

Guide to Sustainable Mountain Trails



Trail Assessment, Planning
& Design Sketchbook
2007 Edition

Table of Contents

Table of Contents	3
History of the Sketchbook	4
Sketchbook Purpose & Target Audiences	5
<i>Foundations of Mountain Trail Sustainability</i>	7
The Olmsted Report	8
Policies of the American Society of Landscape Architects	10
Land Stewardship & Inspiration	14
Stewardship Partnerships & Training	15
Trail Project Management	17
Lessons Learned	
Technique	18
Trail Project Cycle Tool	19
<i>Fundamentals of Mountain Trail Sustainability</i>	21
Mountain Trail Sustainability	22
Interdisciplinary Trail Team	22
Protection of Natural & Cultural Resources	22
Optimum Prevailing Cross Slope Ranges & Trail Profile Grades	23
Trail Sustainability Assessment	25
Trail Sustainability Assessment Tools	28
Mountain Trail Planning	33
Climate	37
Boundary Constraints	37
Easements & Off-Site Connections	37
Geographic Context	38
Colorado Ecosystems	39
Rare Species & Habitats	48
Physical Planning Tools	49
Optimum Soils for Sustainability	50
Design Solutions Hierarchy	51
Trail Profile Calculations	53
Choosing by Advantages	54
Stakeholder Analysis	54
Example Planning Outputs	55 – 61
Basic Design	63
Characteristic Landscape Qualities	65
Design Principles	66
Design Variables	67
New Trail Design	69
Alignment Design Technique	72
Example New Trail Design Outputs	74 – 80
Restoration Planning	83
Ecological Restoration	86
Why Restoration?	87
Funding Strategy	87
Goals	87
Restoration Planning Tools & Techniques	88
Prioritizing Restoration Treatments	88
Volunteerism & Restoration Projects	89
Restoration Implementation	89
4-Step Restoration Planning Strategies	90
Mountain Trail Bridges	95
Implementation Techniques & Options	101
Example Implementation Options	102 – 118
<i>Ensuring Mountain Trail Sustainability</i>	123
Trail Maintenance Design	127
Trail Rehabilitation Design	128
Trail Armor Design	130
Trail Management Options	133
<i>Patience Examples</i>	135
The Challenge ... is to be Patient	136
Rocky Mountain National Park	137
Hayden Green Mountain Regional Park, Lakewood, Colorado	138
Lory State Park, Colorado	139
Colorado Fourteeners Initiative	140
Continental Divide National Scenic Trail	141
Roxborough State Park, Colorado	142
<i>Room to Grow</i>	143
Pitfalls to Avoid	144
Lessons Learned	145
More Tools	148
<i>The Trail Ahead</i>	153
Executive Order 12906	154
Digital Technology	154
New Tools & Techniques	154
Sample Geographic Information Systems Outputs	155
Towards a Mountain Trail Sustainability Ethic ...	156
<i>Credits</i>	157
Co-Authors	158
Contributors	159
<i>Sketchbook at a Glance</i>	160

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.



Foundations of Mountain Trail Sustainability



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

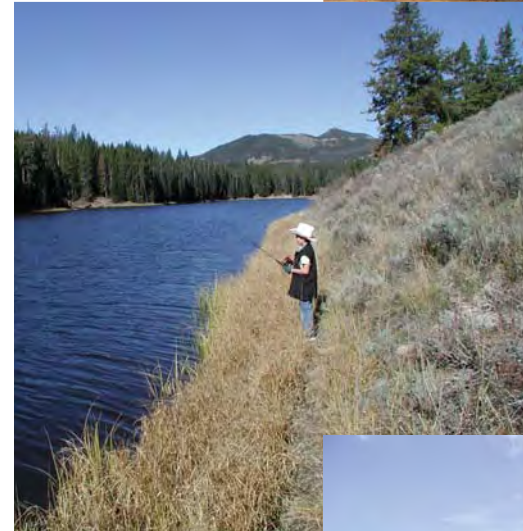
The American Society of Landscape Architects recognizes the critical and functional role of wetlands as essential to the quality of life and well being of the earth's ecological systems. The Society supports the immediate protection, conservation and enhancement of wetland resources. ...

◆ 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.





Brea arvensis,
Credit: Al Schneider

◆ 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.

