Exploring the Social, Environmental and Economic Aspects of Trail Surfacing Decisions

by

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AUTHOR’S DECLARATION FOR ELECTRONIC SUBMISSION OF A THESIS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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ABSTRACT

Visitor activities in parks often have a heavy impact on the soil, vegetation, water and wildlife. In front country areas, the most extreme damage is concentrated on and adjacent to recreational trails. Aside from controlling the numbers, activities and behaviours of trail users, managers may choose to make trails more resistant to impact through surfacing. Unfortunately, surfacing may have negative influences on park visitors' enjoyment of trails by limiting access or detracting from the primitive setting. In addition, some surfaces may be ineffective in certain environmental conditions such as wet ground or steep slopes. Finally, the wide variety in construction and maintenance costs may make some surface types economically unfeasible.

The goals of this research are to investigate the role of trail surfacing in the management of impacts from outdoor recreation; to develop better understanding of the social, economic and environmental aspects of trail surfacing decisions; and to explore a comprehensive framework for incorporating these three factors in trail management. It is hoped that this research can assist park managers in selecting surfacing options to reduce visitor impact without excessively compromising recreational experience or organizational limitations, such as financial resources.

In addition to a comprehensive review of literature on visitor impact management on trails and surfacing techniques, this research employs three methods to further investigate the social, environmental and economic aspects of trail surfacing: a trail user survey, manager survey and trail condition assessment. The trail user survey was conducted at two well-used natural areas in southwestern Ontario, Canada: Presqu'ile Provincial Park and Belfountain Conservation Area. Surveys at each area explored trail users' perceptions and preferences of trail surfacing techniques in late summer 1999. The managers' survey provided insight into organizational approaches to surfacing, including construction cost and observations on recreational or environmental effectiveness. Finally, the trail condition assessment explored an approach to determining environmental effectiveness of trail surfacing techniques, but was limited by the physical and recreational variation between trails.

Seven recommendations for trail managers are presented, tying in several conceptual frameworks of visitor impact management and trail surfacing decisions developed in the thesis. First, trail managers are recommended to develop a full understanding of trail design principles and alternative visitor impact management techniques. If surfacing is selected as the best impact management technique, trail managers should obtain as much information on user characteristics, environmental conditions and organizational limitations as possible. Despite the benefits and drawbacks for all surfaces, road base gravel (or angular screenings with fines) merits special attention as an excellent surface, while asphalt and concrete are not recommended for front country, semi-primitive recreation. Finally, trail managers are encouraged to share information on surfacing more freely and open surfacing decision processes to affected trail users.

Overall, trail managers are provided with an approach to surfacing decisions that considers the social, environmental and economic aspects of trail surfacing, with the goal of working toward more enjoyable, environmentally responsible and cost-effective trail solutions.

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George Giles and Linda-Mary Bluma,
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1 INTRODUCTION AND RESEARCH OBJECTIVES

1.1 INTRODUCTION

With increasing recreational use of natural areas over the past several decades, park managers have been faced with the problem of balancing recreational use and natural preservation values of the environment. While enjoying parks, visitors affect the very resources attracting them in the first place. Without management intervention, the natural condition of the resource will often deteriorate. Impacts resulting from recreational use increasingly threaten the natural and cultural values of protected areas (Leung and Marion, 1996). Action may be required to ensure visitors can experience natural areas without the environment becoming so degraded that it loses its value and attraction.

Parks at all administrative levels have faced ongoing problems with degradation of the natural condition of protected areas resulting from high levels of use. Some of the most extensive impacts have been from the development of new trails and from the deterioration of existing ones. As a result of the recreational use of trails, significant changes to the soil, vegetation, wildlife and water near park trails have occurred (Liddle, 1997). In addition, the primitive and natural experience desired by many trail users has been compromised.

Trails represent a major outdoor recreation resource, with over two-thirds of all local Park and Recreation Departments in the United States managing about 4500 recreational trails in 1989 (McDonald, 1989). This represents a total length of approximately 43,000 kilometres, and does not include trails at state and national parks or forest recreation areas. With use of recreation trails expected to increase in the future (Bowker *et al.*, 1999; Cordell *et al.*, 1999), the importance of sound visitor impact management measures is underscored.

Aside from controlling the numbers, activities and behaviours of trail users, park managers may choose to make the trail more resistant to impact through surfacing (Hammitt and Cole, 1987). This is particularly true in heavily used areas or environmentally sensitive locations, where drastic changes in the use characteristics would be necessary to prevent unacceptable change to the environment.

Trail surfacing is the application of a material to a trail in order to provide a suitable tread for recreation activities. Materials such as wood chips, crushed limestone, asphalt, soil cement and boardwalks have been installed on trails in an attempt to mitigate damage caused by trail users. The selection of surfacing material depends on the type of activity pursued, environmental conditions at the site, desired recreational experience, installation cost and maintenance requirements.

Unfortunately, surfacing may have negative repercussions for park visitors. Soft surfaces, such as gravel or wood chips, may limit access for users with mobility impairments, including those with wheelchairs. Hard surfaces, such as asphalt or concrete, may detract from the primitive trail setting. In addition, some surfaces such as wood chips and loose gravel may be ineffective in certain environmental conditions including wet ground or steep slopes. Also, the wide variety in construction and maintenance costs may make some surface types economically unfeasible. Park managers must keep all of these considerations in mind when selecting a trail surface. The relationship of these considerations to the surfacing decision and some of the components affecting them are shown in Figure 1.

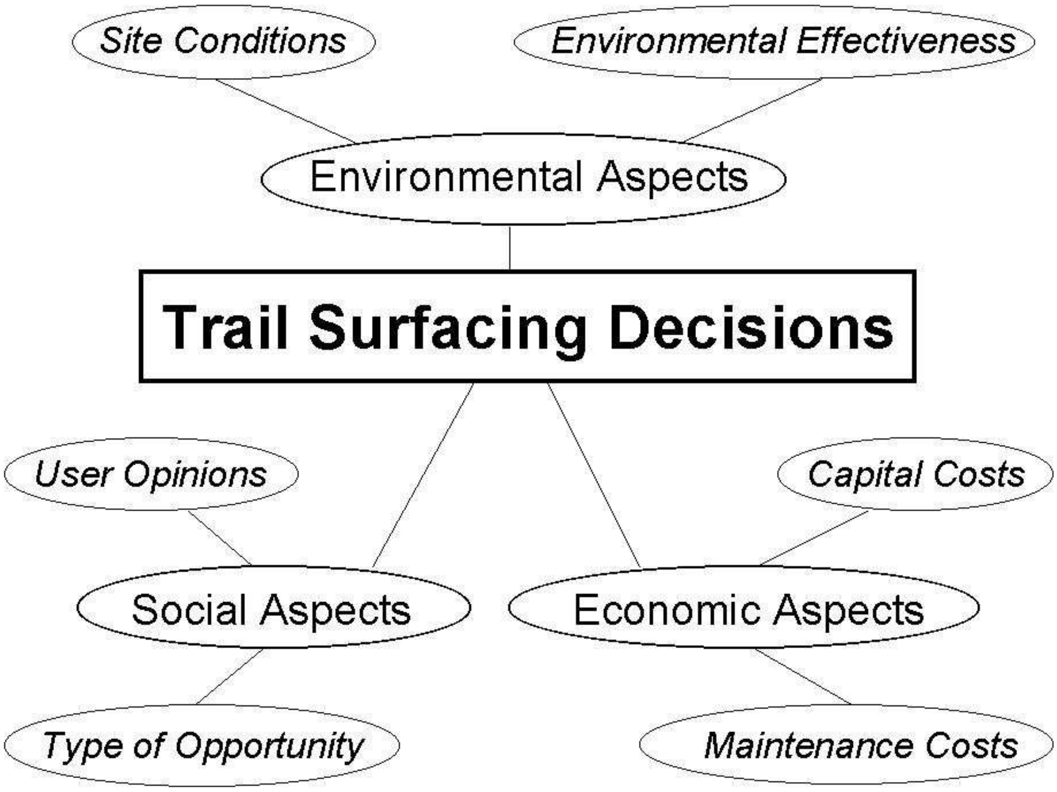


Figure 1. Conceptual framework of the trail surfacing decision.

Our understanding of the direct impacts of recreation on soils and vegetation is well developed. However, there is a paucity of research on the social and environmental effectiveness of different surface types, such as the effect of trail surfacing on visitor experiences. More research is needed in the field of recreation ecology on the effectiveness of impact management techniques such as trail surfacing (Cole, n.d.). In particular, there is little discussion integrating the economic costs of trail surfacing techniques with social and environmental aspects of the decision-making process.

1.2 PROBLEM STATEMENT

There is very little literature available regarding the economic, social and environmental aspects of trail surfacing. In particular, there is a lack of research into the effects of different surfacing types on the experience of the user, the types of activities favoured and the effectiveness in keeping users on the trail. Overall, research into the integration of social, environmental and economic aspects of trail surface types needs to be completed in order to provide park managers with a conceptual and empirical foundation on which to base more effective trail surfacing decisions.

The goal of this research is to develop and explore a conceptual framework for trail surfacing decisions. In this way, this research may assist in optimizing social, environmental and economic considerations in the allocation of scarce recreation budgets.

1.3 OBJECTIVES

The objectives of this research are as follows:

1. Examine the role of trail surfacing in the management of environmental and social impacts from outdoor recreation.
2. Assess the social acceptability of trail surfacing types based on demographic and activity characteristics.
3. Evaluate the effectiveness of trail surfacing types in limiting recreational use to the surface of the trail and minimizing environmental impact.
4. Investigate the experiences of trail managers with construction costs, maintenance requirements, and successes or failures of a variety of surfaces.
5. Develop a framework for integrating the social, environmental and economic aspects of trail surfacing into management decisions.

2 STATE OF THE KNOWLEDGE AND STUDY CONTEXT

This research can be categorized with studies in applied recreational geography. Geography, with its focus on physical, economic and social phenomena in space and its integrating approach to analysis, is particularly well suited to providing information of relevance to trail surfacing decision makers (Stankey, 1977). This line of research also forms an integral component of recreation ecology, which can be defined as: "an emerging field in natural resources research which seeks to understand the human-nature ecological relationships in recreation contexts, including identification of recreational impacts on ecosystems and the landscape, the influence of use-related and environmental factors, and the roles management can play modifying these factors" (Leung and Marion, 1996).

Unlike many other areas of recreation ecology, few peer-reviewed studies of trail surfacing have been published. While journals or refereed conference proceedings contain numerous articles on other aspects of trail research, little attention has been focused on the topic of trail surfacing. Over the course of their career, trail managers conduct extensive informal research and develop knowledge of what works and what does not through personal experience (Burch, 1979). This reflects the informal nature of the investigation and dissemination of trail surfacing information. Perhaps it is for this reason that little attention has been given to the relationship between trail surfacing and other recreation impact management concepts.

2.1 THE ROLE OF SURFACING

Despite the lack of research on trail surfacing, numerous studies have investigated the impact of recreational use on trails over the past thirty years (Cole, 1991; Liddle, 1997; Giles, 1998; Leung and Marion, 1999). Many approaches have been proposed to manage these impacts, including limiting number of users, restricting type of activity, changing behaviour of users and altering site conditions (Hammitt and Cole, 1987). The latter category includes site hardening by the surfacing of trails. Site hardening is the increase in resistance of a location to impact on soils, vegetation or other environmental attributes from recreational use, including trail surfacing. In a survey of U.S. Forest Service managers, 36 percent mentioned site hardening as a key impact management strategy in addressing the resource damage from outdoor recreation activities (Chavez, 1996).

As only one of many impact management tools at the hands of park managers, selection of trail surface is secondary to whether surfacing is the correct approach in the first place. For instance, if the trail is in an environmentally sensitive location, it may be better to simply close that section and relocate the trail to a less sensitive site. Environments sensitive to trail development include areas of wet or organic soils, homogeneous soil textures, high clay or sand contents, threatened or sensitive flora and fauna, edges of water bodies and areas of high erosion. Building trails through such areas often requires extra design considerations and should be avoided if at all possible.

In addition to proper location, trail design is very important to minimize the impact of trail-based recreation on the environment. Incorporating techniques such as switchbacks, waterbars, and tread outsloping minimizes damage from erosion and concentration of surface runoff. Waterbars are ditches dug at an angle to the trail which move water to the downhill side of the path. Tread outsloping is the grading of the trail surface to follow the natural contour of the hillside, allowing water draining onto the trail surface to continue uninterrupted across the path. As an alternative to these physical approaches, an initiative to educate users to stay on the path could reduce impact on trailside soil and vegetation to acceptable levels without the expense of artificial surfacing. Without careful consideration of these other impact management tools, trail hardening tends to simply treat the symptoms of trail impact instead of the cause (Cubit and McArthur, 1995.). However, if a review of each of these impact management alternatives shows that surfacing is the most appropriate management tool, then managers need to understand the choices of available surface types. Their decisions will not only have economic costs, but also will have ramifications for the experience and enjoyment of park visitors. Despite the best intentions and “environmentally sound” materials and techniques, trail managers should be aware that surfacing can alter trail experiences and displace visitors from the area (McArthur, 1994.).

Each trail provides an opportunity for a certain type of outdoor recreation. The trail surface has a strong relationship to both the type of activity and the quality of experience provided by the site. Not all surfaces are suitable for all recreation pursuits. For instance, cycling is difficult on a wood chip path due to the soft, loose surface. In addition, there may be several surfaces that are suitable for a certain activity, but each type provides a different experience. The preferred surface depends on the desires and motives of each recreationist. Walking on a wood chip path differs from walking on gravel or concrete. Understanding these preferences is important in order for the trail manager to make decisions to provide for the activities and experiences desired at that site.

Different recreational activities also have different types of impact on the environment. For instance, the rotational torque of the tires of mountain bikes or off-road vehicles create a lateral force in addition to the downward compaction under the weight of the user. Hikers not only have a downward force with their steps, they also have a shearing force as the toe or heel of the boot digs in toward the beginning and end of a stride. Horses have particularly strong shearing forces with each step, as the front of the hoof cuts into the soil with considerable force under the weight of the horse and rider (Weir, 2000). The differences in each of these actions make the measurement of impacts by different modes of trail use difficult. Studies examining impact from different trail activities have shown little measurable difference between horseback riders, hikers, mountain bikes and motorbikes (Wilson and Seney, 1994), or hikers and mountain bikers (Cessford, 1995; Thurston, 2000). However, the impact from hikers has been found to be more pronounced on downhill trail segments, while impacts from off-road vehicles is higher on uphill climbs (Weir, 2000). Skidding from inexperienced mountain bikers on downhill trail sections has also been recognized as a significant concern (Weir, 2000). Consideration of the impacts of different modes of outdoor recreation is important to designing resilient trails for a variety of recreational activities.

In addition to different surface requirements between activities, there are also different types of surfaces desired within each activity type. For example, a recreational cyclist might prefer a hard smooth surface, while an adventure mountain biker would seek out single track, bare earth paths for a greater challenge. Some walkers may seek an even footing, while others may prefer the unpredictability of a rougher tread. Trails to satisfy each group are significantly different, even though the mode of recreation remains the same. To further complicate the understanding of user preferences, the same recreationist may enjoy different experiences on different days. It is up to the trail manager to provide trail opportunities that support experiences appropriate to the objectives for the site. Often, this translates into developing a variety of trails to satisfy different recreational goals.

2.2 CONSIDERATIONS FOR SURFACING DECISIONS

As discussed above, there are three main considerations that the trail manager should address in making the most informed surfacing decision: environmental, social and economic. Careful understanding of these factors is necessary to ensure the long-term viability and enjoyment of recreational trails in all natural areas.

2.2.1 Environmental Considerations

The environmental aspects of surfacing decisions involve two factors: site conditions and environmental effectiveness. Consideration of site conditions (such as hydrology, soil type and vegetation) is necessary in selecting appropriate surfacing techniques. For instance, placing a boardwalk across a segment of wet ground may be more effective than using crushed limestone or wood chips. Placing gravel on steep slopes may result in water erosion and gullying, quickly degrading the tread and surrounding features. Depending on the site conditions, some surfacing alternatives may not be viable.

Trail surfaces also differ in their environmental effectiveness. One of the main objectives of trail surfacing is to contain recreational use to the path. Selection of an appropriate surface material can control where people travel in a greenway, which can be used to reduce both environmental impact and user conflict (Cole, 1993). In a study of the Pennine Way in England, the percentage of walkers straying from the path decreased from over 30 percent to 3.8 percent following surfacing with flagstones (Bayfield, 1973; Pearce-Higgins and Yalden, 1997).

Some surfaces, such as a boardwalk, may better contain impacts from recreation users to the path itself. A study of visitor control measures in fragile environments found that a boardwalk decreased the percentage of users straying from a path (Hultsman and Hultsman, 1989). Another study showed that a boardwalk in a low heath bald in the Southern Appalachian Mountains was not an effective deterrent to trampling, although the boardwalk most likely reduced the level of trampling that would have occurred had the boardwalk not been constructed (Sutter *et al.*, 1993). With some surface types, such as gravel fines or cinders, trail users may still wander off the sides due to muddy or dusty conditions. By straying from the trail, users widen the path and continue environmental degradation. Also, some soft surfaces may spread out with continued use. For instance, rocks from gravel trails and wood chips from mulch paths can be scuffed from the tread, further widening the path. Reduction of the impact of recreational use on soil and vegetation is important, especially given the long recovery time necessary for heavily damaged areas (Charman and Pollard, 1995).

Proper design of the trail itself can mitigate many of these impacts. Water management is the most critical variable in maintaining a path (Hammitt and Cole, 1987). Side ditches, waterbars, cross-ditches, culverts, outsloping and sub-bases with geotextiles are just some of the many features which may need to be incorporated into surfacing design to prevent water damage.

Overall, the literature on the environmental effectiveness and implications of site conditions on surface selection has not been well developed. There are some brief discussions based on experiential information, but no field experiments or empirical measurements have been found to validate these sources. Manuals published by groups such as the Rails to Trails Conservancy (Ryan, 1993; Rails to Trails Conservancy, 1999), Appalachian Mountain Club (Burch, 1979; Proudman and Rajala, 1981), Federation of Mountain Clubs of British Columbia (Altman *et al.*, 1986; Federation of Mountain Clubs of British Columbia, 1990) and Greater Victoria Greenbelt Society (Greater Victoria Greenbelt Society, 1987) are the best sources for discussions of environmental aspects of trail surfacing decisions.

2.2.2 Social Considerations

Two main factors make up the social aspect of trail surfacing decisions: type of opportunity and opinions of users. The first factor recognizes that surfacing of a trail detracts from the natural appearance of the area, thus compromising the enjoyment of the area by users seeking a primitive experience. Some surfaces appear more natural than others and are thus more tolerable in natural areas. For example, where an asphalt trail may be unacceptable, a soil cement surface may provide the desired protection without being as visually obtrusive. A survey on a trail in a Pennsylvania State Park found 77 percent of trail users strongly agreed that a natural surface was essential to the trail experience, compared with only 24 percent who strongly agreed that a human-made surface was essential (McCay, 1978).

In contrast, the Capital Regional District (on southern Vancouver Island) conducted a visitor use survey on the Galloping Goose Trail showing a user preference for paved surfaces (Capital Regional District Parks, 2000). This popular regional trail was used for commuting by 24 percent of respondents, recreation by 41 percent and for both commuting and recreation by 25 percent. When asked about their preferred trail surface, users selected pavement first overall (57 percent), followed by compacted gravel (14 percent). Only 1 percent of the 110 respondents selected loose gravel, while 16 percent stated that trail surface was not an issue. The more urban setting and high level of bicycle use (53 percent of users) compared to walkers/hikers (27 percent) may have influenced the surfacing preference indicated by trail users. Other studies in the Chicago area have corroborated the importance of trail surface to users in the design of cycling, hiking and jogging paths (Gobster *et al.*, 1988).

In back country settings or wilderness areas, trail surfacing is generally not a favoured option for visitor impact management. Users seeking the pristine conditions of the wilderness do not generally tolerate this level of management intervention. Even where use levels are high, other alternatives, such as use rationing, may be preferred over altering these conditions. For example, surfacing was ranked as the lowest favoured management action in a survey of park users in Arches National Park (Manning *et al.*, 1996). Surfacing may be more appropriate in front country areas where higher management intervention is acceptable to visitors.

The Recreation Opportunity Spectrum has been used by many park agencies to guide development policy according to desired opportunities (Hendee *et al.*, 1990; Watson *et al.*, 1999). Trail surfacing is a valuable tool within the urban, rural and semi-primitive settings, but would exceed development criteria for primitive settings. In the Parks Canada Spectrum of Appropriate National Parks Opportunities, this translates to meeting criteria in the natural environment (Class 3), outdoor recreation (Class 4) and parks services (Class 5) activity zones, but not the special preservation (Class 1) or wilderness (Class 2) zones (Parks Canada, 1996). Concern over the appropriateness of trail surfacing in back country settings of Canada's National Parks had been identified as early as 1986 (Marsh, 1986). The U.S. National Parks Service has responded to this same concern in suggesting that trail surfaces must support and respect the character of the intended pathway uses, reflect the local environment, historical influences and local tradition, and harmonize with the landscape (Duffy, 1992).

The second factor in the social aspect of trail surfacing decisions is the opinions of the users. Trail surfacing is used to mitigate the environmental impacts of recreation use, but it can also result in limitations for certain activity types. These limitations can be designed or unintended. For instance, surfacing a trail with wood chips discourages rollerblade and bicycle use; however, it would also exclude wheelchair access and persons with strollers. In addition, some users may dislike walking on the soft surface or may be apprehensive about splinters if walking with open footwear. Softer surfaces also have the effect of reducing speeds of users on trails, increasing trail safety and potentially preventing user conflicts. Such considerations need to be included in trail surfacing decisions in order to provide for the best user experiences while minimizing environmental damage. An evaluation of the suitability of various surface materials for different trail uses is presented in Table 1.

Table 1: Surface materials and individual use types.

