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Trail Resource Impacts and An Examination of Alternative Assessment Techniques

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ABSTRACT: Trails are a primary recreation resource facility on which recreation activities are performed. They provide safe access to non-roaded areas, support recreational opportunities such as hiking, biking, and wildlife observation, and protect natural resources by concentrating visitor traffic on resistant treads. However, increasing recreational use, coupled with poorly designed and/or maintained trails, has led to a variety of resource impacts. Trail managers require objective information on trails and their conditions to monitor trends, direct trail maintenance efforts, and evaluate the need for visitor management and resource protection actions. This paper reviews trail impacts and different types of trail assessments, including inventory, maintenance, and condition assessment approaches. Two assessment methods, point sampling and problem assessment, are compared empirically from separate assessments of a 15-mile segment of the Appalachian Trail in Great Smoky Mountains National Park. Results indicate that point sampling and problem assessment methods yield distinctly different types of quantitative information. The point sampling method provides more accurate and precise measures of trail characteristics that are continuous or frequent (e.g., tread width or exposed soil). The problem assessment method is a preferred approach for monitoring trail characteristics that can be easily predefined or are infrequent (e.g., excessive width or secondary treads), particularly when information on the location of specific trail impact problems is needed. The advantages and limitations of these two assessment methods are examined in relation to various management and research information needs. The choice and utility of these assessment methods are also discussed.

KEYWORDS: Visitor impacts, trail impact assessment, trail surveys, impact monitoring, Great Smoky Mountains National Park

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Introduction

A recent national survey revealed that walking was the most popular outdoor recreation activity, engaged in by 67 percent (134 million) of Americans age 16 or older (Cordell, 1999). This activity may occur on neighborhood streets but is commonly focused on recreational trails in urban, suburban, rural or wildland settings. Since the early 1980s, participation rates for many other trail-related activities, such as running/jogging, biking, wildlife viewing, hiking, horseback riding and backpacking, have also increased substantially (Cordell, 1999).

Trails are constructed and managed to support these myriad recreational activities by a variety of entities. For example, the National Trails System, which comprises National Historic, Scenic, and Recreational trails, has grown to 842 in number and nearly 47,000 miles (Chavez, Harding, & Tynon, 1999; Cordell, 1999). Extensive trail systems including bicycle, hiking, horseback riding, jogging, nature, and multipurpose trails are also developed and managed by state, federal, municipal, nonprofit and private entities (Moore & Ross, 1998).

Regardless of affiliation, a perennial concern of trail providers is sustaining the condition of trail resources through a wide range of climatic conditions with highly concentrated foot, hoofed, and wheeled traffic. In developed environments, trail providers frequently surface trails with gravel, wood, or pavement to limit resource impacts. However, many visitors prefer more natural-looking unsurfaced trails, even in developed settings. In natural and wildland settings, installing and maintaining hard-surfaced trails is often cost-prohibitive and inappropriate (Jubenville, 1995). Numerous recreational trails, therefore, remain unsurfaced and are subject to degradation forces induced by nature and recreational use. Indeed, trail degradation is a major concern for many trail providers. For example, nearly 45% of National Park Service backcountry managers reported that soil erosion on trails was a problem in many or most areas of their park's backcountry (Marion, Roggenbuck, & Manning, 1993).

Professional trail management requires objective and timely information about resource conditions of the trail tread, including physical characteristics, resource impacts, and needed maintenance work. Limitations in staff and funding frequently constrain trail providers in obtaining such information. This difficulty can be reduced by increasing the utility and efficiency of trail assessments. This paper has two objectives: (1) to review trail resource impacts and different types of trail assessments, and (2) to compare the procedures, data type and utility of two common assessment methods as applied to a 15-mile segment of the Appalachian Trail within Great Smoky Mountains National Park.

Related Literature

Trail Resource Impacts

Trails are generally regarded as an essential facility in parks and recreation areas, providing access to unroaded areas, offering recreational opportunities, and protecting resources by concentrating visitor use impacts on resistant tread surfaces. Much ecological change assessed on trails is associated with their construction and is considered unavoidable (Birchard

& Proudman, 2000). The principal challenge for trail providers is therefore to prevent post-construction degradation from both recreational use and natural processes such as rainfall and water runoff.

Unsurfaced trail treads are susceptible to a variety of trail impacts. Common impacts include vegetation loss and compositional changes, soil compaction, erosion, and muddiness, exposure of plant roots, trail widening, and the proliferation of visitor-created side trails (Table 1) (Hammitt & Cole, 1998; Leung & Marion, 1996; Tyser & Worley, 1992). Soil erosion exposes rocks and plant roots, creating a rutted, uneven tread surface that increases the difficulty of travel. Eroded soils may find their way into water bodies, increasing water turbidity and sedimentation impacts to aquatic organisms (Fritz, 1993). Similarly, excessive muddiness renders trails less usable and aggravates tread widening and associated vegetation loss as visitors seek to circumvent mud-holes and wet soils (Marion, 1994). Trail widening and the creation of parallel treads and side-trails unnecessarily increases the area of land disturbed by trails (Liddle & Greig-Smith, 1975).

