve long-term erosion control and should be integrated with all erosion control structures.

3. Revegetation Strategy

Once erosion is addressed, revegetation treatments can be applied to achieve long-term slope stabilization and develop a self-sustaining plant community. Revegetation can be accomplished using transplants (nursery stock, vegetation plugs, or turf blocks), seeding (preferably native seed), cuttings (Willow stakes or wattles), or a combination of these. It is important to use the correct plants for the site (i.e.: don't use wetland plants on dry hillsides, and vice versa).

4. Monitoring & Evaluation Strategies

Monitoring is the process of making periodic observations to detect changes or trends. Not all restoration techniques will be 100% successful. Therefore, monitoring and evaluation are important to document lessons learned. The success of any restoration treatment depends largely on appropriate implementation and subsequent weather patterns. If implemented correctly and subsequent weather is favorable, few, if any, restoration treatments will require ongoing maintenance.

After restoration treatments are applied, monitoring the site for 3 years will help determine how successful the project was. Monitoring could be as simple as taking post-project photographs and comparing them to pre-project photographs. If resources allow, monitoring transects can be used to provide more accurate data. In either case, monitoring data, once analyzed, will help to determine if further restoration is necessary or if management goals have been met.

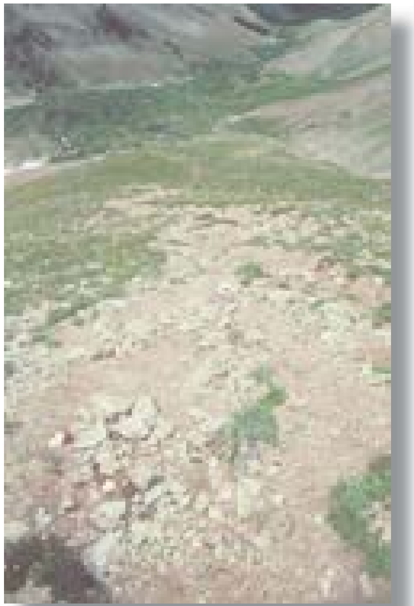
Lessons learned from restoration activities are filed in the project files with the land management agency for use as inputs into future project plans.

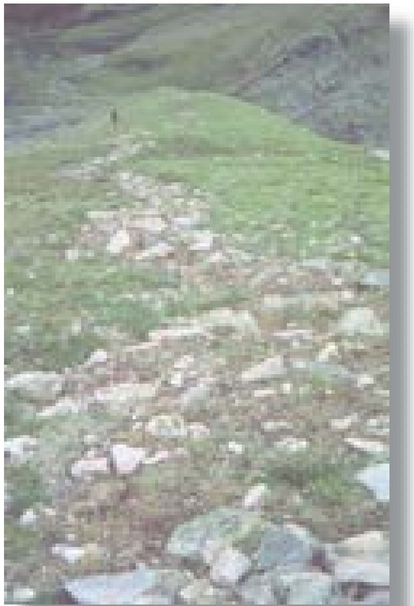
Photographs

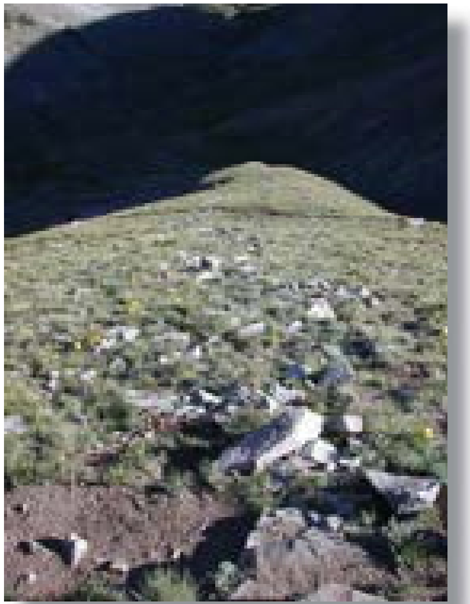
A picture is worth a thousand words, or as in the case of these restoration examples "several pictures are worth a million words."

Pre-restoration project photograph

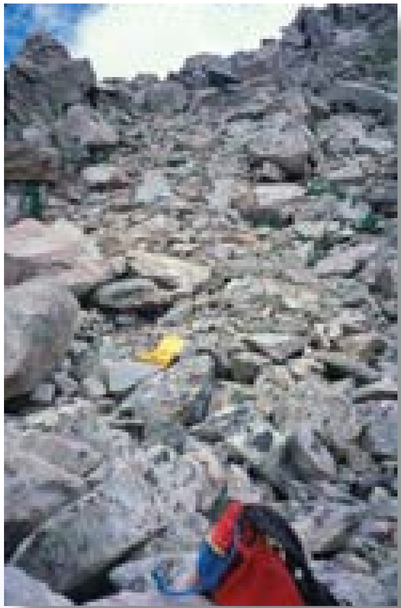
Post-restoration project photograph







Mount Belford, 1997, 1999, 2004. Restoration, in this case by the Colorado Fourteeners Initiative, is worth the significant effort required. Visitors to Mount Belford will now enjoy natural scenes where once they would have experienced extensive visual resource impacts. Thoughtful trail planning in advance will preclude this type of impact from happening in the future.



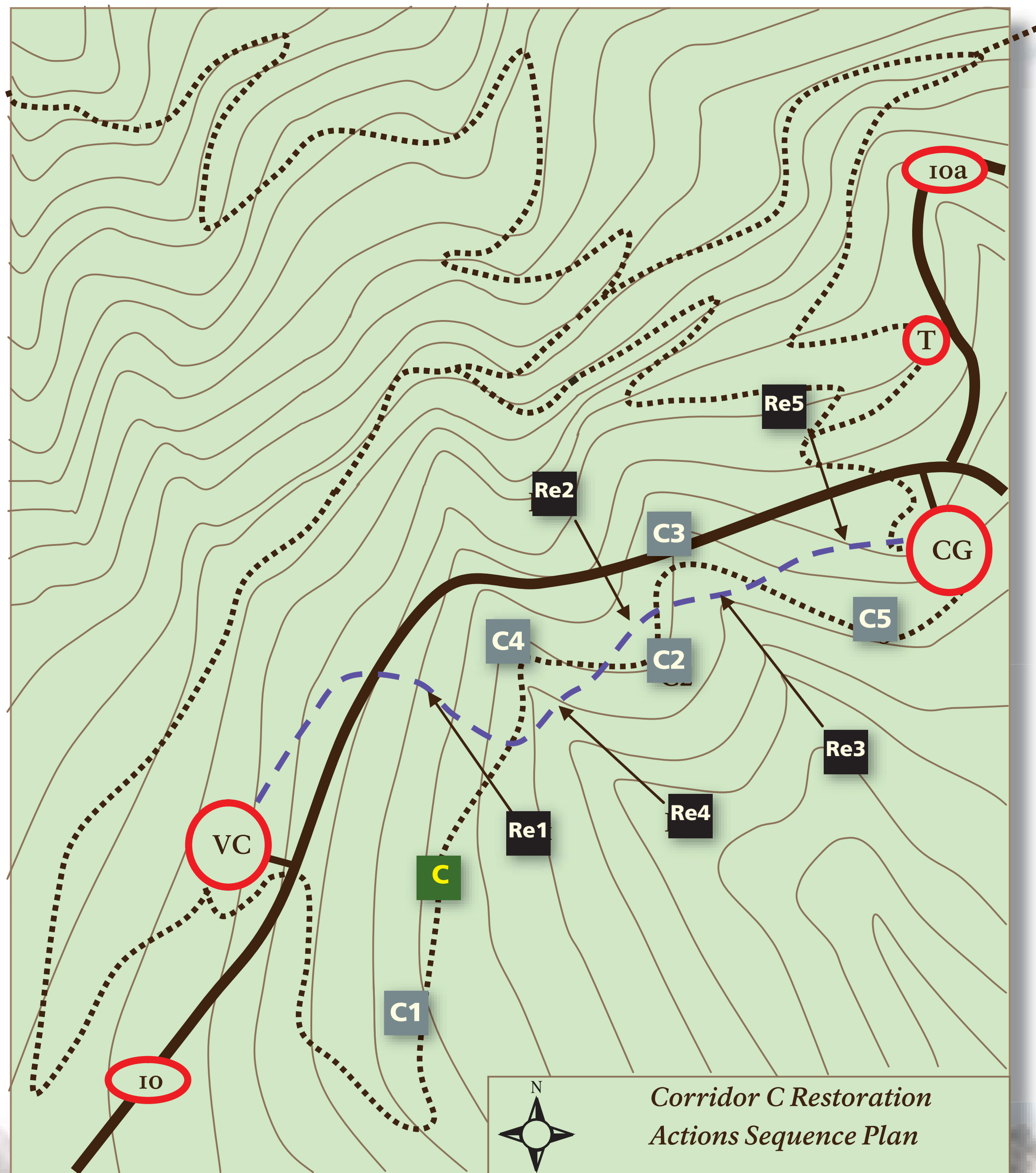
Mount Harvard, post-restoration project (above) and pre-restoration project (below).

Corridor C Restoration Actions Sequence – Plan

Legend

Restoration Actions Re4

Construction Actions C5



The restoration plan on the preceding page depicts a common project. A nonprofit agency plans to construct a sustainable trail from the visitor center (VC) to the campground (CG). An unplanned social trail currently crisscrosses the planned sustainable trail route, and restoration of this trail to natural conditions is one of the project's goals. In order to most effectively close and restore the social trail, the following action sequence is planned according to management priorities:

1. Construct trail section C1 to address safety issue: social trail section Re1 currently crosses County Road 10 at an unsafe crossing. Salvage all topsoil and vegetation plugs (excluding weeds) from the construction of C1 and use in restoration of closed areas.
2. Restore Re1 using salvaged soil and vegetation plugs from construction of C1.
3. Install a "Closed for Restoration—Do Not Enter" sign at the point where Re1 leaves the VC and at the junction of Re1 and C1.
4. Construct trail sections C3 and C4 to address urgent drainage and erosion issues caused by seasonal flow events in gulches. Salvage all topsoil and vegetation plugs (excluding weeds) from trail construction for restoration of closed areas.
5. Restore sections Re3 and Re4 using salvaged soil and vegetation plugs. Fill gullies with debris, rocks, and topsoil to recontour the land. Install check dams to stabilize eroding areas that are not recontoured.
6. Install "Closed for Restoration—Do Not Enter" signs at junction between Re4 and C4 (one sign at each end), and C3 and Re3 (one sign at each end).
7. Construct trail section C2 to address wetland impacts caused by existing social trail section Re2. Salvage topsoil to fill in gullies in section Re2. Note: Do not use transplants from C2 (dry upland site) to restore Re2 (wetland site). Plants from C2 will not survive in Re2.
8. Restore section Re2 using salvaged topsoil to fill in gullies and vegetation plugs harvested from the surrounding wetland site.
9. Install "Closed for Restoration—Do Not Enter" signs at each junction of Re3 and C3.
10. Construct trail section C5 to solve access issue to Camp Ground. Salvage topsoil and vegetation for use in restoration of Re5.
11. Restore section Re5 using salvaged topsoil and vegetation from construction of C5.
12. Install "Closed for Restoration—Do Not Enter" signs at the junction of Re5 and C5, and at the campground entrance from section Re5.

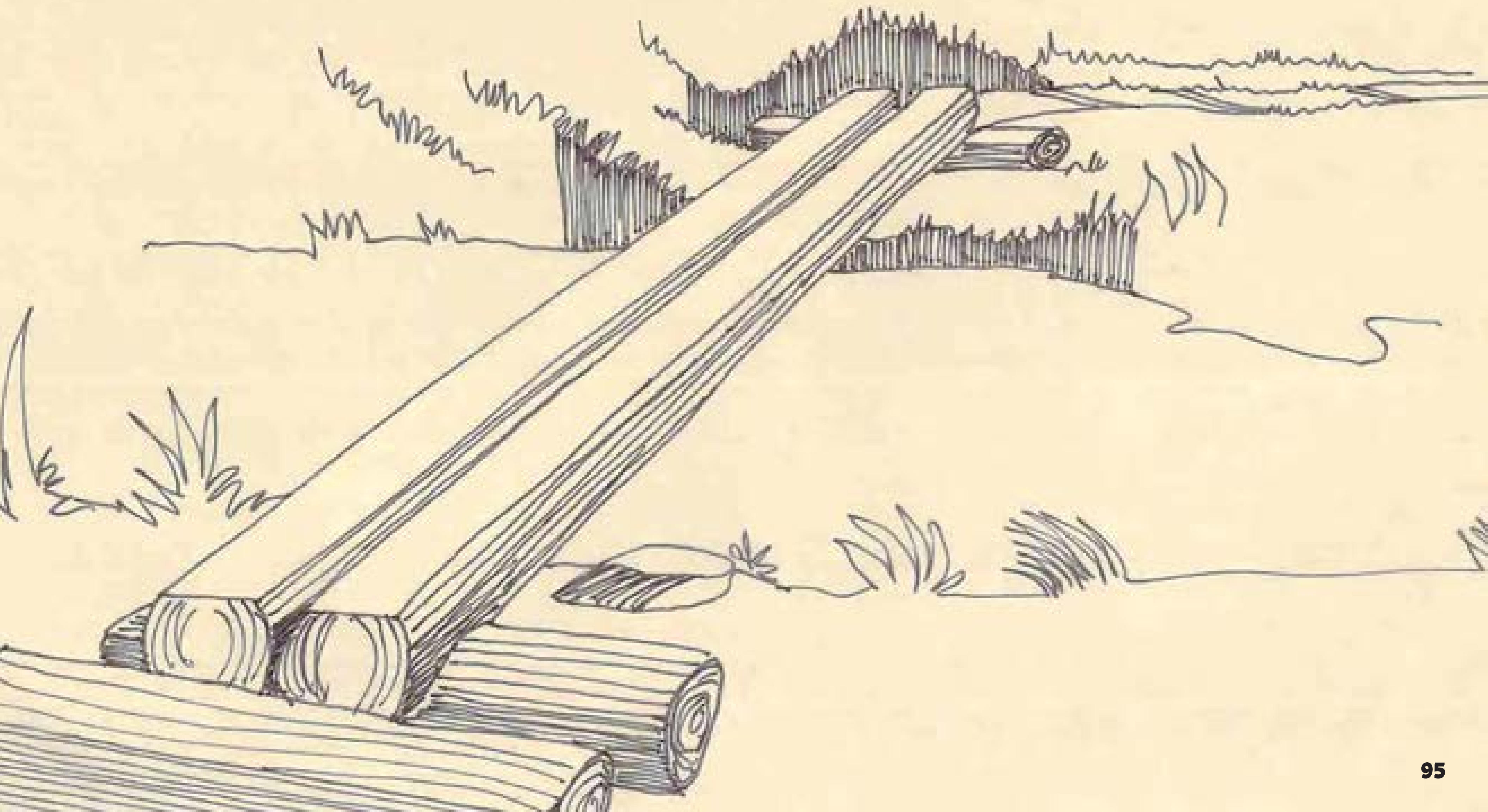
Sudoku

Planning for restoration parallel to new trail design is like solving a five star Sudoku puzzle. Oh, but what satisfaction when complete!

Restoration Planning Checklist

- ❑ Web Search / Literature Review
- ❑ Restoration Goals
- ❑ Ecosystem Type Summary
- ❑ Rare Species & Habitat Summary
- ❑ 4-Step Restoration Planning Strategies
  - ❑ Step 1 – Closure
  - ❑ Step 2 – Stabilization
  - ❑ Step 3 – Revegetation
  - ❑ Step 4 – Monitoring & Evaluation
- ❑ Trail Management Options
- ❑ New Trail Design
- ❑ Lessons Learned
- ❑ DRAFT Restoration Planning Package
- ❑ Review
- ❑ FINAL Restoration Planning Package

Mud River
Southeast Alaska



Best designed by professionals, mountain trail bridges and boardwalks are many times required to prevent resource impacts while also providing recreational access. Bridges and boardwalks are best located during the planning process as a corridor control point, and they can be simple or complex.

Inputs

- Typical Inputs
- Outputs from Other Process Areas
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Web Search / Literature Review
- Site Analysis
- Identify Alternative Stream Crossings
  - Choosing by Advantages or Value Analysis Summary
- Select Preferred Crossing Location
- New Trail Design to Match Preferred Stream Crossing
- Bridge Option Selection
- Bridge Option Design
- Management Team Review
- Compliance Review

Outputs

- DRAFT Mountain Trail Bridges Package for Review
  - Written Summary
  - Annotated Site Analysis
  - Annotated Alternative Stream Crossings Plan
  - Summary of Rating / Evaluation Process
  - Plans, Sections
  - Details
  - Material List
  - Labor Estimates
  - Cost Estimates
  - Trail Management Techniques
  - Actions Sequences
  - Checklists
  - Lessons Learned
- FINAL Mountain Trail Bridges Package

Trail Bridges

Trail bridges may be used for crossing swift waters areas prone to flash-flooding, and other places that present potential safety hazards. Less obtrusive alternatives to bridges (such as, fords) and trail relocation will be considered before a decision is made to build a bridge. A bridge may be the preferred alternative when necessary to prevent stream bank erosion or protect wetlands or fisheries. If a bridge is determined to be appropriate, it will be kept to the minimum size needed to serve trail users, and it will be designed to harmonize with the surrounding natural scene and be as unobtrusive as possible. – National Park Service Management Policies, 2006.

A bridge is a structure designed to elevate a trail above running water or a waterway for resource concerns and safety. Bridges are built from a variety of materials including wood, native stone, metals, and plastics, pressure treated lumber and recycled or hybrid materials.

Bridges are trail assets that can be standardized for economy of implementation as well as uniformity throughout a management unit. For safety, as well as liability concerns, bridges are to be properly engineered and implemented. The more complicated the design, obviously the more significant the investment of time and materials is required to build and maintain the structure. Even the most basic bridge designs require some advancement in skills, tools and labor to construct. Handrails may be required if drop-offs over 3 feet are present, depending upon the location, land management agency policy, and governing codes. Prudence indicates that code review and detailed engineering are required for bridge designs.

As with planning and design, extensive field work is required to ensure that bridges are located in permanent locations. Comparisons must often-times be made between alternate bridge locations, length and type of trail improvements needed on either or both sides of the bridge, as well as logistical concerns and implementation crew ability.

Crossing a ravine or gorge or a stream are the most common uses for a bridge. The simplest circumstance is when the trail origin is on one side of a stream, and the destination is on the other side of the stream, resulting in one bridge being required. If an interdisciplinary trail team is forced to cross to the far side of a stream away from the intended destination, a second bridge may be required, or even a third.

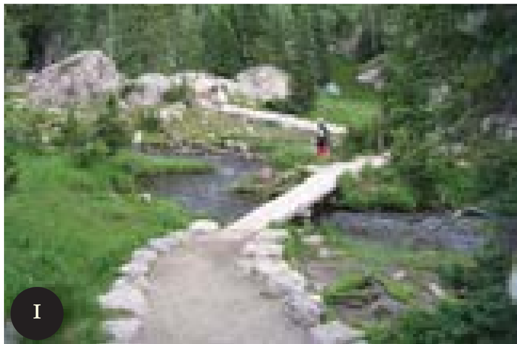
Design and aesthetic guidelines for bridges vary between agencies and may depend on historic president, the geographical context, and distance from the trailhead. A bridge considered appropriate across an equally large stream in one area may be considered unnecessary or inadequate in another. Bridges in legislated wilderness areas by default would have different characteristics than a frontcountry bridge near a major visitor facility.

Trail approaches to bridges are best located to minimize potential for damage from high water or erosion. Elevation transitions that are smooth so as to appear as natural as possible best conform to sustainable design principles.

Calculating trail profile grades and expected vertical gains will ensure that significant investments in corridor control points such as bridges are implemented in permanent locations.