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

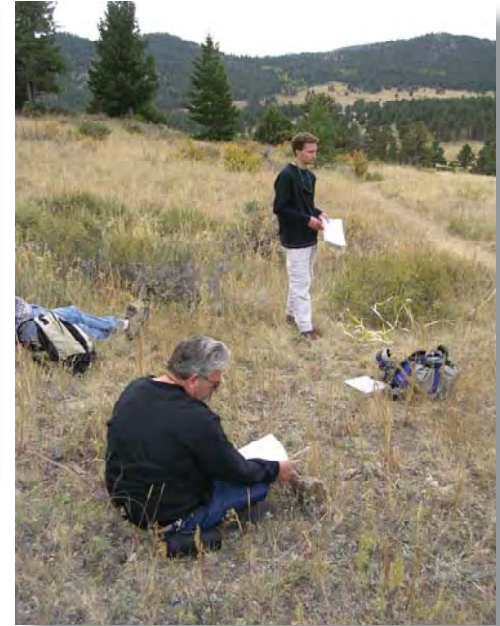
A partnership can be defined as a relationship between individuals or groups that is characterized by mutual cooperation and responsibility, as for the achievement of a specified goal. A hallmark public / private stewardship partnership is the Appalachian Trail Conservancy's partnership with the National 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.