	Concrete	Brick/Masonry	Asphalt	Boardwalk	Road Base Gravel	Soil Hardener	Limestone Fines	Sandstone Fines	Wood Chips	Natural Surface	Sand	Over Snow
Walking	**	*	***	**	**	***	**	*	*	***	*	
Hiking								*		***		*
Jogging					*	*	**	**	**	***	*	
Fitness	*	*	*	*	*	**	*	*	**	***	*	
H. Accessible	***	*	**	*								
Bicycle	**	*	***	*	**	*	**	*				
Mtn Bike	*		*	*	**	**	**	**		***	*	
Equestrian									*	***	*	
Ski												***
Key: *** most desirable ** medium desirability * acceptable												

Source: (Duffy, 1992).

One area of increasing importance in the trail surfacing selection is the issue of accessibility for trail users of all abilities. In the United States, the implementation of the Americans with Disabilities Act Accessibility Guidelines (ADAAG) has raised significant concerns over the accessibility of various trail surfaces, particularly with agencies such as the U.S. National Parks Service and U.S. Forest Service. The ADAAG stipulates that trails in natural areas should be firm, stable and slip resistant. Some research has been completed on the testing of surfaces for accessibility, particularly on evaluating maneuverability and regularity of playground surfaces (Anonymous, 1997), and firmness and stability of trail surfaces (Axelson *et al.*, 1997). According to Dave Park, Chief of the Office of Accessibility for the U.S. National Parks Service, the three most stable surfaces are asphalt, wooden boardwalk and concrete, but more research is needed before any decisions are made on whether other surfaces are accessible (Anonymous, 1996). Managers of the Waterfront Trail in Toronto, Ontario, considered accessibility in its design, with asphalt paving proving to be ideal, although boardwalks are acceptable if the gaps between the planks are less than 13 millimetres (Victor Ford Associates, 1997). Although Duffy (1992) suggests gravel screenings (both limestone and sandstone) and trails treated with soil hardener are unsuitable for handicapped accessibility (Table 1), other researchers have found these surfaces, if constructed properly, can meet the needs of trail users with mobility aids (Axelson and Chesney, 1999). Principles of universal access and design have already been incorporated into many agencies' trail design guidelines (B.C. Parks, 1993; Parks Canada, 1996; United States Department of Agriculture, Forest Service, Engineering Staff, 1996; United States Department of Transportation, 1999). Further research into trail design and the selection of surfacing for accessible trails will be necessary to meet the requirements of recent policy changes in the United States.

2.2.3 Economic Considerations

Information on construction costs and maintenance requirements for various surfacing types is often available from park maintenance departments or from material suppliers. In general, surfaces such as asphalt and concrete are considerably more expensive than materials such as crushed limestone or wood chips. However, the longer replacement intervals for asphalt or concrete and their ability to withstand heavy use may outweigh any short-term savings. The cost of surfacing materials varies according to the availability and proximity of the supplier to the site. In many cases, surfacing materials are available within the park, such as gravel or flat stones. In addition, some trail construction projects may benefit from donation-in-kind of materials, equipment or labour, significantly decreasing costs. Cost will also depend on the standard to which the trail is built. Even with the same type of material, there are many ways of building a trail. Different thicknesses, widths or designs result in variable costs. In some cases, sub-grade construction beneath the selected trail surface is necessary, increasing the cost of the trail. In addition, varying maintenance commitments and life expectancies associated with each surface alter the long-term expenses for different types of trails.

2.3 SURFACING OPTIONS

The following section addresses the benefits and drawbacks of several types of surfacing commonly in use today. There are many other excellent sources that can be referred to for design and installation details used in the construction phase Cook (1965), Huxley (1970), Parks Canada (1978), EDAW Incorporated (1981), Ontario Provincial Parks Branch (1982), Ryan (1993). It is important to recognize that for most surfaces, a proper base and sub-base needs to be prepared (Figure 2). These provide the firm, stable foundation that distributes the weight of trail traffic and maintenance vehicles over the lifetime of the surface.

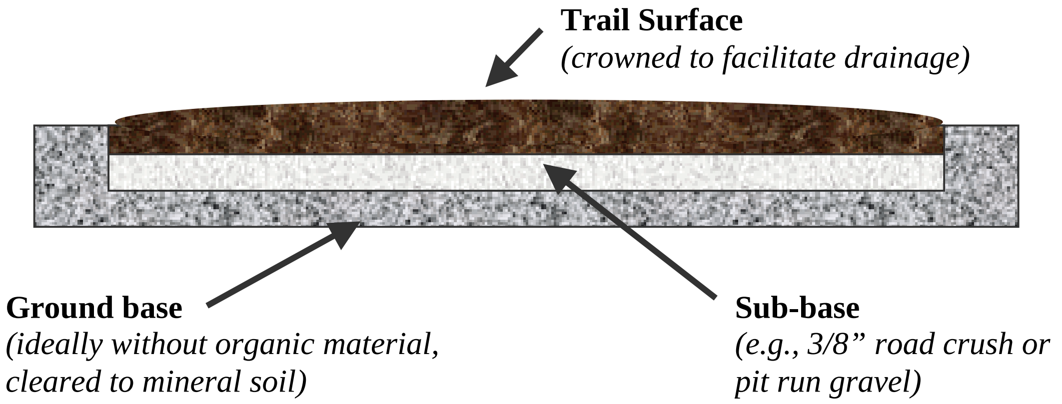


Figure 2. Cross-section of a well-designed trail.

The sub-base protects against frost heaving or subsidence, which could prematurely deteriorate the surface. In wet or frost prone areas, a layer of logs (corduroy) or a geotextile mat is often necessary between the sub-base and the surface, or the sub-base and the ground, to prevent the tread from being absorbed by the underlying soils. More information on the use of geotextiles in trail construction can be found in (Monlux and Vachowski, 1995)).

In some particularly high-use areas, a combination of trail surfaces may provide the desired trail characteristics for different types of users. The design of the Waterfront Trail in Toronto reduces user conflict by providing a boardwalk alongside an asphalt trail (Silbergh, 1998). This approach provides opportunities for a broader group of trail users, such as rollerbladers, cyclists and pedestrians, while reducing potential conflicts among them. Another example of the boardwalk/asphalt combination can be found along the Fraser River waterfront at the Quay in New Westminster, British Columbia.

2.3.1 Bare Earth

In locations where the existing soil is resistant to impact from recreational activities or where the level of use is relatively low, no additional surfacing may be required. More substantial surfacing is needed where the soil conditions are less impact-resistant, where higher use is anticipated, or where a firmer and more even surface is required (e.g., for cyclists or people using mobility aids) (Long and Todd-Bockarie, 1994). This option is easiest to develop and maintain, but can deteriorate rapidly if the trail is improperly designed or site conditions cannot support the level of trail use.

2.3.2 Wood Chips

Wood chips are often available from tree-trimming, telephone or power companies at little or no charge, making them an attractive option for trail managers. Chips made from hardwood limbs when leaves are off the trees are the most durable (Ashbaugh, 1967). Shredded bark or wood compact better than wood chips, while still allowing water infiltration and holding soil particles in place (B.C. Parks, 1993).

Wood chip trails have a more natural appearance than gravel or hard surfaces (asphalt, concrete) and have a soft, elastic feeling underfoot. However, wood chips do not provide a firm, even surface for trail users. This may be helpful in discouraging cyclists from a pedestrian path, but it also effectively excludes those using wheelchairs or strollers. Wood chips and gravel surfaces are categorized as “difficult” as they relate to accessibility requirements outlined by Parks Canada Design Guidelines for Outdoor Recreation Facilities (Parks Canada, 1994). In addition, if the wood chips are placed at a thickness greater than 75 millimetres, walking becomes difficult (B.C. Parks, 1993).

Some organizations (such as Ontario Parks and the District of Saanich Parks Department, near Victoria, BC) have moved away from the use of wood chips on trails for other reasons, including problems with decreased product availability, spreading and rapid deterioration (McDonald, 1999; Bell, 2000). In Saanich, selection of municipal trail surfaces is moving toward more use of gravel surfacing, but not without opposition from some users who prefer the look, feel and sound of the wood chips (Anonymous, 2000).

Wood chips have a number of drawbacks from an environmental and economic point of view. Their initial cost is relatively low, particularly if chips are available from a utility or landscaping company; however, wood chips tend to decompose rapidly (especially in wet areas) and require topping up every one or two years (Ryan, 1993). Wood chips also spread easily unless contained, widening the path beyond its design specifications. This is particularly problematic on equestrian trails. In addition, some wood chips can leach chemicals or introduce detrimental organisms into the surrounding environment, potentially altering local conditions (Parks Canada, 1978). For instance, chips made from cedar contain a toxic leachate that can enter nearby watercourses (B.C. Parks, 1993). The use of wood chips does allow increased soil moisture and reduced bulk density of soil, which may be beneficial to long-term soil productivity and have a positive effect on adjacent trees (Kimber and Jenkin, 1996). Overall, wood chips are a popular surface for walkers, but should be used only with consideration of site conditions, proper design and long-term maintenance commitment.

2.3.3 Gravel

A wide variety of types and sizes of aggregate can be used for surfacing. Some aggregate surfaces may be loose and unstable, particularly if the edges are rounded. In general, the three main categories of aggregate materials are: gravel, road base and crusher fines (Parker, 1994). Gravels are made from stone with the fines removed to facilitate improved drainage. As a result, gravels do not compact well. Road base is usually made from crushed pit run (fluvial sediment of silt and cobbles) from gravel pits. With the high silt content, road base surfaces tend to drain poorly, often resulting in muddy conditions in wet weather. The high silt content also compromises the interlocking of the larger particles, giving road base a poor surface finish, but proving acceptable for construction of a trail sub-base. Finally, crusher fines, including limestone or granite screenings, provide the optimum aggregate surface. The angular shapes and full range of particle sizes, from dust to 9.4mm (3/8 inch), provide a surface that is difficult to break, even with a pickaxe (Parker, 1994). The natural binders found in the rock dust hold the particles closely together and provide resistance to water falling on the trail surface. Shale or cinders from railway or industrial operations are also suitable, as they break down into fine particles that fill the voids in the lower sections. These fines tend to reduce the spreading problems experienced with coarser gravel trails (B.C. Parks, 1993). Overall, a well-constructed gravel trail can provide an excellent hard surface in good conditions, while maintaining a relatively firm and mud-free surface in poor conditions (Scott-Parker, n.d.).

Unfortunately, many gravel surfaces can get dusty in the summer or muddy and slippery in spring if the content of fines is too high. Gravel paths also have the tendency to spread over time. To combat this, the edges should be filled back against the stone or contained with wood planks. Colour and local character should be considered in the selection of gravel materials for surfacing. For instance, using crushed limestone in an area of igneous or metamorphic rock may appear out of place and also alter the acidity of local soils.

Gravel surfaces can be difficult to walk on, scar shoes and get into footwear (Ashbaugh, 1967). Some trail users also dislike the noise of walking on gravel and the unnatural appearance. One unique way to mitigate these drawbacks is to top dress a newly constructed trail of crushed gravel with a finely ground layer of bark mulch. This mulch breaks down with foot traffic and percolates into the gravel fines, softening the surface and providing conditions similar to those following a season of leaf drop and detritus accumulation (Gurney, 2001).

The National Capital Commission (1986) in Ottawa states that, when compared to asphalt, stonedust is often preferred when the deciding factor is visual compatibility with park character. The construction cost of a crushed limestone trail is lower than asphalt or concrete (Ryan, 1993) and decreases significantly if a nearby source can be quarried or local rock is crushed on site (United States Department of Agriculture, Forest Service, 1975). Also, from a maintenance perspective, gravel is less expensive to repair, only requiring regrading every 7 to 10 years (Parks Canada, 1978; Ryan, 1993).

Many jurisdictions have provided basic gravel trails and then upgraded them to asphalt or other surfaces at a later date. This allows for increased exposure and growth of public support for improving the surfacing, which may not have been possible when the trail was first opened (Ryan, 1993). An excellent source for further information on the design and construction of gravel trails can be found in (Charney, 1994).

2.3.4 Soil Stabilizers

Similar to concrete, soil stabilizers use a binder to hold together an aggregate; however, native soil is used as the aggregate instead of the sand and gravel used in conventional concrete. An array of materials is available as stabilizers for trail surfaces, including soil cement (portland cement), quicklime such as in Class ‘C’ flyash (byproduct of coal power plants), bentonite (naturally occurring clay), ECO-50 (asphalt polymer), Stabilizer™ (ground seed hulls of the plantego plant, native to Arizona), Lignosite™ lignin (byproduct of calcium bisulfite pulping process), and RoadOyl™ (pine resin emulsion from the distillation of turpentine). Information on these materials can be found in Gusey (1991), Robb (1992), Bergmann (1995), IES Utilities (1997), Soil Stabilization Products Company (1999) and Portland Cement Association (n.d.).

Soil stabilizers can be applied to many soil types; however, stabilizers such as soil cement are most successful when used in areas with well-graded granular materials (Lai, 1976). Soil cement can provide a hard, more natural surface at a lower cost than asphalt or conventional concrete (Ryan, 1993). It is particularly useful where hardening is needed at a long distance from an access point, since only the binder needs to be transported. However, careful design and commitment to long-term maintenance are required to prevent deterioration of this surface. Drainage and thermal cracking are primary concerns with this surface but, with the proper sub-base and crowning of the tread, soil stabilizers can work effectively.

2.3.5 Boardwalk

Boardwalks provide a prominent attraction for many Ontario protected areas, including Presqu'ile Provincial Park and Point Pelee National Park. The wood composition reflects the rustic attributes of the natural environment, particularly after several years of weathering. In many cases, boardwalks allow access to areas that may be too wet or sensitive for other types of trail, such as marshes or sand dunes. The hard, smooth and even surface of properly designed boardwalks provide for people of all abilities, including seniors, toddlers and those using mobility or visual aids. Generally, boardwalks favour pedestrian users, as cyclists are reluctant to ride on boardwalks given the more elevated position.

As a result of this elevated position, boardwalks decrease the impact of the trail on the soil, vegetation or hydrology of the area. In addition, handrails can be installed to discourage recreationists from straying off the trail and damaging trailside vegetation. Unfortunately, the use of preservative or pressure treated wood is almost a necessity to prolong the expected lifetime of the boardwalk. Consideration must be given to the leaching of preservatives from treated wood placed in wet areas. Plastic wood, manufactured from recycled plastics, is currently being tested in many areas as a longer lasting and less harmful alternative (Flink and Searns, 1993). Regardless of material, regular maintenance is required since hazards such as broken or loose planks can present a significant liability to the managing organization. Also, wooden structures are susceptible to being slippery when wet, especially in areas with overhanging vegetation or moss growth.

Similar to boardwalks, other techniques such as wood planking, corduroy and movable mats are useful in many trail surfacing applications. A mat of boards such as 2x6's, attached at the edges by cable, rope or disused firehose, can be used to cross sandy areas. This flexible walkway can be moved easily with shifting sands each season. Wood planks and corduroy can be laid to provide access over local wet areas or small streams, or as a base for other surfaces.

Overall, boardwalks are significantly more expensive than gravel or wood chip trails, and can cost more than asphalt and concrete, depending on design. Maintenance costs can also be expensive in areas prone to blowdown of trailside trees or vandalism problems. However, dealing with these problems may be worthwhile given the opportunity and experience provided to trail users by the boardwalk.

2.3.6 Asphalt

Asphalt is composed of a small aggregate held together by either a hot-mix or cold-mix bituminous compound. The resulting path is hard and smooth, providing an ideal surface for a wide range of recreation activities. In addition, when properly constructed, asphalt and concrete surfaces are able to support the weight of service vehicles.

A survey on bicycling facilities in the United States found that over 76 percent of park executives indicated asphalt as the surface best suited for bicycle paths, taking into consideration such factors as appearance, ease of maintenance, safety and construction cost (Cook, 1965). Other researchers have found similar results for higher use, urban bicycle trails (Case and Hulbert, 1972; National Capital Commission, 1986).

The cost of asphalt surfacing is higher than soft surfaces such as wood chips or gravel; however, the expected lifetime of a well-constructed asphalt path is much longer at between 7 and 15 years (Ryan, 1993). Sealing asphalt in its second year can double or triple the life span of asphalt material to between 15 and 30 years (Parker, 1994). In addition, annual maintenance costs for paved trails are much lower than trails with other types of surface treatment (B.C. Parks, 1993). Good sources of information on the design and maintenance of hard surface trails including asphalt and concrete can be found in Haber M.A. *et al.* (1993) and Colorado Asphalt Pavement Association (1998).

One of the primary drawbacks of asphalt is its dark colour, resulting in a more urban connotation than desired at many sites. Coatings can be applied to change the colour, or if path edges are allowed to collect natural debris such as leaves or pine needles, the path can become more naturalized. This dark colour can be a benefit in colder climates, reducing snow and ice clearing requirements by warming up more quickly in sunny weather.

The trail manager should pay particular attention to the sub-base under asphalt trails as the surface can easily be cracked by frost heaving and tree roots (Parker, 1994). Proper drainage management is also required along the edges of the trail as asphalt and concrete channel and focus the erosive energy of surface water along the sides of the trail, often resulting in negative environmental and aesthetic impacts.

2.3.7 Concrete

Concrete also provides a hard, smooth surface for recreation activities, providing a longer lifetime than asphalt. When built on a good base and sub-base, concrete paths can last 25 years (Ryan, 1993) or even up to 50 years (Parker, 1994). Cost is often a limiting factor as concrete is one of the most expensive surfaces to install. The longevity of a concrete path is primarily a function of the concrete mix and careful handling techniques (Parker, 1994). Frequently used in sidewalks, concrete has a strong urban connotation. When placed in a natural setting, the stark white colour of concrete often detracts from the aesthetic beauty and local interest of the area (Holmes, 1999). The lighter colour of concrete does provide some benefits in hot environments when compared to asphalt. Concrete has a higher albedo (0.10 to 0.35), re-radiating less heat and offering lower surface temperatures than asphalt (albedo 0.05 to 0.20) (Akbari *et al.*, 1992).

Concrete can also be used in the form of cinder blocks on edge. When placed in a sand foundation, cinder blocks can provide space for vegetation to grow up through the surface, while still providing the support for trail users. Unfortunately, this technique does not work well in areas prone to frost heaving.

Both asphalt and concrete are generally less suitable than the other surfaces mentioned above due to their higher cost, difficulty in transportation of equipment and materials, and incompatibility with the natural setting. They are most acceptable on heavy-use, urban oriented and multiple use trails (Herbert *et al.*, 1973; Parks Canada, 1978).

2.3.8 Alternative Surfacing Techniques

As new products, processes and technologies emerge, trail managers will continue to experiment with a variety of unconventional surface types in the quest to build the best possible trail. Recycled asphalt paving is emerging as one such viable surfacing option. This surface is formed by mixing a petroleum-based emulsion with gravel aggregate or ground asphalt surface. Using existing surface materials and a more basic construction technique, this approach is much less expensive than hot-mix asphalt paving and provides a more durable surface than untreated gravel. Recycled asphalt is particularly useful in situations where gravel surfaces on steep slopes result in unsafe footing and erosion problems (Nyhof, 2000).

Trails that cross eroding or shifting substrates such as sand have been stabilized using plastic snow fence or hemp / polypropylene mesh. By stabilizing the loose substrate, vegetation growth is often facilitated on areas that would otherwise remain bare and susceptible to erosion. In some areas, the portable nature of these types of surfaces has provided flexibility in the location of trails. For instance, at Presqu'ile Provincial Park, snow fencing has been used intermittently to provide a route across sandy areas, which would otherwise be more difficult to cross.

Wisconsin Department of Natural Resources has experimented with the application of a pine pitch emulsion to bind a prepared gravel or soil surface. This sticky material takes several days to dry and harden in ideal summer weather conditions. In the meantime, the trail must be closed to prevent damage to the surface and to shoes, bicycles or anything else that comes in contact with the pitch (Hajewski, 2000). Similar to soil stabilizer products, this surface improves resistance to impact from trail use and water erosion.

Many trail surfaces are also derived from local industrial operations, which would otherwise not likely find widespread use as a surface type. Areas close to tire manufacturing, for instance, may find an inexpensive supply of recycled rubber that could be applied to form a trail surface. Bottom ash from local coal-fired power generation facilities can also provide a trail base (Flink, 1996). Another example is the use of 15 tons of crushed ceramics on a trail close to the Pfaltzgraff China Company in York, Pennsylvania (Ryan, 1993).

Overall, the variety of trail surfacing is not limited to the commonly used alternatives such as gravel, wood chips and asphalt. Trail managers across North America continue to experiment with a wide range of materials in balancing the need to protect the natural condition of the site while providing recreational opportunities.

3 METHODS

3.1 APPROACH AND OVERVIEW

The gaps in knowledge of the social, environmental and economic aspects of trail surfacing are numerous, including a poor understanding of the relationship between the recreational experience and type of surface. In addition, the volume and quality of information available to trail managers to aid in making surfacing decisions is sparse and operationally oriented. Most information is based on observations of trail managers through an experiential process based on trial and error. Few studies have been designed to investigate topics such as preferences or environmental effectiveness. In addition to bringing together a variety of different sources including trail construction manuals, surfacing product promotional material, and assessments of surface types, this research further develops the state of knowledge by conducting surveys of trail users and managers and assessing the environmental condition of different surfaces.

The approach of this research is exploratory and descriptive, building a surfacing decision framework from a set of concepts such as recreational experience, recreational carrying capacity, recreation opportunity spectrum, and visitor impact management techniques. The goal is to generate ideas, develop tentative theories, and describe relationships between recreationists and a variety of surface types. This basic research provides the foundation for more explanatory studies in the future. Quantitative analysis of data such as trail condition measurements and user/manager surveys are used to develop a better understanding of the social, environmental and economic aspects of trail surfacing decisions.

As with many areas of research, the scope of the investigation reflects time and budgetary constraints. For instance, although surfacing preferences are expected to vary between recreational activities, the survey process focussed exclusively on day-use walkers in front country parks. This group represents the trail users for which most park managers explore trail surfacing alternatives in providing recreational opportunities. The needs of this group are important to trail managers in a wide variety of park settings, from almost any municipal park through to the higher use areas of most provincial or national parks. As discussed in Section 2, users pursuing different recreational activities, such as cycling or horseback riding, have different needs for trail surfacing. Although this research does not address these groups of trail users, future researchers may wish to explore these preferences further. Also, although trail surfacing is not a preferred impact management technique in back country settings, different front country settings in parks should be explored, including urban trails, such as off-road commuter routes and high-use areas such as waterfront walkways.

