Impacts of non-motorized trail use

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SUMMARY

This is a Summary of a Much Larger Work Available from the Author that is a short course companion manual - 311pp.

The key types of impacts, that are discussed, in the published, peer-reviewed scientific literature, fall into two categories and five broad sections:

Environmental Impacts	Impacts to People and Society
· Physical Impacts to Trails	· Social Impacts
· Vegetative Impacts	· Economic Impacts
· Ecological Impacts	

NATURAL DEGRADATION OF TRAILS

Deterioration of the physical structure of trails results from both natural processes and the forces exerted by trail users. Some studies indicate that natural degradation erodes trails more than trail users. The opposite is also sometimes true: User-caused erosion can exceed natural processes where use is heavy or soils are particularly weak.

Empirical studies have looked at natural degradation processes throughout the globe. Leung and Marion (1996) in their literature review looked at these various studies and found that a trail surface's susceptibility to erosion depends on the soil texture, trail width, dead vegetation width, the amount of vegetation cover relative to bare area, the slope angle and climate.

To understand the effect of these natural processes we first have to look at the trail surface, its composition and its genesis. Trail surfaces are primarily soils, geologic deposits and rock.

Horton, (1997) strictly defines soils, deposits and rock in the following way:

- A soil as a material that is formed in place from material in place by chemical or physical processes of weathering or by the deposition and decomposition of organic material.
- A geologic deposit is an accumulation of sediment that has been transported and deposited at a particular location by the action of water, ice or wind.
- Rock is any material that is of a competent nature.

The properties that keep a material together (i.e. resist stress generated by gravity) are collectively known as shear strength. Shear strength is a critical factor in the resistance of a trail surface to human travel-generated forces. In order for a soil or deposit to erode or experience mass transport, the forces acting on the deposit must exceed the shear strength of the material. The forces that work against shear strength are known as shear stress. When the shear stress exerted exceeds the shear strength material, starts to move.

Factors that affect the shear strength of a deposit, soil and rock are smoothness and shape of the grains of the strata (how they interlock), moisture content, mineralogy and the degree of compression, compaction and cementation. These factors affect the properties of internal friction, effective normal stress, and cohesion, which altogether determine the shear strength of a material.

The main processes of natural degradation are erosion and mass transport. The primary processes of erosion are the actions of water, wind and ice on the soil. In the case of mass transport the main culprit is gravity and results in soil creep, landslides or mudflows.

For trails, the processes of most concern are those relating to water movement across the soil surface, particularly splash, wash, and gully erosion. In splash erosion the impact of raindrops mobilizes the surface of the trail. Each raindrop can dislodge a grain of sediment or soil that is three to four times the drop's mass. Ellison, 1947, found that the impact of raindrops on bare soil can mobilize 3,600 tons per hectare of sandy soil in a five-year period. Wash is the action of water flowing smoothly as a sheet across the surface of the trail and removing the dislodged particles.

According to Horton (1997) gully erosion is the process whereby water accumulates in narrow channels and, over short periods of time, removes soil from this narrow area to considerable depths, ranging from 1 - 2 feet (0.3 - 0.6 meters) to as much as 75 - 100 feet (23 - 31 meters). In this type of erosion, the water flow is turbulent and has the ability to remove large amounts of material with small volumes of water.

Steepness is a critical factor in any trail's erosion. Steep trails erode more quickly because when water accelerates its erosive power increases exponentially. In other words, if water speed increases five-fold, the erosive power increases not by five, but by 25.

HUMAN USE IMPACTS ON TRAILS

A clear distinction must be made, however, as the transmission of the compactive and shearing forces is very different for wheels than of feet and hooves. Soane et al. (1981), identified the types of forces exerted on soils surfaces by wheels. Of those that apply to mountain bicycling the most important are the downwards compaction force due to dynamic load on the wheel and the rotational shearing stress from the wheel torque acting around the wheel's axis. Due to the low wheel torque of mountain bicycle this force is negligible in comparison to motorized vehicles.

With the bicycle, the vertical force is a combination of the weight of the rider, the weight of the bicycle, and any downward force caused by the motion of the bike. This vertical force is applied to the trail surface through a small contact patch of tire rubber. This patch varies in size according to inflation pressure and total vertical force. When loaded, such a tire will conform to the trail surface until the loading force divided by the tire's contact area (with the trail surface) equals the inflation pressure of the pneumatic tire. The result is the pressure is equal to the tire's inflation pressure, 35 to 50 psi. In contrast, Cole (1987) found that the instantaneous contact pressure of a human foot can exceed 1200 psi.

This explanation assumes the ideal tire with a smooth surface. Real mountain bicycle tires are knobby and to the extent that the tire sits on knobs, the soil contact pressure increases. In harder soils, tires will sit more on the knobs; in softer soils, pressure will distribute more evenly over the entire surface of the tire. We are unaware of any studies that have actual soil contact pressures.