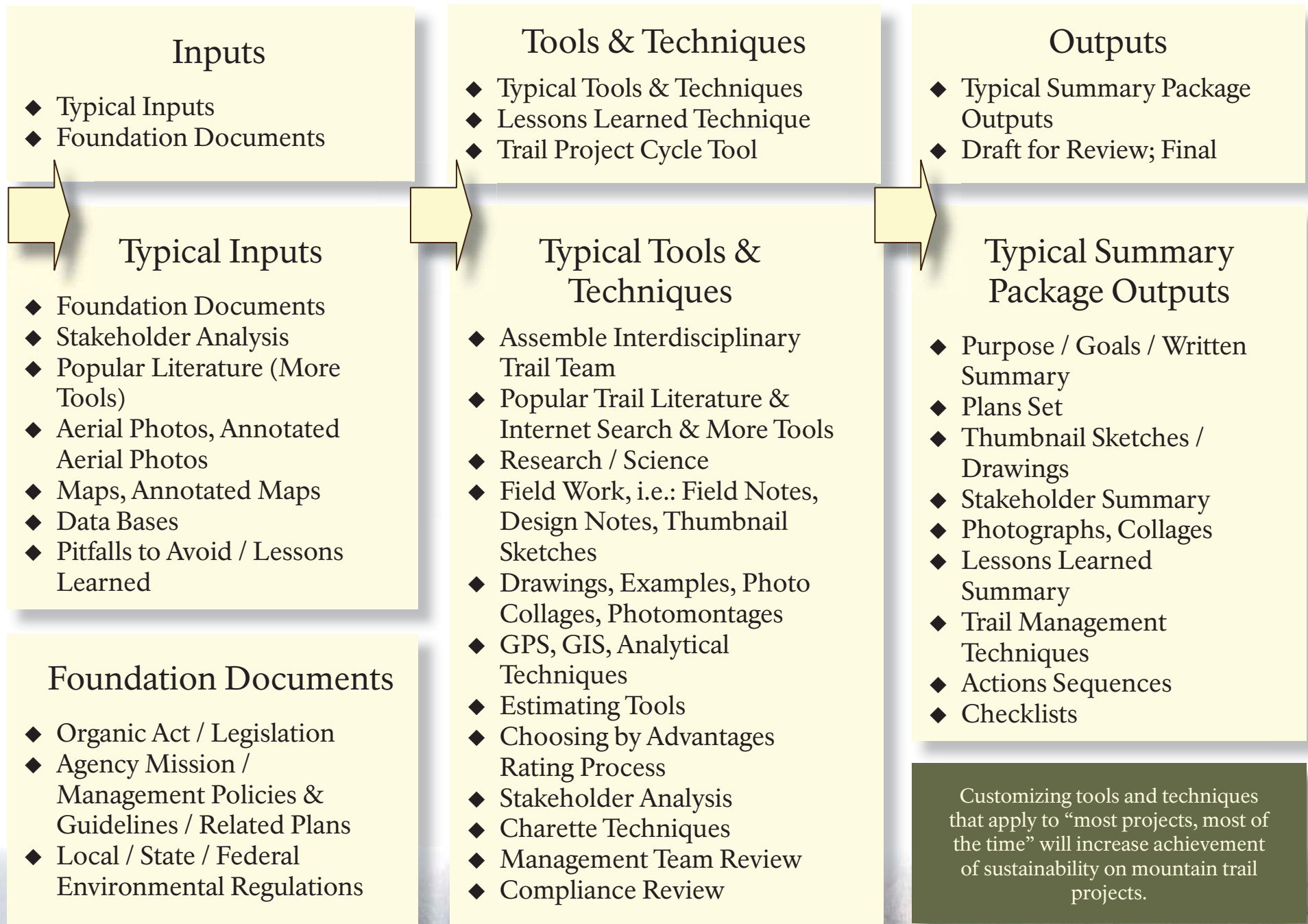
COTI's Guiding Principles

- ◆ *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 training program.*

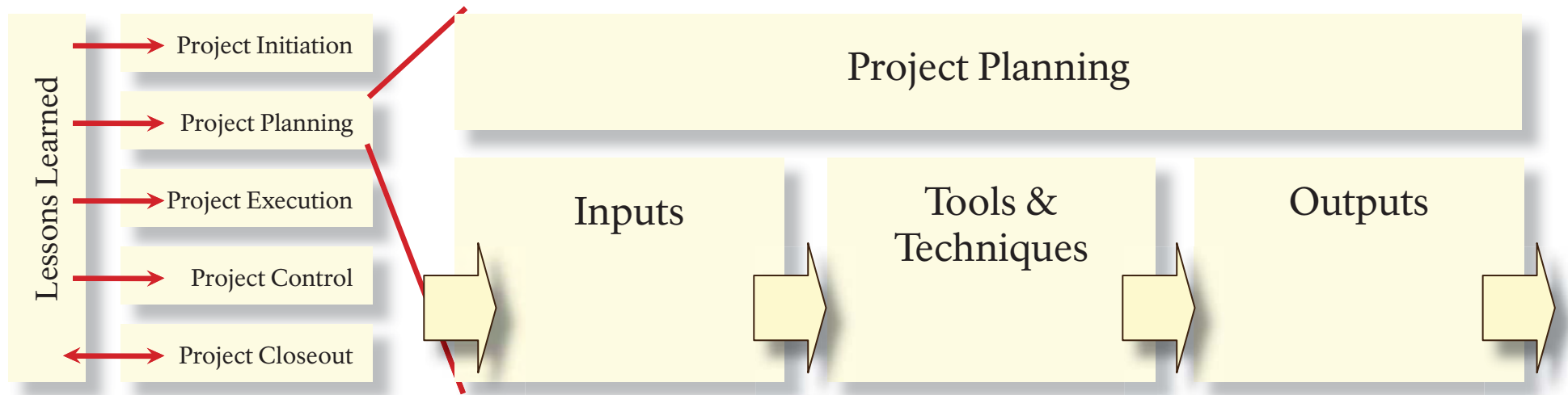


Stewardship Partnerships & Training.
Providing agency staff and volunteer training opportunities streamlines the delivery of sustainable trail projects while increasing achievement of land management agency stewardship goals.





Lessons Learned Technique



Project Planning Process Areas

The Project Management Institute (PMI) recognizes 5 process areas where interrelated project activities take 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.