Table 1
Different Forms of Trail Resource Impact and Their Ecological and Social Effects

Form of Impact	Effect: Ecological	Effect: Social
Soil Erosion	Soil and nutrient loss, water turbidity/sedimentation, alteration of water runoff, most permanent impact	Increased travel difficulty, degraded aesthetics, safety
Exposed Roots	Root damage, reduced tree health, intolerance to drought	Degraded aesthetics, safety
Secondary Treads	Vegetation loss, exposed soil	Degraded aesthetics
Wet Soil	Prone to soil puddling, increased water runoff	Increased travel difficulty, degraded aesthetics
Running Water	Accelerated erosion rates	Increased travel difficulty
Widening	Vegetation loss, soil exposure	Degraded aesthetics
Visitor-Created Trails	Vegetation loss, wildlife habitat fragmentation	Evidence of human disturbance, degraded aesthetics

Trails, and the presence of visitors, also impact wildlife, fragment wildlife habitat and cause avoidance behavior in some animals and attraction behavior in others to obtain human food (Hellmund, 1998; Knight & Cole, 1991). While most impacts are limited to a linear disturbance corridor, some impacts, such as alterations in surface water flow, introduction of invasive plants, and disturbance of wildlife, can extend considerably further into natural landscapes (Kasworm & Monley, 1990; Tyser & Worley, 1992). Even localized disturbance can harm rare or endangered species or damage sensitive resources, particularly in environments with slow recovery rates.

Impacts such as severe soil erosion and exposed roots are visually offensive and can degrade the aesthetics and functional value of recreational settings. Survey research has shown that resource impacts are noticed by visitors, and that they can degrade the quality of recreation experiences (Roggenbuck, Williams, & Watson, 1993; Vaske, Donnelly, & Shelby, 1993). Impacts such as deep ruts and excessive muddiness increase the difficulty of travel and compromise visitor safety. From a managerial perspective, legal mandates that guide management decision making within many protected areas require achieving a balance between facilitating visitor use, including the construction and maintenance of trail systems and achieving resource protection objectives. Excessive trail-related impacts to vegetation, soil, wildlife or water quality could represent an unacceptable departure from natural conditions and processes. Carrying capacity planning and management frameworks such as Limits of Acceptable Change (LAC) (Stankey, Cole, Lucas, Petersen, & Frissell, 1985) and Visitor Experience and Resource Protection (VERP) (National Park Service, 1997) are increasingly being applied by managers in their efforts to achieve and sustain such a balance. Impacts also result in substantial costs for the maintenance and rehabilitation of trails and operation of visitor management programs.

Factors Affecting Trail Resource Impacts

The type and extent of trail impacts are influenced by use-related and environmental factors, both of which may be modified through management actions. Use-related factors include type of use, amount of use, and user behavior; environmental factors include attributes such as vegetation and soil type, topography and climate. Recent comprehensive reviews of the role of these factors are provided by Leung and Marion (1996), Hammitt and Cole (1998), and Marion (1998).

For well-designed and constructed trails, post-construction trail impacts would be minimal in the absence of use. Initial rainfall might erode some soil, but in most environments organic litter and vegetative colonization would increasingly minimize such impacts. The trampling disturbance associated with visitor use generally removes most organic litter and vegetation cover from well-used trails, exposing soils to erosion from water or wind. Some specific impacts, such as trail widening and creation of parallel treads or side trails, are strongly influenced by user behavior (Hammitt & Cole, 1998). Type of use has also been shown to be a significant determinant for some trail impacts. Trampling and erosional impacts caused by horses have been found to be significantly higher compared to hikers, llamas, mountain bikes and even off-road motorcycles (Cole & Spildie, 1998; DeLuca et al., 1998; Wilson & Seney, 1994). Horse use has also been significantly correlated to muddy trail conditions, excessive trail width, and creation of secondary treads and informal trails (Dale & Weaver, 1974; Marion, 1994; Whittaker & Bratton, 1978).

Amount of use has been linked to trail widening (Cole, 1991; Lance, Baugh, & Love, 1989), soil erosion (Marion 1994) and muddiness.

Numerous studies have documented a curvilinear relationship between amount of use and most forms of trail impact (Cole, 1983; Sun & Liddle, 1993; Weaver, Dale, & Hartley, 1979). Initial or low levels of use generate the majority of use-related impact, with per-capita impacts diminishing as use increases. For example, vegetation and organic litter are either removed during trail construction or are quickly lost from trail treads. Further traffic causes relatively little additional impact, particularly on trails with adequate maintenance to control water runoff and tread widening. An important implication is that substantial use reductions must occur on highly visited trails to achieve any significant reduction in impact.