> Further Cessford (1995) asserts that:
> *Mountain bikes will exert downward force through their tires, although the "mean ground contact pressure", which comprises the wheel load divided by the contact area (Soane et al. 1981, Smith and Dickson 1990), is likely to be less than that of heavier motorized vehicles, horses and heavily laden hikers. Weaver and Dale (1978) noted that motorcycles had least impact on downhill slopes, due to exerting lesser downward forces than hikers or horses. With the lower wheel loadings of mountain bikes, their impacts upon downhill slopes are likely to be much less than those from motorbikes.*

The horizontal force is the power applied from pedals, through the drive train, into the rear wheel. Horizontal force is also exerted when the rider squeezes the brakes and transmits this force through both wheels. We estimate, based on an analysis of the effective drive train force, that the lateral force of a bicycle wheel is roughly ten percent of vertical force.

When it comes to foot travel, Quinn et al. (1980) noted that damage from feet was caused first by the downward compaction forces from the heel early in the step, and then from rotational shearing forces from the toe at the end. The shearing action was found to be most important, particularly through soil deformation and "smearing" in wet conditions, and was found to be greatest on up-slope travel. These forces will also cause the impacts to vegetation through trampling.

Weaver and Dale (1978) and Weaver et al. (1979), that during down slope travel, found that downhill stepping (by foot and hoof) was more erosive than downhill motor biking. This was due to the greater downward forces exerted through the heels in down stepping. In an earlier work Bayfield (1973) observed that although 20 percent fewer steps were taken downhill than uphill, the erosive impacts of downhill stepping was still higher.

Repeated passes by bicycles (and most other users) on level ground tend to compress the soils of a trail tread. Vertical compression tends to push particles closer together, thereby increasing shear strength. An increase in the shear strength of the soil means it will have greater ability to resist erosive forces. Thus, trails may erode significantly when young, and then stabilize.

Nevertheless, these compactive forces may create an adverse impact when they occur on soils that cannot withstand compactive forces. Weak soils include hydrated clays that deform easily, loose sands that resist compaction, and organic soils found in wet areas, which over-compact and become susceptible to break down and disintegration, such as the soils of bogs and muskeg.

The effects of these compactive forces can be seen in further detail in Smith and Dickson, 1990, Soane, Blackwell, Dickson, and Painter, 1981 and Ritter, 1978.

Lateral force exerted during acceleration and braking has more significance for trail degradation because it breaks particles apart, lowering shear strength. When lateral forces overcome the shear strength of the soil, spinning out occurs during acceleration and skidding during braking, resulting in the mobilization of soil material.

During acceleration, the lateral forces and consequent erosion occur only through the rear tire. In braking, both tires will cause erosion.

EMPIRICAL TRAIL IMPACT STUDIES

Bjorkman, 1996, conducted tests of the impacts of mountain bicycles in areas of glacial and periglacial terrain in Wisconsin, USA. His findings indicated that wear resistance of trails was highest in areas were the soil was higher in silt content and decreased as the soil had a higher sand content. This is primarily due to a higher grain-to-grain cohesion in smaller grain-sized sediments. This study looked only at bicycles.

Since the advent of the mountain bicycle in the mid-1970s, only one study has been conducted to compare the impacts of bicycles and other travel modes on the physical structure of trails. This was the study conducted by Joseph Seney and published in 1990. Seney, 1990, and Seney and Wilson, 1990.

Seney measured the erosive effects of mountain bicycles, hikers, horses, and motorbikes. His results could not effectively distinguish the impacts of hikers and cyclists. Users in his study caused less erosion than natural processes. Seney observed significant erosion to trails when used by horses and by motorcycles, particularly when they traveled uphill or on a wet trail.

This one study used sound methods involving control, minimizing variables, and careful measurements. But the study used only 100 passes by trail users and it occurred in only one locale, western Montana. More thorough study is needed before conclusive judgments can be made about the relative trail erosion impacts of different users.

ANALYSIS OF PHYSICAL IMPACTS

> Cessford, 1995a, in a literature review and analysis, concluded: *Research to date has indicated that the degree of impacts from mountain bikes, relative to those of walkers who have their own unique forms of impacts, appear to be similar. The general consensus drawn from studies comparing activity impacts was that [erosional] impact was greater on slopes than on level sites; on wet rather than dry surfaces; and that it tended to be greatest for hikers and horses moving down slope, and motorbikes moving upslope. Mountain bikes were not included in these comparisons, but like motorbikes they would tend to roll downhill except when over-braking, and lacking the power to the wheels, generate far fewer gouging impacts from wheel-spin on up hills.*

The lower weight of mountain bikes would also suggest that their impacts are much less than those of motorbikes.