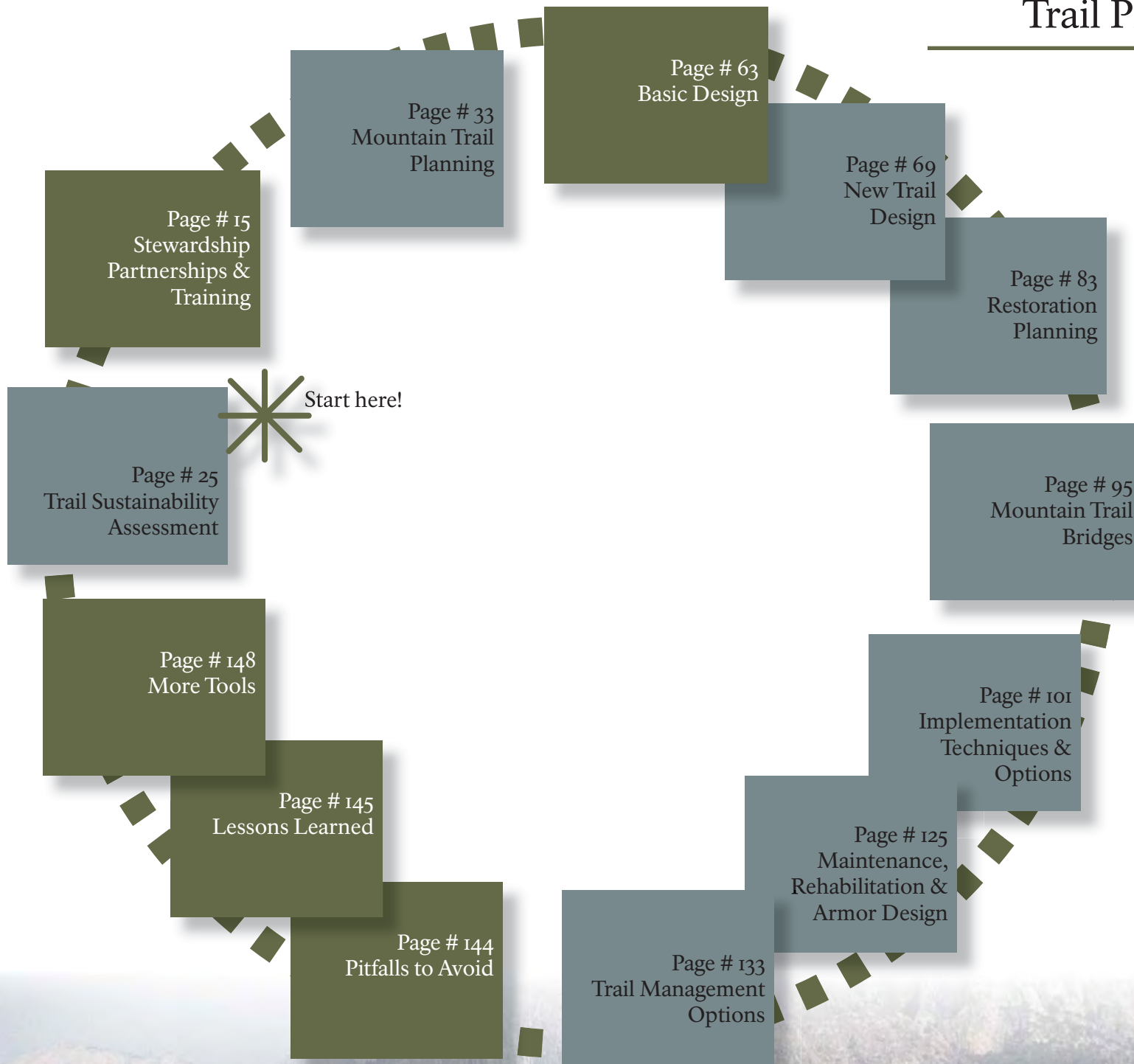
Shown is the *Project Planning* process area schematic as defined by PMI. Outputs from *Project Initiation* would be inputs to *Project Planning*, and outputs from *Project Planning* are inputs to *Project Execution*, *Project Control* and *Project Closeout*.

PMI encourages the application of a lessons learned technique to activities throughout the project cycle. Outputs from each project process area 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!



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.