Mountain Trail Bridges

Mountain trail bridges fall into the general framework shown on the right, and the photographs below illustrate options used at Rocky Mountain National Park.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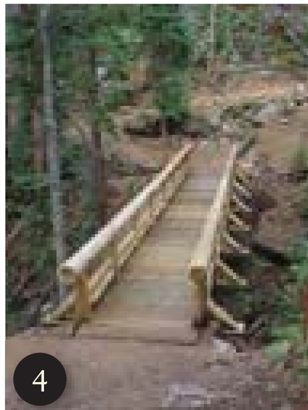
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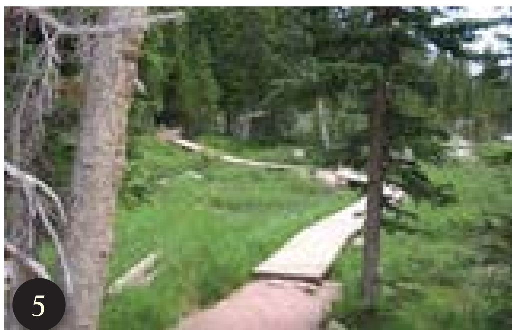
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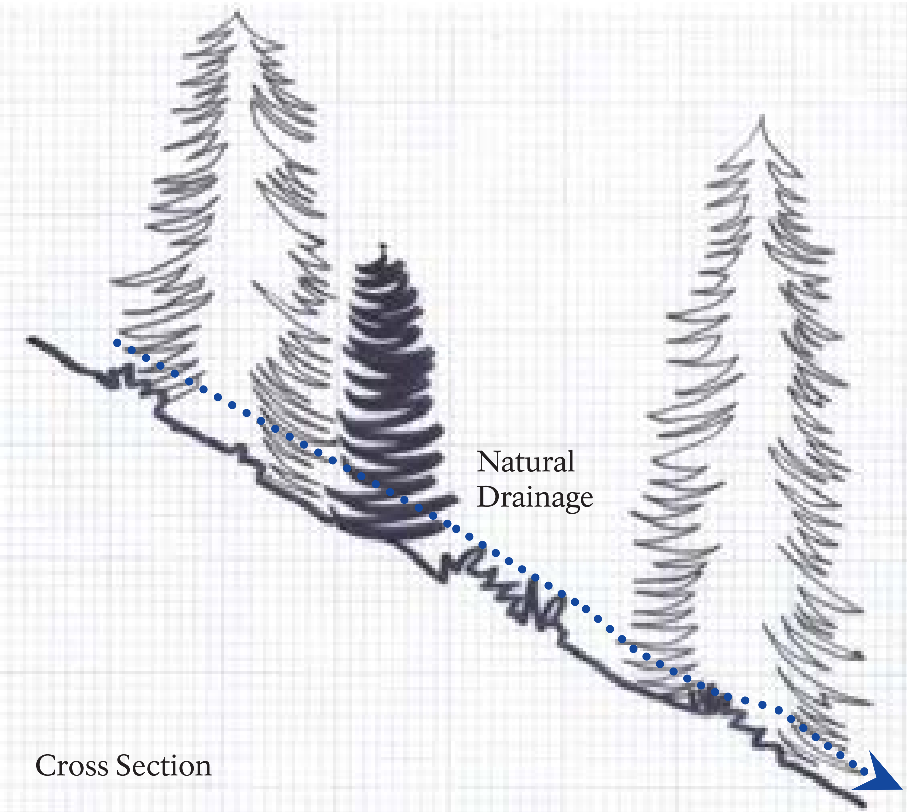
3

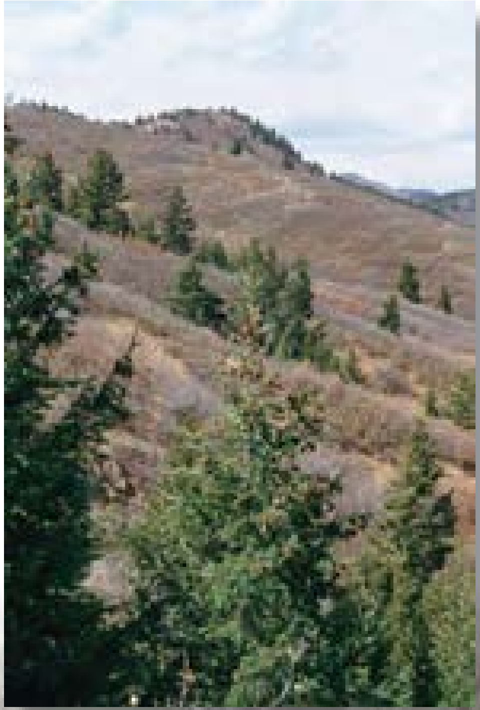
	Mountain Trail Bridge Options
1	**Simple Foot Log Bridge**. For light to medium foot traffic only across small and / or intermittent water courses. Minimal dimensions, tools, time and labor required. Appropriate in frontcountry to backcountry areas. No vertical drop-offs of more that 5 feet allowable anywhere along the span. Native materials typical.
2	**Simple Foot Log Bridge With Handrail**. Light to medium pedestrian use without horse or multiple use fords. Medium complexity of tools, labor and skills required due to the possible size and weight of materials. May incorporate a pier or abutment within the water channel to support center posts for longer spans. Native materials typical.
3	**Foot Traffic Only Bridge**. Appropriate in frontcountry to backcountry areas with medium to heavy volume of use. May be multiple-member foot log or decked stringer type. Approach and abutment may need to accommodate a ford for light to heavy horse and / or multiple users. May require additional skills and tools for harvesting, moving and assembling materials for larger structures. Kick-rails are common with many designs. Native materials typical.
4	**Multiple Use Access Bridge with Handrail**. Medium to heavy volume of use. Appropriate in frontcountry to backcountry areas. Decked multiple stringer design with steel super-structure preferred. Design may include mixed materials for optimum strength, life cycle costs and aesthetic concerns. Will require complex logistics, skills and tools, and material handling techniques. Non-native materials may be required, and if permitted by management policy.
5	**Boardwalk**. Many design variations and definitions vary by region and agency. The goal is to elevate the walking surface over wet, unsustainable soils or conditions. Common designs and names include: turnpike, puncheon, corduroy and Gadbury. Native materials typical.

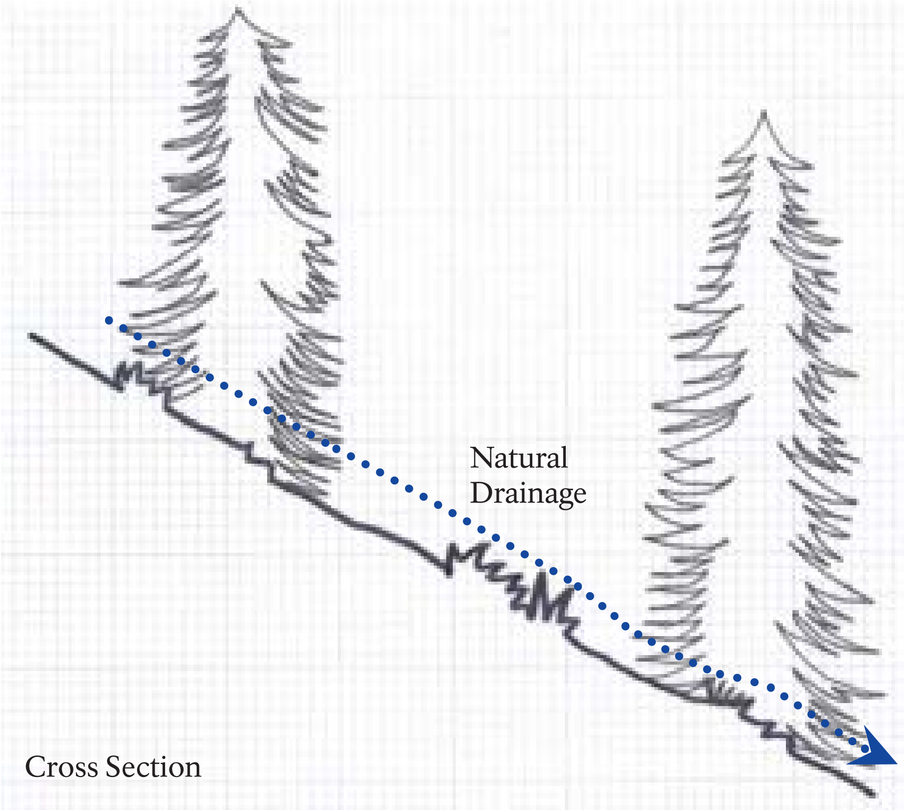
The views from Colorado's high peaks are breathtaking!

Existing Conditions



Many mountain trail projects are on moderate to steep prevailing cross slope ranges. This example is drawn on a 40% cross slope. Earthwork quantities can be estimated from the cross slope condition. A variety of vegetation types are typically encountered, and sometimes significant clearing of trees is required before tread construction can begin.

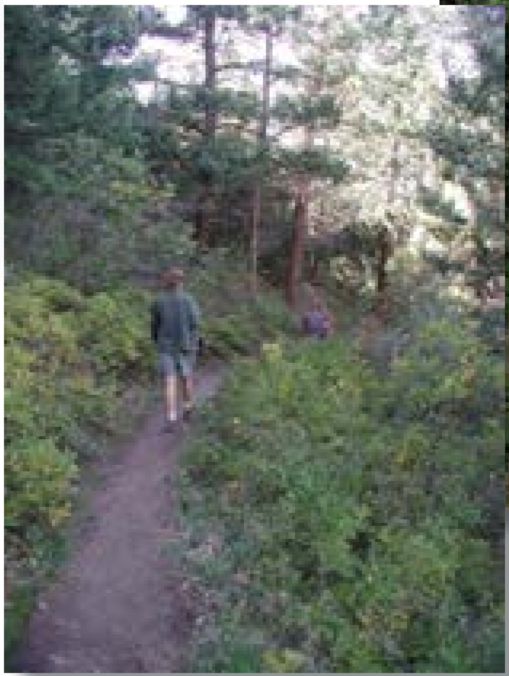


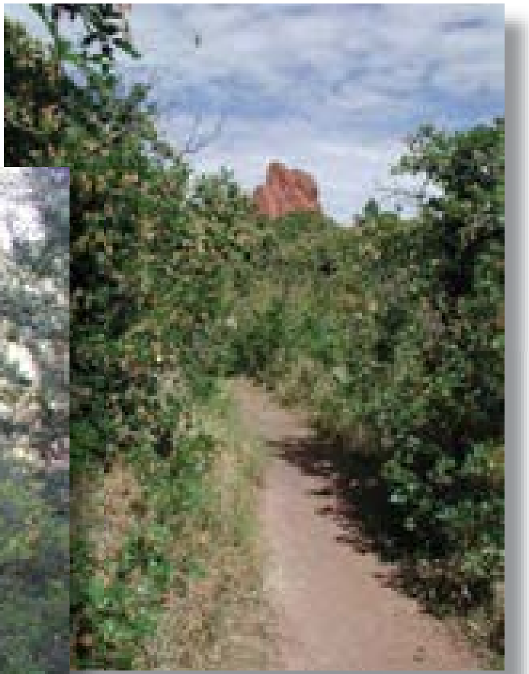


Proper clearing / pruning can be achieved through the following

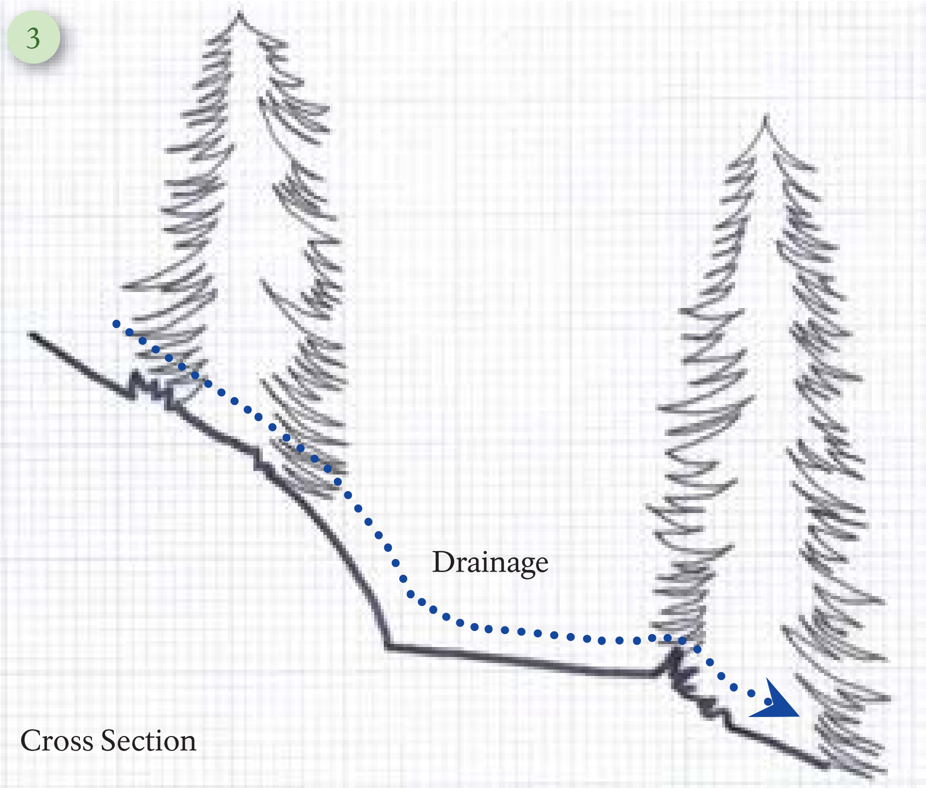
- Proper identification of species
- Understanding the ecology of plant in question
- Accurately predicting beneficial / adverse impacts on trail corridor
- Deciding what to do
- Doing this correctly
- Realize that some plants cannot be pruned, but must be removed

Corridor Clearing Options	Height (H)	Width (W)
A	8 Feet	6 Feet
B	8 Feet	8 Feet
C	10 Feet	6 Feet
D	10 Feet	8 Feet
E	10 Feet	10 Feet





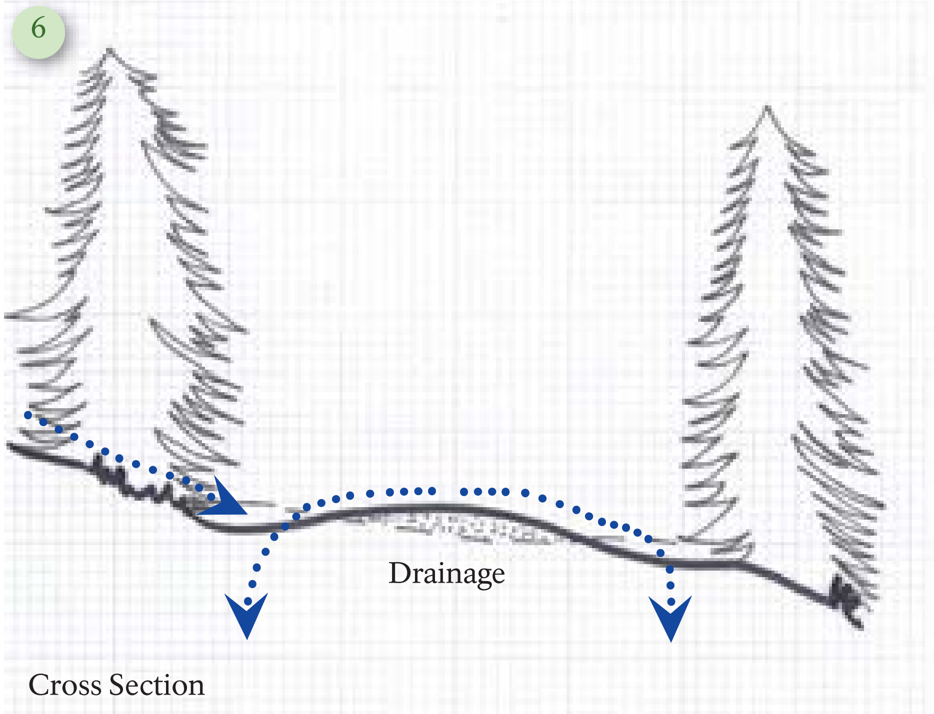
Tread Cut Options



Well constructed, properly sloped, and well compacted trail tread can be attained by following these pointers:

- Work across the trail for efficiency when cutting tread
- Out slope trail approximately 10% (1 inch in 10 inches) to allow for drainage
- Remove all vegetative material from the trail tread, and allow for drainage off the trail's edge
- Backslope trail approximately 1:1 (45 degree angle) to allow for quick revegetation, see individual project specifications – backslope may approach 5:1
- Improve inadequate surfaces with imported materials if necessary
- Excavated materials must be disposed of according to project specifications
- As soil is at a premium, leave as much as possible!
- Broadcast or dispose of excess materials only according to individual project specifications

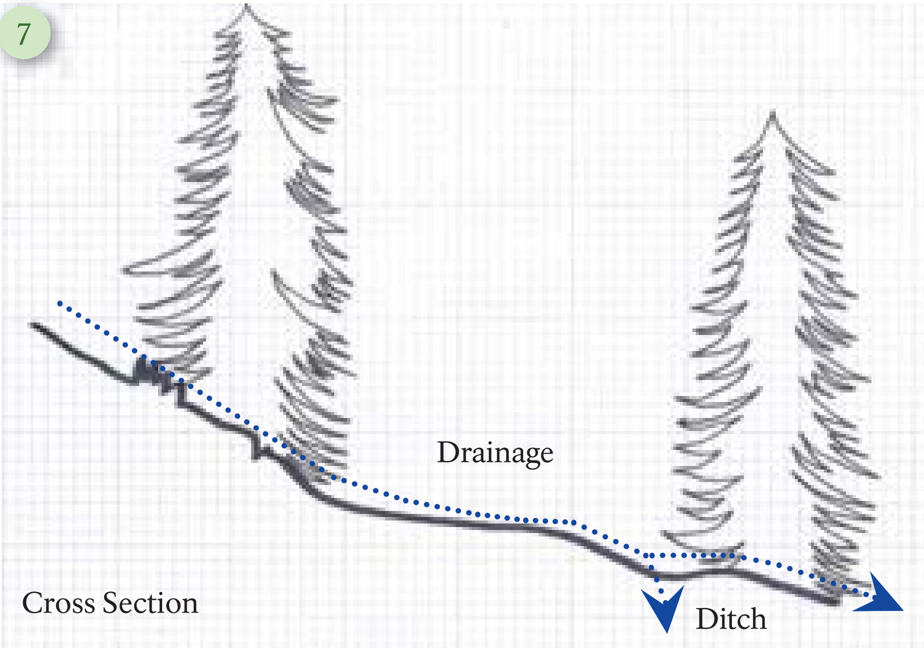
Tread Cut Options	Prevailing Cross Slope (%)
1	0 – 20%
2	20 – 40%
3	40 – 60%
4	60 – 70%
5	> 70%
6	Crowned Trail
7	Tread Cut with Ditch



Trails in prevailing cross slope grades of less than 20% can be crowned to improve the opportunity for drainage. Some pointers:

- Begin by stripping all vegetative matter
- Cut a ditch on either side or both sides of the trail
- Salvage any mineral soil or stones that can be utilized to improve the subgrade or trail surface
- Compact all materials
- Establish the trail surface at the approximately the same elevation as the existing prevailing cross slope grade

Tread Cut with Ditch

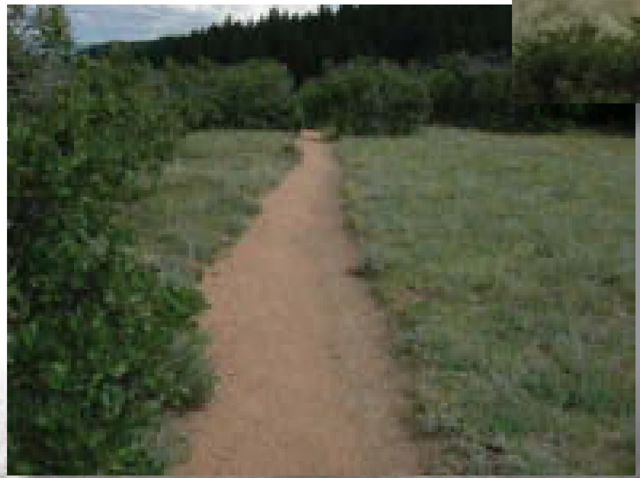


Trails in less than 20% prevailing cross slope areas can be protected by constructing a ditch parallel to the trail to allow drainage off of the trail while still allowing travel on the trail surface. Some pointers:

- Begin by clearing all vegetative matter
- Cut trail tread as in the tread cut detail, including backslope
- Cut a ditch parallel to the lower edge, removing all soils. Width of the ditch depends upon topography, 1 foot is minimum
- 4:1 slopes are desired to allow for smooth transitions into the surrounding landscape

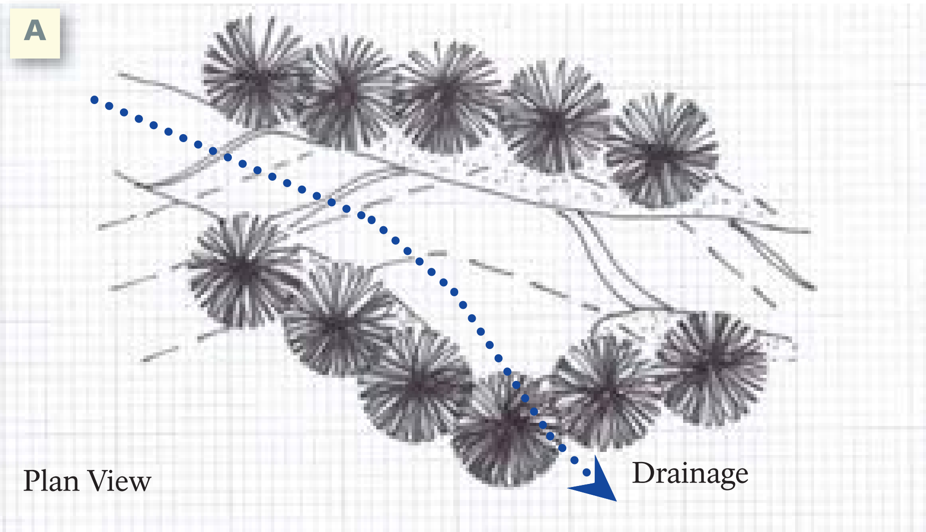
Tread Cut Finishing

The frequently asked question is how far to go on trail finishing. It is not practical to do such refined grading as will not stand up under relatively small amount of maintenance that those trails will probably receive in the future. The best answer to this question is that trail finishing should be carried to such a point that erosion will be discouraged and natural growth will be encouraged.
– Guy Arthur, 1975.