This does assume that the wheels continue to turn rather than skidding with hard braking. Such skidding can loosen track surfaces and move material. However, where skidding does not occur, impacts from the normal rolling effects of wheels appear to be less than those of footsteps.

Where a trail is constructed or laid on a hard surface such as rock, bicyclists have negligible physical impact because of the high shear strength of the material. An example of such a trail is the Slickrock Trail of Moab, Utah.

ECOLOGICAL IMPACTS

The ecological impacts of non-motorized recreation occur in three broad realms: impacts to terrestrial vegetation, aquatic impacts, and impacts to wildlife and ecosystems. Very little research has addressed the impacts of mountain bikes to any of these systems, and none has compared mountain bikes to other trail users. This paper attempts to make some educated guesses. These hypotheses need much more investigation.

VEGETATIVE IMPACTS

Trampling

The Webster's Ninth Collegiate Dictionary (1983) defines trampling as "to tread heavily so as to bruise, crush, or injure." In the study of environmental impacts trampling commonly refers to the process of destroying flora by the passage of feet, hooves and wheels.

In normal system trail use, trampling of vegetation is a minor factor. Trails facilitate travel in part because of their minimal vegetation and bare ground. Bicycles generally remain on trails, in contrast to hikers and equestrians.

When users walk or ride cross-country or on non-system a path, trampling usually occurs. The ability of flora to resist these forces is species dependent, according to Cessford (1995). With repeated travel, the compaction and shearing forces exerted by travelers will eventually overwhelm a linear corridor of plants and a new pathway will form. These user-created, unplanned trails may cause ecological problems.

Common belief holds that wheeled vehicles cause new trails to form more readily than the actions of feet and hooves, thus justifying the allowance of off-trail travel by hikers and equestrians. Yet, erosion studies cited above, particularly Weaver and Dale (1978), Weaver et al. (1979), Quinn et al (1980), Soane et al. (1981), and Cole, (1987), suggest that in many places, feet and hooves will trample more than bicycle tires. The instantaneous sheer forces exerted on a plant by a foot or a hoof will have much more of a tearing effect than the rolling over and crushing force of a bicycle wheel.

The primary issue regarding vegetative trampling by bicycles is the locomotive force, particularly when their wheels spin. In the case the motorized vehicles, the torque applied to the wheel can exceed the strength of the plant material, thereby ripping it. As noted above, bicycles have much lower torque and weight than motorized vehicles. Even if bicycles cause less trampling than other travel modes, the vertical pressure and lateral sheer of bicycles can harm sensitive plants.

Trampling occurs primarily in campsites. This is of concern as it alters soil biota, destroys the humus components of soils and destroys the productivity in these areas.

Non-native species

Recreationists may introduce non-native species, which then disrupt the native ecological balances.

Recreationists can introduce parasitic and exotic species by:

- The importation of firewood (as happened with the Dutch Elm disease);
- Use of contaminated feed for pack stock; (Weed introduction is exemplified by the infestations in the Lake Louise area of Banff National Park, Alberta, Canada.)
- Lack of cleanliness. (A muddy bicycle, hiking boots and clothing can have non-native species seed and spores present in the transported soil.)

AQUATIC IMPACTS

The impacts to aquatic ecosystems by trail-based recreation include:

- Siltation;
- Biologic loading; and
- Introduction of non-native and parasitic species.

Siltation

Siltation in streams and rivers is largely the result of bank erosion. The largest recreational culprits are the wakes of motorized watercraft that erode unconsolidated sediments.

There are examples where significant trail erosion has caused acute siltation impacts. In the mid-1990s, managers of the Tahuya State Forest in Washington state realized that an old system of trails, heavily used by motorcycles and bicycles, was introducing silt into spawning habitat for endangered anadromous fish. They isolated the problem to the stream crossings. Scientists from the state Department of Natural Resources, aided by local high school students, measured and analyzed the problem and experimented with erosion control measures. The results provide some of the best scientific data on trail erosion and excellent information on trail design and tread hardening. They found that, given sufficient commitment and resources, trails can be constructed in a manner that will not cause sedimentation at stream crossings. However, absent commitment and resources, serious water pollution problems can occur at crossings.

The siltation impacts of stream crossings occur with or without use by trail travelers, as much of the erosion is caused by the splash and gully erosional forces noted in Section II, Natural Degradation.

Biological Loading

Recreational impacts resulting in biologic loading are largely due to trail users practicing inappropriate excreta disposal. This excreta acts as fertilizer and will affect the flora and fauna in surface waters. The normal measurable effect is a reduction in the total dissolved oxygen and elevated nitrate and phosphate concentrations in the aquatic environment. These changes in the chemical composition of the water result in changes in the ecosystem species balance, and may manifest as algae blooms.