A substantial number of studies have demonstrated the influential role that environmental factors play in influencing trail degradation (Leung & Marion, 1996). Erosional rates are greatest on steep trail grades and in locations where topography and elevation combine to create higher precipitation (Hartley, 1976). Soils with fine and homogeneous textures are also more susceptible to erosion (Bryan, 1977). Poorly drained and organic soils are most susceptible to tread muddiness, particularly in flatter terrain where trails become incised, and water is difficult to drain from treads (Bryan, 1977). Furthermore, tread muddiness is a strong contributor to tread widening and multiple trail creation as hikers seek to circumvent muddy sections of trails (Bayfield, 1986; Marion, 1994). Vegetation type and density may also play a role by indirectly influencing visitor behavior. For example, open meadows and forests permit trail widening and secondary tread development behaviors that are inhibited by dense vegetation (Bright, 1986).

Few studies have directly examined the influence of managerial actions, though they have considerable potential for modifying the roles of use-related and environmental factors (Leung & Marion, 1996). Through educational and regulatory actions, managers can influence or control all use-related factors. For example, the impacts of horses may be limited by restricting their use to more resistant trails, limiting their numbers, or prohibiting their use during wet seasons. Knowledge of relationships between environmental factors and trail impacts can be applied to route trails in the most resistant locations. Muddiness can be limited by avoiding wet organic soils and flat terrain, erosion can be limited by avoiding steep trail grades, and parallel treads and tread widening can be limited by locating trails in sloping terrain where steeper off-trail terrain will direct visitors to stay on the provided tread (Birchard & Proudman, 2000). Trail maintenance actions, including installation and upkeep of tread drainage features, rock steps, and bridging, are also vital to limiting soil erosion and tread muddiness, which in turn, influence user behavior and the extent of impacts such as tread widening and secondary tread development (Birchard & Proudman, 2000).

Types of Trail Assessment Methods

Trail resource assessments provide information for a number of important management needs. Trail routes can be mapped and existing physical and cultural features documented. Trail conditions may be assessed to identify the location, type and extent of trail resource impacts. An inventory of existing and needed trail maintenance features, such as water bars, steps, culverts, and signs, may also be recorded. Trail assessment information can be used to inform the public about trail resources, justify staffing and funding, evaluate the acceptability of existing resource conditions, analyze relationships between trail impacts and contributing factors, identify and select appropriate management actions, and evaluate changes in trail conditions and the effectiveness of implemented actions.

A variety of rapid-assessment methods for evaluating trails and their resource conditions have been developed and described in the literature, as reviewed and compared by Coleman (1977), Cole (1983), and Monz (2000). Marion (1994) described three general types of trail assessments: trail inventory, trail maintenance, and trail condition. Trail inventories may be employed to locate and map trails and to document trail features such as type of use, segment lengths, hiking difficulty, and natural and cultural features. Trail inventories generate information useful for general planning and management activities. Many now employ global positioning system (GPS) devices to accurately map trail positions, which can be input to a geographic information system (GIS) for display and analysis (Wolper, Mohamed, Burt, & Young, 1994; Wing & Shelby, 1999).

Trail maintenance assessments provide information on existing or needed trail maintenance features or work. These assessments may be used to develop databases on signs (e.g., location and text) and existing facilities and tread features (e.g., bridges, water bars, steps, bog bridging). Prescriptive trail maintenance work log assessments have also been developed to describe recommended solutions to existing tread deficiencies, such as installation of water bars and steps or trail rerouting (Birchard & Proudman, 2000; Williams & Marion, 1992). Data can be summarized to provide cost and staffing estimates and to direct actual field work.

Trail condition assessments seek to describe resource conditions and impacts for the purpose of identifying trends in trail conditions and investigating relationships with influential factors. Leung and Marion (2000) provide a further classification of alternative trail impact assessment and monitoring (A&M) assessments. Sampling-based approaches employ either systematic point sampling, where tread assessments are conducted at a fixed interval along a trail (Cole, 1983; Cole, 1991), or stratified point sampling, where sampling varies in accordance with various strata such as level of use or vegetation type (Hall & Kuss, 1989). Alternately, census-based approaches employ either sectional evaluations, where tread assessments are made for entire trail sections (Bratton et al., 1979), or problem assessment evaluations, where continuous assessments record every occurrence of predefined impact problems (Cole, 1983; Leung & Marion, 1999a; Marion, 1994). These two approaches of assessment have been combined in an integrative survey (Bayfield & Lloyd, 1973). More elaborate and time-consuming methods for accurately characterizing soil loss (Leonard & Whitney, 1977) and vegetation changes (Hall & Kuss, 1989) have also been developed.

Methods

Study Area

The Great Smoky Mountains National Park (GSMNP), located along the Tennessee-North Carolina state border and established in 1934, has grown to 514,965 acres in size. Its large elevation range (840 - 6,643 ft), moist climate, and limited human disturbance have contributed to some of the most diverse flora and fauna in North America. Eighty-three percent of the park area is also under consideration for wilderness designation (National Park Service, 1981).