Above: The West Valley Trail at Lory State Park, Colorado.

Left: The Carpenter Peak Trail at Roxborough State Park, Colorado.



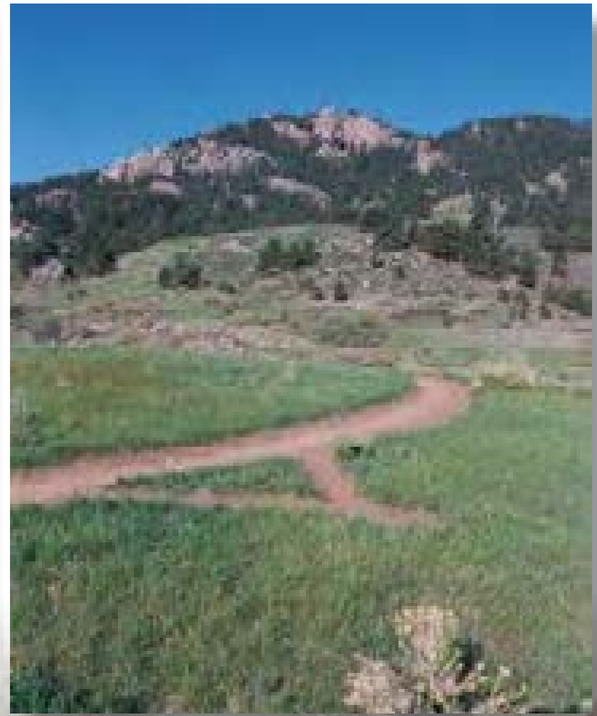
Erosion is the single greatest threat to trail sustainability. Prevention of erosion is critical to achieving trail sustainability and minimum impact to natural and cultural resources. Some pointers:

- Trail drains should be installed on trails at locations where normal cross slope will not allow for adequate drainage. In general, drainage should be studied every 25 to 50 feet, with provision made to protect the trail.
- Careful study of topography adjacent to the trail may yield an insight to maximizing protection of the trail, while minimizing structures required.

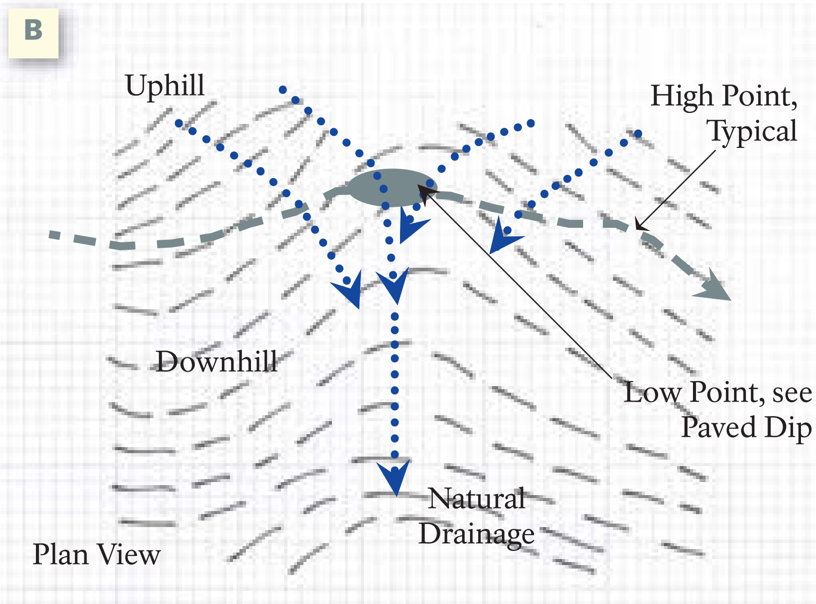
	Trail Drainage Options
A	Trail Drain
B	Swale Crossing
C	Paved Dip / Stone Paving
D	Stepping Stones
E	Stone Waterbar
F	Stone Drains

Drainage

No factor in trail construction is more important than proper drainage, and many sections of good trail are damaged and destroyed by erosion which could have been prevented. All drainage should be planned for ahead of construction. The method of carrying surface water off of each trail section should be determined in advance, along with the location, type, size, and construction details of all drainage structures. – Guy Arthur, 1975.



Swale Crossing

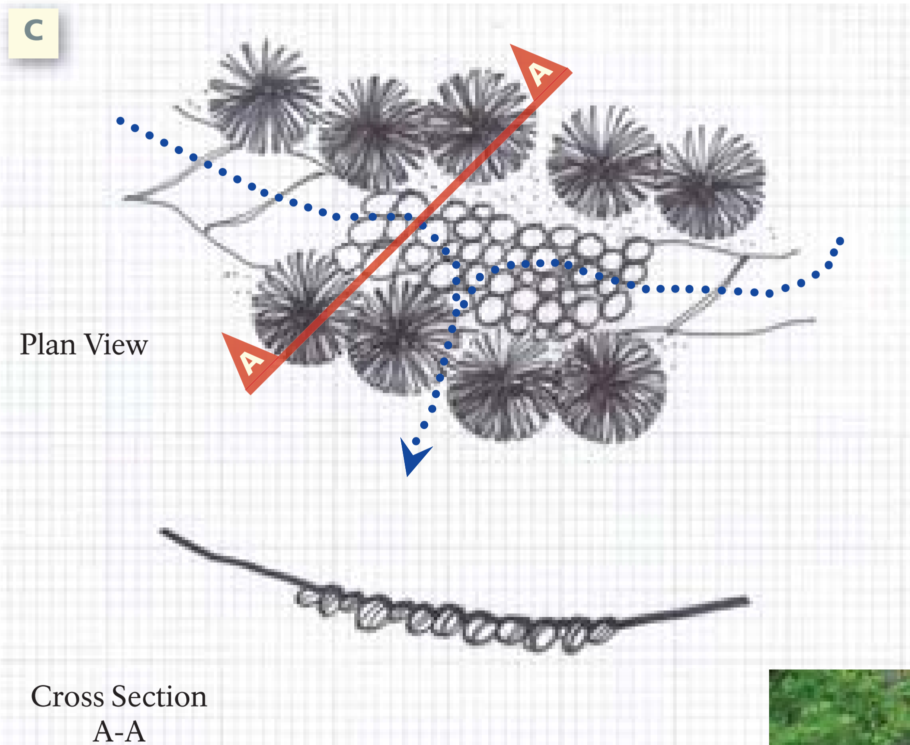


Even the slightest swale must be crossed properly to ensure protection of the trail. Some pointers:

- Careful study of the prevailing profile grades will assist the crew leader in successfully solving drainage crossings.
- On the downhill side of the drainage, it is required that the trail profile switch directions.
- The length of the change in grade is dependent upon the size of the swale. Usually a 10 foot change of profile direction either side of the drainage is sufficient to ensure that water will not continue down the trail.

Even small swales that are not crossed properly or improved can deteriorate rapidly in muddy messes, causing natural resource, visual resource and water quality impacts. These impacts can be avoided by designing drainage improvements into the original new trail design.

Descending down into any drainage, then climbing out the other side is the best way to ensure that your trail does not become a creek.

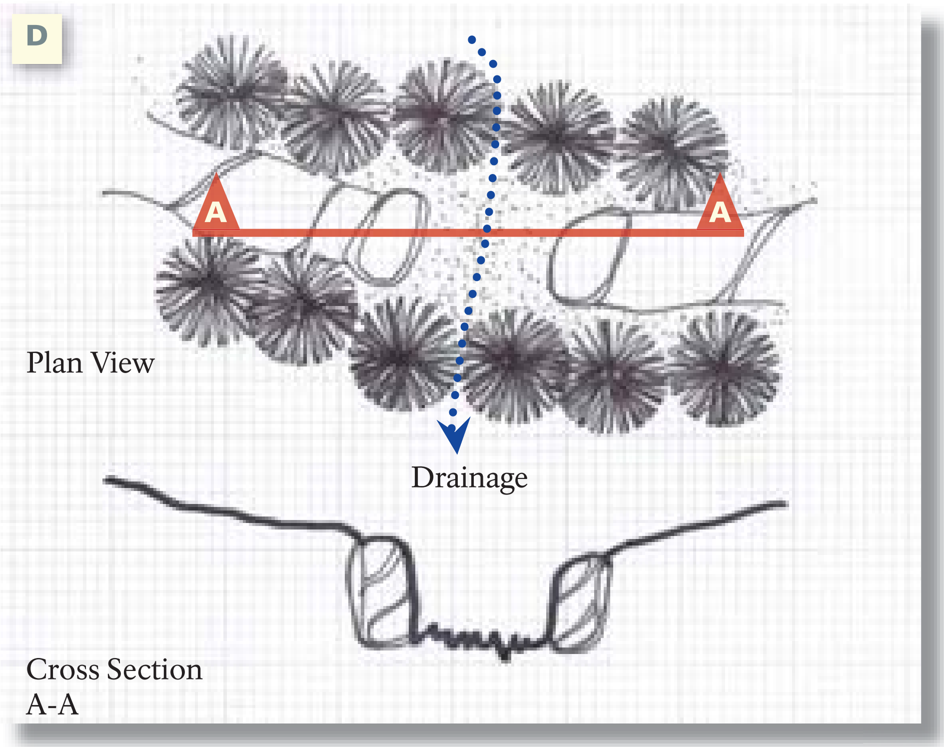


Stone paving or a paved dip can be used to improve unsuitable soil conditions or in low points along the trail corridor that experience wet conditions or areas that otherwise would not support a sustainable trail surface. Some pointers:

- Establish the trail tread as in the tread cut detail, remove all organic materials and stockpile for restoration activities
- Establish a firm and stable footing which will hold the stone paving in place, using the largest available stones
- Pave the trail tread with additional large and medium sized stones
- Fill voids with smaller stones or mineral soils
- Trails surface should be relatively smooth, without projections of stone greater than 1/2-inch in frontcountry areas

This section of the Appalachian Trail in Shenandoah National Park is improved by stone paving.

Stepping Stones

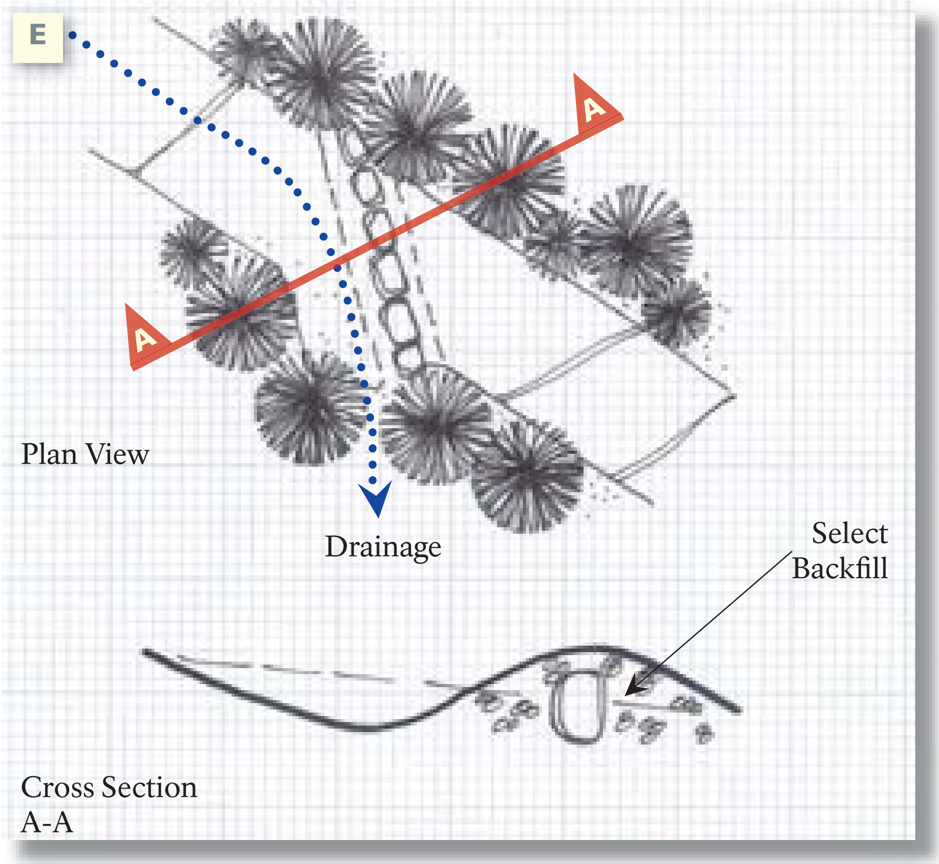


Stepping stones can be used to provide alternative pedestrian routes across wet areas or intermittent streams. Some pointers:

- Proper stepping stone crossing location
- Selection of adequate materials regarding type, size, and shape
- Proper bedding (foundation)
- Accurate stone location for easy crossing
- Cross where your work will not be impacted by high flows
- Choose stone based upon longevity, i.e.: choose granite over sandstone
- Choose stones of adequate size to cross the drainage, most stones will need to have at least 2 flat sides
- Do not over-excavate and improve wet or boggy conditions
- Place stones for a comfortable crossing, walk the stones several times yourself and adjust them if necessary
- Finally, analyze the work during wet conditions and make adjustments if necessary

Note: Boulder stepping stones are used to cross narrow, but steep, drainages, or where evidence indicates high flows. Stepping stones are used to cross areas of low flow. Strive to choose stones that are between 12" and 18" square for all stones.

Stepping stones allow cross trail drainage at Rocky Mountain National Park



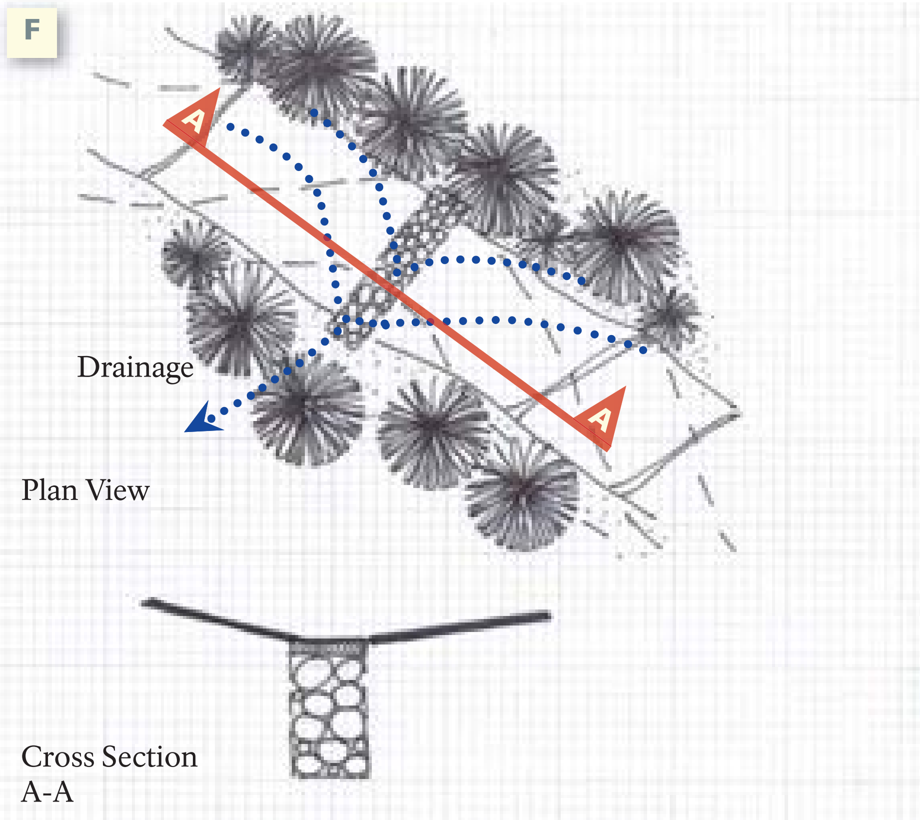
Good waterbars will cut down erosion and subsequent maintenance of otherwise well built trails. Some pointers:

- Take advantage of natural features when selecting a location for your stone waterbar
- A natural dip or a bend in the trail is often the best location for a waterbar
- Avoid areas without an outlet for drainage
- Choose "waterbar stones" for use, usually 6" thick minimum and are generally rectangular in shape, avoid round or narrow stones
- After digging the trench, arrange the stones and see how they will work and rearrange if necessary
- Set aside unusable stones and look for better stones
- When you are satisfied with the choice, quality, and arrangement of stones, backfill to top of stones with select backfill and compact
- Grade over the top with 6" of select backfill
- Test your stone waterbar by walking over it, adjust it if necessary
- Create drainage outflow (in cut section)
- Come back when its raining to observe your masterpiece

Additional Notes:

- As with all stone work, make a large selection of stones available to the installer!
- Save the soil from the trench for use on top of the stone waterbar if it is acceptable material
- Select backfill must be free from organic matter
- Select backfill is usually less than 1/2" maximum dimension
- Depth of outflow at edge of trail = 4"

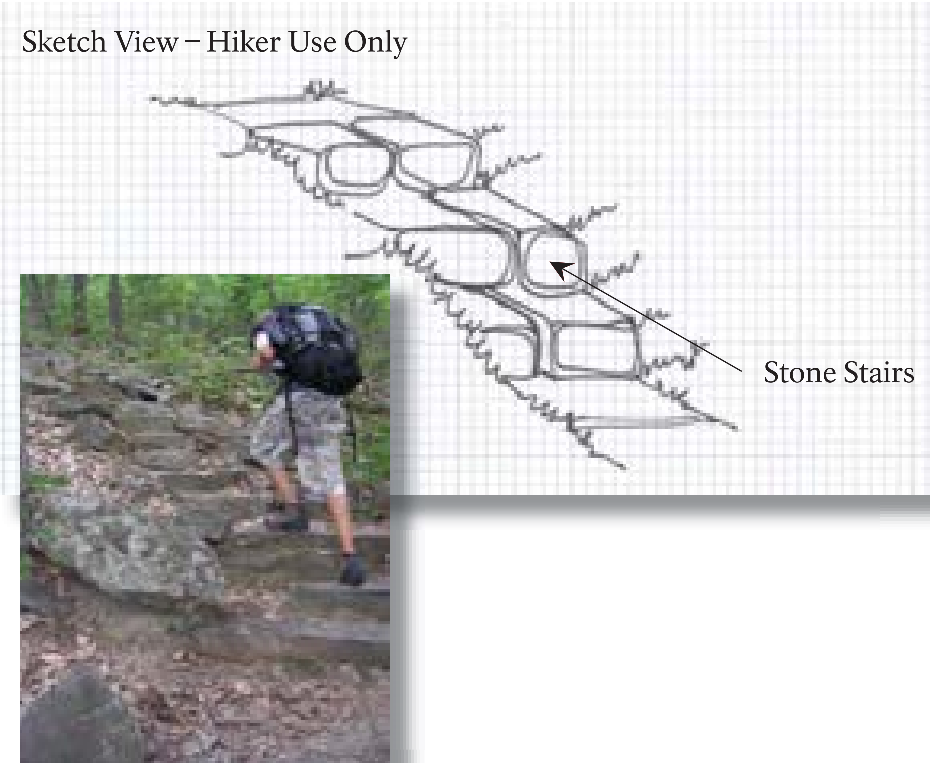
Stone Drains



Stone drains collect runoff and carry it across the trail. French drains carry runoff under the trail, and sometimes parallel to the trail (yet still underground) and then under the trail. Some pointers:

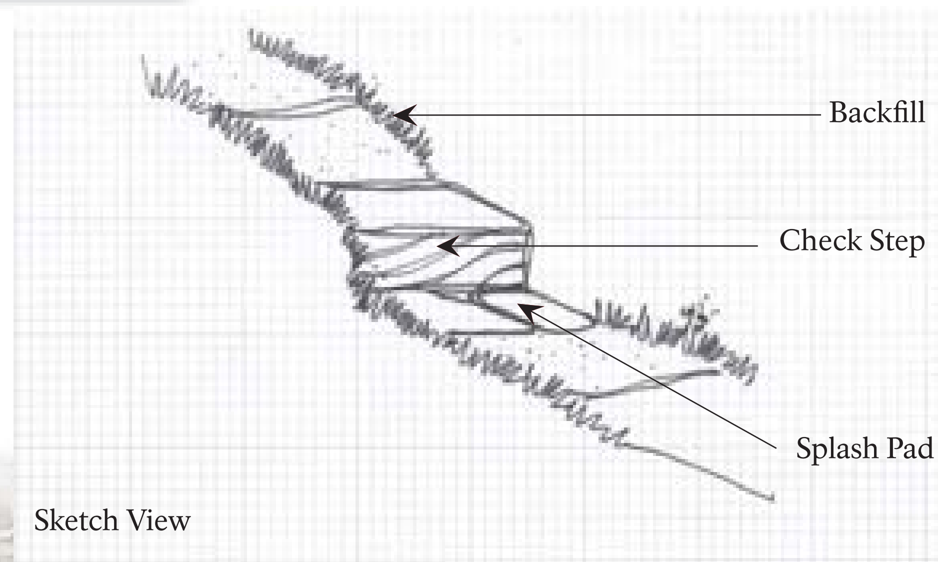
- Round cobbles provide the best drainage capacity as the pore space between the stones is larger than if gravel is used
- Rounded gravel is the second preferred drainage gravel type, crushed gravel is least desirable
- Study the site conditions to determine the location, alignment and depth required to provide proper drainage
- Fabrics can be used if they can be imported easily, and if used in a non-wilderness area
- If desirable and available, top off the trail with finer soils to ensure a usable tread surface

Stone drains come in many varieties and are commonly dependent upon available materials and distance from the trailhead.



Stone stairs can be used where grade must be gained quickly. Stairs are not intended to be used on trails that have horse or mountain bicycle use. Build stone stairs to withstand significant use and impact. Some pointers:

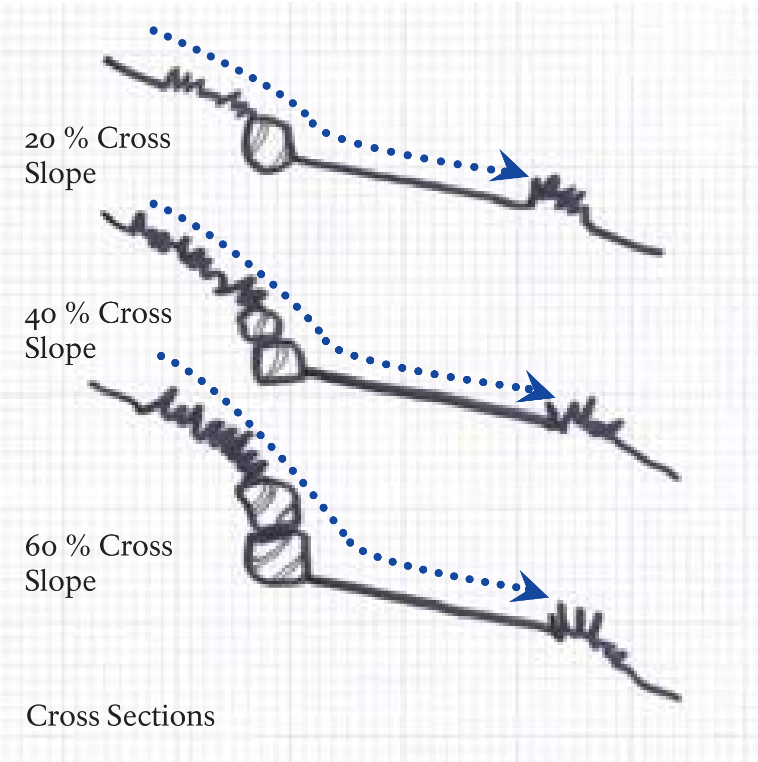
- Choose stones with a good shape for stairs
- Start at the bottom and work upwards
- Use the biggest stones possible to span the trail
- Make sure strong people are on the crew!
- Stairs made of one stone are best, two are fine, and three is usually maximum
- Completely cross the trail, choose the areas where people will stay on the trail and stairs
- Build to the dimensions shown and make each set of stairs uniform
- Maximum trail profile grade at top and bottom of stairs as well as between steps should be 8%
- Walk your staircase to ensure it is smooth and uniform



Check steps are an option when severe erosion has gullied out a trail and relocation of the trail is not an option.

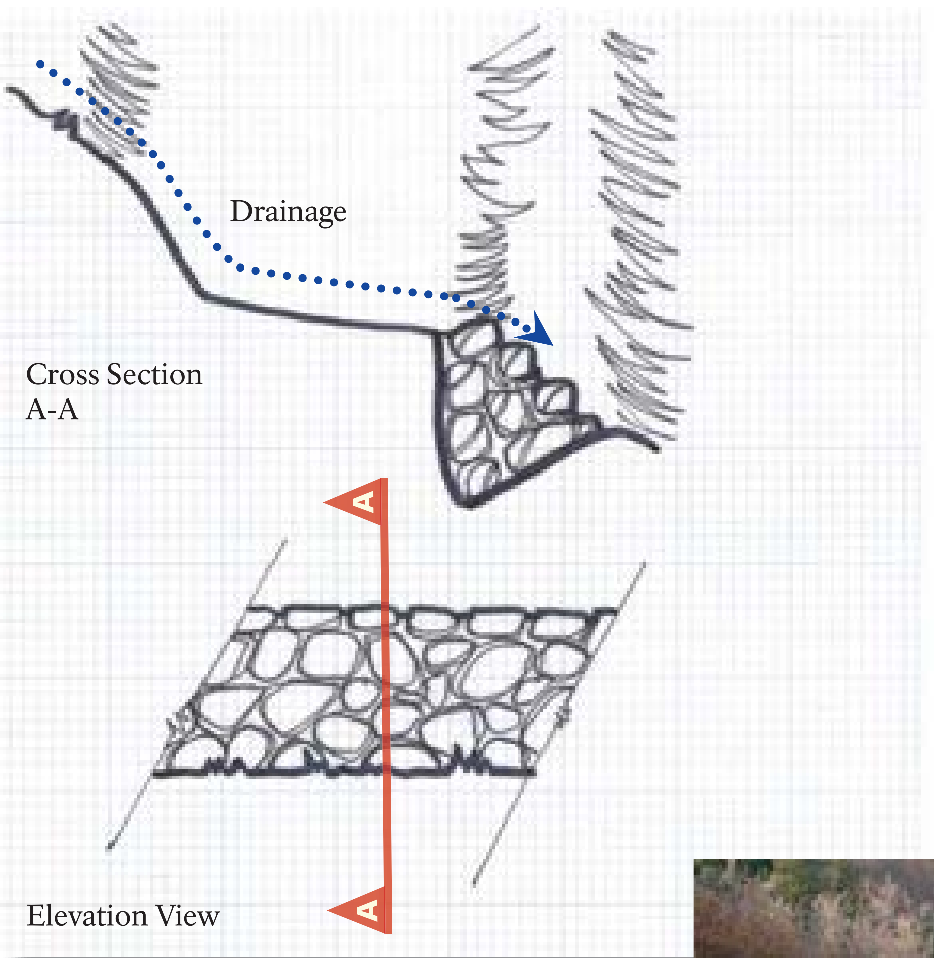
- As with stone stairs, choose large stones, even stones that can cross the trail
- Excavate to allow the step to sit on undisturbed ground
- Backfill with select backfill and compact each 4-inch layer
- A splash pad can be included to minimize the effect of drainage on the trail tread
- Check steps may be required for many hundreds of feet of trail in the high country, requiring expert crew skills to design and implement

Alpine Tread Cut Options



Cutting trail without backslope rounding but rather with select stones placed in the backslope area will protect high country trails. The growing season is not sufficiently long in the high country for revegetation efforts to occur naturally. The alignments shown in these photographs protect fragile tundra ecosystems.

Stone Retaining Wall

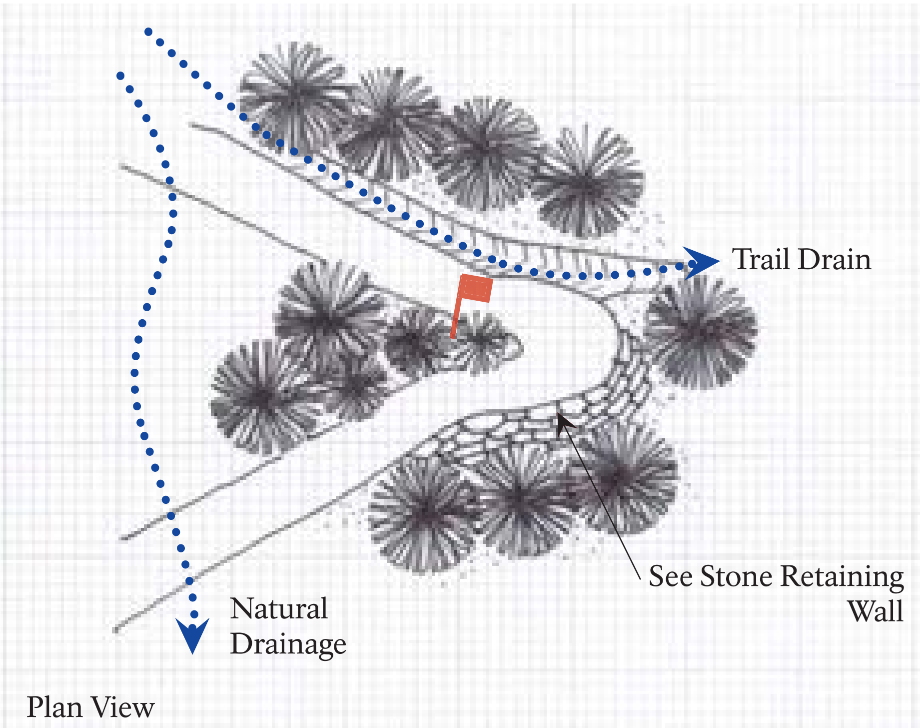


Stone retaining walls allow trails to be built where they normally would not be able to be built, or to improve unsustainable conditions. Some pointers:

- Begin by cutting a footing off the trail edge
- The finished wall will be outside the width of the trail
- Daylight the footing for drainage
- Stack larger stones intermingled with medium stones near the foundation, fill voids with smaller stones
- More contact between stones means more friction which means a better built wall
- Stagger joints vertically and horizontally
- Utilize gravity to advantage
- Miscellaneous materials excavated from the trail corridor can be utilized as select backfill
- Stone retaining walls are indicated on the design notes by height (H) estimated in feet X length (L) also estimated in feet

Stone retaining walls do not need to be complex. Simple walls provide great protection benefit to the trail surface and also provide easier and safer trail passage for trail users of all types.

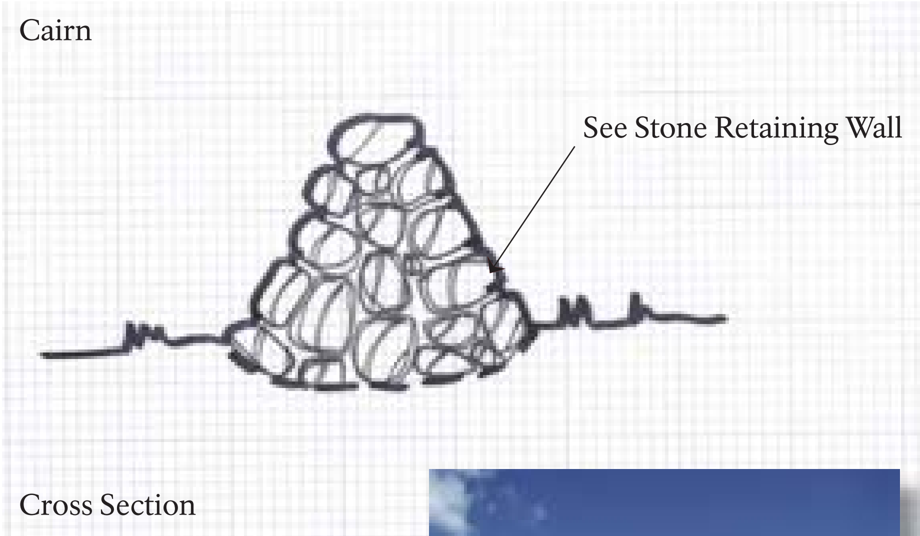
Switchback



Switchbacks are utilized where it is necessary to change the direction of the trail. Some pointers:

- The Point of Intersection (POI) marks the theoretical intersection of the two trail legs
- A 5-foot radius from the POI is required to accommodate hiker-only uses and an 8-foot radius is required to accommodate multiple uses (including horse or mountain bicycle use)
- Stone retaining walls can be utilized to create a landing on which trail users turn
- Sometimes stone retaining walls or freestanding stone walls are required to separate the upper leg of the switchback from the lower leg
- The landing is normally relatively flat, allowing easy turning without impacts
- Provision for drainage is required, especially above the uphill leg close to the landing so that it is not impacted by rainfall or snowmelt
- Switchbacks are best built by expert crews!

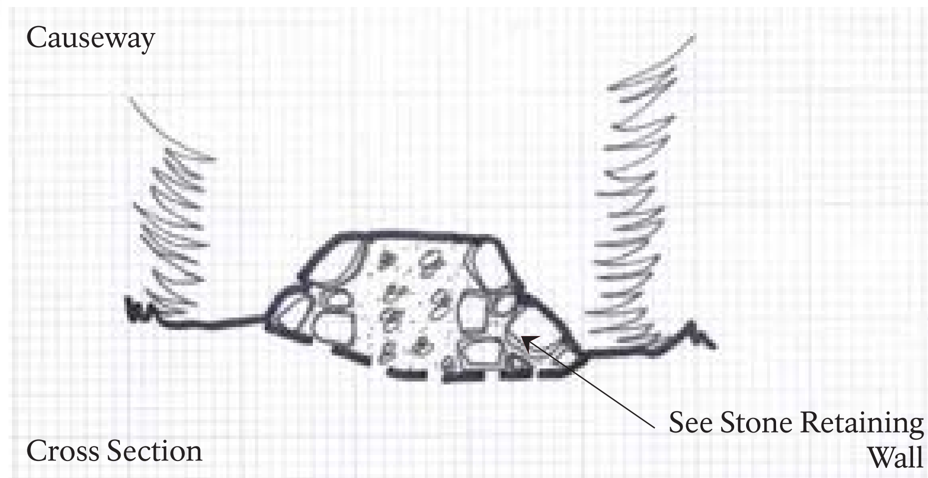
Switchbacks work best on relatively gentle prevailing cross slopes. Detailed field work and field notes are required for proper construction. Hayden Green Mountain Park, Lakewood, Colorado (left photograph). Willow Creek Trail, Roxborough State Park, Colorado (right photograph). Drainages above the upper leg were not installed on these examples during the original construction and could be identified as a "perform as needed" rehabilitation activity.



These cairns along the trails up Greys and Torreys Peaks mark the trail during inclement weather and in snow conditions.

Cairns are used to mark trail corridors where they otherwise would be indistinct. In areas of abundant stone, cairns can be used to add aesthetic value to the trail, while also marking the trail corridor and guiding appropriate trail use. Some pointers:

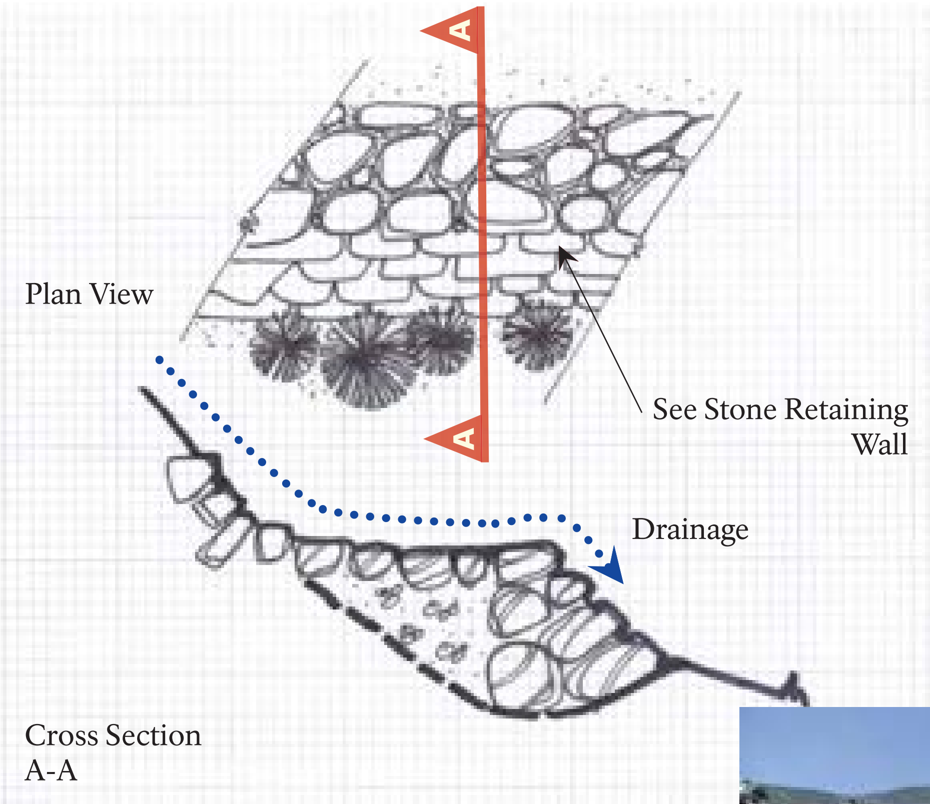
- Begin by cutting a circular footing trench, removing all vegetative materials
- Stack stones salvaged from trail clearing activities first, using the 'one over two' method shown, other stones may be used, care must be taken to not create other impacts by taking too many stones from within sight of the trail or from one area
- Height of cairn according to the design notes, usually less than 3 feet, and where large mammals knock over cairns, they of greater height can be used
- Choose weathered stones, if possible, for sides of the cairn facing the trail corridor.



Causeways are options to consider when crossing unstable soils or for use in riparian areas. Two stone retaining walls are built to elevate the trail surface above the unstable condition. Some pointers:

- Width of the causeway is dependent upon type and volume of use
- Begin by digging a trench and removing unstable soils
- Build the two stone retaining walls at the same time back-to-back, raising each course simultaneously, and backfilling with suitable materials and compacting each 4-inch layer as you go
- Top off the trail surface with granular soil materials.

Talus Crossing



It is occasionally necessary to cross talus in complex mountain trail projects. This is usually done by rearranging rocks in the trail corridor, and building stone retaining wall supports if necessary. It is important to point out that a talus crossing must be sufficiently wide to safely accommodate all allowable types of traffic. See the stone retaining wall detail.