Another possible reason for the lack of a theoretical framework in trail surfacing research may be the complexity of environmental and recreational characteristics of different trails. Surfaces successful in one area will not necessarily have the same result when applied in a different situation. In addition, within each surface type, a wide variety of design, construction and maintenance standards exists, which makes comparison difficult. For example, gravel surfaces can be built with a range of products from pea gravel to crushed limestone to pit run, each with vastly different properties. While pea gravel may be slippery and loose, crushed limestone, with its angular clasts and high percentage of fines, may compact and seal to form a surface that is firm enough to use with a wheelchair. Also, wood chips can be made from different tree species, to different sizes, and with different proportions of bark depending on the supplier. Therefore, sharing of trail surfacing information requires an understanding of the specific characteristics of the surface applied in addition to the physical and recreational conditions at the site. This allows trail managers to apply the experiences in other locations to the local conditions. Unfortunately, many of the publications on trail surfacing do not provide basic trail information such as design width, thickness or composition of the surface, making comparison difficult.

The data from the user and manager surveys were primarily nominal and ordinal in scale, meaning responses were broken down into mutually exclusive groups that in many cases could be ordered, but the data were not always continuous in nature. This limited the types of analytical tools that could be used. In addition, given that population parameters such as the mean or variance in preference for trail roughness in the general public are unknown or may not be normally distributed, use of parametric t-tests, ANOVA, or multiple regression could not be supported. Instead, non-parametric tests, such as Kolmogorov-Smirnov Categorical Difference Test and Spearman's rank correlation, were selected to investigate the significance of relationships between sample variables. The purpose of this analysis was not to develop an explanation or investigate causality between variables, but to investigate the degree of association between them and describe the results. By highlighting these relationships, areas for future research have been identified in the application of this basic knowledge to surfacing decisions in general.

In response to the limited literature on trail surfacing decisions, this research centres on summarizing the state of knowledge and conducting three types of field studies: park user surveys, environmental condition assessments, and trail manager discussions and surveys. These approaches were selected to provide insight into both trail user and trail manager perspectives on surfacing types. The environmental condition assessments were performed to gather quantitative information on the condition of different trail types independent of user or manager perception. Discussions with park managers and maintenance personnel prior to field surveys assisted with information gathering and design of the field assessment techniques, and increased the relevance and interest of park managers in this research.

To improve the quality of information from the survey, a pilot study of the user survey was carried out at Belfountain Conservation Area on August 15, 1999. The pilot survey ensured that the questions elicited the type of information desired and pointed out areas that could be clearer. Once the questions were set after the pilot survey, the language, explanation and tone of delivery remained the same throughout the samples at both study areas. This ensured consistency between the samples and minimized researcher influence in the responses.

3.2 STUDY LOCATIONS

Trail surfacing is common in Southwestern Ontario given the high volume of use and the accessibility of trails. National parks such as Point Pelee and Bruce Peninsula, Provincial Parks such as Presqu’ile and Rondeau, Conservation Areas such as Crawford Lake and Belfountain, and Municipal parks such as those in the City of Kitchener Community Parks

System all use some form of trail surfacing to reduce the damage to the natural environment. Thus, a study of the environmental, social and economic aspects of surfacing decisions could be carried out in dozens of locations.

Sites were selected on the basis of two main criteria: the variety of trail surface types within the park and the variety of opportunities for different types of trail activities. Belfountain Conservation Area, located within a half-hour drive from Mississauga, Ontario, was ideal for a study of trail surfaces due to the number of surface types within a small area. Formerly a private estate, the site includes walkways, gardens and historic stonework, including a cave and a pond formed by the damming of the West branch of the Credit River. A nature trail circles the pond and crosses the river just upstream of the pond and again over a suspension bridge just below the dam. The trails continue downstream to a second bridge crossing over the river, from which users can choose to walk back along the opposite bank or continue downstream toward the Bruce Trail. The trails around the pond and to the second downstream bridge provide walkers with a variety of different trail surfaces, including bare earth, wood chips, gravel screenings, concrete, flat paving stones, wood planks and boardwalk. Conservation Area users pay a small fee for entrance to the park and enjoy activities including picnicking, trout fishing, swimming, wedding photography, garden and fall colour viewing. Horseback riding, motorized trail use and mountain biking are not permitted on the trails in Belfountain Conservation Area. Belfountain Conservation Area received between 15 and 20 thousand visitors per year between 1999 and 2001 (Hastings, p. comm., 2002).

The second selected site was the Boardwalk Trail at Presqu'ile Provincial Park. Like the trails at Belfountain Conservation Area, the Boardwalk Trail directly exposed park visitors to six surface types, with several other surfaces located elsewhere in the park. Presqu'ile Provincial Park is well-known for its significance as a home to waterfowl and shorebirds, its position along a major flyway for migrating birds, and its role as a staging point for Mexico-bound monarch butterflies. The park contains 937 hectares and contains a 394-site campground, picnic and day use area, broad sandy beach and important marsh habitat. An average of over 130 thousand people visit the park each year (Usher, 1996). The Marsh Boardwalk provides users with an opportunity to view this wetland habitat and exposes walkers to four types of trail surface in just over one-kilometre (gravel, boardwalk, bare earth and wood chips). Other trails in the park expose trail users to several more surface types including sand and asphalt. Provincial Park users pay an entrance fee for day use or an overnight camping fee if they are staying in the campground. Mountain biking and motorized trail use is prohibited on all of the nature trails within the park. Maps showing the locations of the Belfountain and Presqu'ile study areas are in Appendix C.

Both study sites are in a front country setting, providing recreational experiences for trail users wanting to get away from the urban setting while not embarking on a longer back country excursion. This research will not approach trail surfacing design in urban or back country settings. At these extremes, the social conditions differ greatly: user attitudes and appropriate surfaces may differ substantially from those found in a front country area. Urban settings involve sidewalks and bicycle lanes; back country settings discourage the use of any surfacing. The park resources between these two, the park walkways, interpretive trails and heavily used hiking trails, form the focus of this research. In the Recreation Opportunity Spectrum, this intermediate area includes the semi-primitive and rural settings in which visitors tolerate a significant amount of site alteration and user interactions.

The pilot survey was conducted at Belfountain Conservation Area at a site located on the north side of the river at the entrance to the wooded trail from a grassed open area. This area was selected for its diversity in trail surface types, including bare earth, wood chips, grass and flat paving stones. Seven respondents were surveyed during the one-day pilot. After the pilot survey, an alternative location with a similar variety of surfaces and a higher level of use was selected. This location was at the base of the concrete path leading from the parking area to the river. At this location, four surface types could be compared: bare earth, gravel screenings, concrete and wood chips.

At Presqu’ile Provincial Park, the Marsh Boardwalk was selected as the second sample site. After walking each of the trails in the park and speaking with park employees, the Marsh Boardwalk was identified as the most suitable site for its level of use and diversity in trail surface types, including wood chips, bare earth, gravel screenings and boardwalk.

3.3 TRAIL CONDITION ASSESSMENTS

The physical condition of the trail is the result of the interaction among many variables. Site characteristics, level of use, type of use, behaviour of users, trail routing and surface type all have a role in determining the condition of the trail. Therefore, it is difficult to assess the causal factors for trail condition; however, it is clear that different surfaces have different abilities to resist degradation. Many variables such as muddiness, widened trails, and eroded sections can be quickly and easily measured along trail segments. The condition of the trail has a direct impact on the environment by exposing more soil, damaging more vegetation and exacerbating runoff or erosion problems. In addition, the natural setting sought by the park visitor can be impaired. Several trail studies have been designed to investigate the condition of trails, such as Cole (1983).

Trail condition can be assessed either by a census-based or sample-based approach (Leung and Marion, 1999). A census-based approach records all incidences of trail deterioration beyond pre-determined thresholds along a trail. However, this technique is quite laborious. A sampling-based approach records any incidences of the same conditions at a fixed interval, such as 100 metres. This is less time consuming; however, the accuracy of the assessment is decreased. Given the small number of trails to be assessed in this study, a census-based approach was used to accurately document the condition of the trail at the time of sampling. Expanding on the trail standards presented in Burde and Ervin (1998) and Lajeunesse *et al.*, (1997), the following conditions were recorded for the sample trails: tread width, muddy sections, rocky sections, dusty sections, sections with water crossing the trail, sections with a loose surface, sections with exposed roots, sections with entrenchments/gullies, and sections with trails alongside the main tread.

Although a statement regarding the environmental condition of each particular trail section can be made, statistical comparisons cannot be made between trail types. Due to the variation in soils, vegetation, level of use and type of use, surface type cannot be isolated without a larger sample of trail segments. In this study, 2141 metres of trail were assessed at the Belfountain and Presqu'ile study sites. This represented the entire length of the loop trail at Belfountain and the Marsh Boardwalk at Presqu'ile. Given the changing site conditions and levels of use along these trails, making generalizations about the environmental effectiveness of different surface types is not feasible. Future researchers may wish to design a more detailed study to investigate differences in environmental condition between surface types; however, this is beyond the scope of this thesis.

3.4 TRAIL USER SURVEYS

To better understand the social aspects of trail surfacing decisions, a user survey was designed. The best way to get answers to questions concerning quality or satisfaction with a recreational facility such as a trail is by asking the users. The standard technique to accomplish this in recreation research is the survey (Wessell, 1997). Rather than providing a take-home or mailed survey, on-site surveys were selected due to the more accurate recall of visitors while still in the park (Cole *et al.*, 1997). The survey was administered to 36 visitors using the Marsh Boardwalk Trail at Presqu'ile Provincial Park and to 45 visitors using Belfountain Conservation Area over the course of three weekends in late summer 1999. The survey dates and weather conditions are reported in Table 2.

Table 2: Survey dates and weather conditions at Belfountain and Presqu'ile study areas.

Survey Location	Date	Weather	Last precipitation
Belfountain (pilot)	08/15/99	Partly cloudy	Showers 08/13 and 08/14
Belfountain	08/21/99	Sunny	Scattered thunderstorms 08/20
Belfountain	08/22/99	Sunny	
Presqu'ile	08/28/99	Sunny and warm	Rain 08/25 and 08/26
Presqu'ile	08/29/99	Sunny and warm	
Belfountain	09/18/99	Sunny	Rain 09/13

The weather conditions during the user survey at both Belfountain and Presqu'ile were sunny and mild, with temperatures between 20 and 30 degrees Celsius. Precipitation was not a factor in trail conditions at the time of the surveys, with the most recent rainfall events occurring several days before each sample. If there had been significant rainfall or very dry conditions at the time of the surveys, surface preferences or significance of trail problems noted in the user surveys may have been affected. Future researchers may wish to explore the relationship between surface preferences and trail condition related to local weather conditions.

Recognizing that Presqu'ile Provincial Park and Belfountain Conservation Area receive thousands of visitors annually, these surveys are limited in their ability to be generalized to a broader population. However, the survey results still have representative validity for three main reasons. First, trail users at Belfountain and Presqu'ile did not differ significantly in terms of their responses, as supported by Kolmogorov-Smirnov tests, which showed no significant difference between them for almost all questions. Second, the response rate to each of the surveys was exceptionally high (1 declined survey at each park, a 98 percent response rate). When compared to other survey techniques, such as mail-out surveys, where response rates are commonly 10 to 15 percent, the concern over non-participant bias is reduced. Finally, although the sample sizes for the surveys are limited, they did provide a closer understanding of individual responses as a result of the researcher personally conducting the surveys. This understanding was critical in exploring the social aspects of trail surfacing and developing conceptual approaches to surfacing decisions. In addition, this exploratory approach emphasized the value of every opinion and comment on trail surfacing. As highlighted in the results, every comment or opinion of trail surfacing from the surveys is important, even if that sentiment was echoed by only a small number of individuals. For the purpose of gaining a better understanding of people's perceptions and preferences for trail surfacing, the survey results were considered appropriate for statistical analysis and discussion. The results of the case studies at each park build on the literature in providing areas for trail managers to consider in developing an understanding of the social aspects of trail surfacing decisions. However, to do so, the survey results must be considered in the context of the limitations in sampling, selected methods and research design.

The survey questions were designed to seek user opinions on the appropriateness of the surface type for the enjoyment of activity and the appearance of each surface type. Overall, the survey provides information on the surface preferences of trail users and explores possible relationships with other visitor characteristics, including demographics, frequency of use, and reason for visit. Finally, the survey gauges user perceptions of the efficacy of surfacing in reducing the environmental impact of recreation and the overall importance of surfacing to their park experience.

Several sources were used in the design of the survey for park visitors. Selecting standard recreation terms and phrasing of questions were aided by use of a manual of standard classifications for questionnaire surveys (Great Britain Countryside Commission, 1970). Most questions were closed-ended, organizing the answers of each individual within a certain set of responses for each question, providing for the quantitative analysis of their responses. A sample survey of surface types used in Britain in 1970 formed the basis for questions on demographics and visitor use characteristics (Great Britain Countryside Commission, 1970). General survey design principles, including the use of a Likert scale to quantify trail users' responses in terms of the strength of positive or negative opinion, were applied from sources including Davidson (1970), Eberhardt and Thomas (1991), Neuman (1997), Leung and Marion (1999), and Capital Regional District Parks (2000).

The Office of Human Research at the University of Waterloo reviewed the survey to ensure the ethical treatment of subjects and further strengthen the quality of the survey. Finally, the survey was field tested in a pilot study in Belfountain Conservation Area on August 15, 1999. From this test, the wording and order of a few questions were modified to reduce confusion and potential between-question bias prior to conducting the actual surveys. In addition, this offered the opportunity to become more comfortable with approaching potential respondents, streamline the survey process, and anticipate problems.

It is important to note that the sampling framework for this study was biased toward surveying the opinions of the park visitors using that particular type of park and particular type of trail. For instance, surveys in Belfountain Conservation Area would only explore the preferences of visitors who were seeking a shorter walk, able to travel to the park, and willing to pay the entrance fee for day use of the park. This could presumably result in a sample with a higher number of responses from picnickers and young families than other trail users such as birdwatchers or day hikers. This issue stems from the observation that people who dislike the surface type or other aspects of the park may not be captured in a survey at the site. If the position of these groups was not recorded, the results of the surveys would not show these alternative preferences. Recognizing the limitations to the sampling framework, this research explores the preferences of people using the trails to better understand this particular segment of the trail user population.

The preference for surface is highly contextual; it depends greatly on the mode of recreation, purpose of activity, location, and environmental conditions. Selecting two situations where the use of surfacing is most prevalent serves as a first step toward the better understanding of the different aspects of surfacing decisions. Thus, the sampling framework was designed to explore a certain subset of the population using front country recreation facilities. The result of this sampling prevents the researcher from making generalizations to all trails, all types and motivations of outdoor recreation, under all conditions.

The best method of finding out about user opinions of surface types might be to lay out sample sections of each surface and ask questions based on these plots. However, there was inadequate funding and reluctance on the part of park managers to construct sample trail sections for this study to approach the question in this manner. Instead, parks with a variety of surfacing types in them were selected. Visitors were surveyed on these trails, where several surface types met. This sampling design was purposive; intentionally designed to select sample locations where the largest number of people would pass and where an array of different trail surfaces exists (Lucas and Oltman, 1971). In this way, the number of samples was maximized over the five days of in-park surveys. A stratified random sampling technique was initially intended for user surveys, sampling every third group; however, the small number of groups passing the survey location made this sampling technique unfeasible. Therefore, respondents were approached as long as there was no other group being surveyed at the time. This increased the number of samples for the five days of field surveying with the assumption that groups were independent of each other.

In addition to asking trail users for their preferences between trail surfacing immediately adjacent to the sample location, photographs were used to investigate perceptions of a wider variety of surfaces. Photographs have been found to be a useful means of indirectly presenting environmental displays and investigating user perceptions of trail settings (Dahms and Wall, 1979; Hammitt and Cherem, 1980). Photographs of trails of different surface types at each study site were given to respondents who ordered the photographs based on their preference to walk on and their perception of naturalness. These photographs provided a second approach to verifying the ranking of surface types according to user preference.

After determining each survey would require 10 to 15 minutes to administer at each park, a sample size goal of 100 surveys for each site was intended, for a total of 200 surveys. This size was chosen to allow a sample of trail user preferences and perceptions within a total of 25 hours in each park. In the five days of surveys at the Belfountain and Presqu'ile study areas, 45 and 36 surveys were administered, respectively, for a total of 81 between both parks. Overall, time constraints limited further surveys, since many surveys took longer than the projected 15 minutes due to further conversation about trail issues with respondents. In addition, due to the late summer time for the field research, further surveys would not have captured the same type of trail users in the fall. In particular, the type of user at Belfountain shifts from the summer day use visitor walking, picnicking and swimming to autumn leaf colour viewing. It was felt that this group represented a shift in the sample population which was beyond the scope of this research. Future researchers may wish to explore the changes in surface preference related to different activities and user types at the same location over the course of a year.

3.5 TRAIL MANAGER SURVEY

Most information on successes and failures of different trail surfacing techniques lies within the experiences of trail managers. As such, it was necessary to develop a standardized approach to investigate and compare the knowledge accumulated by these managers over their careers. A survey was designed to provide structured responses and open-ended responses to the array of issues facing trail managers in their trail surfacing decisions (Appendix E). In particular, the survey provided information on costs, innovative solutions and remaining problems in the construction and maintenance of a variety of surfaces. Unlike the trail user questionnaires, no pilot survey was conducted for the questions directed to trail managers. However, the design and format of the survey were developed in discussion with

City of Kitchener Parks and Recreation Department staff, with several questions adapted from the trail user survey.

The survey was sent to a total of 34 trail managers between April and August 2000, many of whom were personally approached by the researcher at the Fifth Annual Ecotourism/Adventure Tourism Conference (Dorset, Ontario; November 19 to 22, 1999), Science and Management of Protected Areas (SAMPA) IV Conference (Waterloo, Ontario; May 19 to 22, 2000) and the National Trails Conference (Owen Sound, Ontario; June 1 to 4, 2000). Other trail managers were given the survey by mail in the spring of 2000, including national, provincial, regional and municipal parks organizations across Canada and university grounds maintenance personnel. Eleven responses were received to the survey in addition to eight discussions when a telephone follow-up was conducted. The eight trail managers who were unable to fill in the survey were comfortable with discussing trail surfacing experiences verbally, but expressed concerns with the amount of time available to fill out the survey, likely due to the level of park and trail work during the spring. Future researchers may wish to consider conducting surveys of this nature during the slower winter season when managers may have more time to participate.

4 ANALYSIS AND DISCUSSION

4.1 SOCIAL ASPECTS OF TRAIL SURFACING

Of the 14 questions in the user survey, 7 explored the characteristics, motivations, and details of the visit for each respondent. To better understand the type of visitor and trail use information, a summary of these questions is provided in Section 4.1.1, followed by an analysis of the remaining 7 questions on trail surfacing perceptions and preferences.

Analysis of the user surveys for each park using the Kolmogorov-Smirnov Test shows that, with almost all questions, there was no significant difference between the two population distributions from which the two samples were drawn. In other words, observations and responses to survey questions were similar at Belfountain Conservation Area and Presqu'ile Provincial Park. Respondents at each park had similar demographic profiles, motivations, and preferences for trail surface characteristics.

4.1.1 Demographic and Visitor Use Characteristics

The greatest proportion of visitors to both study sites was between the ages of 35 and 49 (43 percent), with a college or university degree (53 percent) and an annual household income of over $75,000 (36 percent). The gender ratio of the respondents was close to equal between male and female. Overall, approximately 30 percent of respondents shared their visit with children under the age of 7 years in their group. Visitors to Presqu'ile Provincial Park had a higher proportion of visitors with children (37 percent), possibly due to the presence of the family campground within the park.

The length of the visit to both parks was surprisingly short, with 63 percent of visits less than 2 hours. At Presqu'ile, the number of visitors reporting a stay of less than one hour (40 percent) was especially high, and may have resulted from a misunderstanding of the question as to whether it referred to the marsh trail or the park as a whole. Visits to the roughly 1-kilometre marsh trail could be expected to be less than one hour given its length, but visitors may in fact have spent more time at the beach or in other areas of the park but not reported this in the context of this particular question.