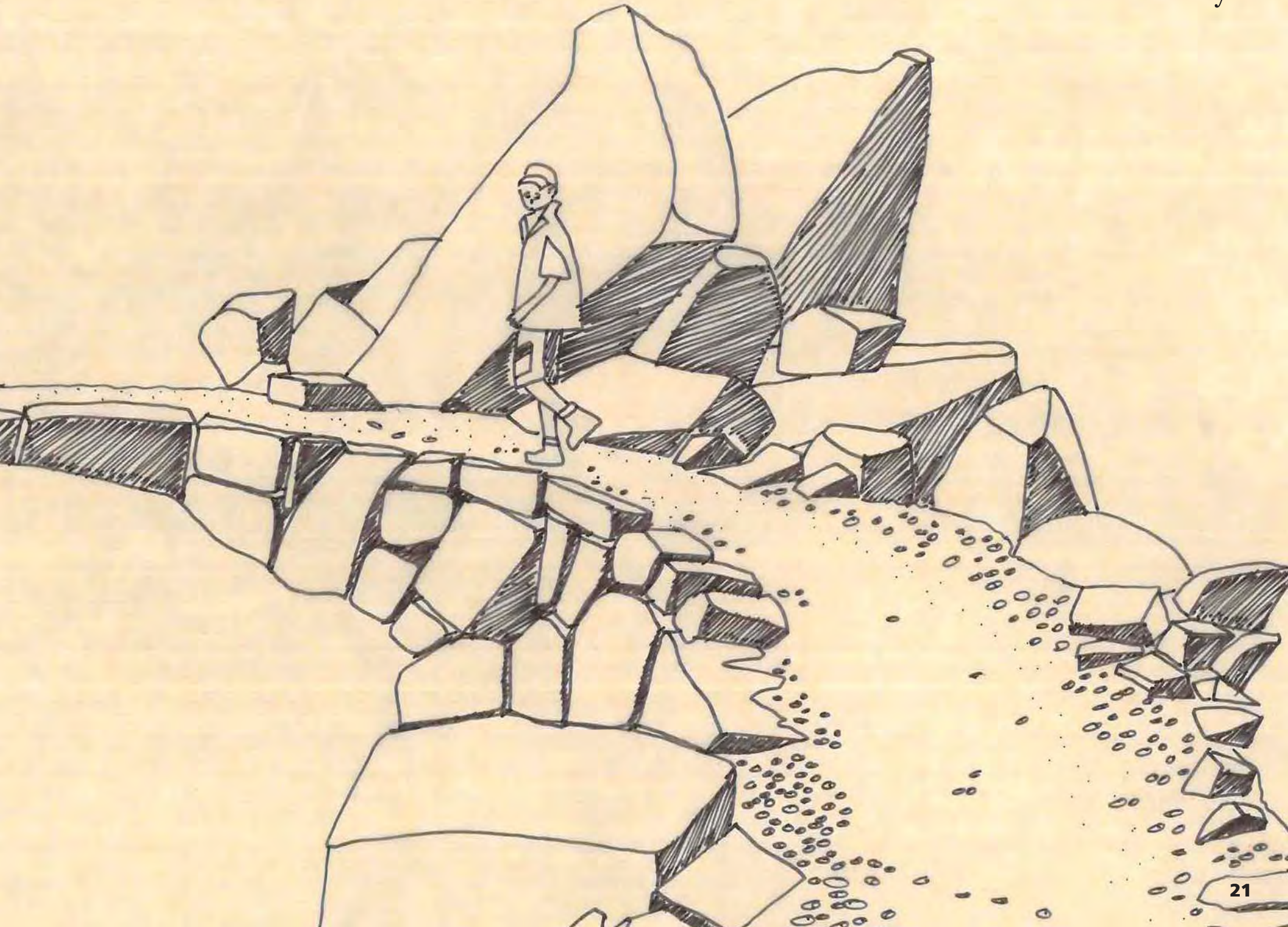
- ◆ Who could not delight in these environments or be awed by these naturally occurring scenes?
- ◆ Whose relationships could not benefit from time spent having a sack lunch on a mountain trail?
- ◆ In one of the best equipped classrooms, who could not learn about alpine environments or traditional use 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!



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!

Fundamentals of Mountain Trail Sustainability



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 $\frac{1}{4}$ 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.

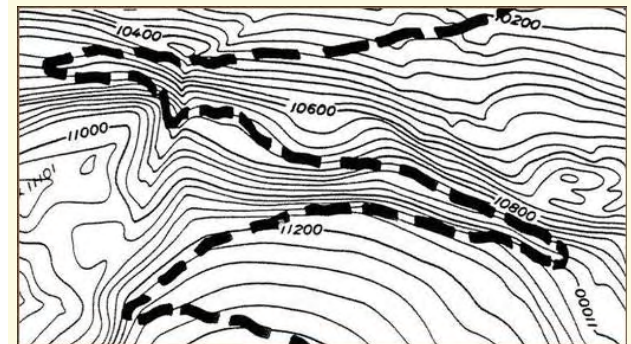
Prevailing cross slopes between 20% and 70% provide the best combination of cross slope for drainage with the commonly preferred trail profile grades near 10% to allow proper drainage across or off a trail surface without undue erosion.

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.