The park's strong resource protection mandates are significantly challenged by heavy use (10 million recreation visits in 1998), the third highest use of any unit in the National Park system (National Park Service, 1998). Although many visitors remain close to their cars, day hiking, backpacking, and horse riding are popular visitor activities. A 1985 study estimated the number of day hikers at approximately 700,000 annually (Peine & Renfro, 1988), while 470,000 over- night stays were reported in 1998 (National Park Service, 1998).

This heavy visitation places considerable pressure on the park's 930-mile trail system. One of the most popular park trails is the Appalachian National Scenic Trail (AT), a segment of which was assessed for this study. The AT stretches 2,162 miles across 14 eastern states; 71 miles are contained within GSMNP. Several investigations of trail degradation on the AT within the park have been conducted (Bratton et al., 1979; Burde & Renfro, 1986; Marion, 1994; Leung & Marion, 1999a), but no monitoring of trail conditions has been conducted on a routine basis. A revised backcountry recreation management plan calls for the development and use of standardized assessment procedures to monitor trends in trail conditions (Great Smoky Mountains National Park, 1995).

Procedures

Two trail assessment methods were selected for application to a single 15-mile segment of the Appalachian Trail (AT) from Newfound Gap north to the Tricorner Knob shelter. The assessment methods were selected because each method represents a different approach, and they are commonly used in other studies. These were the point sampling method with a systematic sample scheme (Leung & Marion, 1999b) and the problem assessment method (Leung & Marion, 1999a).

The AT segment selected was chosen for its uniform environmental conditions and design attributes and substantial gradient in visitor use. The trail consistently follows the highest ridgeline at elevations between 5,000 and 6,200 feet. Visitation along this trail is strongly related to distance from U.S. Highway 441, a heavily trafficked road that crosses Newfound Gap and provides easy visitor access to the AT. The 15-mile segment was divided into three trail sections to examine the relationship between amount of trail use and trail condition and to permit further comparison of the data yielded by the two assessment methods. Trail use statistics from a separate study by Van Cleave, Beard, & Shunamon (1990) reveal decreasing levels of use with increasing distance from the trailhead on Highway 441. Section 1 is 3.06 miles in length and is directly accessible from the large parking lot used by backpackers and day-hikers. Trail use statistics reveal an average of approximately 570 visitors/day near the trailhead to 215 visitors/day 0.5 miles along the trail. This section is referred to as "High Use" henceforth. Section 2 is 3.8 miles long and receives approximately 132 visitors/day at a point 1.2 miles from the beginning of the section and 35 visitors/day at 1.5 miles. This section is referred to as "Moderate Use." Section 3 is 3.91 miles long, receives approximately 9 visitors/day, and is referred to as "Low Use." Thus, trail use varies in a decreasing fashion within each section, with substantial reductions in use from the first to the third section. Section 4 is 4.33 miles long and is open to horse use. This section is included in presentations of general results but omitted from use level comparisons because use data was unavailable.

The Point Sampling Method (Sampling Approach)

The 15-mile AT segment was assessed in September of 1997 by a field staff pushing a trail measuring wheel (122 cm circumference). Sampling points were located at a fixed interval of 1,000 feet beginning at Newfound Gap. At each sample point, the trail's condition was assessed through measurements of its width, incision, and tread condition characteristics (Table 2). Two rapid-assessment estimates of trail erosion were evaluated. The first was a maximum incision measurement within the current tread boundaries. However, tread boundary points may themselves be located below post-construction tread surfaces. Field staff also measured maximum incision to estimated post-construction tread surfaces, ascertained by examining the adjacent topography, edges of formerly constructed trail benches, and extent of erosion on large protruding rocks within the trail tread. We expect this measure more accurately reflects post-construction tread erosion, but the requisite estimation of a post-construction tread surface likely makes the measure less precise than the erosion estimate based on current tread boundaries. Further discussion and diagrams illustrating field assessment methods are provided in Farrell and Marion (In Press).

Trail tread condition characteristics, including vegetation cover, rock and exposed soil (Table 2), were defined to be mutually exclusive and were assessed in 10% categories (5% where necessary). These indicators were evaluated as a proportion of a linear transect oriented perpendicular to the trail at each sample point. Transect endpoints were defined by the most pronounced visual changes in ground vegetation height, cover composition, or organic litter, intended to reflect conditions on that portion of the trail receiving the majority of traffic.