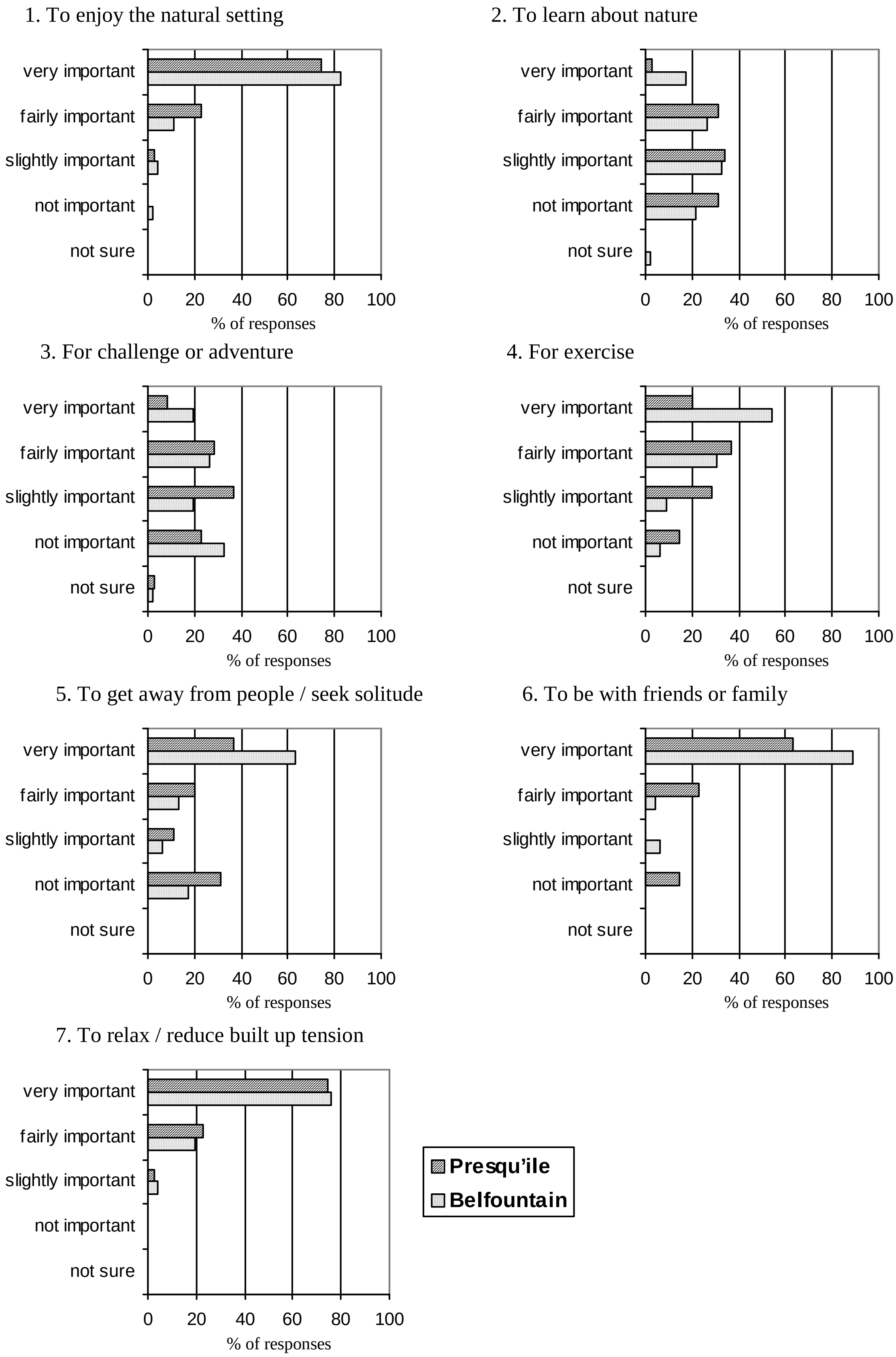
Most trail users enjoyed the park with one other person (46 percent) or in a group of four (24 percent). The marsh trail at Presqu'ile attracted seven groups of 6 or more (20 percent) compared with only one (2 percent) at Belfountain. The higher number of large groups visiting Presqu'ile appeared to be made up of either individuals camping in the park or bird watchers enjoying the marsh trail. Most respondents enjoyed the park with other family members (62 percent) or friends (33 percent). A very small number of trail users walked alone or as part of an organized group (1 percent each).

For most visitors, their visit was their first of the summer to that park (63 percent), with more regular visitors to Belfountain Conservation Area (33 percent with over 2 previous visits) compared with Presqu'ile (14 percent with over 2 previous visits). Most respondents visited parks or conservation areas once or twice a month (44 percent), followed by those who visit less than once a month (37 percent).

4.1.2 User Motivations

The most important motivations for visiting the parks were to enjoy the natural setting (79 percent rated as very important), to be with friends and family (78 percent - very important) and to relax or reduce built up tension (75 percent - very important). Secondary motivations included getting away from people or seeking solitude (52 percent - very important) and for exercise (40 percent - very important). To learn about nature (26 percent - very important) and for the challenge or adventure (15 percent - very important) seemed to be of minor importance to most respondents at these two parks (Figure 3). Visitors to Presqu'ile Provincial Park differed significantly from those at Belfountain in the importance of exercise and getting away from people or seeking solitude in their visit. Exercise was ranked 'very important' by 54 percent of Belfountain visitors while only 20 percent of Presqu'ile visitors ranked exercise this highly. This may be due to the varied trail network and proximity to the Bruce Trail, providing better opportunities for outdoor exercise than the Presqu'ile marsh trail.

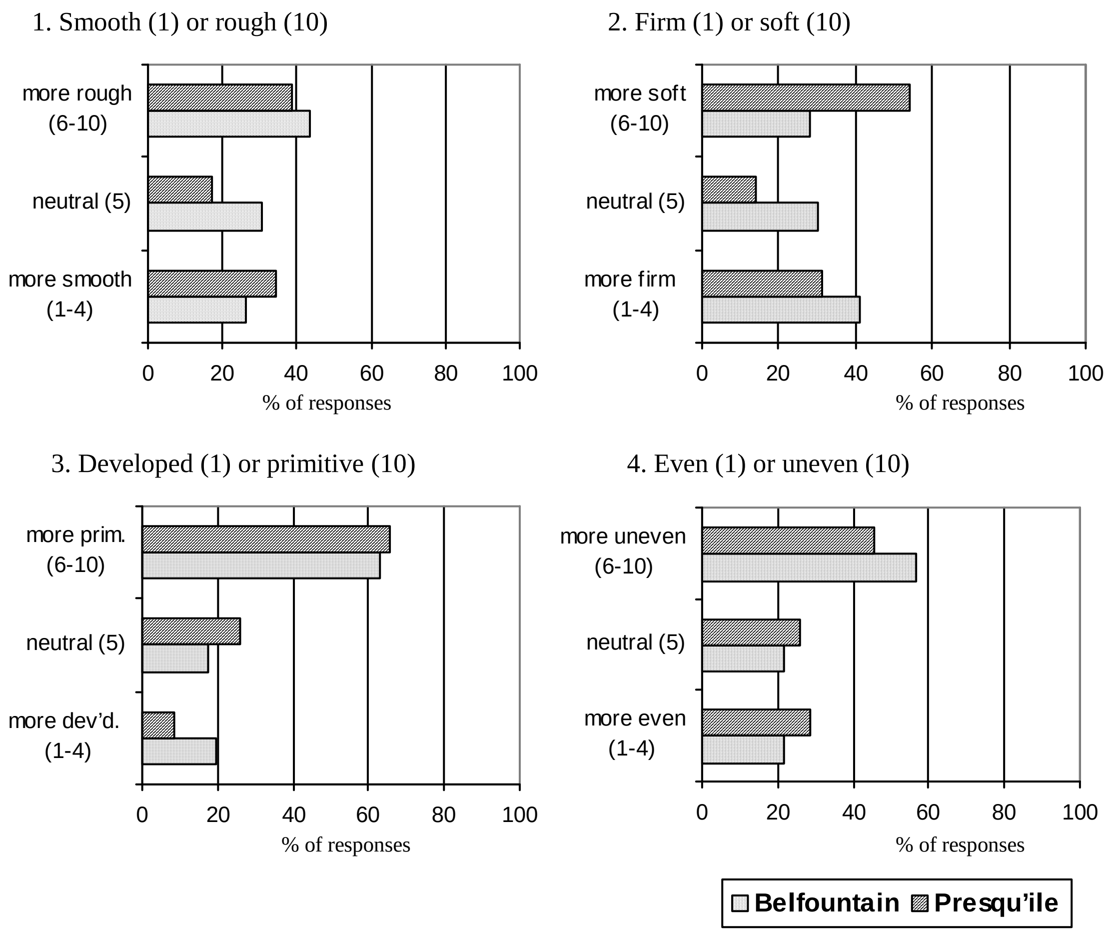
Figure 3: Importance of different reasons for park visits



4.1.3 Preferred Trail Characteristics

Building from this understanding of the type of visitor and experiences pursued at Belfountain and Presqu'ile, the following section outlines the results pertaining to trail surface perception and preference. Asked to rank their preference for trail surface properties on a Likert scale (from 1 to 10), trail users provided a general sense of desirable trail characteristics (Figure 4).

Figure 4: Preferences for trail surface properties



Throughout the surveys, the ten-point Likert scale used for the trail surfacing property questions was found to be ineffective. While respondents were able to state a preference for one side or another, most were confused over assigning a numerical value to the strength of this preference. As such, the results of each question are grouped into three categories for analysis, reflecting a basic preference for one property or another, or a neutral position.

Trail users at the two study areas showed a slight preference for trail surfaces that were more rough, uneven and primitive. Respondents frequently added qualifications for their preference, such as enjoying firm surfaces for safety, ease of stroller use, or type of footwear worn.

4.1.4 Significance of Trail Impacts to Trail Users

Trail users were also asked about the impact of several common trail problems on the enjoyment of their visits. Figure 5 summarizes the responses to this question in both study areas.

Figure 5: Effect of trail problems on the enjoyment of the visitor's activity.

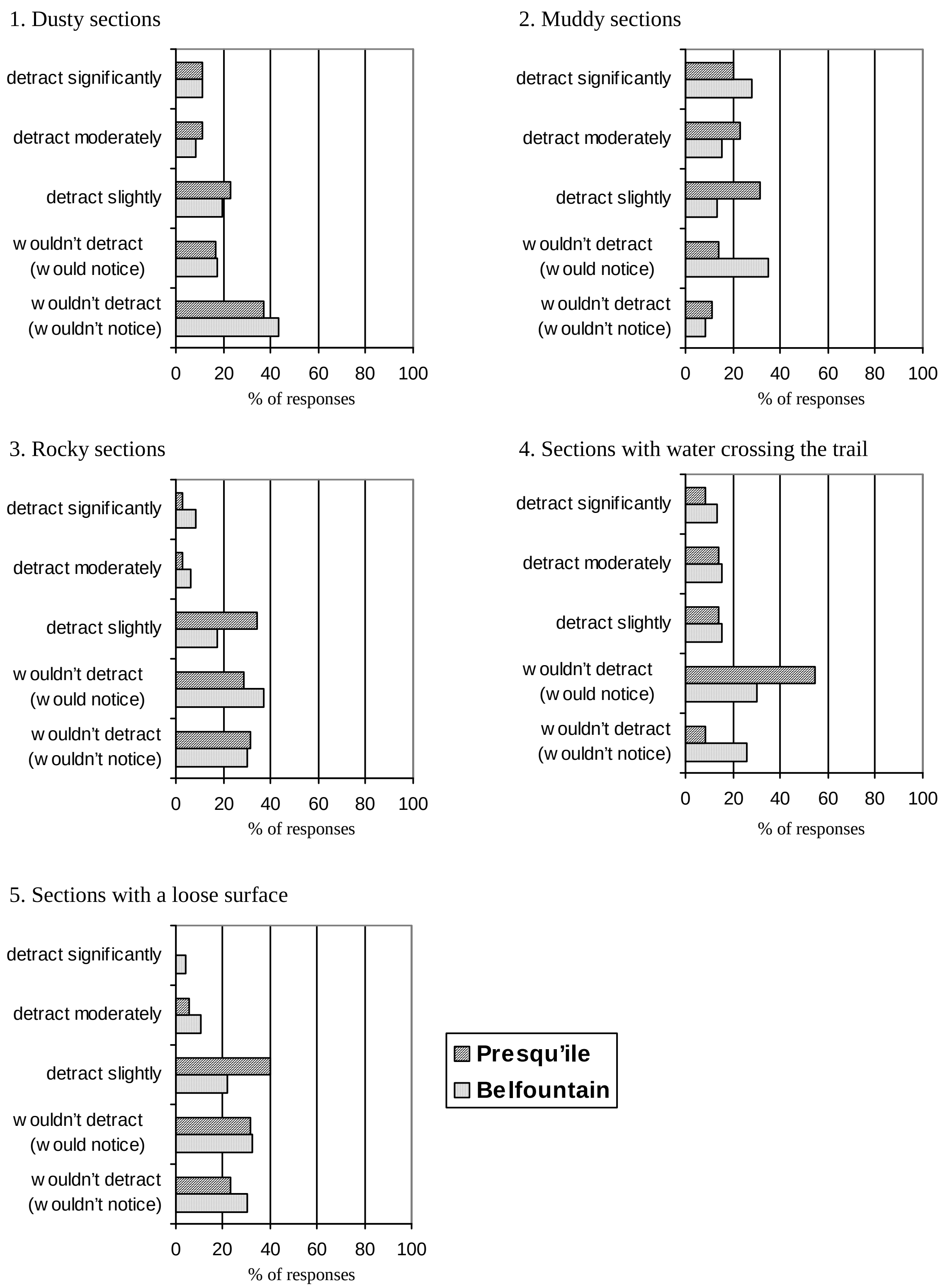
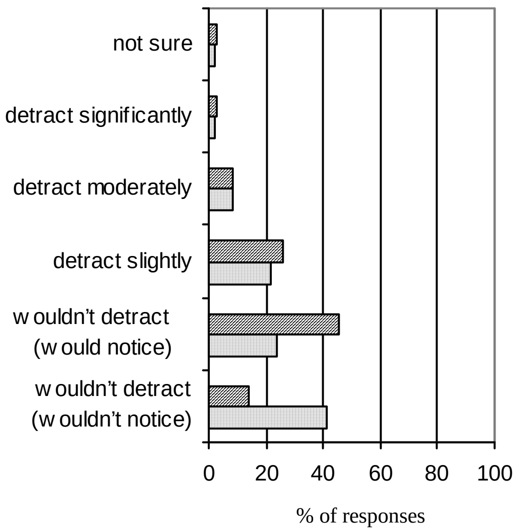
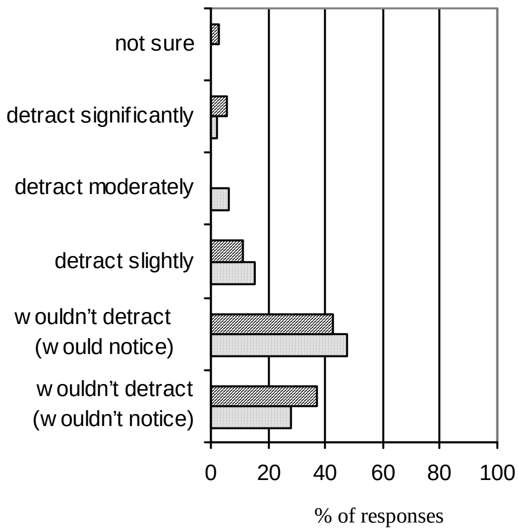


Figure 5: Effect of trail problems on the enjoyment of the visitor's activity. (continued)

6. Sections with several parallel trails



7. Sections where the trail is widened



Overall, respondents at both Belfountain and Presqu'ile reported minor effects on the enjoyment of their activity related to trail problems. Many suggested that trail conditions were a part of the setting and problems such as muddiness or rockiness were therefore actually desirable, to a point. Minor sections with trail problems such as muddiness, dustiness and stoniness were considered part of the recreational experience.

It is possible that the wording of the survey question had some bearing on the responses. The question, as it was asked, implied that these problems were located only in "sections" of the trail. Whether these same respondents would change their opinions if asked about an entire trail with a certain problem is uncertain. Further research into personal limits for acceptable trail conditions (including length and severity of damage) may provide trail managers with more detailed information that could be applied in optimizing trail maintenance programs.

Dusty conditions detracted to some degree from the experiences of 39 percent of Belfountain visitors and 46 percent of Presqu'ile visitors. Several respondents indicated dusty trails would irritate their allergies or get into their footwear. Muddy sections elicited the strongest response, detracting to some degree from the experiences of 57 percent of Belfountain visitors and 74 percent of Presqu'ile visitors. Over 20 percent of respondents at both study sites stated that muddy sections would detract significantly from their experience. This finding shows a strong aversion to muddy areas for many trail users, suggesting one reason for trail widening and twinning frequently observed on many trails containing muddy sections. Interestingly, sections with water crossing the trail did not seem to have as strong an impact for most respondents, detracting from the experiences of only 43 percent of Belfountain visitors and 37 percent of Presqu'ile visitors in total. Several respondents pointed out that as long as the water could be stepped across, it would not matter to them. Many of the same individuals for whom water crossing the trail detracted from their experience also felt the same way about muddy sections. This was particularly evident at Belfountain, with a Spearman rank correlation coefficient of 0.518 (significant at α=0.01) between these two variables.

Rocky sections, sections with a loose surface and sections with several parallel trails detracted from the experiences for similar numbers of people at each study site, at between 30 and 45 percent. Overall, the distribution of the responses to these questions was fairly consistent across the two study areas, except for the percentage of people suggesting parallel trails would detract from their activity. Although a similar number of respondents felt that parallel trails would not detract from their experience, only 14 percent of respondents at Presqu'ile stated they would not notice parallel trails compared with 41 percent at Belfountain. In other words, although a similar proportion of respondents suggested that parallel trails would detract from their enjoyment at both locations, more Presqu'ile visitors reported they would notice parallel trails than those at Belfountain. A possible explanation for this observation is that Presqu'ile respondents may have been sensitized to the presence of parallel trails due to the presence of two 7-metre sections of braided trails just before approaching the survey station.

Wider sections of trail had less impact on the enjoyment of user's activities than any other conditions in the survey. Only 24 percent of Belfountain respondents and 17 percent of Presqu'ile respondents reported that sections where the trail has been widened would detract from their experience. One respondent even suggested that wider trails enhanced their experience, suggesting that a widened path made it easier to pass. Another stated that the acceptability of widened or parallel trails depended on the environment; in heavily used areas, more impact was acceptable than in remote areas. There was a strong association between the respondents' views of parallel trails and widened trails, with a Spearman rank correlation coefficient of 0.596 at Belfountain and 0.629 at Presqu'ile (significant at α=0.01). Often, those individuals who felt parallel trails detracted from the enjoyment of their activity were similarly affected by trails that were widened.

4.1.5 Natural Appearance of Surfacing

One of the key questions in the user survey focused on the perception of degree of natural appearance of different surface types. Trail users were asked to place a set of photographs in order according to how natural they appeared to them. It was expected that users would find the bare earth trails the most natural and concrete or asphalt trails least natural. These hypotheses were supported by the results from both study areas. Table 3 shows the median ranks for the different surface types at each study site.

Table 3: Ranking of surfaces in terms of how natural they appeared to respondents (1 – most natural).

Belfountain (median rank)	
Bare earth	1
Gravel screenings	3
Wood chips	3
Wood planks	4
Boardwalk	5
Inset flat stones	6
Concrete steps	7

Presqu'ile (median rank)	
Bare earth	1
Wood chips	2
Sand	3
Gravel	5
Boardwalk	5
Asphalt	6

Throughout the analysis of the questions using the photographs, several issues arose regarding potential influences that were external to the surface type being ranked. For example, the photograph of the gravel surface at Presqu'ile was taken at the entrance to a trail which had two 4-inch concrete parking barriers and two traffic signs also present. This may have biased respondents in ranking that photograph against others without such anthropogenic modifications. Also, puddles along the Presqu'ile trail and cross-trail drainage in the Belfountain photos may have influenced respondents when ranking gravel surfaces against others.

Despite being asked to rank each photo for the surface itself, many respondents may have been influenced by external factors such as trail conditions, signage and other features present in the photograph. Even differences in the openness of each trail or contrast and brightness of each photograph may have had an impact on respondent's perceptions. Future researchers may wish to consider attempting to better isolate the surface in each photograph to reduce the effects of external factors. A possible technique is to manipulate the photographs by cropping the trail from the photo of each surface and applying a standard background for all photographs. In this manner, differences between the settings of each trail would be eliminated from the ranking. Overall, the degree to which each photograph's setting affected the respondent's perception is not certain. Therefore, the results presented here should be considered with these limitations in mind and confirmed through future investigation before applying the results in any way.

As expected, users at both Belfountain and Presqu'ile ranked the hard surfaces (concrete steps and inset flat stones at Belfountain and asphalt at Presqu'ile) as the least natural, with medians of 6 and 7. These results are consistent with the more developed or urban connotation of these types of surfaces described in other trail sources (Metropolitan Toronto and Region Conservation Authority, 1992; Ryan, 1993).

Respondents at Belfountain ranked gravel and wood chips similarly in terms of natural appearance (median=3). This contrasted with the ranking of gravel at Presqu'ile, which received a median rank of 5 for natural appearance compared to a median rank of 2 for wood chips. As discussed earlier, this observation may partially be explained by the differences in photographs between the two study areas. The gravel photograph at Presqu'ile showed two 4-inch concrete parking barriers and two traffic signs, which may have affected the natural appearance when compared to the wood chips photograph, which showed a wooden "no cycling" sign and trail registration box that fit more closely with the surroundings.

The ranking for boardwalk surfaces was lower than less engineered trail types such as wood chips or sand, but higher than asphalt, concrete or inset flat stones. At Presqu'ile, respondents ranked the boardwalk closely with gravel (median = 5), perhaps showing that the natural colour and grain of the wood appeared more natural than the gray colour of the gravel.

Overall in this section of the study, combining the rankings from the Belfountain and Presqu'ile study sites was not possible, due to the different photographs used for each sample. The reason for providing different sets of photos at each site was to focus on the local trail surfaces and conditions at each area. The array of surface types at Belfountain differed from those at Presqu'ile. Unfortunately, this question design did not allow for comparison between some surfaces, such as asphalt and concrete, as they were not found on trails at the same study site. Future studies may consider standardizing a set of photographs so that they can be applied to any study area to allow for comparison and combined analysis of the data.

4.1.6 Surfacing Preferences of Trail Users

The main objective for the user survey was to investigate the preferences for different surface types as they related to the respondent's activity. This question was approached in two ways. First, the respondents were made aware of several surfaces immediately adjacent to the survey location and asked which of those surfaces they preferred to walk on. Later in the survey, respondents were asked to place the same set of photos used to rank surfaces for their natural appearance in order of which ones they would prefer to walk on.

The first approach of pointing out several surfaces near the study site allowed for further questioning on the reasons for each respondent's preference. Using the photographs allowed the extension of the question to other surfaces local to the area but not directly visible from the survey location.

When asked directly, respondents ranked bare earth as the most preferred surface at both Belfountain and Presqu'ile study sites (43 percent and 44 percent, respectively). This was closely followed by wood chips, which were ranked first by 38 percent of respondents at both Belfountain and Presqu'ile (Table 4). If the percentage of respondents at Presqu'ile who ranked each surface as either first or second over the others is examined, wood chips were actually mentioned more often than bare earth. Respondents at Presqu'ile seemed to either rank bare earth first overall or not mention it at all, compared with the high number of respondents who consistently ranked wood chips fairly high, even if they were not their first choice. Many respondents at both study sites noted their preference for the natural condition of the bare earth trail, but if the level of impact necessitated surfacing, wood chips was their preferred alternative. Concrete was the least preferred surface among those present at the Belfountain survey site, with only 1 respondent ranking it in the top two. In this case, the reason for preferring concrete was its easiness to walk on and evenness for toddlers.