Talus crossings are common on high country mountain trail projects. Sometimes they become a giant jigsaw puzzle or a "stone-rearrange" project.

Stone stairs on Mount Evans constructed by the Colorado Fourteeners Initiative provide a sustainable ascent route on a constrained site.

These ascent route solutions at Rocky Mountain National Park required significant investment of time and materials to implement, while protecting the park's resources Hikers will enjoy these trail solutions for many years!

The recommended design solutions hierarchy for sustainability on page 51 applies to most but not all site conditions that will be encountered by the interdisciplinary trail team. Many times highly popular destinations, sustained profile grades over 15%, prevailing cross slopes over 70%, unsuitable soils and high user volume (and corresponding natural resource impacts) require customization of sustainability criteria to the project at hand. Therefore typical implementation techniques and options and individual armor improvements will not be sufficient.

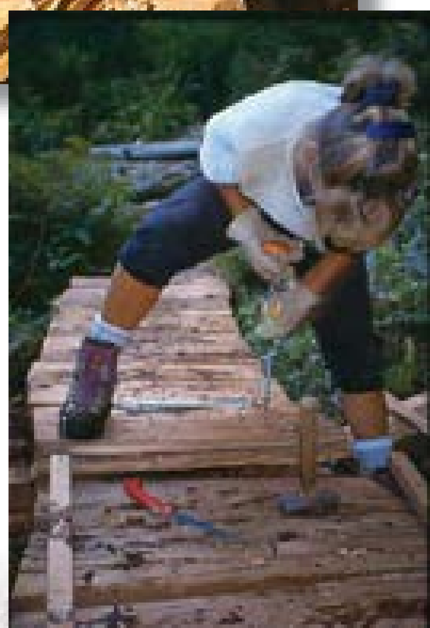
Ascent routes, typically continuous stone armor improvements, are many times required to peaks or other features and destinations. Stone stairs, stone switchbacks and stone retaining walls are the most common details in ascent route solutions. The most common design criteria that must be customized in ascent route design is the vertical alignment criteria for profile grade, including the use of profile grades on stone stairs over 15% and sometimes up to 30%. Significant expertise in site analysis, alternatives analysis, alignment design and implementation will be required to ensure ascent routes are located in permanent locations.

Timber Craftsmanship

Highly skilled art and craft of native timber structures communicate land management agency stewardship and sustainability principles while inspiring trail users.

Use of on-native materials may be prohibited by policy. Native materials are more economical than importing non-native or pressure treated materials, are easy to craft and when weathered, evoke the form, line, color and texture of the surrounding characteristic landscape.

Use of a Lodgepole Pine log for a simple foot log bridge on the Colorado Trail near Breckenridge, Colorado evokes the forested character of the surrounding area.



Craftsmanship of native timber materials in the creation of this raised boardwalk enabled a rare bog orchid to thrive in a previously impacted area and communicate stewardship principles of the U.S. Forest Service.

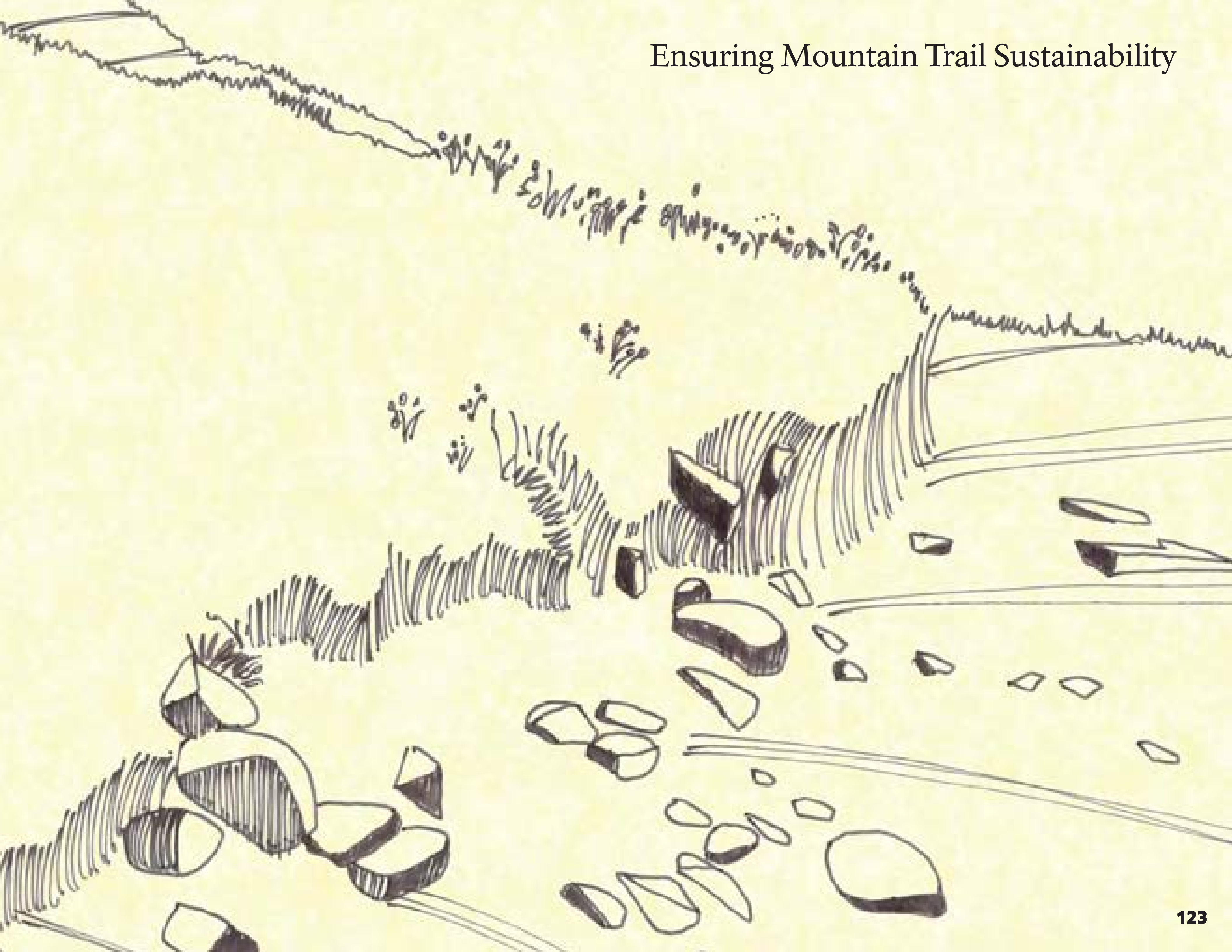
Use of native timber at Rocky Mountain National Park, combined with art and craft, exemplify sustainability principles and communicate the mission of the National Park Service to trail users.

Stone is the most sustainable trail building material. Locally selected and highly crafted stone in these examples exemplify the artistic and stone craftsmanship tradition established at Rocky Mountain National Park in Colorado by the Civilian Conservation Corps. Trail users delight in the character of these details, and are not distracted by non-native materials, introduced colors or textures, or natural resource impacts. Shown are:

- 1 2 3 Stone retaining walls
- 4 Stone retaining wall / talus crossing
- 5 Stepping stones in combination with a boardwalk

Implementation Activities – Photograph Collage

Implementation Activities. Implementation days are exciting, giving form to ideas expressed in drawings and design notes. Realizing that agency staff, day-labor staff, youth corps crews or volunteers are following your leadership is a humbling experience. Your diligent efforts will be appreciated by all!



A pastoral scene in northwest Colorado

Inputs

- Typical Inputs
- Outputs from Other Process Areas
- Lessons Learned Summary

Tools & Techniques

- Typical Tools & Techniques
- Site-Specific Site Analysis
- Maintenance Strategies
- Rehabilitation Strategies
- Armor Strategies
- Actions Sequences
- Management Team Review
- Compliance Review

Outputs

- DRAFT Maintenance, Rehabilitation or Armor Design Summary Package for Review
  - Document Summary
  - Spot Improvements Summary
  - Plan Drawings
  - Typical Sections
  - Typical Details
  - Custom Details
  - Cost Estimate
  - Materials List
  - Labor Estimates
  - Specifications
  - Trail Management Techniques
  - Actions Sequences
  - Checklists
  - Lessons Learned Summary
- FINAL Maintenance, Rehabilitation or Armor Design Summary Package

Wisdom from Our Predecessors

To maintain the present degree of accessibility by adequate upkeep of existing trails is more important as a general rule than the building of additional mileage. – U.S.F.S., 1923.

Differentiating out focused projects across the maintenance, rehabilitation and armor design spectrum will assist trail program managers in streamlining their delivery of trailside improvement activities.

Maintenance Strategies	Rehabilitation Strategies	Armor Strategies
Each season - up to 4X / year frequency	Up to 5 - 20 year frequency	Once in up to 50 year frequency
Low investment to bring corridor to sustainable status (< 10% of original $ annually)	Moderate to high investment to bring corridor to sustainable status (10% < X > 50% of original $ / rehabilitation cycle)	High to very high cost to bring corridor to sustainable status (> 50% of original to 5X original $)
Sustainable prevailing cross slopes	Sustainable prevailing cross slopes	Unsustainable prevailing cross slopes
Sustainable Soils	Sustainable Soils	Unsustainable soils
Existing cross section generally in good condition	Restore cross section	Existing cross section is unsustainable
Minor management activities (i.e.: install barriers, plantings, educational signage)	Some management activities	Management activities proven unsuccessful
Minor earthwork activities	Moderate earthwork activities	Significant earthwork activities required
Little or no off-site materials required	Off-site materials make up a small % of required improvements	Off-site materials make up a large % of required improvements
Routine trail maintenance activities will upgrade the corridor to sustainable status	Limited segments of the overall corridor, may be less than 25%	Over 50% of the corridor is unsustainable / management concerns prohibit trail relocation or new trail design
Typical sections and typical details apply	Rebuild - or - add new structures	Build new cross section on unsustainable soils or prevailing cross slopes
Outline design notes only	Competent design drawings / design notes required	Complex to very complex solutions required
No problem solving by trail crew required	Problem solving required by trail crew	Expert construction skills required
High production per person or trail crew	Moderate production per person or trail crew	Low production per person or trail crew
Minimum design time required	Some design time required	Expert design skills required / extensive time and substantial cost may be required
Simple tools required	Simple to difficult tools required	Difficult to complex tools required
Some supervision required	More supervision required	Extensive supervision required
Some training required	More training required	Extensive training required
Loads of time to still go hiking or fishing!	Some time left to go hiking or fishing!	Little time left to go hiking or fishing!

Trail Maintenance Design

Trail maintenance activities are those activities which restore the original design features of the trail and its accompanying structures. Maintenance activities are appropriate for trails that are in good condition and already deemed sustainable, or have already gone through an intensive rehabilitation or armoring process. Trail maintenance does not involve intensive addition of structures or trail relocations.

Maintenance activities, when carried out on seasonal or periodic frequency, not only extend the life cycle of the initial investment, but also prevent the need to invest significantly more resources at a later time due to deferred maintenance. Savings to monetary investments vary, but can approximate 50% to 250% over the life cycle (20 years) of the initial investment. It is therefore prudent to schedule maintenance activities regularly, either through paid staff or through a partnership agreement with a nonprofit agency or individual volunteer at seasonal frequencies of up to 4X / year for some trails.

Maintenance activities can also realize benefits to non-monetary values such as visitor satisfaction, safety, and natural and cultural resource protection.

Maintenance and Monitoring

Maintenance is required to perpetuate a trail's intended dimensions and integrity and to minimize impacts to natural resources. Monitoring and updating maintenance schedules each season and year ensures continued sustainability. In addition, monitoring various use factors over time such as access, patterns, and intensity is important to ensure ongoing sustainability. Consistent multi-year record keeping is important to ascertain trends. The type and amount of use on a particular trail, along with that trail's ability to support changing patterns of use, will influence the type and complexity of the monitoring program. – National Park Service Natural Resource Management Reference Manual # 77, 2006.

Plan to spend up to a half day per mile of trail to plan maintenance activities. It is wise to visit the trail in various seasons of weather and use to observe problem areas. Note the locations of areas that need the type of action shown in the matrix below. "Regular Basis Activities" must be performed regularly, whenever a trail is being maintained, and "Perform as Needed Activities" indicates activities that only need to be performed as noted in the maintenance design summary package.

Trail Maintenance Tools & Techniques	Regular Basis Activities	Perform as Needed Activities
Prune vegetation overgrowth	X	
Remove fallen logs		X
Ensure proper trail outslope and remove minor critical edge berms	X	
Block and restore switchback shortcuts		X
Clean waterbars	X	
Restore backslope		X
Switchback drainage maintenance	X	
Clear culverts, side ditches, and other drains	X	
Sign replacement or maintenance		X
Replace worn structures (waterbars, steps, stone retaining walls or other structures)		X
Relocate structures (stone waterbars, stone stairs, stone retaining walls or other structures) that are in unsustainable locations		X

Trail Rehabilitation Design

Trail rehabilitation is upgrading an existing trail to the original design features of the trail and its accompanying features. This is typically done on a trail that has suffered resource damage beyond what typical trail maintenance can alleviate. It is important to determine the cause of the trail's degraded condition. It may be due to a lack of past maintenance or improper design. Understanding this will help you to program trail rehabilitation efforts in anticipation of future impacts and conditions.

Trail rehabilitation activities, when carried out a multi-year frequency, can significantly extend the life cycle of trail facilities while also realizing benefits to non-monetary values such as visitor satisfaction, safety, and natural and cultural resource protection. Savings to monetary investments vary, but can approximate 50% to 100% over the life cycle of the initial investment. It is therefore prudent to schedule rehabilitation activities on a periodic frequency to ensure the trail corridor stays in a sustainable condition.

Determining whether a trail needs to be rehabilitated or relocated is a delicate process that requires consideration of

- Potential for future impact and erosion
- Land management goals and regulations
- Resource and monetary investment costs of rehabilitation versus re-routing, keeping in mind that re-routing will also involve closing and restoring the old trail
- Safety to trail users

Rehabilitation will likely involve the addition and / or reconstruction of a number of erosion control structures. Stone waterbars and check dams are frequently added to divert water off of the trail and hold soil in place. Switchbacks may need to be rebuilt, stone retaining walls may need to be added, and stone stairs may need to be installed. Be sure to consider re-locations of sections of trail that are a recurring problem, of significant natural resource impact, unsafe, or beyond the scope of what typical trail structures can solve, such as very deep erosion. Observing problems in several seasons or under different types of use will strengthen your problem solving skills.

A rehabilitation design summary package will be required to guide the efforts of trail crews and document where and when structures and improvements were made on the trail. Details such as GPS coordinates or civil engineering station markers for work items and dimensions of work items will be needed to estimate resources needed for the project and to guide trail crews.

The trail approach to the log bridge would benefit from rehabilitation activities. The bridge will need periodic maintenance, including the replacement of the stringers or handrail approximately every 5 to 10 years.

This trail would benefit from rehabilitation activities, including the re-establishment of the proper trail outslope as well as selection and installation of trail drainage options.

Trail Rehabilitation Tools & Techniques

Problem	Spot Improvement Design Solutions
Soil Erosion	1. De-berming (for minor erosion) 2. Combination of waterbars and check steps work well (check dams hold soil in place, waterbars divert water off of the trail) 3. Stone paving, stone stairs / check steps or ascent route solutions on steep grades 4. Re-fill trail with mineral soil to original grade. Consider waterbars and check steps to prevent reoccurrences of erosion
Muddy Areas	5. French drains 6. Turnpikes with culverts or french drains 7. Boardwalks 8. Replace trail surface with mineral soil or crushed gravel
Trail Shortcuts	9. Natural physical barriers (i.e.: large stones, logs) 10. Structural barriers (i.e.: buck-and-rail fences, stone retaining walls) 11. Directional signage or educational signage 12. Consider restoration strategies
Unsafe Sections	13. Site-specific solutions required 14. Trail widening 15. Consider new trail design
Trail Braiding	16. Consider new trail design 17. Consider restoration strategies

This trail is insloped and would benefit from rehabilitation activities to restore the proper outslope.

This social trail to a popular scenic overlook will likely see continued and increasing use. Upgrading this corridor with a new trail design may be prudent at this time. Alternately, management actions such as installation of signage or barriers may be prudent.

Trail Armor Design

While the foundational goal of sustainable mountain trail development is to provide the best experience to the user with the minimum short-term and long-term impacts and cost, most trails – even in ideal conditions – will have segments where natural surface sustainable criteria are unachievable or exceeded. In these segments, trail armor design may be required to achieve trail improvements that are easy to maintain.

These situations may be the result of

- Poor or inadequate original planning and design
- Poor, inadequate or impatient original construction
- Overuse of a trail or the unplanned increase or change in the type, pattern and volume of use
- Lack of adequate maintenance
- Natural events like wildfires, floods and rockslides that significantly impact or alter the environment
- Corridor constraints

Corridor constraints may be caused by

- Topography / environment (there is nowhere else to locate the trail or no better corridor alternatives)
- Compliance restrictions – a historically significant corridor, or proximity of sensitive natural (i.e.: wetlands) and / or cultural resources (i.e.: archaeological sites)
- Property boundaries / easements
- Land management agency restrictions, policies or decisions

Trail armor design (armoring) can cause extensive short term resource impacts, can be costly, complex and a logistical challenge. Substantial amounts of time and materials may be required to complete each segment. However, an appropriately designed and constructed armored solution can provide a sustainable, easily maintainable trail for many years. Armor solutions require higher percentages of improved / complex tread construction or water management structures, activities or practices. Armor solutions require thorough planning, thoughtful design and expert skill to properly implement.

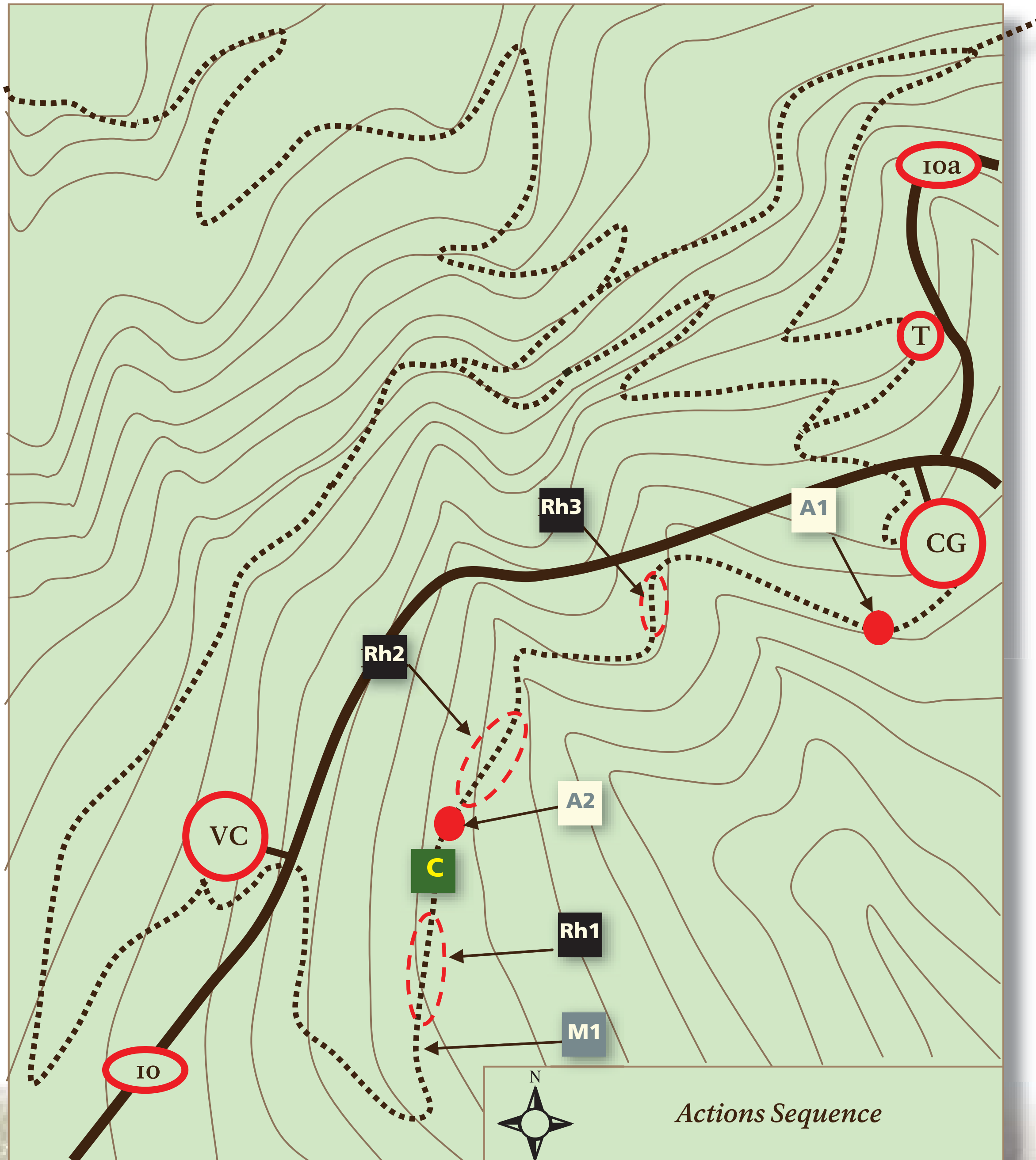
Armoring is characterized by

- Short sections are typical, however longer sections are sometimes required
- Found in areas with steep grades and / or where water is a major seasonal or annual factor in localized areas
- Excellent for the long-term management of surface and sub-surface water (i.e.: stream crossings, boggy areas)
- Usually undesired by equestrian users, but not unsafe if properly constructed
- Labor and material-intensive (i.e.: slow linear foot production per day per person or crew)
- Heavy impacts and challenging logistics including temporary trail closures during construction
- May require complex tools, intense training, or specialized / experienced labor force
- High cost of installation / ownership, but very long life-cycle expectancy if properly constructed (50+ years)
- Common in the high Sierra trail tradition and other areas similar in topographic and environmental factors (i.e.: abundant slick rock, generally shallow, sandy soils, plentiful, good building rock, multiple and / or high-use trails)
- Very challenging yet equally rewarding for the trail crew to implement

Armor solutions are usually required on trail profile grades over 15%, on prevailing cross slopes over 70%, and in silt or clay soil conditions, hence the desirability to avoid these conditions. Interdisciplinary trail teams can expect to utilize a higher percentage of armor design solutions the further they go into the backcountry, and on ascent routes to popular peaks.