Table 2
Indicators Included in the Point Sampling Method as Applied to Great Smoky Mountains National Park

Indicator	Description
Tread Width (in)	Tread width between boundaries defined by pronounced changes in ground vegetation height, cover, composition, or organic litter
Max. Incision, Current Tread (in)	Maximum distance between tread surface and a line connecting tread boundaries
Max. Incision, Post Construction tread (in)	Maximum distance between tread surface and a line configured to depict the ground level immediately following trail construction
Informal Trails (#)	Count of the number of informal trails branching off since the last sample point
Secondary Treads (#)	Count the number of separate or multiple trail treads that parallel the main tread at the sample point
Tread Condition Characteristics	Percentage of the trail width transect by tread surface category:
Exposed Soil (%)	Exposed soil of all types, excluding rock and organic litter
Rock (%)	Naturally occurring rock surfaces (bedrock, rocks, and gravel)
Organic Litter (%)	Organic litter and duff sufficient to cover tread surface
Exposed Roots (%)	Exposed tree or shrub roots
Muddy Soil (%)	Seasonal or permanently wet and muddy soils
Vegetation Cover (%)	Vegetative cover rooted within the tread boundaries

The number of visitor-created informal trails branching from the AT since the last sample point were also tallied and recorded at each sampling point.

The Problem Assessment Method (Census Approach)

The same AT segment was also assessed with problem assessment procedures in August 1993. Two categories of indicators were included: (1) inventory indicators to characterize use type and design and maintenance indicators, and (2) impact indicators to characterize the location, number, and lineal extent of predefined tread problems (Table 3) (see Marion, 1994, for a complete listing of indicators and assessment procedures). A measuring wheel (122 cm circumference) was used to identify the cumulative trailhead distance for point features (e.g., water bars) and the begin/end distances of lineal features (e.g., wet soil) that exceeded a length of 10 ft. For example, a trail segment eroded between one and two feet below the estimated post-construction tread surface would be recorded if it extended along the trail for more than ten feet.

The accuracy and precision in assessing the starting and ending points for each condition indicator were improved through the use of staff training and a manual of detailed descriptive procedures and color photographs (Marion, 1994).

Data Analysis

Data were input and analyzed using SPSS for Windows (ver. 8). Due to the skewness of data, median values in addition to means were reported for central tendency and non-parametric statistical tests were performed.

Results

Point Sampling Method

Tread width at sample points (n=80) ranged from 9 to 57 inches with a median of 17 (Table 4). Maximum tread incision from soil erosion within current tread boundaries ranged from 0 to 6 inches with a median of 0. However, maximum tread incision measurements to the estimated post-construction tread surface are greater, ranging from 0 to 14 inches with a median of 4 (Table 4). Only ten informal visitor-created side-trails were located along the 15-mile trail segment, and no secondary (parallel) treads occurred at the sample points.

The tread is predominantly rock (53.1%) and exposed soil (31.8%) (mean values). Very little vegetation cover occurred within the boundaries of this heavily trafficked trail (1.1%). Surprisingly, organic litter cover accounts for 10.9%, typically from leaves that collect within incised treads. Muddy soil, assessed as only 1.1% of the tread, does not appear to be a problem for this segment.

Problem Assessment Method

Thirty-three percent (27,388 lineal ft) of this 15-mile trail segment is open to horses, a rare exception to the Appalachian Trail's standard "foot

Table 3
Indicators Included in the Problem Assessment Method as Applied to Great Smoky Mountains National Park

Indicator	Description
Inventory Indicator	
Use type:	
Pedestrian	Segment is restricted to pedestrian use
Horse/Pedestrian	Segment is open to horse use
Excessive Grade	Segment has a grade exceeding 20%
Drainage Dip:	An obvious human-constructed dip and berm configured to divert water from the tread, evaluated in terms of its effectiveness
Very effective	
Partially effective	
Ineffective	
Water bar:	An obvious wooden or rock structure configured to divert water from the tread, evaluated in terms of its effectiveness
Very effective	
Partially effective	
Ineffective	
Impact Indicator	
Soil Erosion:	Segment has eroded below the estimated original, post-construction, tread surface by the amount specified
1-1.9 ft	
2-2.9 ft	
3-3.9 ft	
Wet Soil	Segment has wet muddy soil over more than half of the tread width, including muddy soils or mud holes with standing water
Excessive Width	Segment has expanded 3-6 ft wider than adjacent, more typical, sections of the trail
Excessive Root Exposure	Segment has severe tree root exposure: tops/sides of roots are exposed
Secondary Treads	Segment has more than one definable tread
Running Water on Trail	Segment has running water on the tread

Table 4
Summary Results of Trail Impact Assessment
Using the Point Sampling Method
(Appalachian Trail: Newfound Gap to Tricorner Knob Shelter)

	Summary Statistic		
Indicator	Median	Range	Sum
Tread Width (in)	17	9 - 57	NA
Maximum Incision, Current Tread (in)	0	0 - 6	NA
Maximum Incision, Post Construction Tread (in)	4	0 - 14	NA
Informal Trails (#/1000ft)	0	0 - 2	10
Secondary Treads (#)	0	0 - 0	0
Tread Condition Characteristics			
Exposed Soil (%)	20	0 - 100	NA
Rock (%)	55	0 - 100	NA
Litter (%)	0	0 - 90	NA
Exposed Roots (%)	0	0 - 80	NA
Muddy Soil (%)	0	0 - 90	NA
Vegetation Cover (%)	0	0 - 50	NA

traffic only" policy. Only once did trail grade exceed 20% on this ridge-top trail, though steep side slopes are relatively common as indicated by 74 occurrences of retaining walls. Trail maintainers employ water bars (N=407) more frequently than drainage dips (N=11) to remove water from the treads. However, 128 water bars were judged to be largely ineffective, indicating that relatively little water would be diverted from the tread at these locations during rainfall or snow melt.