Table 4: Percentage of respondents ranking each surface first or in the top two when evaluating surfaces directly.

	Belfountain		Presqu'ile	
Surface Type	**Ranked 1st**	**Ranked 1st or 2nd**	**Ranked 1st**	**Ranked 1st or 2nd**
Bare earth	43	51	44	46
Wood chips	38	49	38	67
Gravel screenings	17	29	0	3
Boardwalk	Not present	Not present	19	39
Concrete	2	2	Not present	Not present

There was a notable difference in the rankings of gravel screenings between the two study sites, with Belfountain visitors mentioning screenings within the top two choices 29 percent of the time, while only 3 percent of Presqu'ile visitors felt the same. This difference may be partially explained by the inclusion of different surfaces in the options for answering the question at each study site (concrete at Belfountain or boardwalk at Presqu'ile). With a different range of surface options to select from, gravel screenings may have been mentioned in the top two choices less frequently when the boardwalk was the fourth option instead of concrete.

Boardwalk was ranked first overall by 19 percent of respondents at Presqu'ile, which may be partially biased by the identification of the trail as "The Marsh Boardwalk". Visitors to the trail may have been predisposed to enjoying the boardwalk as a trail surface given their awareness of the trail's attraction. Some respondents noted that the boardwalk allowed them to access areas they would not otherwise be able to experience. Others noted that the boardwalk kept people off the sensitive marsh underneath.

The second approach used to analyze trail users' surface preferences involved the ordering of the same photographs used to explore the natural appearance of different surfaces. Despite the differences between the photographs of bare earth surfaces, respondents at both study sites ranked them close to first overall in terms of preference to walk on (Table 5). Of particular note is the rough and rocky trail section represented in the photograph at Belfountain. Respondents preferred this trail despite the steep rocky slope and numerous roots that required careful footing.

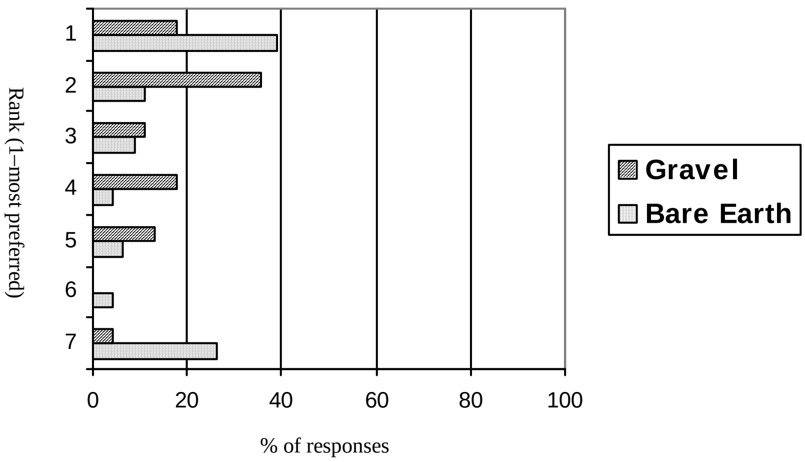
Table 5: Ranking of surfaces in terms of which ones respondents would enjoy walking on the most, based on photographs (1 – most preferred).

Belfountain (median rank)	
Bare earth	2.5
Gravel screenings	2
Wood chips	3
Wood planks	4
Boardwalk	3
Inset flat stones	6
Concrete steps	6

Presqu'ile (median rank)	
Bare earth	1
Wood chips	2
Sand	4
Gravel	5
Boardwalk	3
Asphalt	6

It was expected that, similar to the results when asked directly, respondents would identify bare earth as the most preferred surface to walk on. This was supported at Presqu'ile, where respondents ranked bare earth with a median of 1. In fact, all but one of the 35 respondents mentioned bare earth in their top 3 choices. However, the users at Belfountain found bare earth and gravel screenings to be roughly equal (medians 2.5 and 2, respectively). This may have been due to the fact that the area shown in the bare earth photograph was especially rocky, with little indication of a treaded walkway, compared to the photo of the gravel trail, which had a visible tread. This may have affected respondent's opinion of the bare earth surface. In fact, the distribution of the ranking for the bare earth surface was found to differ substantially from the distribution for the gravel surface (Figure 6).

Figure 6: Distribution of preference rankings for bare earth and gravel surfaces by respondents at Belfountain Conservation Area.



The distribution of the rankings for bare earth at Belfountain showed a bimodal pattern, with a large number of individuals ranking that photograph as the least preferred to walk on. This skewed the median to the middle instead of the higher end. When compared to the distribution for gravel, the effect of this bimodal distribution on the median becomes evident.

Overall, one of the most remarkable differences between the two study sites was the ranking of gravel. Despite both photographs showing drainage problems and trail modifications, respondents at Belfountain ranked gravel at a median of 2, while those at Presqu'ile ranked gravel at a median of 5. This difference was also reflected in the stated preferences of respondents when directly comparing surfaces, where 22 percent of respondents ranked gravel first or second overall at Belfountain, compared with 2 percent at Presqu'ile. The reason for this difference is uncertain, but may have been affected at Belfountain by the presence of a well-maintained gravel trail adjacent to the survey location. Although the Presqu'ile site also had a gravel trail in good condition near the survey location, it was located further away and may have been less prominent in walker's memory than the other surfaces they had traveled across more recently.

Boardwalk was ranked just after wood chips and bare earth at both study sites. Despite the more engineered appearance, trail users preferred this surface to sand, wood planks, or the hard surfaces of asphalt, concrete or inset flat stones. The sand trail at Presqu'ile and wood planks at Belfountain were not ranked highly among almost all respondents, with Presqu'ile respondents ranking sand in their top three choices less frequently than all other surfaces except gravel and asphalt. At Belfountain, respondents also ranked wood planks in their top three choices less frequently than all other surfaces except concrete and inset flat stones. At both study sites, the hard surfaces of concrete, inset flat stones and asphalt were ranked well below the other surfaces, with a median of 6 in all cases.

4.1.7 User Comments on Trail Surfaces

Many respondents provided comments explaining their preferences for and perceptions of various surface types. The range of feedback on each surface was surprising, from physical conditions such as hardness, to more intangible elements such as novelty or feeling. These comments are summarized in Table 6.

Table 6: Comments on different surfaces from the survey at the Belfountain and Presqu'ile study sites (number of respondents mentioning in parentheses).

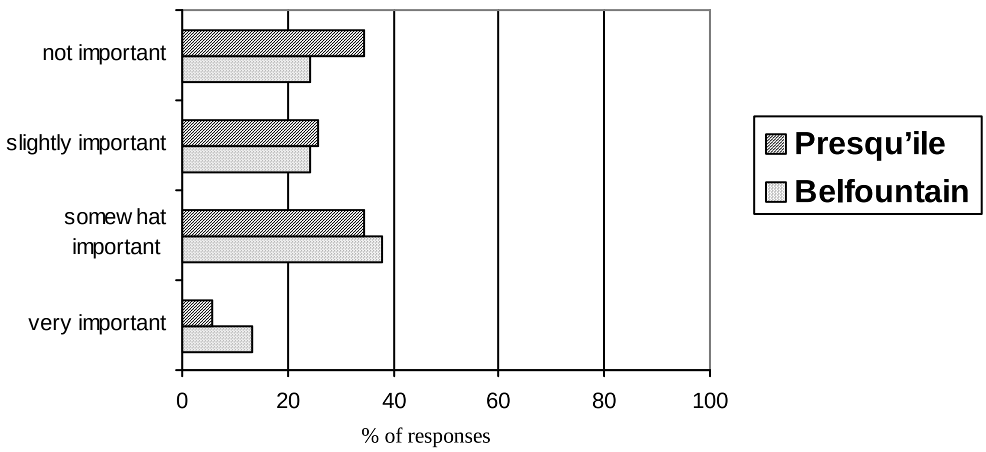
Surface	Comments	
Bare Earth	• Enjoyed the natural appearance (17) • Enjoyed unpredictability / excitement / interest / adventure (7) • Not good when raining / too wet (5) • Liked as long as it was safe (3) • Easy to walk on / comfortable (3) • Need the right shoes (2) • Rocky is poor for toddlers footing	• Liked the smell, brought back memories, roots are natural. • Better to enjoy nature • Less engineered / manipulated • Mysterious, fun, different • Cool, restful and quiet • Doesn't give way and is not as hard
Wood Chips	• Softer / feels good on feet (23) • More natural (7) • Good when wet / dries quickly (4) • Liked smell from wood (3) • Clean (2) • Looks nice / aesthetically pleasing (2) • Better for shoes than gravel (2) • Breaks down into more natural surface (2)	• Not good with sandals (2) • Liked the sound • Sure footed, safer than bare earth • Protects the environment • Too soft • Depends on shoes • What I expected for a conservation area
Gravel Screenings	• Good all weather surface / drains easily / doesn't get as muddy (5) • More comfortable / softer / easier to walk on (4) • Disliked the sound: crunchy, hard, noisy (2) • More natural (2)	• Gets in the sandals / shoes (2) • Bad for allergies when dusty (2) • More secure • Not as dirty as bare earth • Better than concrete
Boardwalk	• Closer to nature / inaccessible otherwise / see more (6) • Liked the movement with steps over water (4) • New experience (3) • Keeps people on the trail / off the ground (3) • Good for older persons / toddlers (2) • Liked being suspended above the ground	• Needed to stay dry • Loose shoes are OK • Green lumber not good • Noisy for wildlife • Looks natural in the surroundings
Concrete	• More even for toddlers (2) • Hard on back • Easier on feet • Reminder of the city	• Can't walk as far • Spoils the setting • Too hard / urban • Doesn't belong

Comments that were mentioned most frequently related to the natural appearance of bare earth and the soft texture of wood chips. Overall, many people noted the importance of a proper surface in wet conditions, with wood chips and gravel screenings both being an improvement in drainage over bare earth trails. Boardwalks were enjoyed for the ability to explore areas that were otherwise not accessible due to wet or sensitive soil and vegetation conditions. Most comments on concrete were negative, aside from those respondents noting the benefit of evenness for toddlers using the trail.

4.1.8 Importance of Surfacing to Trail Users

One of the later questions on the survey explored the importance of surfacing to trail users. If the type of surfacing was unimportant, trail managers might have reason to place less emphasis on the social aspects of surfacing decisions when faced with environmental or economic limitations. Overall, although the proportion of respondents stating surfacing was "very important" to the enjoyment of their activity that day was relatively small, the responses were fairly evenly distributed across the other three points on the Likert scale, as shown in Figure 7.

Figure 7: The importance of type of trail surface to the enjoyment of respondent's activities.



Overall, 76 percent of Belfountain respondents and 66 percent of Presqu'ile respondents indicated the type of surface was of some level of importance to the enjoyment of their activity. In order to establish how important trail surfacing is in relation to other site conditions, future researchers may wish to explore questions that ask trail users to rank other elements, such as number of encounters with people, in terms of the effect on their experience. Many respondents stated that surface type was unimportant as long as it was safe to walk on and fit in reasonably well with the surroundings. Others stated that surface type was not important, as long as they were prepared for it with proper footwear. These comments underscore the importance of not making surfacing decisions based on individual perception alone, but considering the wide array of social, economic and environmental factors that affect the choice of surface type.

4.2 ENVIRONMENTAL ASPECTS OF TRAIL SURFACING

Trail managers are often concerned about the environmental effects of different surface types, particularly in more natural areas in which managers strive to protect the environment from human impact. In many situations, trails suffer from widening or parallel trail formation as a result of users avoiding areas of poor trail condition, such as muddiness or exposed roots. As part of this study, the condition of several trails with different surface types was documented at both Belfountain and Presqu’ile study sites. A summary of the trail impacts for each surface at Belfountain and Presqu’ile is provided in Table 7.

Table 7. Incidence of trail problems along sections of different trail surfaces at Belfountain and Presqu'ile study areas.

Belfountain Loop Trail

Surface	*Length of trail*	*# of instances*	*Problems per 100m*	*Trail problems recorded*
Bare earth	405m	22	5.4	Roots, rocky sections, muddy sections, slippery surface, water crossing the trail, parallel trails
Grass	8m	1	12.5	Undefined tread
Wood chips	25m	1	4.0	Rocky section
Gravel	230m	8	3.5	Water crossing the trail, roots, unsafe trail edge, muddy sections, slippery sections, soft sections
Boardwalk	125m	4	3.2	Rotten wood, guard rail damaged, high fall height
Inset flat stones	132m	1	0.8	Parallel trail
Concrete	90m	3	3.3	Cracked edge, loose step, missing concrete

Presqu'ile Boardwalk Trail

Surface	*Length of trail*	*# of instances*	*Problems per 100m*	*Trail problems recorded*
Bare earth	166m	4	2.4	Soft sections, sections with parallel trails
Wood chips	82m	2	2.4	Soft sections, sections covered with needles
Gravel	34m	0	0	
Boardwalk	840m	6	0.7	Unstable sections, sections with a parallel trail, trip hazards, large spaces between boards.

In interpreting the environmental effectiveness of different surfaces, the short length of many of the surface types along the two trails should be considered. For instance, although the 34-metre gravel section at Presqu'ile did not have any trail problems recorded, this does not provide a sufficient sample from which to determine the environmental effectiveness of gravel surfaces overall. The same note of caution applies to the average width for each section of trail (Table 8). Furthermore, different trail surfaces may be consciously chosen to be used in different environmental conditions, such as on steep slopes or wet areas, because of their greater suitability for these situations.

Table 8. Average tread width for different surfaces at Belfountain and Presqu'ile study sites.

Belfountain Loop Trail

Surface type	*Length of trail (m)*	*Average tread width (m)*
Bare earth	405	1.3
Grass	8	1.8
Wood chips	25	1.6
Gravel	230	1.1
Boardwalk	125	3.8
Inset flat stones	132	1.6
Concrete	90	1.1

Presqu'ile Boardwalk Trail

Surface type	*Length of trail (m)*	*Average tread width (m)*
Bare earth	166	1.2
Wood chips	82	1.0
Gravel	34	1.6
Boardwalk	840	1.1

Measurements of surface condition and average tread width were not found to be valuable in the evaluation of environmental effectiveness. With differing physical characteristics such as slope, aspect and soil type for each trail, combined with varying levels and types of recreational use, the effectiveness of each type of surface was difficult to isolate. In fact, trail condition is likely a function of many physical and recreational variables, including the type of surface. In order to isolate the type of surface as the experimental variable, sample sections of different trail surfaces could be constructed. Other variables such as slope and soil texture would then be mostly consistent between sample trails.

Another way to explore the environmental effectiveness of trail surfacing was to ask trail users and park managers about their perceptions of surfacing. The user survey conducted at Belfountain and Presqu'ile study areas asked trail users how effective they thought surfacing was in reducing the impact of trail users on the natural environment, such as the soil and vegetation. A majority of respondents at both study sites indicated that they thought surfacing was very effective in reducing impact (Table 9).

Table 9. Perceived effectiveness of trail surfacing in reducing the impact of trail users on the natural environment (% of responses).

	Trail Users		Trail Managers
	Belfountain	Presqu'ile	
Not effective	7	0	18
Slightly effective	4	6	6
Somewhat effective	42	34	21
Very effective	44	54	56
Not sure	2	6	0

This high perception of environmental effectiveness was shared with trail managers answering the survey. Surfacing was rated as "very effective" for 56 percent of the 34 trail sections for which a rating was provided. Overall, despite the impact on the environment caused by the surface itself, it was generally thought that this impact was less than the impact caused by trail users if the trail was left unsurfaced. In areas with high visitor use or sensitive physical conditions, many managers stated that surfacing was required to prevent unacceptable damage to the trail.

4.3 ECONOMIC ASPECTS OF TRAIL SURFACING

Trail surfacing costs were investigated through a review of trail construction literature and a survey of trail managers. The eleven trail managers responding to the survey and eight others with whom discussions were held after a telephone follow-up provided approximate costs for different types of trail surfaces. While managers were often able to share a rough figure for construction costs, maintenance expenses were difficult to isolate. For many organizations, trail maintenance is a part of general park operations and is therefore not routinely reported separately from overall park maintenance expenses.

The construction cost for different surfaces is a strong consideration for many trail managers. In the manager survey, cost was tied for third overall ranking behind suitability for user requirements and site constraints (Table 10). With tighter park funding for many jurisdictions over the past decade, both the cost of trail construction and maintenance requirements have become heavily scrutinized.

Table 10: Importance of surfacing considerations to trail managers.

Considerations in trail surfacing decisions	**Median ranking**
Site constraints	2
Availability	3
Cost	3
Suitability for user requirements	1
Ease of maintenance	3
Successful past use	4
Vehicular access	6

Overall, trail managers reported that suitability for user requirements was the most important consideration in trail surfacing decisions followed by site constraints. Vehicular access and successful past surface use were less important.

As mentioned in an earlier section, estimates for trail surfacing costs are directly related to the design and location of the trail segment. For instance, a section of trail in a flat, well-drained area with easy vehicle access will be many times cheaper than the same trail design located in an area with drainage problems, steep slopes or access limitations. Also, trail design elements such as surface thickness, tread width and sub-base preparation significantly alter construction costs. Some surfaces, such as a boardwalk, can be constructed to meet an assortment of different standards. A boardwalk built with high grade lumber and made strong enough to support the weight of small equipment or an equestrian user would be much more expensive than a boardwalk built from on-site materials with a narrow width. Therefore, it is difficult to develop an average unit cost for trail construction between different surface types without including these external factors.

One of the objectives of the trail manager survey was to compile examples of trail construction and maintenance costs on trails with a range of surface materials. Rather than providing an average unit cost for each surface, a range of examples is provided (Table 11). In this way, managers are able to gauge the relative costs of different surfaces under the physical and recreational limitations of the trail. Note that costs are not standardized to a yearly price index due to the difficulty in identifying accurate dates for some of the estimates and the relatively small impact on the range of costs presented resulting from this adjustment. The range of costs is provided as a guide to trail managers to be interpreted in their own applications.

Table 11. Trail Construction Costs based on Surface Type (page 1 of 3)

Type	Cost	Source of Quote	Details
Bare Earth	$2/m^2$	Colorado State Trails	1 metre wide, moderate terrain
Bare Earth	$2/m^2$	Rails to Trails Conservancy	3 metres wide, 1994 cost
Bare Earth	$5/m^2$	BC Parks Strathcona District	1996 cost
Bare Earth	$8/m^2$	Flink and Searns, 1993	1993 cost
Bare Earth	low	Arkansas Cooperative Extension Service	durability and mtce. depend on location, drainage, soil type and amount/type used
Wood Chips	$2/m^2$	Regional District of Nanaimo	cedar chips; cedar bark usually free - trucking only 2 metre width/150mm thick
Wood Chips	$5/m^2$	Rails to Trails Conservancy	3 metres wide, 1994 cost
Wood Chips	$8/m^2$	ESG International	
Wood Chips	$18/m^2$	Flink and Searns, 1993	1993 cost, includes subgrade, sub-base with geotextile and placement of surface
Wood Chips	low-medium	Arkansas Cooperative Extension Service	performance depends on compaction, frequent replenishment required
Gravel	$5/m^2$	Rails to Trails Conservancy	3 metres wide, 1994 cost
Gravel	$5/m^2$	Grand River Conservation Authority	material and haulage, 2 metre width
Stonedust	$5 - $24/m^2$	Colorado State Parks	from a survey of crusher fines trails
Gravel	$8/m^2$	Metro Toronto and Region Conservation Authority	pedestrian trail, 2.5 metres wide
Stonedust	$8/m^2$	City of Guelph	installed, 2 metres wide
Crushed Gravel	$10/m^2$	Hamilton Region Conservation Authority	includes granular A base surfaced with 50mm of 7mm diameter limestone, 2m width
Gravel	$12/m^2$	ESG International	
Crushed Gravel	$12/m^2$	Rails to Trails Conservancy	3 metres wide, 1994 cost
Gravel	$13/m^2$	BC Parks Strathcona District	1996 cost
Stonedust	$15/m^2$	ESG International	
Gravel	$20/m^2$	Ryan, 1993	3 metres wide
Limestone Screenings	$20/m^2$	Flink and Searns, 1993	1993 cost, includes subgrade, sub-base with geotextile and placement of surface
Stonedust	$22/m^2$	City of Cambridge/ IMC Consulting Group	2.5 metres wide, includes granular base
Crushed Gravel	medium	Arkansas Cooperative Extension Service	aggregate mix must be properly sized and compacted for good performance

Table 11. Trail Construction Costs based on Surface Type (page 2 of 3).

Type	Cost	Source of Quote	Details
Soil Cement	$14/m^2$	Ryan, 1993	3 metres wide
Soil Cement	medium	Arkansas Cooperative Extension Service	proper mixture is very difficult and seldom successful
Tar and Chip	$4/m^2$	Grand River Conservation Authority	small/local sections with erosion problem
Tar and Chip	$28/m^2$	City of Cambridge/ IMC Consulting Group	2.5 metres wide, includes granular base
Chip and Seal	high	Arkansas Cooperative Extension Service	may require periodic patching
Asphalt	$15/m^2$	BC Parks Strathcona District	1996 cost
Asphalt	$15/m^2$	Colorado State Trails	2.5 metres wide, 100mm full-depth asphalt 125mm gravel base, seal coat
Asphalt	$15 - $18/m^2$	City of Guelph	installed, 2-metre width
Asphalt	$17/m^2$	Haylock Brothers Paving Ltd.	tight blade and compact the existing base, 50mm thick hot mix asphalt for 220 sq. metres
Asphalt	$17/m^2$	Metro Toronto and Region Conservation Authority	2.3 metres wide, 100mm thick
Asphalt	$21/m^2$	Flink and Searns, 1993	1993 cost, includes subgrade, sub-base with geotextile and placement of surface
Asphalt	$22/m^2$	Rails to Trails Conservancy	3 metre width, 1994 cost
Asphalt	$22/m^2$	Ryan, 1993	3 metres wide (1992 dollars, including some subgrade preparation)
Asphalt	$25/m^2$	ESG International	
Asphalt	$32/m^2$	City of Cambridge/ IMC Consulting Group	2.5m wide, includes granular base
Asphalt	$32/m^2$	University of Waterloo Plant Operations	supply and install or for patching $175 per tonne
Asphalt	$35 - $39/m^2$	Colorado Asphalt Pavement Association	75mm thick, 3m wide path (metropolitan area) fine graded mix
Asphalt	$58 - $68/m^2$	Colorado Asphalt Pavement Association	75mm thick, 3m wide path (remote area)
Asphalt	very high	Arkansas Cooperative Extension Service	hot or cold mix

Table 11. Trail Construction Costs based on Surface Type (page 3 of 3).