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



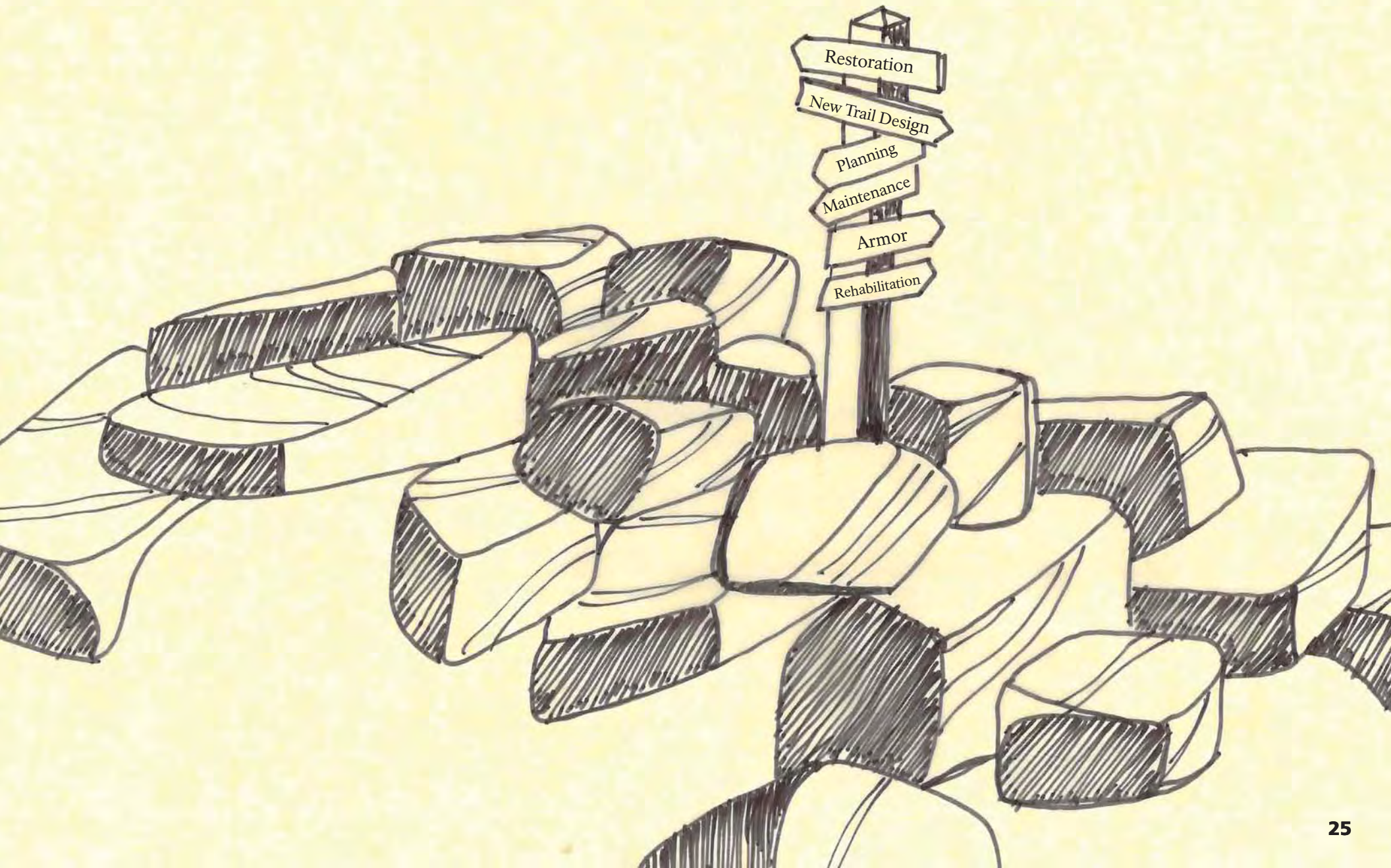
Natural areas are the setting for many activities, including weddings.

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



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.