Soil erosion is the most common type of trail impact for this segment, with 55 occurrences of soil erosion (6,006 ft, 7.1%) estimated to be one or more feet below the original post-construction tread surface (Table 5). Five of these occurrences were 2-2.9 feet in depth and one occurrence was 3-3.9 feet. Excessive root exposure (35 occurrences, 1,272 ft) and secondary treads (32 occurrences, 984 ft) were also frequent tread impacts along this segment. Wet soil (muddiness) was less frequent (19 occurrences, 666 ft) and running water on the trail and excessive width were rare (117 ft and 347 ft, respectively) (Table 5).

Trail Use Comparisons

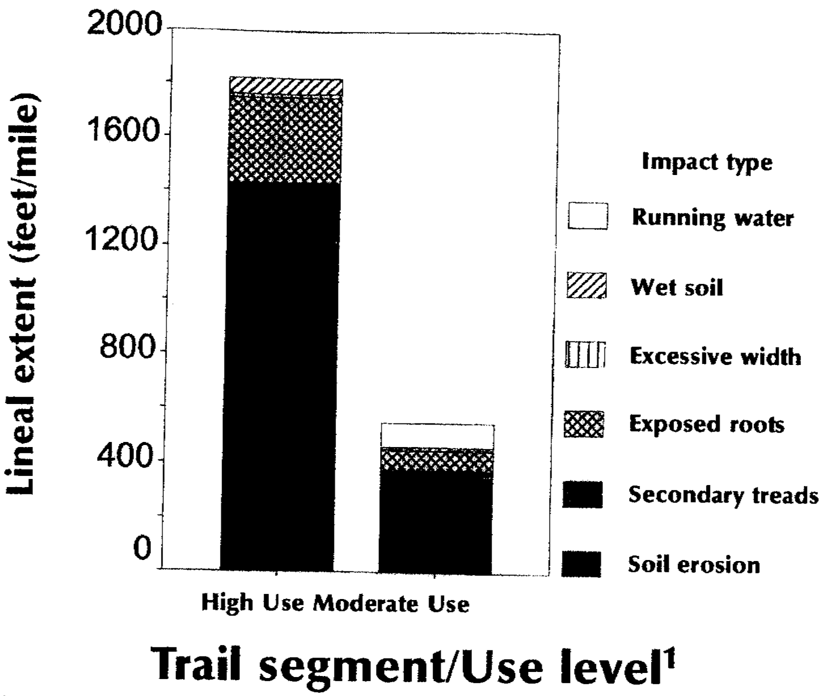
Point sampling trail condition data revealed a statistically significant relationship with level of trail use (high, medium, and low) for only one impact indicator: tread width (Kruskal Wallis test: $\chi^2 = 26.0$, $p < .01$). Median tread width declined from 30 to 19 to 16 inches from the high to the low use section. Median maximum tread incision values (post-construction estimate) were unrelated to amount of use.

In contrast, many of the problem assessment trail condition indicators appear to be related to amount of trail use (Figure 1). Data are not shown for the low use section, because there were no occurrences for any of the problem assessment indicators. Soil erosion exceeding one foot in depth declined from 1,212 feet/mile on the high use section to 354 feet/mile on the moderate use section (Figure 1). The number of occurrences of severely eroded sections and the percentage of section lengths affected by this form of impact also declined substantially with decreasing use level, from 18 to 10 occurrences and from 23 to 5.4 percent. Exposed roots, declined from 319 to 72 feet/mile (Figure 1) and from 24 to 7 occurrences. Secondary treads declined from 219 to 22 feet/mile, also suggesting a relationship with amount of trail use. In contrast to the point sampling trail width indicator, excessive trail width was rarely found and is less related to amount of use, declining from 14 to 5 feet/mile (Figure 1).