Type	Cost	Source of Quote	Details
Concrete	$24 - 29/m^2	Colorado Asphalt Pavement Association	100mm depth, 3 metres wide (metro area)
Concrete	$25/m^2	Niko Projects Inc.	
Concrete	$30/m^2	Colorado State Trails	2.5 metres wide
Concrete	$55 - 59/m^2	Colorado Asphalt Pavement Association	100mm depth, 3 metres wide (remote area)
Concrete	$75/m^2	Rails to Trails Conservancy	3 metres wide, 1994 cost
Concrete	$75/m^2	Ryan, 1993	3 metres wide
Reinforced Concrete	$80/m^2	Flink and Searns, 1993	1993 cost, includes subgrade, sub-base with geotextile and placement of surface
Concrete	very high	Arkansas Cooperative Extension Service	
Interlocking stone	$63 - $85/m^2	University of Waterloo Plant Operations	supply and install
Brick	very high	Arkansas Cooperative Extension Service	proper subgrade preparation and compaction is essential to a smooth surface
Boardwalk	$200/m^2	ESG International	3 metres wide, complete with handrails and decking
Boardwalk	$396/m^2	Flink and Searns, 1993	1993 cost
Boardwalk	high	Arkansas Cooperative Extension Service	durability depends on chemical treatment may require periodic surface treatment
Alternative Surfaces			
Soil Stabilizer with Gravel	$5/m^2	Hamilton Region Conservation Authority	with fines and organic stabilizer includes grading, fill and armourstone, 2 metres wide
Safetytread™ / Safety Deck™	$9/m^2	Max Factory Inc.	0.5 metre x 0.5 metre sections fabricated from recycled automobile tires
Geoweb™	$12/m^2	Presto Products Co.	2.4 metre x 6 metre plastic grid for grass, 100mm thick
Portapath™	$60/m^2	Avenues Unlimited Inc.	0.3 metre x 3 metre interlocking treads that clip together; polypropylene
Beach Access Ramps	$90/m^2	Beach Access Unlimited	1 metre x 3 metre sections, roll-up ramp
Superdeck™ Boardwalk	$135/m^2	Aggressive Industries Inc.	1 metre x 1.5 metre panel

Note: For ease of comparison, quotes have been converted to $CDN (US$1=CDN$1.50). Imperial units have been converted to metric. Figures are rounded to the nearest dollar.

In general, bare earth trails were reported as the most inexpensive, with an average cost of $4/m^2. The cost for this basic trail construction reflects the labour necessary to clear and grub the soil surface and grade the surface for recreational use. Wood chips were the next least expensive surfacing alternative, averaging $8/m^2, followed by a variety of gravel surfaces, averaging $13/m^2. Although few case studies including costs for soil cement and tar and chip surfaces were found, the average costs are roughly $14/m^2 and $16/m^2, respectively.

Asphalt was the least expensive of the harder surfaces at an average cost of $26/m^2 compared with $53/m^2 for trail surfaced with concrete. Interlocking stone and brick work require significant amounts of labour and expensive materials, making these surfaces especially costly. The one case study using interlocking stone quotes a range between $63/m^2 and $85/m^2. The most expensive surface was boardwalk, with an average cost of roughly $300/m^2.

Several case studies providing costs for alternative surfacing types were also found, including a variety of portable trail surfaces developed under proprietary names such as Superdeck™ and GeoWeb™. These products provide a flexible alternative to permanent trail construction, giving trail managers the ability to temporarily place a trail to provide access where desired. The cost of these products was higher than most other surface types, ranging from $9/m^2 to $135/m^2.

The response to the trail manager's survey did not provide the information anticipated regarding the maintenance costs for different types of surface. General maintenance requirements are discussed for trail surface types in Section 2, from which trail managers can make rough comparisons between each alternative.

4.4 INTEGRATING THE THREE ASPECTS OF SURFACING DECISIONS

Surfacing decisions are a compromise between social, environmental and economic aspects of each surface type and the desired characteristics based on the mandate of the area. The needs of the users will have to be weighed against those of the environment, all within the economic limitations of the management body. Decisions need to be made along several continua prior to selection of surface type, as outlined in Figure 8.

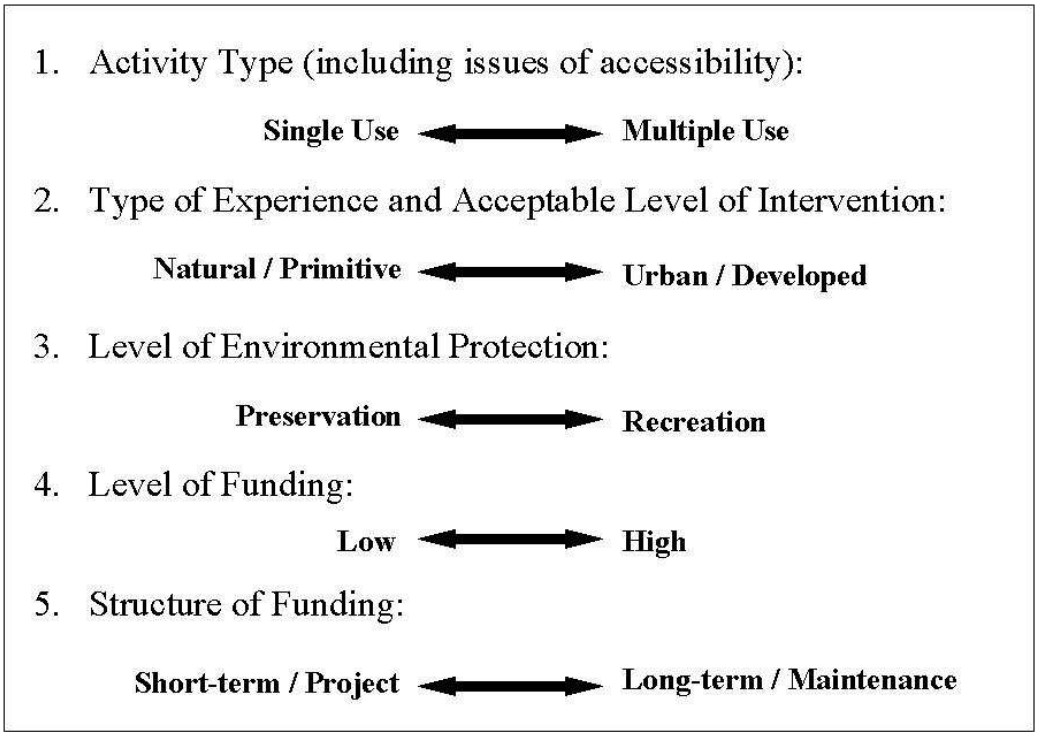


Figure 8. Several continua for consideration in trail surfacing decisions.

After making these decisions, trail managers may find many surface types are excluded immediately. For instance, if the capital available for the project is low, more expensive materials such as asphalt, concrete and boardwalk can be disregarded. If there is little budget or human resources available for long-term maintenance, a wood chip surface might be impractical due to its high maintenance requirement. If the soil is frequently wet, gravel may not provide a suitable surface for trail users. Finally, if the trail is to be used for wheeled activities such as rollerblading, soft surfaces can be ruled out.

Once the trail manager has considered all the needs and effects of the candidate surfaces, the selection will be based on a prioritization of the environmental, social and economic aspects of the proposed trail. There are no right or wrong answers and there are no methods that are guaranteed to work, as the combination of site conditions is usually unique to that area. Adaptation of established surfacing and design techniques to suit the particular conditions will often be necessary to provide the optimal solution. Many organizations have developed standards for different types of trails that can guide trail managers in the selection of an appropriate surface. These agency standards generally incorporate some consideration of the social, environmental and economic aspects of trail design for a particular recreational setting. Often, the sound application of agency standards can narrow the range of surfacing alternatives by excluding those that do not provide the desired level of environmental protection or recreational experience.

4.5 THE ROLE OF SURFACING DECISIONS IN TRAIL MANAGEMENT

Throughout this discussion, trail surfacing has been presented as one tool in the trail managers' toolbox in addressing the impact of outdoor recreationists. Surfacing should be considered in the context of other impact management practices. If the impact of outdoor recreationists can be mitigated through practices such as limiting user numbers, trail surfacing may not be necessary.

In those circumstances where trail managers select surfacing as the best approach to impact reduction, a decision-making process can be developed to identify, select and evaluate surfacing options. A framework showing this decision-making process in relation to recreational impact management options is shown in Figure 9.

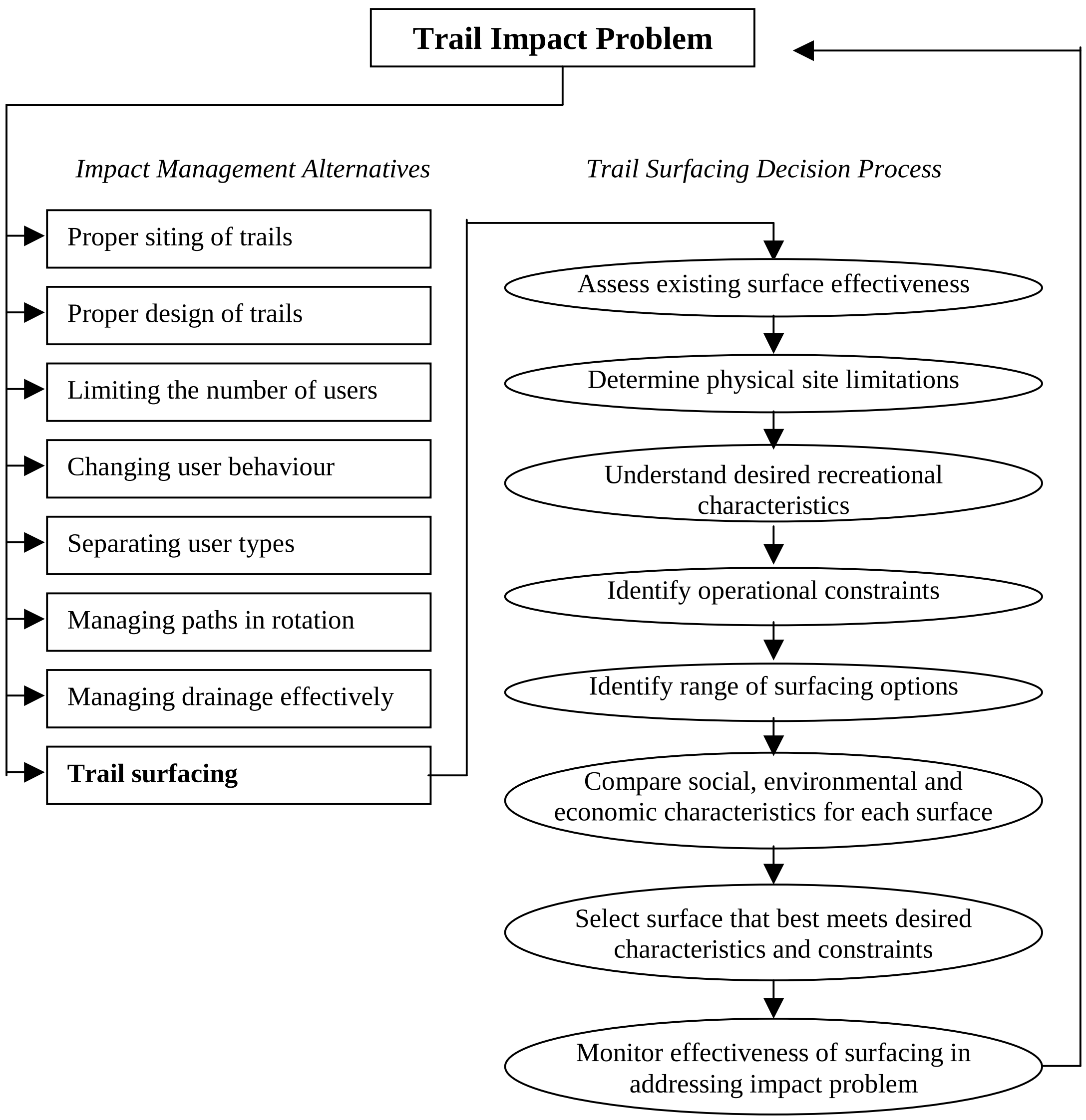


Figure 9. Trail impact management and surfacing decision process.

Following this framework involves a strong understanding of visitor impact assessment and management techniques. Although only the decision process for trail surfacing is expanded on here, similar processes could be developed for each impact management alternative. For example, the decision process for "proper design of trails" would require much more knowledge and understanding in its application. In fact, several publications focus exclusively on this aspect of visitor impact management (Ontario Ministry of Natural Resources, 1976; Parks Canada, 1978; United States Department of Agriculture, Forest Service, Engineering Staff, 1996; Parks Canada, 1996).

The Trail Surfacing Decision Process (figure 9) guides the trail manager through the social, environmental and economic aspects of trail surfacing. At the first stage, the existing surface is assessed to determine its strengths and weaknesses. In particular, some of the limitations of the trail may be highlighted for consideration in selection of a new surface. For example, if the existing wood chip surface continues to widen, a firmer surface that does not spread as easily may be a high priority in considering surfacing alternatives. The next three stages involve the determination of recreational, environmental, and economic characteristics and limitations. Based on the continua presented in Figure 8, trail managers need to determine the priorities for the trail.

Once the range of surfacing options is identified, these priorities can be compared to the social, environmental and economic characteristics for each surface. After the surface that best meets the desired characteristics and constraints is selected, it is recommended that trail managers monitor and evaluate the effectiveness of the trail surfacing in addressing the visitor impact problem. In this way, the Trail Impact Management and Surfacing Decision Process becomes a cycle, continuously monitoring and responding to visitor impact problems in a consistent and logical approach.

Many organizations have already adopted frameworks to guide decisions around visitor impact management, such as the Recreation Opportunity Spectrum (e.g., British Columbia Ministry of Forests, U.S. Forest Service, Parks Canada), Visitor Impact Management (e.g., U.S. National Parks Service), Limits of Acceptable Change (e.g., U.S. Forest Service), and Visitor Activity Management Process (e.g., Parks Canada). The Trail Impact Management and Surfacing Decision Process is developed from a similar approach to visitor impact management reflected by each of these other frameworks and applied specifically to trail surfacing. These other frameworks provide a general approach to visitor impact management, while the trail surfacing frameworks fit into these approaches at a more detailed level. In fact, Parks Canada has specifically integrated appropriate trail surfacing types into its zoning system within Canada's national parks (Parks Canada, 1996).

The key to protecting ecological conditions while providing for recreational enjoyment of natural areas lies in the understanding of all aspects of impact management techniques, including trail surfacing. In most trail impact situations, there are no simple problems or clear answers. Adapting and applying trail research and individual experiences, the trail manager is responsible for translating organizational objectives concerning the recreational resources he/she is charged with. This will involve analyses of complex trade-offs between recreational, environmental and economic conditions. Trail managers who understand the factors related to surface material selection and design will be able to promote a safe and aesthetically pleasing trail (Duffy, 1992).

5 SUMMARY AND CONCLUSIONS

5.1 SUMMARY

Surfacing is one option to address the deterioration of the environmental or social conditions along a trail. The purpose of a path surface is to protect the site while facilitating travel and enhancing user experience. Many trails do not require any surfacing as the aesthetic and ecological characteristics of the trail remain within acceptable limits under existing use. However, in many cases, surfacing is required to support the present or anticipated level of use without compromising the recreational resource. Each type of surface has its strengths and weaknesses which must be placed in context with the goals and limitations of the trail jurisdiction. Some of the key factors in selecting a trail surface are summarized in Table 12, followed by highlights of the advantages and disadvantages of several common types of trail surfacing in Table 13.

Table 12. Factors affecting choice of trail surface.

1) *User Needs*
    a) Walkers:
        - rough surfaces are uncomfortable to walk on.
        - unyielding surfaces such as concrete or asphalt can be tiring to walk on.
        - muddy or wet trail sections detract from many walker's experiences.
        - toddlers or people using mobility aids prefer firm, even surfaces.
    b) Cyclists:
        - needs of casual cyclist and mountain biking enthusiast differ.
        - soft surfaces may provide too much resistance.
        - loose surfaces are a skidding hazard, particularly on slopes or corners.
        - rough surfaces can be uncomfortable.
        - angular materials can puncture tires.
    c) Horseback riders:
        - angular stones are uncomfortable for horses to walk over.
        - softer surfaces are preferable to harder ones.
        - fines in some surfaces may cause dusty conditions when dry.
        - muddy conditions result in rapid deterioration of the surface.
    d) Rollerbladers:
        - hard surfaces are required, such as asphalt or concrete.
        - the smoothest surfaces are most suitable.
        - wet or dusty sections pose a safety hazard.
        - urban appearance acceptable.
2) *Site Conditions*
    a) Sub-soil (texture, permeability, susceptibility to freezing).
    b) Drainage (related to sub-soil type and slope).
    c) Vegetation (resistance and resiliency of local plants to trampling).
3) *Appearance*
    a) Local character:
        - local materials often look most appropriate where available.
    b) Desired level of intervention:
        - curbs, stringers, rails etc. often give an urban appearance.
    c) Consider colour:
        - darker colours are associated with vehicles and speed.
        - lighter colours imply pedestrian use.
4) *Environmental Considerations*
    a) Spreading of loose surfaces.
    b) Introduction of foreign material (e.g., hardwood chips, limestone screenings).
    c) Leaching of toxic materials.
    d) Erosion from trail surface.
    e) Concentration of runoff.
5) *Operational Constraints*
    a) Cost of materials (purchase, transport and installation).
    b) Ease of access.
    c) Structure of trail funding (grants often cover capital costs, not maintenance).

Table 13. Synopsis of advantages and disadvantages of selected trail surfaces.

Surface Material	Advantages	Disadvantages
Native Soil	Natural material, lowest cost, low maintenance, can be altered for future improvements, easiest for volunteers to build and maintain.	Dusty, ruts when wet, not an all-weather surface, can be uneven and bumpy, limited use, not accessible.
Soil Cement (native material with portland cement added)	Uses natural materials, more durable than native soils, smoother surface, low cost.	Surface wears unevenly, not a stable all-weather surface, erodes, difficult to achieve correct mix.
Wood Chips	Soft, spongy surface, good for walking, moderate cost, natural material.	Decomposes under high temperature or moisture, requires constant replenishment, not typically accessible, limited availability in some areas.
Granular Stone (various sizes, with or without fines, loose or compacted)	Soft but firm surface, natural material, moderate cost, smooth surface, accommodates multiple use.	Surface can rut or erode with heavy rainfall, regular maintenance to keep consistent surface, replenishing stones may be a long term expense, not for steep slopes.
Cinders or Fly Ash	Inexpensive, compacts and seals well.	Fines may erode into local surface water, limited availability from local railway or industrial operations.
Grass Turf	Natural appearance, soft texture, good with low levels of use.	May deteriorate under high levels of use, unsuccessful if conditions are under deep shade or are excessively wet or dry, requires regular mowing.
Corduroy	Inexpensive, can use local materials, easy to construct, good for wet sections.	Can deteriorate and become unstable without regular maintenance.
Boardwalk	Elevates user from impacting soil or vegetation, good for wet areas, even and firm surface for users of all abilities.	Moderately expensive, regular inspections and maintenance required.
Asphalt	Hard surface, supports most types of use, all weather, does not erode, accommodates most users simultaneously, low maintenance.	High installation cost, costly to repair, not a natural surface, freeze/thaw can crack surface, heavy construction vehicles need access
Concrete	Hardest surface, easy to form to site conditions, supports multiple use, lowest maintenance, resists freeze/thaw, best cold weather surface.	High installation cost, costly to repair, not a natural looking surface, construction vehicles will need access to the trail corridor.

Adapted from Ryan (1993).

This research provides some empirical support for the general information available from most sources on trail management. Through on-site surveys of trail users in two study areas, the social acceptability of trail surfacing was explored. While surface preferences varied slightly between respondents at Belfountain Conservation Area and Presqu'ile Provincial Park, users expressed a strong preference for bare earth or wood chip trails. Gravel was ranked highly at Belfountain but did not share the same high ranking among respondents at Presqu'ile. The lowest rankings were shared by concrete and asphalt surfaces at both study sites.

The effectiveness of trail surfacing types in minimizing environmental impact and limiting recreational use to the trail surface was examined using condition assessments along each trail. However, due to the changing environments through which trails of different surfaces pass, the effect of surface type on environmental condition could not be isolated. Research from other locations provided evidence of the benefits of surfacing in reducing impact from trail users. Also, discussions with trail managers highlighted environmental concerns related to particular surface types, such as spreading and trail widening on gravel surfaces and leaching from wood chips. Experiences of trail managers also provided insight into construction costs, maintenance requirements, and successes or failures of a variety of surfaces.

Building from this research into user preferences and trail manager experiences, a framework for integrating the social, environmental and economic aspects of trail surfacing into management decisions was developed. Addressing the many facets of the surfacing decision greatly increases the likelihood of operating a successful trail in terms of ecological protection, recreational experience and fiscal responsibility. A trail designed with these aspects in mind will continue to provide enjoyment well into the future.

5.2 CONCLUSIONS

To develop the best possible trail system, trail managers need to outline a vision for trail experiences and conditions that meet the organizational objectives for the natural area. This vision guides decisions on the management of recreational impacts from park visitors. There are many alternatives in managing these impacts, including use restrictions and trail design techniques. The selection of the most appropriate impact management approach is complicated, involving extensive knowledge of the social, environmental and economic aspects of park management. Trail surfacing is one commonly used alternative, offering managers a way to control ecological impact and enhance user experiences according to the established vision.