A trail armor design summary package will be required to guide implementation of these complex solutions.

Corridor C Maintenance, Rehabilitation & Armor Actions Sequence



Legend

M1 Regular basis trail maintenance activities each season or up to 4x / year are planned for the entire segment.

Rh1 This backslope on this section of trail (50') has collapsed and the trail needs to be rehabilitated to its original design.

Rh2 A wet seep appeared here and damaged the trail. Ditches (75'-long) need to be cut uphill to direct runoff to a low point. See tread cut with ditch detail.

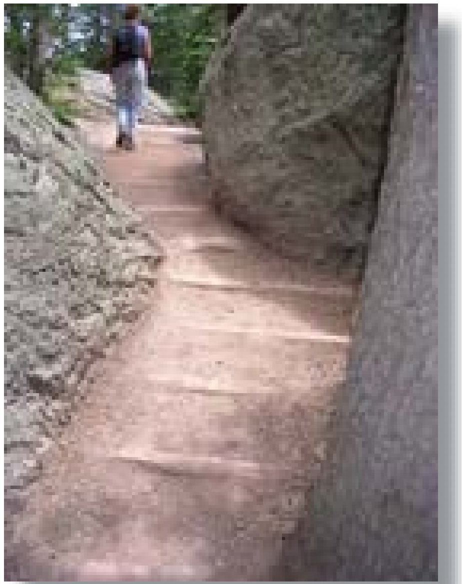
A1 "Yikes!" This section was in deep topsoil. Coarse gravels need to be brought in to strengthen the trail surface, and drainage improvements need to be provided, length = 75'.

Rh3 The backslope on this section of trail (40') also collapsed. Rehabilitation is required.

A2 Another armor improvement is required here, in this case, deep topsoils were encountered for only 25', hence a low priority.

Properly planning out the sequence of maintenance (M), rehabilitation (Rh) and armor (A) improvements will help nonprofit agencies and volunteers focus their efforts where they are most needed, when they are most needed.

Armor Design



Armor solutions which draw their cues from the form, line, color and texture of the naturally occurring landscape provide inspiration to park visitors to Rocky Mountain National Park!

Land management agency staff always has the prerogative to implement actions which may prevent impacts to resources, protect existing resources, improve the condition of resources or economize on investments of time and materials during the implementation of trails. On-trail actions are particularly effective and economical to accomplish.

"Please Help Protect Your Park." Closing trails that are impacting natural resources is a difficult decision. Here at Lory State Park several parallel tracks were recontoured and ecologically restored. Visible results were apparent within just one year of this restoration project. Installation of the barrier fence helped keep visitors off of the restored area.

Directional signs help trail users understand their location and correspondingly help prevent impacts to natural and cultural resources.

Trail Management Options

	On-Trail Management Options
1	Barriers. Installation of barriers help prevent off-trail impacts.
2	Educational Signage. Signs can educate park visitors about on-trail or off-trail resource impacts, off-trail restrictions or restoration activities.
3	Directional Signage. Trail directional signs assist park users with wayfinding.
4	One-Way Routes. Establishing one-way ascent and descent routes on heavily used trails reduces impacts.
5	Clockwise / Counterclockwise Routing. Establishing alternating clockwise or counterclockwise trail uses can minimize multiple use conflicts or high volumes for use.
	Other Management Options
6	Ethics. Trail ethic brochures, signs, or seminars can educate park visitors about multiple use conflict, on-trail or off-trail resource impacts, safety and other issues.
7	Restoration Activities. Investment in restoration of abandoned trails or other impacted areas communicates to visitors land management agency stewardship responsibilities.
8	Educational Activities. Increasing interpretive and / or educational opportunities can strengthen the overall trails program.
9	Off-trail Restrictions. Establishing and enforcing off-trail restrictions can prevent the continued creation of social trails or impacts to natural and cultural resources.
10	Thresholds. Establishing thresholds for muddy trail closures can reduce impacts to trail surfaces during inclement conditions and seasonal trail restrictions can minimize impacts to trail surfaces during specific seasons.

Maintenance Design Checklist

- ❑ Web Search / Literature Review
- ❑ Sustainability Assessment
- ❑ Mountain Trail Plan
- ❑ Rehabilitation Design Goals
- ❑ Trail Management Options
- ❑ Lessons Learned
- ❑ DRAFT Maintenance Design Package
- ❑ Review
- ❑ FINAL Maintenance Design Package

Armor Design Checklist

- ❑ Web Search / Literature Review
- ❑ Sustainability Assessment
- ❑ Mountain Trail Plan
- ❑ Armor Design Goals
- ❑ Distance From Trailhead
- ❑ Trail Management Options
- ❑ Lessons Learned
- ❑ DRAFT Armor Design Package
- ❑ Review
- ❑ FINAL Armor Design Package

Rehabilitation Design Checklist

- ❑ Web Search / Literature Review
- ❑ Sustainability Assessment
- ❑ Mountain Trail Plan
- ❑ Rehabilitation Design Goals
- ❑ Trail Management Options
- ❑ Lessons Learned
- ❑ DRAFT Rehabilitation Design Package
- ❑ Review
- ❑ FINAL Rehabilitation Design Package

On-Trail Management Options

1. Barriers
2. Educational Signage
3. Directional Signage
4. One-Way Routes
5. Clockwise / Counterclockwise Routing

Lake Agnes, in North Park, Colorado

The Challenge ...

Premises

Planning sustainable trails is based upon the following premises:

- Protection of natural and cultural resources
- Where appropriate, make resources available via trails, some areas are best preserved (without trails)
- Appropriate geographically
- Physical and social context studies (where appropriate)
- Appropriate origins, destinations and intermediary linkages
- Recreation accessibility accounted for
- Appropriate prevailing cross slope ranges and profile grades
- Appropriate solutions for intended uses
- Extensive field work is required, including the study and comparison of alternative routes
- Nonprofit agency stewardship partnership support for individual projects

Design Parameters

Planning sustainable trails is based upon the following parameters:

- Frontcountry use patterns may exist upwards of 3 – 5 miles from the trailhead
- Middlecountry conditions may exist 3 – 5 or 7 miles from trailheads
- Backcountry or cross country conditions may exist 7 miles and further from trailheads
- Multiple uses commonly include hiker, equestrian and mountain bicyclist uses
- High volumes of use can be expected in frontcountry areas
- Extended seasons (shoulder season) of use can be expected, even year-round use, in all areas especially close to population centers
- Public land management agencies usually have sufficient land bases to allow study of extensive systems and accommodation of many users and uses
- Both monetary and labor resources are scarce, indicating decisions must be based upon long-term impacts or life cycle costs

Caveats

Planning sustainable trails is based upon the following caveats:

- Heavily used trails may require to be armored with sustainable materials such as gravel or armored with materials such as stone, after long periods of heavy use
- A hierarchy of investment in monetary value, materials and labor is expected across the further the project is from the trailhead
- Maintenance activities, carried out seasonally will do much to ensure the protection of natural and cultural resources as well as recreational opportunities and correspondingly to ensure sustainability

The Challenge ...

Decisions that agency managers may make influence:

◆ Patience		◆ Panic
◆ Protection of resources		◆ Impacts to resources
◆ Conservation of resources		◆ Loss of resources
◆ Optimum experience	- OR -	◆ Less than optimum experience
◆ Wise investment of $		◆ Squander $
◆ Continual Improvement		◆ Continual deterioration
◆ Build partnerships		◆ Lack of support
◆ Cultivate nonprofit agencies		◆ Lack of interest
◆ Leave a legacy		◆ No infrastructure
◆ Pride in program		◆ No worth

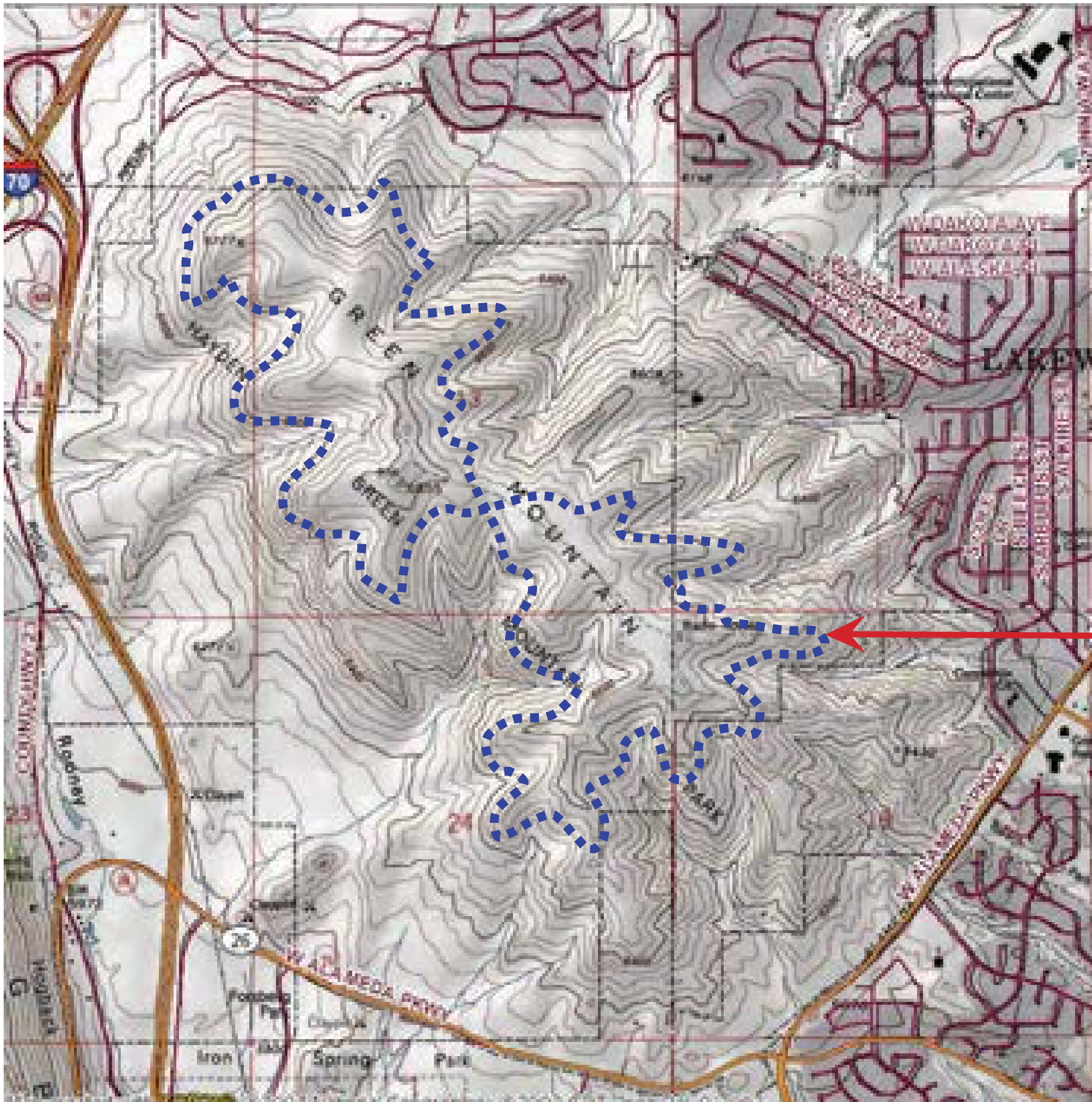
Many times, the hardest decision agency managers have to decide is whether or not to continue to use existing corridors, maintain them, rehabilitate them, or abandon them and start over with a new trail design according to sustainability criteria. Once a decision has been made, incremental and patient actions which are part of the overall design plan will result in the most beneficial project regarding natural and cultural resources protection, land management agency goals and stakeholder interests.

... is to be Patient!

Complex problems deserve careful thought, and many times substantial investments of time and materials. This project restored a lake edge trail that had been heavily impacted by over use causing water quality impacts. Inspired by Rocky Mountain National Park's historic stone craftsmanship tradition, this stone retaining wall was designed by the park's trail crew with irregular lines to mimic the natural forms of the surrounding landscape, as well as to not look unnatural from viewpoints along the opposite lakeshore and along the trail. Between 400 and 600 visitors per day in the peak summer season can now enjoy this more natural setting!

After condition (above), before condition (right) and work under construction (top right).

Hayden Green Mountain Regional Park, Lakewood, Colorado – Summit Loop



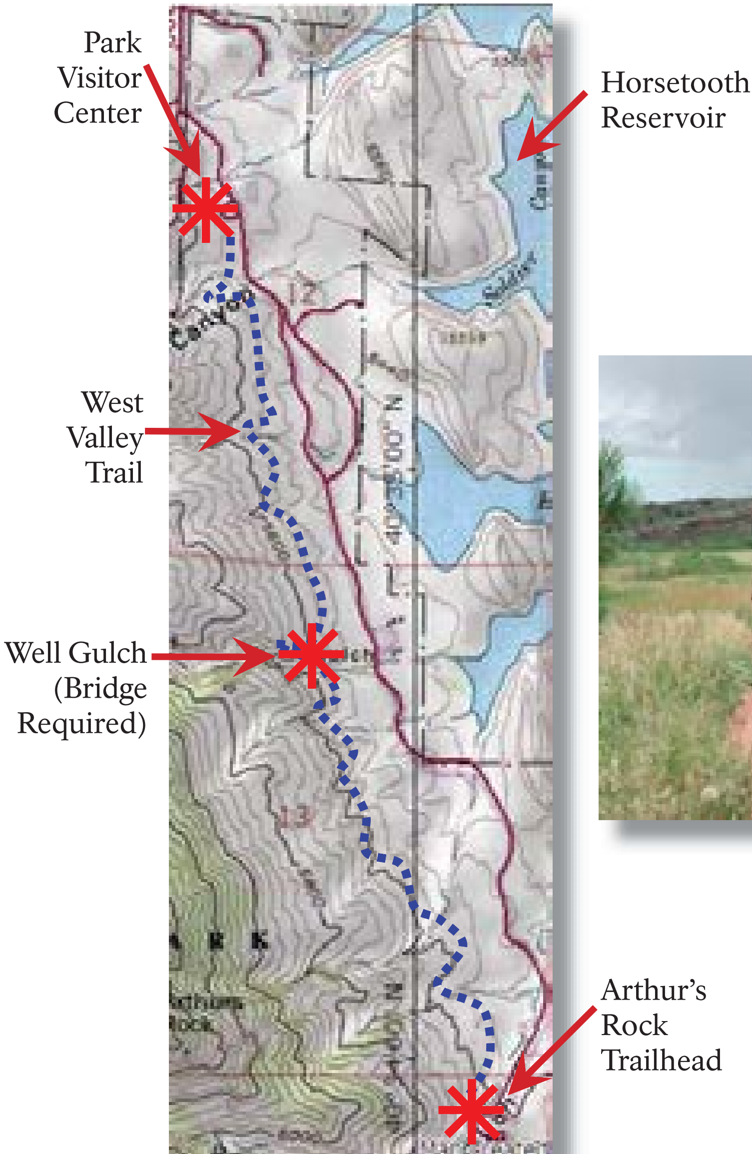
The existing trail is on a maintenance road. The Summit Loop will be a 3-foot wide singletrack.

Summit Loop

Trail users in the future will experience expansive views of the eastern plains of Colorado and Denver's front range.

The Summit Loop Trail at Hayden / Green Mountain Regional Park in Lakewood, Colorado, will be implemented over a series of years. Approximately 8 miles of trail will eventually be linked, providing an alternate route to a maintenance road.

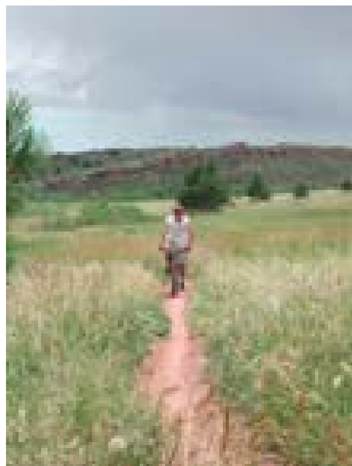
Lory State Park, Colorado – West Valley Trail



The West Valley Trail at Lory State Park were relocated from unsustainable locations to sustainable locations over a period of years.

The original trail was parallel to the park road and ran straight up and down each successive ridge. Heavy rains, in just one storm, severely damaged the trails.

Corridor control points were mapped out using mountain trail planning tools and techniques, and the overall trails were broken into segments and designed using new trail design tools and techniques.



Corridor control points were drainage crossings, including identification of a major bridge needed to cross Well Gulch. Intermediary control points were studied and mapped in new trail design.

As the trails are always within 3 miles of a trailhead and heavy use was expected, gently climbing grades were utilized for the West Valley Trail. Armor spot improvements, i.e.: crushed gravel, were required in many locations. The West Valley Trail is now enjoyed by many users, including novice mountain bicyclists. Steeper areas at Lory State Park will have more challenging mountain bike routes in the future.

A variety of nonprofit agency, government agency and volunteer groups implemented the trail.

Colorado Fourteeners Initiative – Ascent Routes

The Colorado Fourteeners Initiative (CFI) has reestablished 20 high alpine ascent routes on the state's highest peaks to replace old, user-created routes. Witnessing the amount of use of these trails made it clear that there is a significant need for ongoing trail activities, and a plan to carry them out.

Each season CFI staff and trained volunteer field crews team together to prepare detailed trail maintenance, rehabilitation and armor design notes on ascent routes, recording GPS coordinates to relocate specific work items year-after-year. Work items are given length (L) x width (W) x height (H) unit estimates, priority ratings, and a spreadsheet calculates the estimated person hours needed to complete each work item. Adopt-a-Peak volunteer groups are able to use these notes along with a GPS unit to re-locate specific work items.

The benefits of carrying out field work and field notes activities are numerous. Having each work item's location and priority rating recorded with a GPS unit allows Adopt-a-Peak groups to focus their work efforts on the highest needs, and be able to find that area efficiently. This system brings a broader perspective to the entire trail route and identifies the biggest problem areas.

Field crews that investigate site conditions and record field notes for Adopt-a-Peak crews help improve efficiency when crews carry out work items. Right photograph: well maintained trails are in good shape for users to enjoy.