Table 5
Summary Results of Trail Impact Assessment
Using the Problem Assessment Method
(Appalachian Trail: Newfound Gap to Tricorner Knob Shelter)

Indicator	Occurrences		Lineal Distance	
	(#)	(#/mi)	(ft)	(%)
Inventory Indicator				
Use Type				
Pedestrian	1	-	56783	67.46
Horse/Pedestrian	1	-	27388	32.54
Excessive Grade	1	0.06	50	0.06
Drainage Dip				
Ineffective	3	0.19		
Partially Effective	5	0.31		
Very Effective	3	0.19		
Water Bar				
Ineffective	128	8.03		
Partially Effective	123	7.72		
Very Effective	156	9.79		
Impact Indicator				
Soil Erosion				
1-1.9 ft	49	3.07	5569	6.62
2-2.9 ft	5	0.31	412	0.49
3-3.9 ft	1	0.06	25	0.02
Wet Soil	19	1.19	666	0.79
Excessive Width: +3-6 ft	5	0.31	117	0.14
Excessive Root Exposure	35	2.20	1272	1.51
Multiple Treads	32	2.01	984	1.17
Running Water on Trail	4	0.25	347	0.41

Figure 1
Stacked Bar Chart Showing the Cumulative Lineal Extent of Impact Problems for Two Sections (High and Moderate Use) of the Appalachian Trail Using the Problem Assessment Method



[1]Data for low use section omitted; there were no occurrences of the problems depicted.

Discussion

Relative to the segment of Appalachian Trail assessed in this study, the point sampling data depict a trail that is generally in fair condition. Soil erosion is perhaps the most significant impact; an estimated four inches of soil on average has been eroded from the tread since the trail was constructed by the Civilian Conservation Corps in 1934. Indicator range values (Table 4) and frequency distributions (not shown) reveal that the trail has some severely eroded sections. These data also suggest that excessive width and muddiness are not common problems for this segment. Problem assessment data support these conclusions. Soil erosion exceeding one foot in depth is revealed as the most frequent and extensive form of trail degradation, with 55 occurrences affecting 6.6% of the segment. Development of secondary treads, with 32 occurrences, affect only 1.2% of the trail segment. Not surprisingly, no secondary treads were captured by the sampling method (n=80 points). Sample size would have to be increased greatly to obtain an equally precise measure (Leung & Marion, 1999b).

The characterizations of tread conditions are more divergent when data from the three smaller sections were examined and compared to evaluate the effect of amount of use. Tread width was the only indicator from the point sampling method related to amount of use. However, problem assessment data reveal substantial differences in soil erosion, exposed roots, and secondary treads. No relationship with excessive width is apparent in the problem assessment data.

Results from this comparison of trail condition assessment approaches reveal that the point sampling and problem assessment methods provide distinctly different types of quantitative information. Point sampling provides the most efficient, accurate and precise measures of trail width, tread incision, and tread composition. The problem assessment method yields data characterizing the frequency, lineal extent, and location of specific trail impact problems and is a better method for measuring infrequent characteristics (e.g., multiple trails). Both methods can characterize "typical" trail conditions. For example, point sampling provides median values and line plots of actual tread width while problem assessments provide frequency of occurrence (#, #/mi) and lineal extent (ft, ft/mi, cumulative ft, % of segment) measures of excessively wide trail sections.

The point sampling method is a preferred approach for monitoring trail characteristics that are continuous (e.g., width or depth) or frequent (e.g., exposed soil). Measurements are more objective and yield interval data for most variables, permitting greater flexibility in management applications and relational analyses. At larger sampling intervals, the point sampling method provides incomplete and potentially inaccurate information on the frequency, lineal extent, and location of specific trail problems (Leung & Marion, 1999b). Point sampling may miss occurrences of uncommon trail problems, as demonstrated in this study. These limitations can be addressed by reducing the sampling interval which, as intervals diminish, will yield data more similar to the problem assessment method (Leung & Marion, 1999b). However, the substantially greater assessment times required for smaller sampling intervals make this an inefficient method for documenting infrequent trail characteristics.

When sampling intervals are appropriately sized to characterize a given trail characteristic, additional statistics can be estimated from point sampling data. For example, the frequency of occurrence and lineal extent of soil erosion in excess of six inches could be estimated for a trail segment by examining and extrapolating the ratio of sample points with and without tread incision that exceeds six inches. However, information on the location of trail problems is only available from sample points, limiting the utility of this data for planning and directing trail maintenance work.

In contrast, the problem assessment method is a preferred approach for monitoring trail characteristics that can be easily predefined (e.g., excessive width) or are infrequent (e.g., secondary treads). Measurements are more subjective and problems are evaluated on a presence-absence basis. Such data is quantified by the frequency and lineal extent of each trail impact assessed. The ability to document and locate all occurrences of a trail characteristic is the chief advantage of the problem assessment method. Assessment times are low for trails in good condition and high for trails in poor condition.

The need to predefine impact problems underlies the chief limitations of the problem assessment method. Actual trail conditions, such as width and depth of the tread, cannot be characterized. The use of predefined problems (e.g., erosion greater than one foot) limits the flexibility of subsequent data analyses and applications. More important, subjectivity is involved in defining the problems, specifying the minimum lineal extent over which problems must be observed before they are recorded, and identifying discrete beginning and end points of problem segments. Such subjectivity may limit the utility of data for some types of management decision making.