Each recreational activity, user type and site condition has different demands on trail surfacing. In addition, the experience provided by each surface type varies along with environmental impacts and construction and maintenance expenses. The trail manager needs to understand each of these considerations to make the most effective surfacing decisions. Unfortunately, few publications addressing trail surfacing are available. Most trail surfacing information is predominately found as part of broader sources on trail construction, maintenance and design. Many publications devote a few pages out of the entire text to different types of trail surface, but these sections offer mostly generalized statements with little empirical support. In addition, the communication of experiences with different types of surfaces between trail managers is generally by word-of-mouth or other informal approaches; there is little standardized dissemination of information.

Despite these limitations, the experiences of various organizations with different solutions to surfacing problems can be invaluable in providing new surfacing ideas. In addition to this communication, monitoring and evaluating new and existing trails within each trail manager's jurisdiction are important to develop understanding in the field. Future trail projects can be improved by regularly reviewing the successes and failures of different surfaces and considering alternatives. The development of conceptual models to support the surfacing decision like the ones presented in this research can provide trail managers with a comprehensive and objective approach to improved visitor impact management.

At the most general level, trails provide the main avenue for most people to enjoy recreational activities such as walking, sightseeing, horseback riding and bicycling in the natural environment. They provide access to our lakes, forests and other natural resources while reducing the impact of recreational use on soil, water, vegetation and wildlife by concentrating use in specific areas. Well-designed trails provide endless hours of enjoyment and relaxation while reducing environmental impact. Sound surfacing decisions play an important role in providing quality recreational experiences to trail users in an environmentally and economically sustainable manner.

5.3 RECOMMENDATIONS

Through this research, several approaches for trail managers to address questions about trail surfacing have been developed. The following recommendations provide seven key ways by which trail managers can improve future trails for everyone to enjoy. The first three recommendations follow a progression from general impact management techniques and trail design to a more specific consideration of the role of trail surfacing and considerations in the selection of a surface. Each of these three is connected in a comprehensive approach to understanding and addressing recreational impacts through trail surfacing. The next two recommendations present suggestions for trail managers regarding specific surface types as found in the course of this research. The final two recommendations address the need for improved information sharing and trail user involvement in surfacing decisions. These last two recommendations are particularly important to the increased effectiveness of future surfacing decisions.

1. *Recommendation:* Trail managers gain a full understanding of best practices in trail design before looking to trail surfacing as the solution to problems with visitor impact. In particular, a thorough knowledge of trail design principles related to drainage, slopes and soil-types is critical to providing long-lasting, enjoyable and environmentally sound trails.
2. *Recommendation:* Trail managers consider the full spectrum of visitor impact management techniques in addition to trail surfacing, as shown in Section 4.5, Figure 9: Trail impact management and surfacing decision process.

3. *Recommendation:* After a review of other impact management techniques, if surfacing is the chosen option, the trail manager obtains as much information as possible about the user characteristics, environmental conditions and organizational limitations, as shown in Section 4.4, Figure 8: Several continua for consideration in trail surfacing decisions.
4. *Recommendation:* In terms of a preferred surface, this research has shown that there are benefits and drawbacks to each surface type for different recreational, environmental and organizational settings. However, one surface that merits special mention is road base gravel, or angular screenings of assorted sizes. When constructed properly, this surface provides an excellent tread which can be fully accessible, long-lasting and relatively inexpensive to construct.
5. *Recommendation:* Trail managers minimize the use of asphalt and concrete in natural settings, except for extremely high use areas or for wheeled trail use, due to its high cost and low acceptability among many trail users.
6. *Recommendation:* Trail managers increase the documentation and sharing of trail surfacing successes and failures. Few monitoring and evaluation projects are underway and dissemination of trail surface information is at a minimum. Increased communication between trail managers, through organizations such as the Trans Canada Trail and trail information on the internet, may provide an opportunity for increased dialogue.
7. *Recommendation:* Trail managers allow more opportunities for input and feedback from the trail users who are most affected by surfacing decisions. This could include education, consultation and joint decision making with trail users to increase understanding and support for the selected visitor impact management strategies.

5.4 FUTURE RESEARCH

The emerging field of recreation ecology holds many exciting opportunities for improved understanding of the relationship between humans and the environment in a recreational context. In particular, the state of knowledge on trail surfacing is currently not well developed. Further exploratory studies on trail surfacing preference and perceptions would assist trail managers to better understand surfacing options and the impact of surfacing on user experiences.

The Americans with Disabilities Act Accessibility Guidelines (ADAAG) have advocated an urgent need for more information on the accessibility of different trail surfaces in natural areas. Research into developing standards, assessment tools and innovative surfacing alternatives will be an area of concentration for many trail managers in order to meet the requirements of these guidelines.

Future researchers may also wish to develop a broader understanding of the preferences of different types of recreational users in different settings. This study concentrated on the preferences of walkers in a front country park / conservation area setting. However, as indicated in Section 2, the needs and preferences of different trail users vary significantly, depending on their activity and desired experience. Basic research of this nature provides the foundation for explanatory studies and more useful decision support systems.

Photographs of different trail surfaces potentially provide a simple and effective method to gauge user preferences. However, future researchers may wish to better isolate the surface in each photograph to reduce the effect of external factors such as signs, surrounding vegetation or trail problems. One possible technique may be to manipulate the photographs by cropping the trail from the photo of each surface and applying a standard background across all photographs. Standardized photographs could be applied to any study area, providing the ability to compare and combine survey results from different studies. Computer techniques for the manipulation of photographs in landscape evaluation research are further explored in a special 2001 edition of Landscape and Urban Planning (Volume 54). Containing research on the most recent developments in visual landscape modeling and visualization, future researchers may wish to refer to these works in designing graphic instruments for surveys on trail surface perceptions and preferences.

The conceptual framework presented in this research could be expanded on and operationalized by developing checklists or flowcharts to guide surfacing decisions. In particular, interaction with other visitor impact management concepts such as the Recreational Opportunity Spectrum (ROS) or Limits of Acceptable Change (LAC) framework warrants further exploration. In this way, the role of trail surfacing in the management of visitor impacts can be optimized based on social, environmental and economic conditions.

APPENDICES

APPENDIX A: TRAIL USER SURVEY

(As used at Belfountain Conservation Area)

Survey Number: _______	Interview Location:	____________________	
Date: __/__/__	Number in Group:	_____	
Time: _______	Respondent M/F:	_____	Kids? _____

1. For how long will you be using the park today?
   - ❑ < 1 hour
   - ❑ 1 to 2 hours
   - ❑ 2 to 3 hours
   - ❑ > 3 hours
   - ❑ overnight camping

2. What kind of a group are you with?
   - ❑ by myself
   - ❑ with family
   - ❑ with friends
   - ❑ with family and friends
   - ❑ with an organized group (specify) __________________

3. How often have you used trails this summer?

   a) in Belfountain?
   - ❑ 0
   - ❑ 1
   - ❑ 2-3
   - ❑ > 3

   b) in other parks or conservation areas?
   - ❑ less than once per month
   - ❑ once or twice per month
   - ❑ once or twice a week
   - ❑ 3 or more times per week

4. Using this scale, how important are each of the following reasons for your activity today?

	Not Important	Slightly Important	Fairly Important	Very Important	Not sure	Rank
a) to enjoy the natural setting						
b) to learn about nature						
c) for the challenge / adventure						
d) for exercise						
e) to get away from people or seek solitude						
f) to be with friends / family						
g) to relax and reduce built up tension						

5. Between these surfaces, do you like any one more than the other? (Tailor to survey site)

Surface:	Comments:
_____	____
	____
_____	____
	____
_____	____
	____

6. On a scale from 1 to 10, how would you rank your preference for the following properties of trail surfaces?

Smooth	1	2	3	4	5	6	7	8	9	10	Rough
Firm	1	2	3	4	5	6	7	8	9	10	Soft
Developed	1	2	3	4	5	6	7	8	9	10	Primitive
Even	1	2	3	4	5	6	7	8	9	10	Uneven

7. How would you rank the surface of the trails in terms of how natural they appear to you (use photos)?

	Rank (1= most natural)
a) Concrete steps	
b) Inset flat stones	
c) Wood chips	
d) Bare earth	
e) Wood planks	
f) Boardwalk	
g) Gravel fines	

8. How would you rank the surfaces in terms of which ones you would enjoy walking on the most (use photos)?

	Rank (1= most suitable)
a) Concrete steps Likes: Dislikes:	
b) Inset flat stones Likes: Dislikes:	
c) Wood chips Likes: Dislikes:	
d) Bare earth Likes: Dislikes:	
e) Wood planks Likes: Dislikes:	
f) Boardwalk Likes: Dislikes:	
g) Gravel fines Likes: Dislikes:	

9. Using this scale, how would the following trail problems affect the enjoyment of your activity today?

	Wouldn't notice Wouldn't detract	Would notice but Wouldn't detract	Detract Slightly	Detract Moderately	Detract Significantly	Not Sure	Rank (3 most important)
a) dusty sections							
b) muddy sections							
c) rocky sections							
d) sections with water crossing the trail							
e) sections with a loose surface							
f) sections with several parallel trails							
g) sections where the trail is widened							

10. Using this scale, how important is the type of trail surface to the enjoyment of your activity today?
    - ❑ not important
    - ❑ slightly important
    - ❑ somewhat important
    - ❑ very important
    - ❑ not sure

11. Using this scale, how effective do you think surfacing is in reducing the impact of trail users on the natural environment, such as the soil or vegetation?
    - ❑ not effective
    - ❑ slightly effective
    - ❑ somewhat effective
    - ❑ very effective
    - ❑ not sure

GENERAL INFORMATION (OPTIONAL AND CONFIDENTIAL):

12. What age group do you fall in?
    - ❑ 18 or under
    - ❑ 19 to 25
    - ❑ 25 to 34
    - ❑ 35 to 49
    - ❑ 50 to 64
    - ❑ 65 and over

13. What range does your gross annual household income fall into?
    - ❑ under $15,000
    - ❑ $15,000 to $29,999
    - ❑ $30,000 to $44,999
    - ❑ $45,000 to $59,999
    - ❑ $60,000 to $74,999
    - ❑ $75,000 and over

14. What is the highest level of education you have attained?
    - ❑ some high school
    - ❑ high school diploma
    - ❑ technical institute diploma
    - ❑ some college/ university
    - ❑ college/ university degree
    - ❑ graduate degree

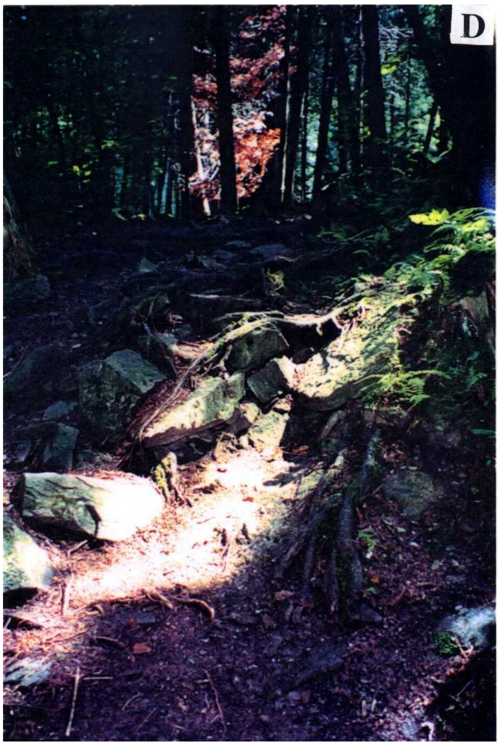
APPENDIX B: PHOTOGRAPHS USED IN TRAIL USER SURVEY

Belfountain Conservation Area (A through G):

Surface A: Concrete

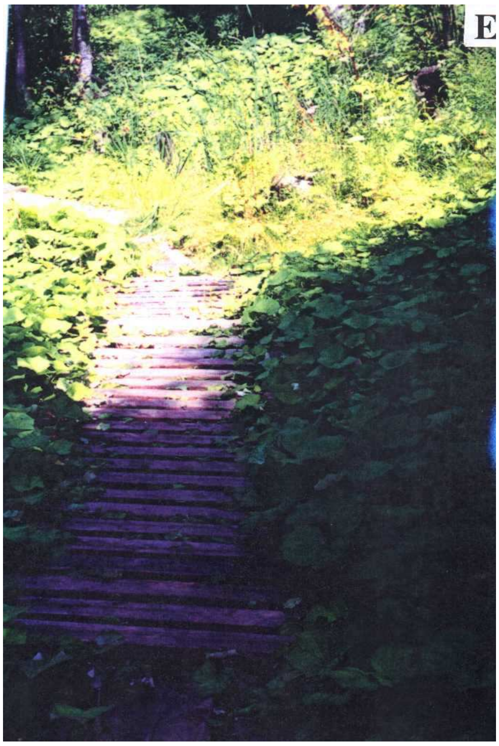
Surface B: Flat Paving Stones

Surface C: Wood Chips



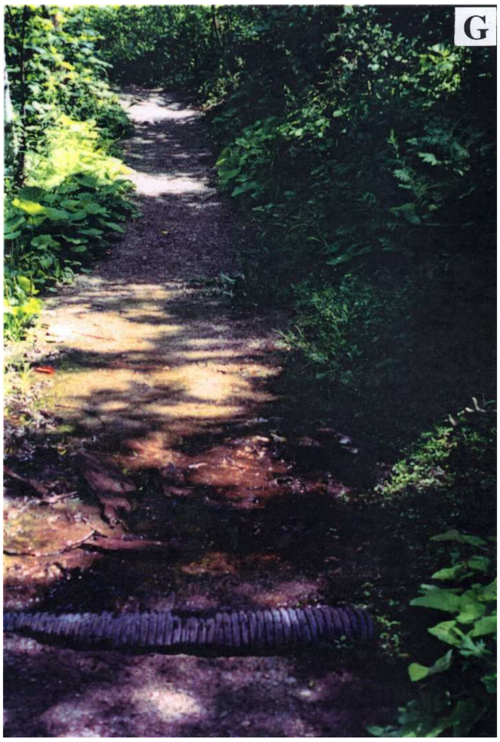
Surface D: Bare Earth

Belfountain Conservation Area (A through G) continued:



Surface E: Wood Planks

Surface F: Boardwalk



Surface G: Gravel

Presqu'ile Provincial Park (Photographs A through F):

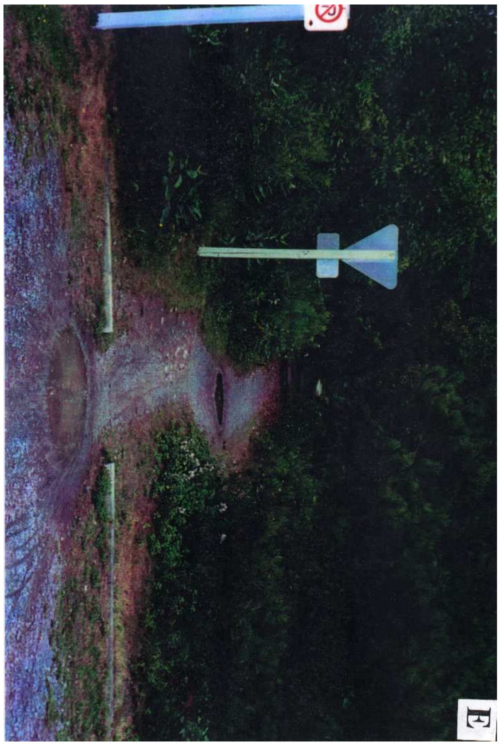
Surface A: Asphalt

Surface B: Wood Chips

Surface C: Bare Earth

Surface D: Boardwalk

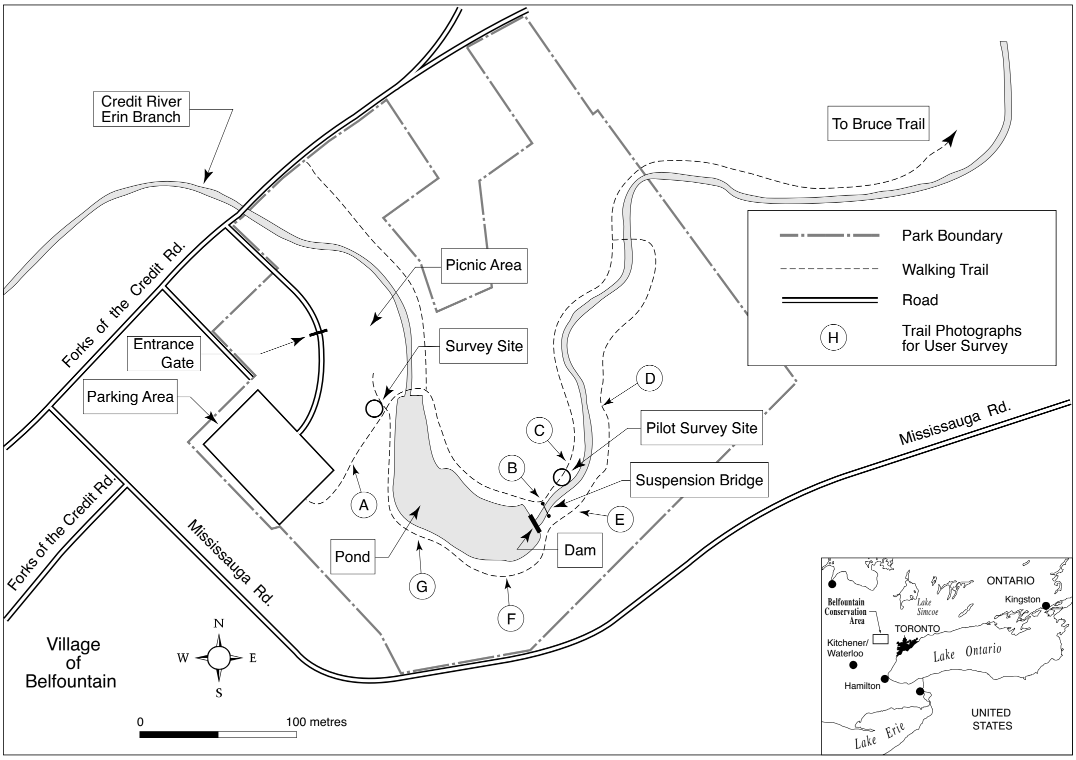
Presqu'ile Provincial Park (Photographs A through F) continued:



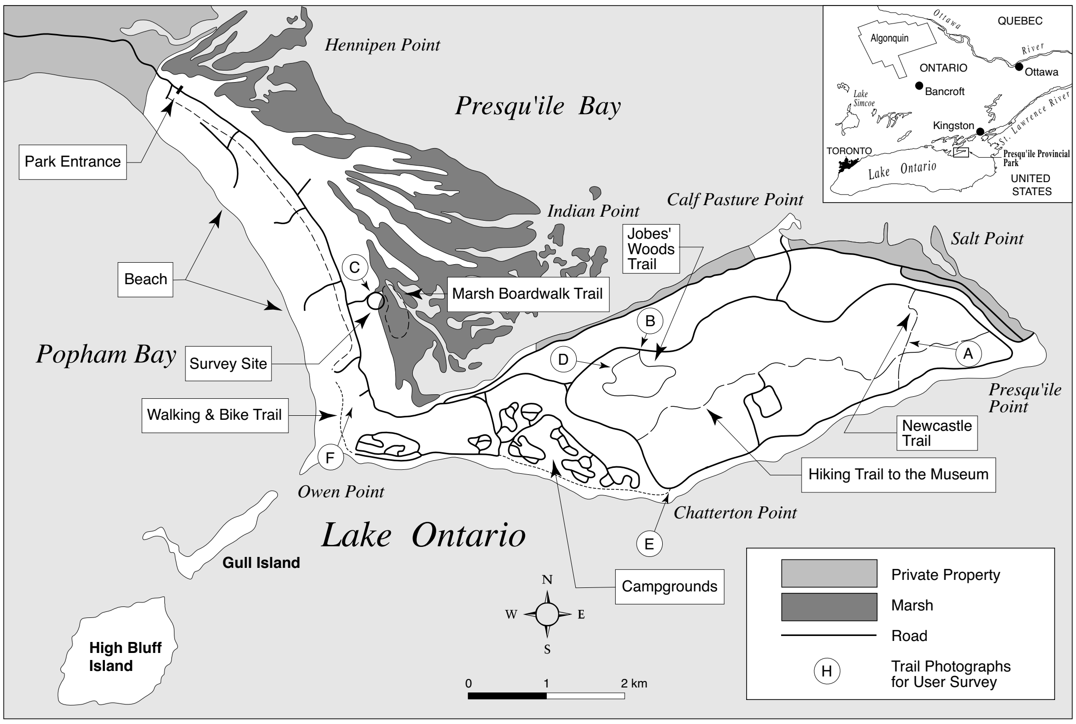
Surface E: Gravel

Surface F: Sand

APPENDIX C: MAPS OF STUDY AREAS



Map 1: Belfountain Conservation Area



Map 2: Presqu'ile Provincial Park

APPENDIX D: SUMMARY OF TRAIL USER SURVEY RESULTS

Number of respondents in plain text, (percentages in parentheses).