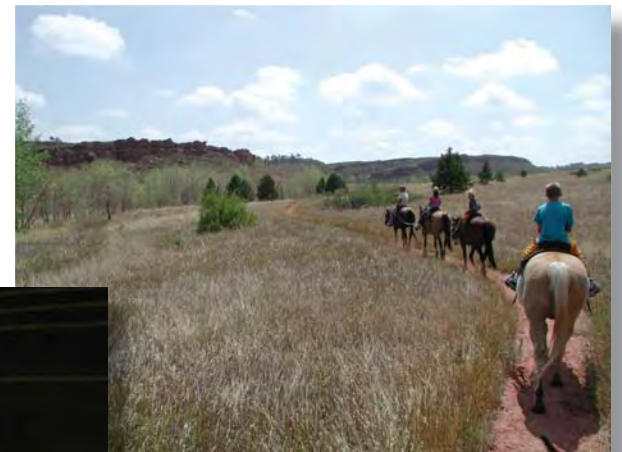
Trail Sustainability Assessment

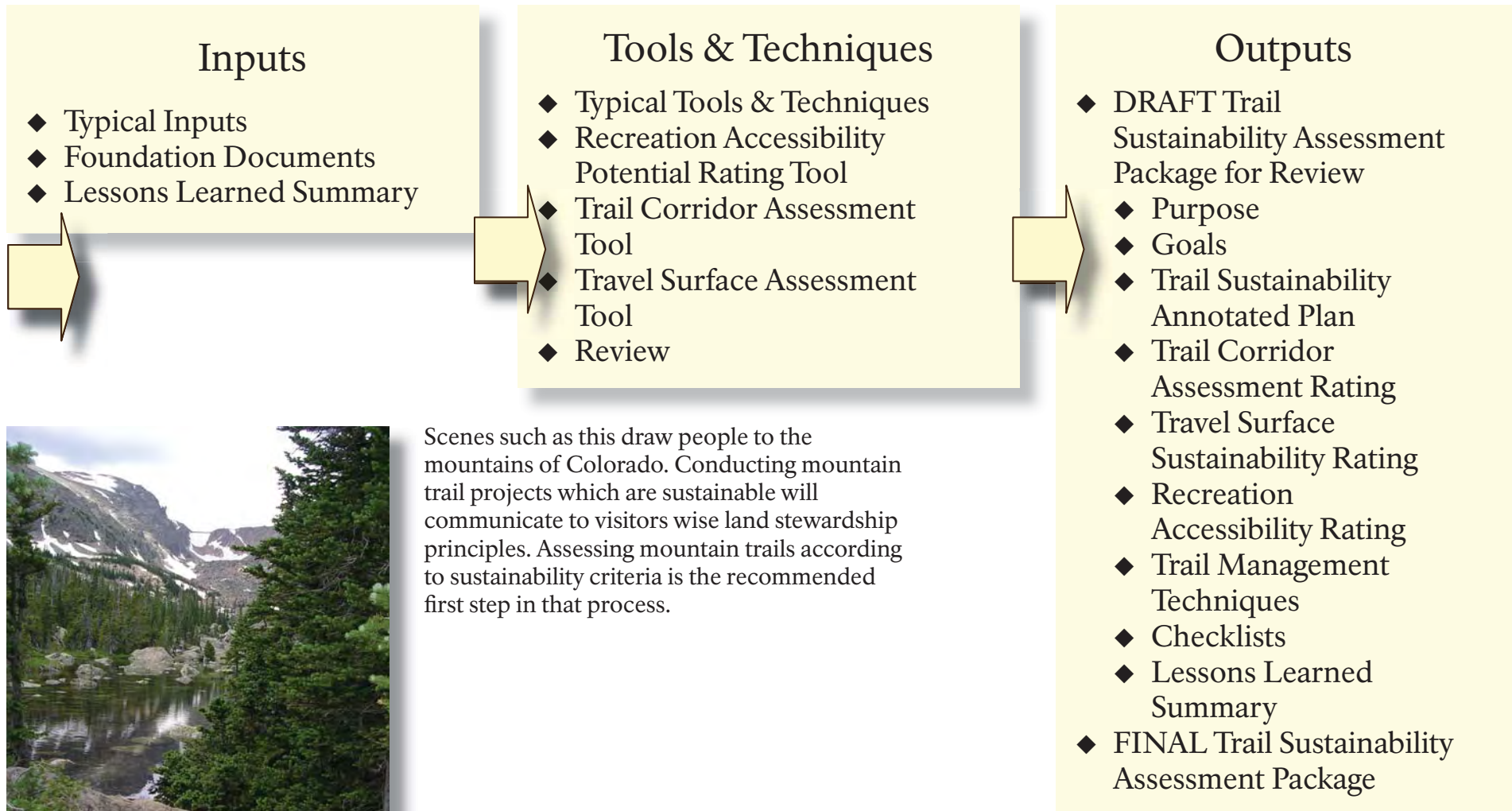




Sustainability Criteria. Sustainability assessment techniques must be customized to specific physical sustainability criteria as well as the anticipated user type, volume of use and frequency of use with an understanding of the recreational reasons that trail users visit public lands.

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





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 ?