Implications for Management and Research

Trail assessment methods are applicable to a wide range of trail types, including single use or multipurpose trails throughout the urban to wilderness continuum. Selection of a specific trail assessment method depends on trail management information needs. Funding and staffing limitations also frequently constrain choices and even the ability to conduct trail assessments. Some managers also discount the value of trail assessments. However, trail assessments provide some distinct benefits that trail managers and scientists should find of value.

Condition assessments provide efficient methods for characterizing trail conditions, the type and extent of trail impacts, and changes in trail conditions over time. Such information can be used in planning and budget proposals to justify requests for additional resources or to reallocate existing resources to address trail management problems. If securing additional resources is a primary need, then the problem assessment method would provide the most compelling data. Such data also provide the best information on where to allocate existing or new trail maintenance resources. For example, trails can be ranked by the lineal extent of impact to identify trails in greatest need of management attention and data from individual trails can be used to direct maintenance efforts to the most pressing impact problems.

If accurate information on trail characteristics like width, depth and muddiness are needed for monitoring trends, then the point sampling assessment method would provide the best data. This method can be used in conjunction with a sampling scheme to select a subset of trails or trail segments that will permit the efficient characterization and monitoring of a larger trail system that would be prohibitive to evaluate in its entirety. Point sampling procedures are more objective than those used for problem assessments and should provide data that is more sensitive in detecting temporal trends for continuous trail characteristics or common trail problems.

Evaluations of trail resource condition standards employed in management decision frameworks (e.g., LAC or VERP) present a dilemma for managers seeking to select a preferable trail condition assessment method. Point sampling methods may miss occurrences of unacceptable conditions for impact indicators and cannot be used to evaluate some standards of the "maximum condition" type. For example, a standard applied to any point on the trail (e.g., trail width < 6 ft.) could not be evaluated, but a standard applied to the entire trail (e.g., average trail width < 3 ft.) could be evaluated. However, standards based on average conditions are somewhat problematic, because poor or declining conditions in some areas may be masked by good or improving conditions in other areas.

One alternative is to use point data to estimate the percentage of a trail affected by selected impacts and establish and evaluate standards based on such measures. For example, the percentage of a trail that is greater than three feet in width could be calculated, and a maximum condition standard could be established for that measure. A preferred alternative may be to employ a combination of mean and maximum condition standards.

As previously noted, the greater subjectivity inherent in applications of the problem assessment method becomes an issue of some significance when data are to be used in the evaluation of management standards. Standards based on the frequency of occurrence of impact problems would be more reliable than standards based on the lineal extent of such problems when using problem assessment data. Furthermore, the locations of specific impact problems is often important in understanding impact causes, the role of influential factors, and in selecting and implementing management interventions.

These limitations may be reduced by employing an integrated assessment approach. In a recent study, the authors employed a point sampling method combined with selected problem assessment indicators to assess the condition of Shenandoah National Park's trail system. This integrated approach provides more comprehensive data in support of park decision making relative to backcountry and wilderness resources (National Park Service, 1997).

Both managers and scientists may be interested in investigating the influence of use-related, environmental, or managerial factors. Typical questions include: "How do vegetation types vary in their resistance to trampling pressures," "How is type of use correlated with trail degradation?" and "How effective is trail maintenance in preventing trail degradation?" Both types of trail assessments provide data that can be analyzed to address these questions. For instance, regression analyses have been performed on point sampling (Coleman, 1981) and problem assessment (Marion, 1994) data to evaluate the relative importance of factors contributing to trail degradation. Point sampling data provides more flexibility in these types of analyses, because values for independent variables can vary with individual sampling points and sufficiently large sample sizes can be generated from assessments of fewer miles of trail.

Social scientists may also be interested in evaluating visitor perceptions of trail degradation. Both assessment methods provide data that characterize the principal trail impact indicators, although the problem assessment method would most likely provide a better characterization of trail impacts most noticeable to visitors. Scientists can evaluate trail users' perceptions of these impacts and the relative importance of such impacts among other forms of camping and social impacts. Other potential studies include the correlation of visitor trail impact perceptions with actual trail conditions as characterized by a trail condition assessment. We are not aware of any studies of this type.

Further research is needed to refine trail condition assessment methods and their management and research applications. What is most important, the accuracy and precision of these methods, is unknown. Comparisons of the rapid-assessment methods employed in this study should be made to more thorough, time-consuming methods to evaluate accuracy. For example, comparisons of single maximum incision measures with more elaborate cross-sectional area determinations (Leonard & Whitney, 1977) would clarify how well these different measures are correlated. Investigations of independent evaluations using the same procedures applied to a common trail segment are needed to evaluate the precision of these methods. A high degree of precision is particularly important in the collection of data used in monitoring and for management decision frameworks.

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