CFI Ascent Routes – Adopt-a-Peak Field Notes

Task	Work Item	GPS Coordinates		Elevation	L x W x H / Units	Priority	Description
1.1	Steps	39°39.630 N	105°47.097 W	11,273'	3	2	Install 3 check steps.
1.2	Drainage	39°39.465 N	105°47.141 W	11,414'	1	1	Ensure drainage into talus slopes.
1.3	Drainage	39°39.440 N	105°47.168 W	11,424'	1	3	Clean stone waterbar.
1.4	Steps	39°39.432 N	105°47.176 W	11,437'	7	4	Repair check steps.

The enabling legislation for the Continental Divide National Scenic Trail (CDNST) established a primarily primitive hiker and stock trail route between Mexico and Canada along and in the vicinity of the Continental Divide. Much of the existing Continental Divide National Scenic Trail 90-mile segment between Mount Elbert and Monarch Pass in Colorado is located on routes and roads open to motorized travel.

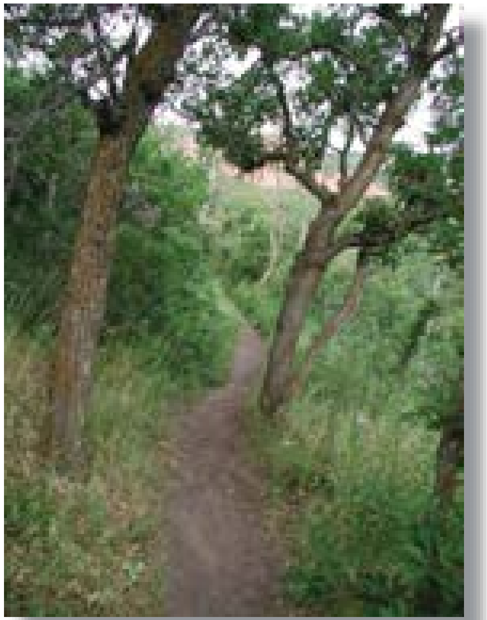
The goal of this project is to better meet the original intent of the enabling legislation for the CDNST and U.S. Forest Service management policy.

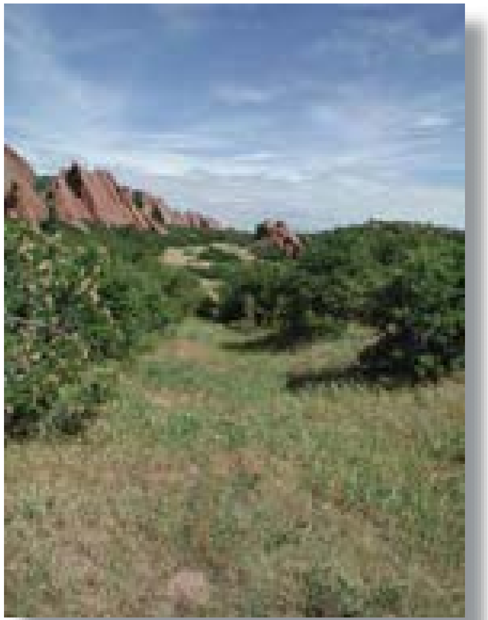
Patience is continually necessary to see a project of this magnitude through to completion. Planning and environmental analysis for this project alone have taken over four years to complete. Implementation will require another 6 to 10 years depending upon funding levels each year.

Sustainability principles incorporated into the planning of this trail and armor design solutions designed into the trail will ensure that maintenance and rehabilitation activities will be minimized.

Those seeking the significant physical challenge of the Continental Divide National Scenic Trail, with its inherent solitude, will delight in this national treasure!

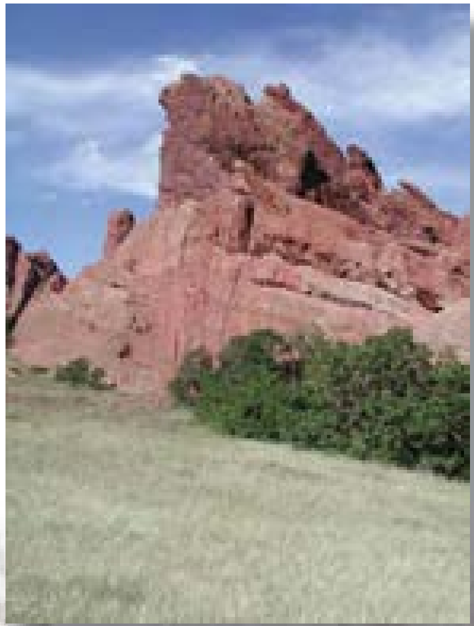
Roxborough State Park, Colorado – Willow Creek & South Rim Trails

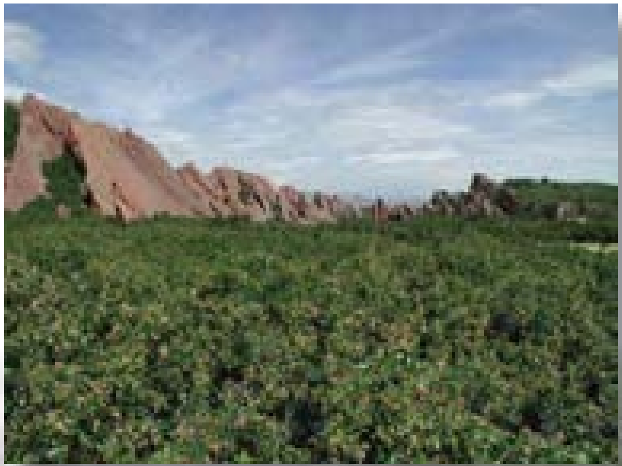




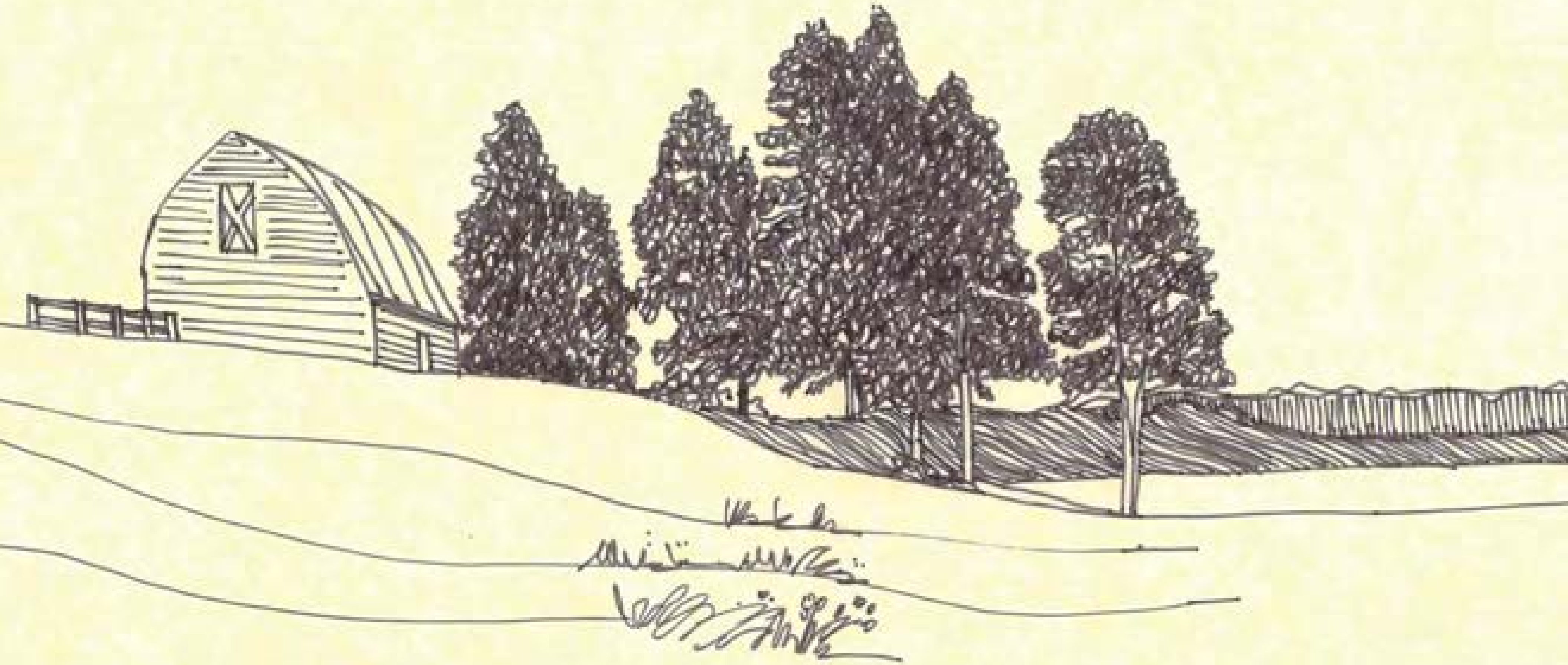
The Willow Creek and South Rim Trails are successful examples of new trail design. The Willow Creek Trail leaves the visitor center at Roxborough State Park and gently meanders through a Gambel Oak forest towards the south. The South Rim Trail splits from the Willow Creek Trail and gently climbs to the South Rim overlook.

Visitors delight in the gently climbing alignment which offers a variety of viewer locations and perspectives of the Willow Creek Valley and the "Red Rocks" Fountain Formation rock outcrops towards the north. Different seasons offer different views for visitors to behold!





The Willow Creek and South Rim Trails at Roxborough State Park benefited from a clean palette. On-going seasonal maintenance keep these trails in sustainable condition.



Pitfalls to Avoid

There are many common pitfalls to avoid when undertaking mountain trail projects. All too common are short-sighted projects, presumably understaffed, under-funded and with a deadline to spend money or open a corridor to use.

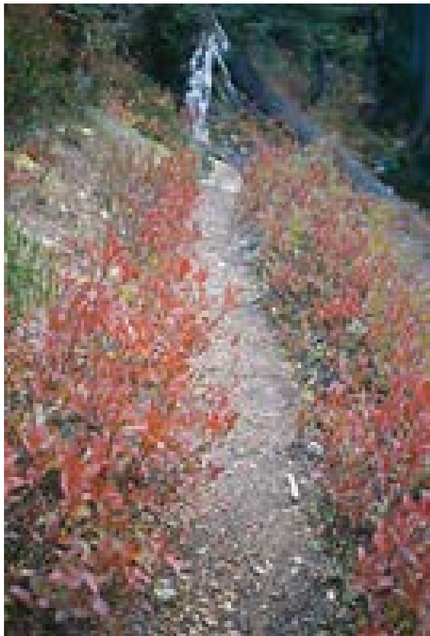
Here is a sampling of other common pitfalls to avoid

1. Failing to comply with state or federal laws, agency management policies or environmental compliance requirements.
2. Not including management reviews as part of your review process.
3. Using inappropriate sustainability criteria and / or failing to consider sustainability throughout the trail project cycle. Using criteria which are founded in science or are based upon common landscape architectural principles (not emphasizing one trail project cycle cog over another) is the more prudent way.
4. Initiating a mountain trail plan without a thoughtful sustainability assessment of existing trails. Assessing existing trail systems according to sustainability criteria assures their consideration for long-term inclusion in a plan, or their recommendation for abandonment and restoration when new trails are implemented.
5. Not considering off-site connections when planning trails. Many times opportunities exist across agency boundaries for suitable and compatible off-site connections, precluding unnecessary expenditure of funds on short-sighted solutions.
6. Initiating a new trail design without a mountain trail plan (and corresponding assessment). Inclusion of a new trail in a plan assures its fitness for use as well as its consideration for priority implementation compared to other projects.
7. Implementing a new trail design without undertaking a parallel restoration project. Failure to carry out restoration of abandoned corridors communicates the wrong message about the value of open space and conservation areas. Land management agencies, in particular, should sponsor restoration of abandoned corridors. Sometimes nonprofit agencies have mission statements or yearly goals which address land management agency restoration goals, and partnerships can be created.
8. Locating switchbacks or other significant trail improvements on unsustainable soils or locations. Switchbacks and other significant trail improvements are best located as corridor control points during the mountain trail planning process and confirmed during new trail design. Doing so ensures their long-term suitability as an component of the trail corridor.
9. Crossing drainages in inappropriate locations, or at the wrong profile grades. Drainage crossings many times require significant investment of time and materials. Drainage crossings also may involve significant expense building sustainable trails to and from the crossing. Wetlands and associated values commonly have to be assessed when crossing drainages. Utilizing the incorrect profile grade at drainage crossings sometimes results in impacts to the adjoining trail.
10. Adopting existing ridgeline trails into a existing trail system, or prescribing ridgeline trails as part of a new corridor. Thoughtful assessment would indicate many ridgeline trails are not sustainable. Many ridgeline trails exceed recommended standards for profile grades. Left unmanaged, ridgeline trails may develop into adverse ecological impacts, even upwards of 25-foot widths or more, inviting non-native invasive species to colonize the area and causing extensive visual resource impacts. Some ridgeline trail segments can form sustainable components of trail systems.
11. Failing to sign a maintenance agreement with a nonprofit conservation agency or individual volunteer. Establishment of a maintenance agreement for life of the project (likely 20 years or more) communicates the long-term intent for both parties, and will likely attract more support.
12. Not adopting a lessons learned approach, including a summary of nearby projects' successes and failures. Adopting a lessons learned approach to trail program management will likely yield visible results in just a few projects or a few years.

Documenting lessons learned is a foundational principle of professional project management. How many of us have re-invented the wheel, more than once? No hands please! Preparing lessons learned summaries or hosting lessons learned retreats are great ways to add to your agency's body of knowledge for mountain trail projects, and your surest way of improving project performance.

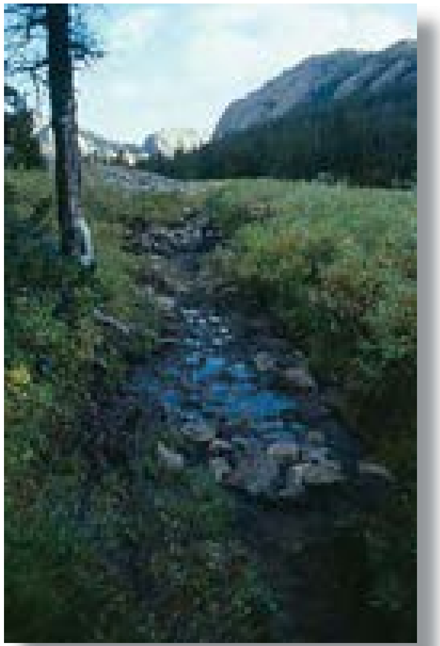
Herewith are a few lessons learned

1. Reduced life cycle costs (with greatly reduced maintenance costs) result from assessing, planning and designing mountain trails according to sustainable criteria.
2. Undertaking too-ambitious of a trail project or trail segment at one time. It is better to implement three one-year projects of one-mile each sustainably, rather than implement a three-mile project in one year if it all will not be according to sustainable criteria.
3. Exceeding recommended profile grades. Exceeding recommended trail profile grades, especially in frontcountry areas, is a sure way to fail to achieve sustainability goals.
4. Exceeding or not responding to recommended prevailing cross slope conditions. Exceeding recommended prevailing cross slope conditions will contribute to excessive force from runoff or snowmelt. Higher velocities equals more potential for erosion. Some prevailing cross slope conditions require more investment of time and materials, which will realize their value over the project life cycle.
5. Specifying techniques or materials that are not sustainable. Importing non-native materials very far into the backcountry is an unsustainable practice. Replacement materials will likely have to be re-imported. Native material alternatives usually exist.
6. Failing to fully document the complete design of the project for land management agency staff, day labor employees, or nonprofit staff or volunteers, including preparation of plans, sections and details, specifications (if appropriate) and estimates (i.e.: design package summary). Fully outlining project requirements is the more prudent way, and has been recommended in the popular trails literature as far back as 1915.
7. Failing to complete time and material estimates for each trail segment. Estimates are the basis of efforts to obtain money, purchase or obtain materials and for organizing volunteers. How else can one ascertain project goal attainment? Comparison of actual investments versus estimated investments is the basis of your next estimate.
8. Failure to conduct training activities in advance of project activities, to ensure that compliance with drawings and specifications is achieved. Conducting training activities in advance of project activities is the surest way to ensure predictability of results.
9. Using unsustainable materials. Stone could be considered one of the most sustainable materials and usually exists in abundance on most trail projects in the proper size and shape to be easily incorporated into trailside structures. Plastics and treated lumber have sustainable options.
10. Failing to hold post-project lessons learned reviews or retreats or failing to prepare a lessons learned summary for inclusion in the project archives. Hey, what better way to enjoy your new friends and spend some quality time in the backcountry than to have a retreat? Summaries of lessons learned can be easily incorporated into project files for use on future projects.



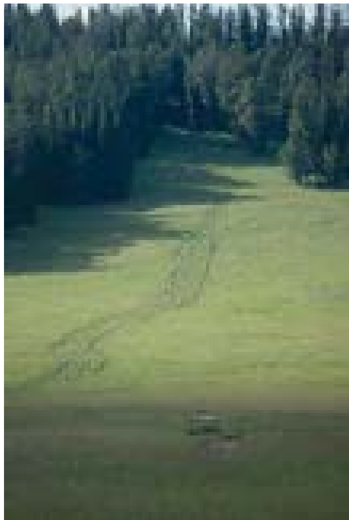
Pacific Crest National Scenic Trail, Mount Baker / Snoqualmie National Forest, Oregon

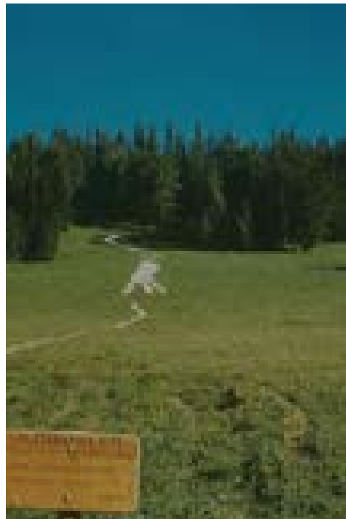
Lack of regular basis trail maintenance activities on this trail segment has allowed vegetation to encroach into the trail tread. This caused stock and hikers to impact the outside trail edge, thereby compromising the integrity of this otherwise well functioning trail. In order to restore the original design features of the trail not only was the encroaching vegetation removed from the trail corridor (including the root structure), but also the backslope, inside edge, outslope, and critical edge required rehabilitation. A lesson learned: to efficiently utilize maintenance resources, regular basis trail maintenance activities must be performed regularly.



Glacier Trail, Wind River Range, Wyoming

Natural resource impacts and safety issues resulted from poor original design where appropriate cross-trail drainage was included in the initial construction. A lesson learned: this rehabilitation project required more effort than the original implementation project. Initial placement of an appropriately designed armoring structure would have saved precious resources to address other areas of need.

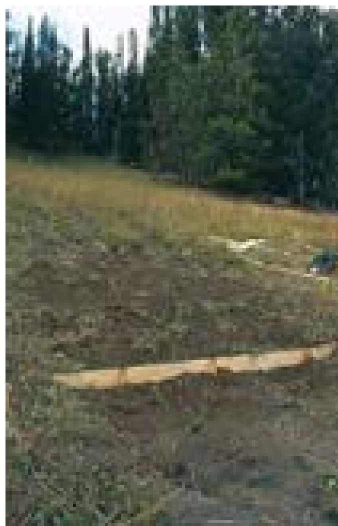


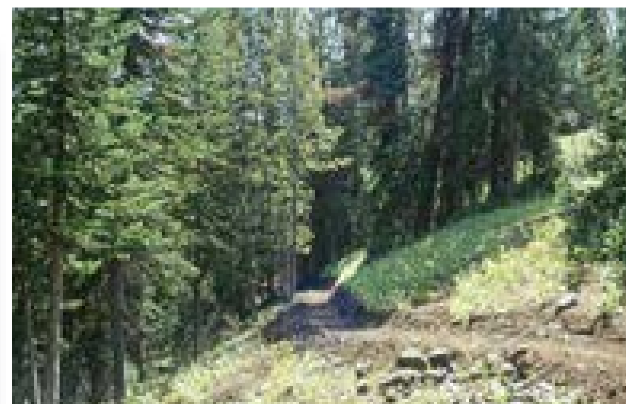


Jade Lake Trail, Shoshone National Forest

Poor trail alignment design can cause an adverse impact to natural resource values, visual resource values and potentially cultural resource values. Established by inappropriate use, this impacted areas was visible from a popular day use area at Brooks Lake that received over 1,000 visitors per day during the summer months. Restoration for this project included three strategies. The first focused on obliterating the braided trails at the bottom of the hill by placing transplants in the trail segments to be abandoned and restored. This strategy in conjunction with an educational sign discouraged use of the restored trail segments. The second strategy focused on filling the braided trail segments at the top steeper section of the meadow with native soil and seeding with seed from native sources. This necessitated the placement of wood plank check dams in order to keep the soil in place until root systems could naturally stabilize the area. Over time the wood planks will decompose. Landscape matting was placed over the seeded soil to provide additional soil stabilization and protection of native seeds.