1. Group Size

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
1	1 (1.2)	1 (2.2)	0
2	37 (45.7)	22 (47.8)	15 (42.9)
3	9 (11.1)	7 (15.2)	2 (5.7)
4	19 (23.5)	11 (23.9)	8 (22.9)
5	7 (8.6)	4 (8.7)	3 (8.6)
6	5 (6.2)	1 (2.2)	4 (11.4)
7	1 (1.2)	0	1 (2.9)
8	2 (2.5)	0	2 (5.7)

2. Sex

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Female	39 (48.1)	24 (52.2)	15 (42.9)
Male	42 (51.9)	22 (47.8)	20 (57.1)

3. Children under the age of 7 years

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Yes	24 (30.0)	11 (24.4)	13 (37.1)
No	57 (70.0)	35 (75.6)	22 (62.9)

4. What age group do you fall in?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
18 or under	0	0	0
19 to 24	7 (8.6)	3 (6.5)	4 (11.4)
25 to 34	25 (30.9)	14 (30.4)	11 (31.4)
35 to 49	35 (43.2)	21 (45.7)	14 (40.0)
50 to 64	11 (13.6)	6 (13.0)	5 (14.3)
65 and over	3 (3.7)	2 (4.3)	1 (2.9)

5. What range does your annual household income fall into?

	Overall (n=70)	Belfountain (n=39)	Presqu'ile (n=31)
Under $15,000	2 (2.9)	1 (2.6)	1 (3.2)
$15,000 to $29,999	8 (11.4)	4 (10.3)	4 (12.9)
$30,000 to $44,999	8 (11.4)	6 (15.4)	2 (6.5)
$45,000 to $59,999	14 (20.0)	8 (20.5)	6 (19.4)
$60,000 to $74,999	13 (18.6)	8 (20.5)	5 (16.1)
$75,000 and over	25 (35.7)	12 (30.8)	14 (41.9)

6. What is the highest level of education you have attained?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Some high school	0	0	0
High school diploma	11 (13.6)	9 (19.6)	2 (5.7)
Technical institute diploma	4 (4.9)	2 (4.3)	2 (5.7)
Some college / university	16 (19.8)	11 (23.9)	5 (14.3)
College / university degree	43 (53.1)	22 (47.8)	21 (60.0)
Graduate degree	7 (8.6)	2 (4.3)	5 (14.3)

7. For how long will you be using the park today?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
< 1 hour	25 (30.9)	11 (23.9)	14 (40.0)
1 to 2 hours	26 (32.1)	17 (37.0)	9 (25.7)
2 to 3 hours	14 (17.3)	12 (26.1)	2 (5.7)
> 3 hours	11 (13.6)	6 (13.0)	5 (14.3)
Overnight camping	5 (6.2)	0	5 (14.3)

8. What kind of a group are you with?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
By myself	1 (1.2)	1 (2.2)	0
With family	50 (61.7)	31 (67.4)	19 (54.3)
With friends	27 (33.3)	13 (28.3)	14 (40.0)
With family and friends	2 (2.5)	1 (2.2)	1 (2.9)
With an organized group	1 (1.2)	0	1 (2.9)

9. How often have you used trails this summer in this park/conservation area?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
0	51 (63.0)	27 (58.7)	24 (68.6)
1	10 (12.3)	4 (8.7)	6 (17.1)
2-3	11 (13.6)	8 (17.4)	3 (8.6)
>3	9 (11.1)	7 (15.2)	2 (5.7)

10. How often have you used trails this summer in other parks and conservation areas?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Less than once a month	30 (37.0)	16 (34.8)	14 (40.0)
Once or twice a month	36 (44.4)	22 (47.8)	14 (40.0)
Once or twice a week	13 (16.0)	7 (15.2)	6 (17.1)
3 or more times a week	2 (2.5)	1 (2.2)	1 (2.9)

11. How important are each of the following reasons for your visit today: to enjoy the natural setting?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	1 (1.2)	1 (2.2)	0
Slightly important	3 (3.7)	2 (4.3)	1 (2.9)
Fairly important	13 (16.0)	5 (10.9)	8 (22.9)
Very important	34 (79.0)	38 (82.6)	26 (74.3)
Not sure	0	0	0

12. How important are each of the following reasons for your visit today: to learn about nature?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	9 (11.1)	8 (17.4)	1 (2.9)
Slightly important	23 (28.4)	12 (26.1)	11 (31.4)
Fairly important	27 (33.3)	15 (32.6)	12 (34.3)
Very important	21 (25.9)	10 (21.7)	11 (31.4)
Not sure	1 (1.2)	1(2.2)	0

13. How important are each of the following reasons for your visit today: for the challenge/adventure?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	23 (28.4)	15 (32.6)	8 (22.9)
Slightly important	22 (27.2)	9 (19.6)	13 (37.1)
Fairly important	22 (27.2)	12 (26.1)	10 (28.6)
Very important	12 (14.8)	9 (19.6)	3 (8.6)
Not sure	2 (2.5)	1 (2.2)	1 (2.9)

14. How important are each of the following reasons for your visit today: for exercise?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	8 (9.9)	3 (6.5)	5 (14.3)
Slightly important	14 (17.3)	4 (8.7)	10 (28.6)
Fairly important	27 (33.3)	14 (30.4)	13 (37.1)
Very important	32 (39.5)	25 (54.3)	7 (20.0)
Not sure	0	0	0

15. How important are each of the following reasons for your visit today: to get away from people or seek solitude?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	19 (23.5)	8 (17.4)	11 (31.4)
Slightly important	7 (8.6)	3 (6.5)	4 (11.4)
Fairly important	13 (16.0)	6 (13.0)	7 (20.0)
Very important	42 (51.9)	29 (63.0)	13 (37.1)
Not sure	0	0	0

16. How important are each of the following reasons for your visit today: to be with friends / family?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	5 (6.2)	0	5 (14.3)
Slightly important	3 (3.7)	3 (6.5)	0
Fairly important	10 (12.3)	2 (4.3)	8 (22.9)
Very important	63 (77.8)	41 (89.1)	22 (62.9)
Not sure	0	0	0

17. How important are each of the following reasons for your visit today: to relax / reduce built up tension?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	0	0	0
Slightly important	3 (3.7)	2 (4.3)	1 (2.9)
Fairly important	17 (21.0)	9 (19.6)	8 (22.9)
Very important	61 (75.3)	35 (76.1)	26 (74.3)
Not sure	0	0	0

18. Percentage of respondents who ranked each reason FIRST over all others:

	Overall (n=79)	Belfountain (n=46)	Presqu'ile (n=33)
To enjoy the natural setting	25 (31.6)	13 (28.3)	12 (36.4)
To learn about nature	1 (1.3)	0	1 (3.0)
For the challenge / adventure	0	0	0
For exercise	3 (3.8)	1 (2.2)	2 (6.1)
To get away from people / seek solitude	8 (10.1)	6 (13.0)	2 (6.1)
To be with friends / family	26 (32.9)	18 (39.1)	8 (24.2)
To relax and reduce built up tension	16 (20.3)	8 (17.4)	8 (24.2)

19. Percentage of respondents who ranked each reason in the TOP THREE over the others:

	Overall (n=79)	Belfountain (n=46)	Presqu'ile (n=33)
To enjoy the natural setting	64 (81.0)	38 (82.6)	26 (78.8)
To learn about nature	14 (17.7)	5 (10.9)	9 (27.3)
For the challenge / adventure	4 (5.1)	3 (6.5)	1 (3.0)
For exercise	17 (21.5)	13 (28.3)	4 (12.1)
To get away from people / seek solitude	27 (34.2)	19 (41.3)	8 (24.2)
To be with friends / family	57 (72.2)	33 (71.7)	24 (72.7)
To relax and reduce built up tension	49 (62.0)	26 (56.5)	23 (69.7)

20. Between these surfaces, do you like any one more than the others? Percentage of respondents who ranked each surface FIRST over all others:

	Belfountain (n=42)	Presqu'ile (n=33)
Bare earth	18 (42.9)	14 (43.8)
Wood chips	16 (38.1)	12 (37.5)
Gravel screenings	7 (16.7)	0
Boardwalk	Not present	6 (18.8)
Concrete	1 (2.4)	Not present

21. Between these surfaces, do you like any one more than the others? Percentage of respondents who ranked each surface FIRST OR SECOND over all others:

	Belfountain (n=41)	Presqu'ile (n=33)
Bare earth	21 (51.2)	15 (45.5)
Wood chips	20 (48.8)	22 (66.7)
Gravel screenings	12 (29.3)	1 (3.0)
Boardwalk	Not present	13 (39.4)
Concrete	1 (2.5)	Not present

22. On a scale of 1 to 10, how would you rank your preference for the following properties of trail surfaces: smooth (1) or rough (10)?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Smooth (1-2)	10 (12.3)	5 (10.9)	5 (14.3)
Somewhat smooth (3-4)	14 (17.3)	7 (15.2)	7 (20.0)
Neutral (5)	20 (24.7)	14 (30.4)	6 (17.1)
Somewhat rough (6-8)	30 (37.0)	17 (37.0)	16 (37.1)
Rough (9-10)	7 (8.6)	3 (6.5)	3 (11.4)

23. On a scale of 1 to 10, how would you rank your preference for the following properties of trail surfaces: firm (1) or soft (10)?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Firm (1-2)	15 (18.5)	9 (19.6)	6 (17.1)
Somewhat firm (3-4)	15 (18.5)	10 (21.7)	5 (14.3)
Neutral (5)	19 (23.5)	14 (30.4)	5 (14.3)
Somewhat soft (6-8)	29 (35.8)	13 (28.3)	16 (45.7)
Soft (9-10)	3 (3.7)	0	3 (8.6)

24. On a scale of 1 to 10, how would you rank your preference for the following properties of trail surfaces: developed (1) or primitive (10)?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Developed (1-2)	3 (3.7)	3 (6.5)	0
Somewhat developed (3-4)	9 (11.1)	6 (13.0)	3 (8.6)
Neutral (5)	17 (21.0)	8 (17.4)	9 (25.7)
Somewhat primitive (6-8)	37 (45.7)	18 (39.1)	19 (54.3)
Primitive (9-10)	15 (18.5)	11 (23.9)	4 (11.4)

25. On a scale of 1 to 10, how would you rank your preference for the following properties of trail surfaces: even (1) or uneven (10)?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Even (1-2)	5 (6.2)	3 (6.5)	2 (5.7)
Somewhat even (3-4)	15 (18.5)	7 (15.2)	8 (22.9)
Neutral (5)	19 (23.5)	10 (21.7)	9 (25.7)
Somewhat uneven (6-8)	30 (37.0)	18 (39.1)	12 (34.3)
Uneven (9-10)	12 (14.8)	8 (17.4)	4 (11.4)

26. How would you rank the surface of the trails in terms of how natural they appear to you? (Respondent's ranking of each surface against the others from 1 to 7) (BELFOUNTAIN):

	Median Ranking
Concrete steps	7
Inset flat stones	6
Wood chips	3
Bare earth	1
Wood planks	4
Boardwalk	5
Gravel screenings	3

27. How would you rank the surface of the trails in terms of how natural they appear to you? (Respondent's ranking of each surface against the others from 1 to 6) (PRESQUI'LE):

	Median Ranking
Asphalt	6
Wood chips	2
Bare earth	1
Boardwalk	5
Gravel	5
Sand	3

28. How would you rank the surfaces in terms of which ones you would enjoy walking on the most? (Respondent's ranking of each surface against the others from 1 to 7) (BELFOUNTAIN):

	Median Ranking
Concrete steps	6
Inset flat stones	6
Wood chips	3
Bare earth	2.5
Wood planks	4
Boardwalk	3
Gravel screenings	2

29. How would you rank the surfaces in terms of which ones you would enjoy walking on the most? (Respondent's ranking of each surface against the others from 1 to 6) (PRESQU'ILE):

	Median Ranking
Asphalt	6
Wood chips	2
Bare earth	1
Boardwalk	3
Gravel	5
Sand	4

30. How would you rank the surfaces in terms of which ones you would enjoy walking on the most? (Percentage of respondents ranking each surface within the TOP 3) (BELFOUNTAIN, n=45):

	Ranked First	Ranked First or Second	Ranked in Top 3
Concrete steps	0	1 (2.2)	3 (6.7)
Inset flat stones	4 (8.9)	4 (8.9)	8 (17.8)
Wood chips	11 (24.4)	20 (44.4)	30 (64.4)
Bare earth	17 (39.1)	22 (48.9)	26 (57.8)
Wood planks	1 (2.2)	11 (24.4)	17 (37.8)
Boardwalk	4 (8.9)	8 (17.8)	19 (51.1)
Gravel screenings	8 (17.8)	24 (53.3)	29 (64.4)

31. How would you rank the surfaces in terms of which ones you would enjoy walking on the most? (Percentage of respondents ranking each surface within the TOP 3) (PRESQU'ILE, n=35):

	Ranked First	Ranked First or Second	Ranked in Top 3
Asphalt	0	1 (2.9)	1 (2.9)
Wood chips	7 (20.0)	19 (54.3)	27 (77.1)
Bare earth	23 (65.7)	31 (88.6)	34 (97.1)
Boardwalk	4 (11.4)	14 (40.0)	25 (71.4)
Gravel	1 (2.9)	2 (5.7)	6 (17.1)
Sand	0	3 (8.6)	12 (34.3)

32. How would the following trail problems affect the enjoyment of your activity today: dusty sections?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	33 (40.7)	20 (43.5)	13 (37.1)
Would notice, wouldn't detract	14 (17.3)	8 (17.4)	6 (17.1)
Detract slightly	17 (21.0)	9 (19.6)	8 (22.9)
Detract moderately	8 (9.9)	4 (8.7)	4 (11.4)
Detract significantly	9 (11.1)	5 (10.9)	4 (11.4)
Not sure	0	0	0

33. How would the following trail problems affect the enjoyment of your activity today: muddy sections?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	8 (9.9)	4 (8.7)	4 (11.4)
Would notice, wouldn't detract	21 (25.9)	16 (34.8)	5 (14.3)
Detract slightly	17 (21.0)	6 (13.0)	11 (31.4)
Detract moderately	15 (18.5)	7 (15.2)	8 (22.9
Detract significantly	20 (24.7)	13 (28.3)	7 (20.0)
Not sure	0	0	0

34. How would the following trail problems affect the enjoyment of your activity today: rocky sections?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	25 (30.9)	14 (30.4)	11 (31.4)
Would notice, wouldn't detract	27 (33.3)	17 (37.0)	10 (28.6)
Detract slightly	20 (24.7)	8 (17.4)	12 (34.3)
Detract moderately	4 (4.9)	3 (6.5)	1 (2.9)
Detract significantly	5 (6.2)	4 (8.7)	1 (2.9)
Not sure	0	0	0

35. How would the following trail problems affect the enjoyment of your activity today: sections with water crossing the trail?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	15 (18.5)	12 (26.1)	3 (8.6)
Would notice, wouldn't detract	33 (40.7)	14 (30.4)	19 (54.3)
Detract slightly	12 (14.8)	7 (15.2)	5 (14.3)
Detract moderately	12 (14.8)	7 (15.2)	5 (14.3)
Detract significantly	9 (11.1)	6 (13.0)	3 (8.6)
Not sure	0	0	0

36. How would the following trail problems affect the enjoyment of your activity today: sections with a loose surface?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	22 (27.2)	14 (30.4)	8 (22.9)
Would notice, wouldn't detract	26 (32.1)	15 (32.6)	11 (31.4)
Detract slightly	24 (29.6)	10 (21.7)	14 (40.0)
Detract moderately	7 (8.6)	5 (10.9)	2 (5.7)
Detract significantly	2 (2.5)	2 (4.3)	0
Not sure	0	0	0

37. How would the following trail problems affect the enjoyment of your activity today: sections with several parallel trails?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	24 (29.6)	19 (41.3)	5 (14.3)
Would notice, wouldn't detract	27 (33.3)	11 (23.9)	16 (45.7)
Detract slightly	19 (23.5)	10 (21.7)	9 (25.7)
Detract moderately	7 (8.6)	4 (8.7)	3 (8.6)
Detract significantly	2 (2.5)	1 (2.2)	1 (2.9)
Not sure	2 (2.5)	1 (2.2)	1 (2.9)

38. How would the following trail problems affect the enjoyment of your activity today: sections where the trail is widened?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Wouldn't notice, wouldn't detract	(26) 32.1	13 (28.3)	13 (37.1)
Would notice, wouldn't detract	37 (45.7)	22 (7.8)	15 (42.9)
Detract slightly	11 (13.6)	7 (15.2)	4 (11.4)
Detract moderately	3 (3.7)	3 (6.5)	0
Detract significantly	3 (3.7)	1 (2.2)	2 (5.7)
Not sure	1 (1.2)	0	1 (2.9)

39. Percentage of respondents who ranked each problem FIRST over all others:

	Overall (n=69)	Belfountain (n=38)	Presqu'ile (n=31)
Dusty sections	8 (11.6)	5 (13.2)	3 (9.7)
Muddy sections	33 (47.8)	15 (39.5)	18 (58.1)
Rocky sections	2 (2.9)	2 (5.3)	0
Sections with water crossing the trail	6 (8.7)	3 (7.9)	3 (9.7)
Sections with a loose surface	6 (8.7)	5 (13.2)	1 (3.2)
Sections with several parallel trails	9 (13.0)	5 (13.2)	4 (12.9)
Sections where the trail is widened	5 (7.2)	3 (7.9)	2 (6.5)

40. Percentage of respondents who ranked each problem in the TOP 3 over all others:

	Overall (n=69)	Belfountain (n=38)	Presqu'ile (n=31)
Dusty sections	26 (37.7)	12 (31.6)	14 (45.2)
Muddy sections	52 (75.4)	28 (73.7)	24 (77.4)
Rocky sections	19 (27.5)	12 (31.6)	7 (22.6)
Sections with water crossing the trail	30 (34.5)	16 (42.1)	14 (45.2)
Sections with a loose surface	18 (26.1)	9 (23.7)	9 (29.0)
Sections with several parallel trails	19 (27.5)	13 (34.2)	6 (19.4)
Sections where the trail is widened	14 (20.3)	11 (28.9)	3 (9.7)

41. How important is the type of trail surface to the enjoyment of your activity today?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not important	23 (28.8)	11 (24.4)	12 (34.3)
Slightly important	20 (25.0)	11 (24.4)	9 (25.7)
Somewhat important	29 (36.3)	17 (37.8)	12 (34.3)
Very important	8 (10)	6 (13.3)	2 (5.7)
Not sure	0	0	0

42. How effective do you think surfacing is in reducing the impact of trail users on the natural environment, such as the soil or vegetation?

	Overall (n=81)	Belfountain (n=46)	Presqu'ile (n=35)
Not effective	3 (3.8)	3 (6.7)	0
Slightly effective	4 (5.0)	2 (4.4)	2 (5.7)
Somewhat effective	31 (38.8)	19 (42.2)	12 (34.3)
Very effective	39 (48.8)	20 (44.4)	19 (54.3)
Not sure	3 (3.8)	1 (2.2)	2 (5.7)

APPENDIX E: TRAIL MANAGER SURVEY

TYPES OF SURFACING MATERIALS USED:

1. Please list the types of surfacing materials used on the trails for which you are responsible. The balance of the questions in this survey will refer to the letters (A through E) as recorded here:

Type of Material (e.g. ¼" crushed limestone with fines)	***Approx. Length of Trail***
A:	
B:	
C:	
D:	
E:	

SITE CONDITIONS:

2. In what environments do you use each of the surfacing types?
(e.g., soil types, vegetation communities, slope gradient, presence of water, etc.)
A: ____
____
B:____
____
C: ____
____
D: ____
____
E: ____
____

3. What user types are the trails of each surface designed for? (Please check appropriate boxes)

Surface type	***Hikers***	***Casual walkers***	***Cyclists***	***Horseback riders***	***People using Mobility Aids***	***Other (specify):***
A						
B						
C						
D						
E						

4. Please check the box that best describes the level of use on each surface during peak periods.

Level of Use	**A**	**B**	**C**	**D**	**E**
Very Low (less than 25 people per day)					
Low (25 to 100 people per day)					
Moderate (100 to 300 people per day)					
Heavy (300 to 500 people per day)					
Very Heavy (over 500 people per day)					

PERFORMANCE OF MATERIAL:

5. Please identify any problems and critical factors you may have experienced with the surface types used on your trails (e.g., dusty sections, muddy sections, sections with a loose surface, sections with several parallel trails, or sections where the trail is excessively widened)?

   A: ____

   ____

   ____

   B:____

   ____

   ____

   C: ____

   ____

   ____

   D: ____

   ____

   ____

   E: ____

   ____

6. What kinds of maintenance are undertaken on each surface type and how often are these activities carried out?

   A: ____

   ____

   ____

   B: ____

   ____

   ____

   C: ____

   ____

   ____

   D: ____

   ____

   E: ____

   ____

7. What is the cost of constructing and/or maintaining the path?
If possible, some breakdown of costs in terms of material in bulk, labour costs, transportation and equipment costs would be valuable.
Any information or examples you could provide would be very helpful!

A: ____
____
____
____

B: ____
____
____
____

C: ____
____
____
____

D: ____
____
____
____

E: ____
____
____

8. Why was the material chosen? Please **RANK IN ORDER OF IMPORTANCE** (1 - most important) or mark N/A if the reason was not a consideration in material selection.

Surface	**Site Constraints**	**Availability**	**Cost**	**Suitability for User Requirements**	**Ease of Maintenance**	**Used Successfully in the Past**	**Need for Occasional Vehicular Access**	**Other (please specify):**
A								
B								
C								
D								
E								

9. Have you had any complaints from trail users about the surface of the trails? If yes, please explain.
A: ______________________________
B: ______________________________
C: ______________________________
D: ______________________________
E: ______________________________

10. How effective do you think each surface is in reducing the impact of trail users on the natural environment, such as the soil or vegetation? (check appropriate box).

Surface	**Not effective**	**Slightly effective**	**Somewhat effective**	**Very effective**	**Not sure**	**Comments**
A						
B						
C						
D						
E						

11. Please comment on any positive and negative experiences you have had with each surface.

A: ______________________________
____
____
B: ______________________________
____
____
C: ______________________________
____
____
D: ______________________________
____
____
E: ______________________________
____
____

12. Can you recommend any reference material which you refer to for information on trail design, construction and maintenance? Any further information you can provide would be of great assistance.

____

____

____

Thank you for your time and effort in completing this survey. Your answers will help to develop a better understanding of the social, environmental and economic aspects of trail surfacing decisions.

OPTIONAL INFORMATION:

Name of Person completing survey: ______________________________
Position: ______________________________
Organization: ______________________________
Telephone: ______________________________

If you would like to receive a summary of the findings from this survey, please fill in your mailing address here:

____
____
____
____

Can I contact you to discuss your experiences in more detail, if necessary?

O **Yes**, that is fine O **No**, I'd rather not

Please send completed surveys to:

Andrew Giles
Department of Geography, Faculty of Environmental Studies
University of Waterloo
200 University Avenue West
Waterloo, ON, Canada
N2L 3G1

Or by fax to: **(519) 746-0658**

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