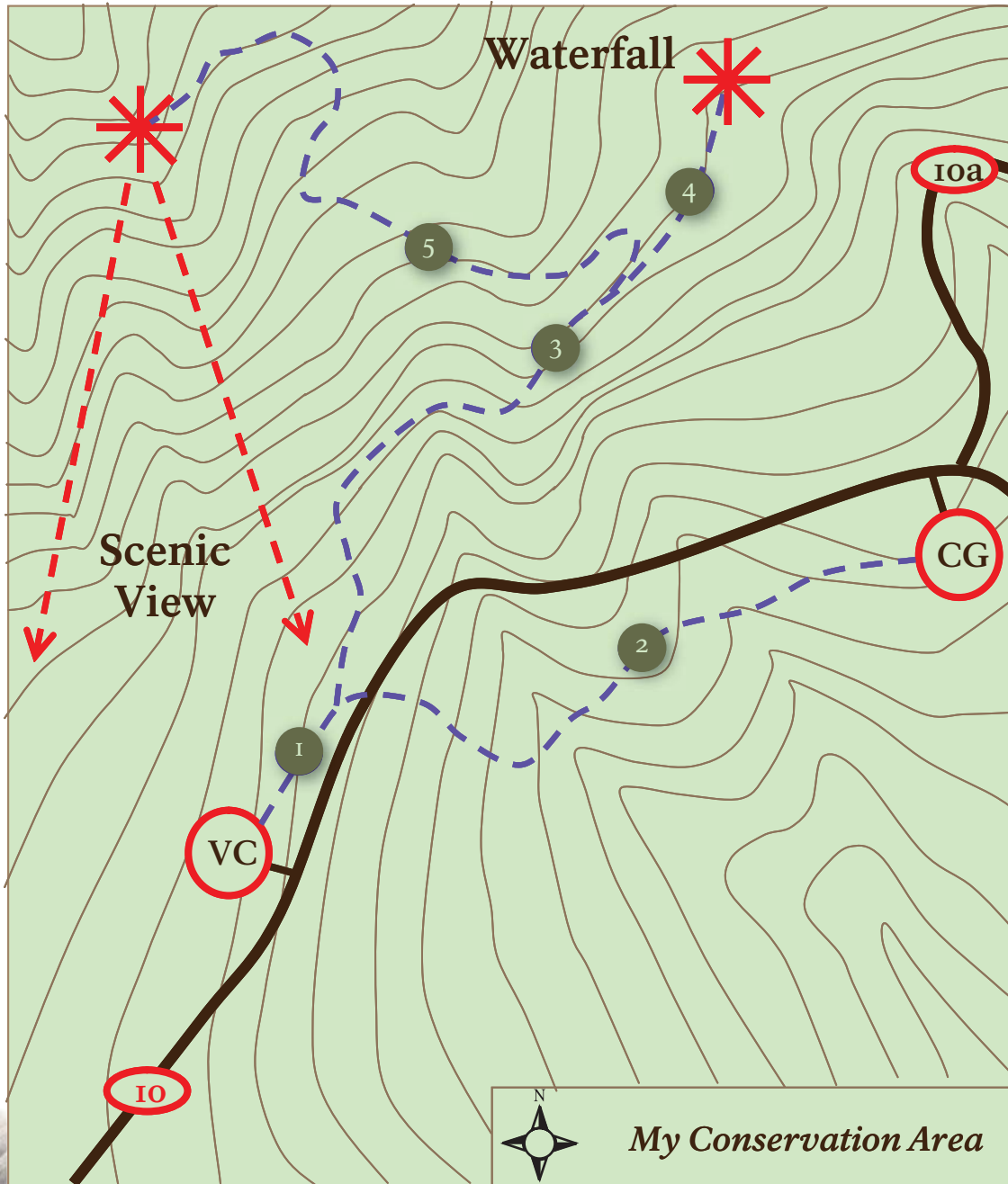
Appropriate

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 <i>As Needed Activities</i>
		1%							
1+00	0%		E	Stone	OK	2'-9"	Cupped	S	Perform <i>As Needed Activities</i>
		10%							
2+00	25%		SE	Coarse	OK	3'	Cupped	S	Perform <i>As Needed Activities</i>
		10%							
3+00	40%		SE	Silt	Eroded	3'	Outsloped	S-	Perform <i>Regular Basis Activities</i>
		0%							
4+00	25%		SE	Organic	Eroded	3'-9"	Outsloped	S-	Perform <i>Regular Basis Activities</i> , excessive erosion occurring
		4%							
5+00	15%		E	Coarse	OK	3'-5"	Outsloped	S	Perform <i>Regular Basis Activities</i>
		12%							
6+00	10%		E	Coarse	OK	3'	Cupped	S	Perform <i>As Needed Activities</i>

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.



Sustainability Assessment Checklist

- Web Search / Literature Review
- Purpose
- Goals
- Appropriate?
- Recreation Accessibility Potential Rating
- Trail Corridor Assessment
 - Trail Corridor Sustainability Questionnaire
 - Trail Corridor Sustainability Rating Tool
 - Travel Surface Assessment Rating Tool
- Trail Management Options Menu
- Lessons Learned
- DRAFT Sustainability Assessment Package
- Review
- FINAL Sustainability Assessment Package

Mount Bierstadt, west of
Denver, Colorado