The last strategy included the construction of an attractive, usable, and sustainable new trail to access Jade Lake.





A sustainable trail was built on this existing hillside (left), ensuring safe access without impact to natural or cultural resources (above).

More Tools

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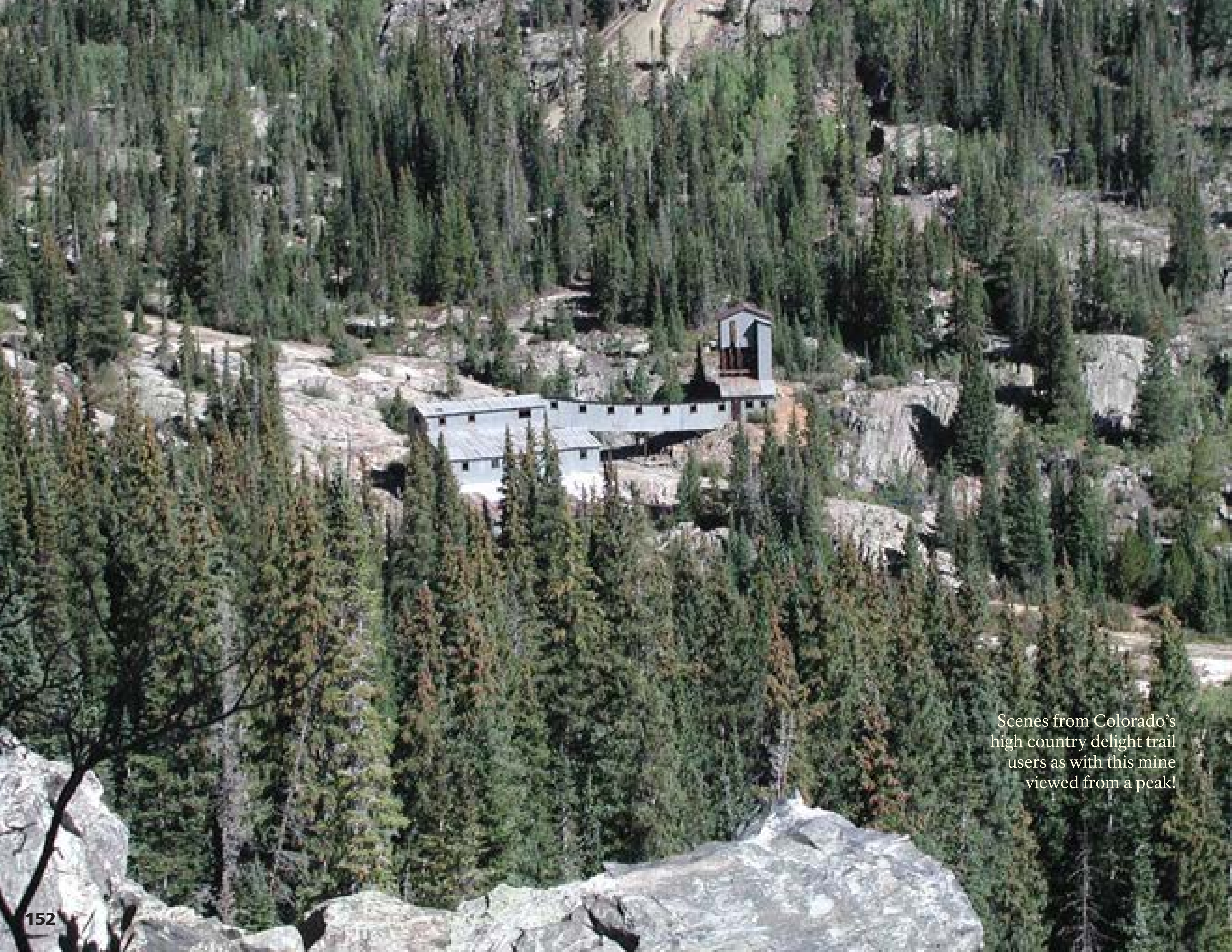
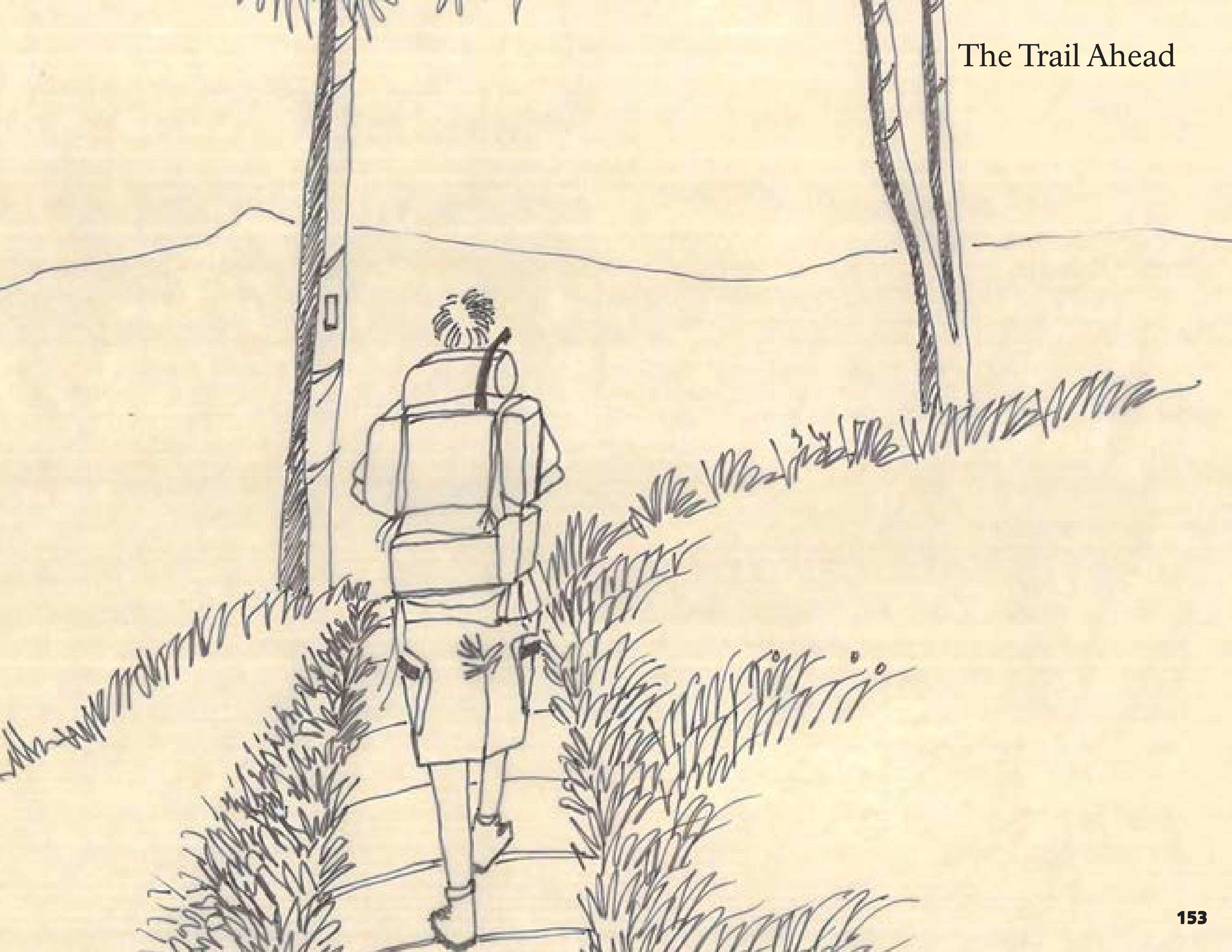


Scenes from Colorado's high country delight trail users as with this mine viewed from a peak!



Executive Order 12906

Executive Order 12906 – "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure" governs the generation and storage of geographic information by the federal government. Since 1994, federal agencies have been mandated to gather geographic data according to standards prescribed by the federal government for record keeping and data sharing purposes.

Digital Technology

The use of digital technology could have a significant beneficial effect on the management of mountain trails. Geographic Information Systems (GIS), specifically, can assist the interdisciplinary trail team in the creation and use of topographic models, the inventory of natural resource and cultural resource data, and the use of sustainability analysis tools. Record keeping, peer-to-peer exchange of information, analysis of data, comparison of alternatives, summaries of data, and decision making can all be strengthened through the use of digital information.

Advantages of the use of digital information include

- Common base maps can be developed
- Corridors can be overlayed onto topographic or resource data to "see through" multiple layers
- Information can be easily updated, scaled, plotted, exported and exchanged
- Internet Map Services can be used to serve data to clients or stakeholders
- Analysis tools can be used, i.e.: buffers, viewsheds, data modeling
- Trail profile grades can be more accurately estimated
- Prevailing cross slope ranges can be more accurately determined
- Trail distances can be estimated
- The classic landscape architectural analysis technique – the McHargian overlay method of analysis – can be customized to your project

New Tools & Techniques

Capture of data via Global Positioning Systems (GPS) data dictionaries, uploading to databases for storage, analysis, and sharing via internet sites is now commonplace. Resource grade GPS tools allow horizontal data accuracies of 1-3 meters.

The improved accuracy of GPS units, combined with their widespread use as well as customization towards sustainability criteria will assist interdisciplinary trail teams, stakeholders and decision makers in streamlining delivery of projects over the trail project cycle.

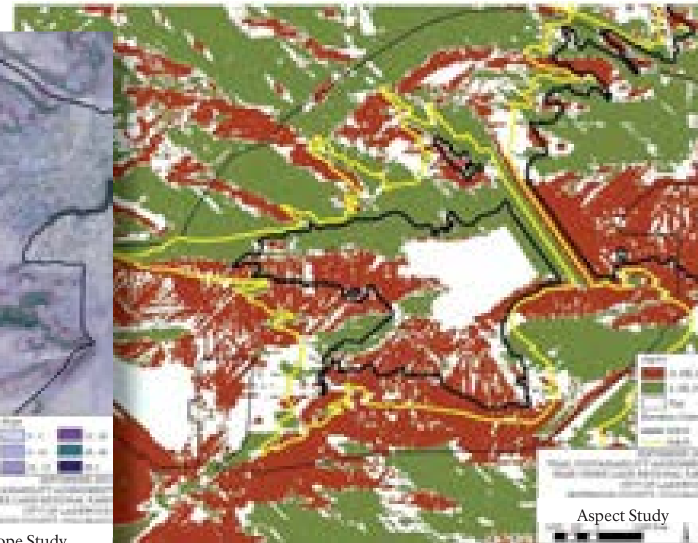
More research and experimentation is required to create and refine new tools and techniques usable to the wider trails community and to derive efficiency from the use, storage and distribution of digital information. This will allow even greater improvements in the management of mountain trails and less impact to natural and cultural resources.

GIS tools were used to conduct a Trails Sustainability Assessment and a Mountain Trails Plan for Bear Creek Lake Park in Lakewood, Colorado in 2003.

Sample Geographic Information Systems Outputs

Elevation Study

Slope Study



Aspect Study

Aesthetics Study

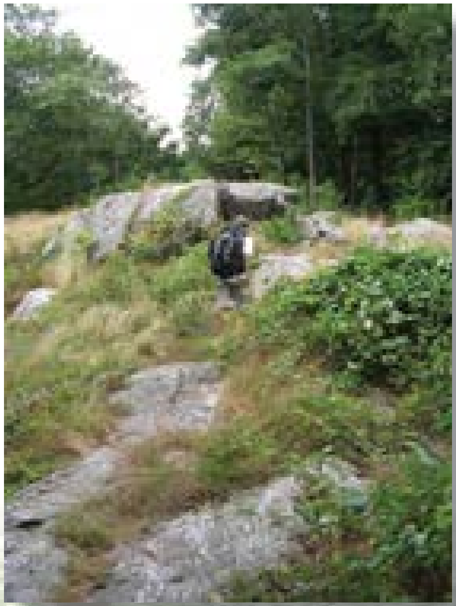
Trail Plan Proposal

GIS tools, combined with hand-held GPS tools and field work can help the interdisciplinary trail team determine sustainable trail corridors. An Elevation Study, a Slope Study, an Aspect Study and an Aesthetics Study shown above aided in the production of the Trail Plan Proposal shown on the right. More research is required to customize GIS and GPS tools to specific projects!

Towards a Mountain Trail Sustainability Ethic ...

Mountain trail sustainability can be summarized as the art and science of the optimum investment of time and materials into a trail over the project's life cycle. It is akin to wise stewardship of a woodlot. Decisions made today may not be realized for a generation or two. It is based upon a wilderness ethic of minimum alteration to natural systems and minimum evidence of human presence established through the historic tradition of federal land management agencies. Visitors to parks and forests today still long for views of naturally occurring scenery. They long also for human-made improvements in harmony with their surroundings, crafted and complementary to the form, line, color and texture of the naturally occurring landscape! And just as development of trails of the early 20th century many times prevented impacts to natural and cultural resources, so too can modern mountain trails!

Mountain trail sustainability ethics echo the policies of the American Society of Landscape Architects to protect, respect, enhance and restore visual resource, open space, wildlife habitat, native species, wetlands and water quality values. They are parallel to stewardship principles of federal land management agencies to manage natural and cultural resources unimpaired for future generations, and they draw inspiration from American conservation literature of the 20th century.



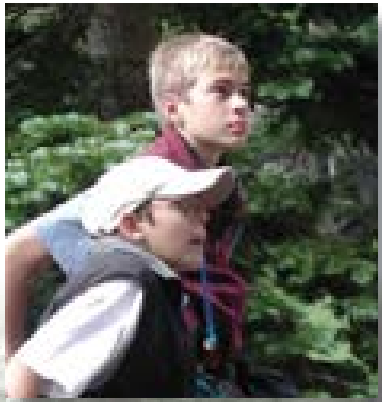
Naturally occurring landscape scenes have been an inspiration to humankind throughout history. Maintaining such scenes, devoid of visual impacts, is the essence of mountain trail sustainability. Please join us in our efforts to develop projects which protect, respect, enhance and restore the value of public lands while allowing for appropriate recreational uses!

Communicating the need to properly assess, plan, design and implement natural surface trail projects, the significance of your work to others who are relying on you, and the lasting legacy that you can leave on trails in your conservation area is our paramount goal. Our hope is that …

- … we have given you landscape architectural tools and techniques which you can customize to fit your project at hand
- … you adopt the lessons learned technique; that you endeavor to test sustainability criteria presented, apply them to the ground, assess your projects, and then incorporate lessons learned into future projects
- … whether you are a land management agency staff, nonprofit agency partner or interdisciplinary team member, that you will be encouraged to provide the highest degree of excellence to your project activities
- … wherever you are affecting trails in the trail project cycle, you can be satisfied that you did the hard work and invested the effort necessary to ensure the optimum investments into your trail project with minimum impact on natural and cultural resources so that trail users can still safely enjoy naturally occurring scenes on public lands

The *Sketchbook* is intended to be a guide only to sustainable mountain trails. More research into sustainability criteria, processes and solutions is required, including the use of technology, as is additional funding for training for land management and nonprofit agency staff. New partnership opportunities also need to be explored.

Not only are land managers, nonprofit agency partners and future generations depending upon you, but our nation's precious public lands – their natural and cultural resources with their associated intrinsic resource values – are also depending upon you. What role will you play in helping shape the mountain trail sustainability ethic in the 21st century?



And, oh, happy trails!

Co-Authors

Danny Basch

Currently — Eastside Trails Supervisor, Rocky Mountain National Park, Colorado Outdoor Training Initiative Master Instructor.

As the Eastside Trails Supervisor at Rocky Mountain National Park, Danny's responsibilities include maintenance, construction and rehabilitation of approximately 250 miles of trail, 900 trail signs and 200 bridges.

E-mail danny_basch@nps.gov
Phone 970-586-1248

Hugh Duffy

Currently — Project Manager (PMP), Landscape Architect (RLA, ASLA), National Park Service, Denver Service Center, Transportation Division; Colorado Outdoor Training Initiative Master Instructor.

1985 – 1990 Various Roles @ Volunteers for Outdoor Colorado, including Projects Committee Chair, Technical Advisor and Board Member.

1997 – 2002 Various professional consultations including production of Trail Assessments, Trail Plans and New Trail Designs.

E-mail hugh_duffy@nps.gov
Phone 303-969-2452
Mobile 303-981-5120

John Giordanengo

Currently	Projects Director Wildlands Restoration Volunteers Board of Directors, Colorado Native Plant Society Master Instructor and co-author of Colorado Outdoor Training Initiative (COTI) Restoration Curriculum
2003-2006	Colorado Fourteeners Initiative Restoration Manager
2002-2003	Restoration Ecologist Blue Mountain Environmental Consulting
2000-2002	Natural Resource Specialist City of Boulder, Department. of Open Space and Mountain Parks

E-mail john@wlrv.org; ~ wlrv.org
Phone 303-543-1411 extension 4

Greg Seabloom

Currently	Adopt-a-Peak Supervisor Colorado Fourteeners Initiative
2004	Pacific Northwest Trail Association, MT Rocky Mountain Regional Coordinator
1998 - 2004	Various Conservation Organization, Trail Planning and Design Roles, including Youth Corps of Southern Arizona, Arizona; USGS, Sequoia National Park, California; Sustainable Trails, Inc., Lakewood, Colorado; and Lory State Park, Colorado
Education	Bachelor's of Science in Natural Resource Management and Minor in Rangeland Ecology from Colorado State University, 2001

E-mail greg@14ers.org
Phone 303-996-2758

National Park Service, Denver Service Center Transportation Division

Larry Walling, Division Chief, Transportation
Bob Welch, Branch Chief, Transportation Planning
Sarah Wynn, Revegetation Technical Specialist
Jessica Hendryx, Landscape Architect
Dennis Nagao, Supervisory Landscape Architect
Romorno Coney, Landscape Architect
Darin Thacker, Landscape Architect
David Kreger, Compliance Technical Specialist

Information Management

Alice Sharp, Library Volunteer
Carol Simpson, Librarian

National Park Service, Washington Office Park Facility Management Division

Mark Hartsoe, Chief, NPS Transportation Program
Kevin Percival, Manager, Transportation Planning Group
Jim Evans, Transportation Planner

Construction Program Management Division

Rich Turk, Value Analysis Coordinator

National Park Service, Intermountain Region

Theresa Ely, Supervisory Geographer

U.S.D.A. Forest Service

Jeff Leisy, Special Projects Manager, Continental Divide National Scenic Trail, Leadville Ranger District, U.S. Forest Service

Colorado Outdoor Training Initiative (COTI) Staff

Pam Packer (former Executive Director)
Walt Horner, Executive Director
Liz Lowry, Training and Outreach Coordinator

COTI's Sketchbook Curriculum Development Team

In addition to the COTI staff, co-authors and contributors to the *Sketchbook* the curriculum development team includes:
Ann L. Williams, Continental Divide Trail Alliance, Crew Leader
Denise Scifres, retired educator
Robert Scifres, retired educator

Photographs & Graphics

Unless noted, photographs and graphics were generously provided by the authors from their respective projects.

Cover photographs are of Arthur's Rock at Lory State Park, Colorado, symbolic of 10 years of initiatives to reverse the trend of natural resource impacts by implementing trails according to sustainability criteria. Long after our humble careers are over, Arthur's Rock will stand resiliently along Colorado's front range, little changed by time while inspiring trail users with trailside improvements which mimic the form, line, color and texture of the characteristic landscape.

Sketchbook at a Glance

Naturally occurring scenes from Rocky Mountain National Park delight trail users, including this mother and her son!

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environment and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also have a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-1811A / Revised September 2007.

National Park Service
Denver Service Center

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Colorado Outdoor Training Initiative
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