The amount of excreta produced by user groups is a function of user type and residence time of the user in the area. We can hypothesize that equestrians produce the most by mass; then hikers, who have a longer residence time; and finally the mountain bicyclists who have the shortest residence time and therefore are less likely to need to void.

Non-native species

The introductions of non-native and parasitic species to aquatic ecosystems by non-motorized trail use are usually the result of poor hygiene practices. *Giardia sp.* and *Cryptosporidium parvum* are classic examples of an introduction of both non-native and parasitic species. Until the 1970's theses organism were unknown in the Canadian Rockies. It was not until the increase in tourism from Asia and Europe that *Giardia sp*. was introduced from the Eurasian landmass to North America. Since then it has contaminated water supplies and infected all manner of mammalian species. This has serious cost to society and to the ecology of an area. *Giardia sp*. infestations have resulted in the need to construct expensive water treatment facilities and decreased the resistance to disease of wild mammalian populations because of the weakening of individuals due to the infection. In the mid 1990's an outbreak of Cryptosporidium related diseases -- attributed to farm run-off, not recreation -- contaminated the water supplies of Milwaukee resulted in the deaths of over 200 people.

WILDLIFE IMPACTS

None of the summer, muscle-powered recreational styles (horseback riding, hiking and mountain bicycling) have been studied rigorously with regard to how they impact wildlife. However, hypotheses may be crafted based upon other studies on the overall effect of humans on wildlife.

Recreational impacts (disturbance) to wildlife are dependent upon a number of different factors that include:

- Wildlife responses, particular to species, to disturbance;
- The sensitivity of different species to disturbance;
- Factors that determine sensitivity to disturbance;
- Environment - cover & escape terrain present in the animals habitat; and
- Type of recreational activity.

Wildlife Responses

Normal responses to disturbance are of two classes. The first is the passive response where the animal feigns death by freezing and hiding, resulting in a lowering of the animal's metabolic rate. This is well documented for most small mammalian species and white-tailed deer. The second response class is the active response, where fight and flight are typified. According to Heuer, 1997 and outlined in Gabrielsen and Smith, 1995, physiologically these two responses are exemplified by the following:

> *The active response is typified by increased blood flow, heart rate, metabolism, respiration rate, and brain and heart blood flow. The passive defence response decreases activity with the intent of avoiding detection; sound, movement, even breathing levels subsides as the body physiologically shuts down.*

Sensitivity Factors

As outlined in Heuer, 1997, the following factors will determine how an animal will react to disturbance by human activity: These include:

- Species
- Time of Day
- Season
- Biological Rhythms
- Age of the Animal
- Previous Experience
- Groups Size
- Social Structure
- Cover & Escape Terrain.

Disturbing Activity Characteristics

The characteristics of the human mode of travel in natural areas will also have influence upon how an animal will react to disturbance. Factors that are most important are the predictability and habituation to travel mode, habituation to the recreationist, noise generated by the recreationist (therefore detectability), and direction of travel relative to the animal and finally the duration of the disturbance.

TABLE 1: HYPOTHETICAL VARIATION IN THE RELATIVE IMPACT OF NON-MOTORIZED TRAIL USER GROUPS ON WILDLIFE
(+ denotes least impact, +++ greatest impact)

Activity	Predictability & Habituation	Noise & Detectability	Directionality	Duration & Residence Time
Horseback	+	+	++	++
Hiking	+++	++	+++	+++
Mountain Bicycling	+	+++	+	+

LINEAR DEVELOPMENTS AND HABITAT FRAGMENTATION

Possibly the most significant recreational impacts to wildlife and ecosystems occur as a result of the existence and use of roads and trails. These effects can occur irrespective of the particular user groups on the routes. The existence impacts relate to fragmentation of habitat, the introduction of non-native species, and the advantages offered to some species that can use roads over other species that cannot.

Landscape

Jalkotzy et al. (1997) in their exhaustive literature review The Effects of Linear Developments on Wildlife: A Review of Selected Scientific Literature prepared for the Canadian Association of Petroleum Producers state that a landscape is a kilometers wide section of land, that when discussing wildlife, is comprised of elements to form what is known as a mosaic. A mosaic .has incorporated into it three major elements:

- **Patch** - a reasonably homogenous non-linear area that differs from its surroundings which could be an oil and gas well site, forestry cut block or a marsh.
- **Corridor** - in general a reasonably similar linear areas that differ from their surroundings which can be termed as disturbance and remnant. Disturbance and development corridors are trails, roads, seismic lines, fence lines, power transmission lines, and hedgerows. Remnant corridors, long, narrow strips of original habitat in an otherwise disturbance-dominated landscape (e.g., roadside verges in an agricultural landscape or forest strips in a logged forest environment).
- **Matrix** - The background ecosystem or land-use type which could be farms or natural forest or prairie.

Development Corridors

When discussing development corridors the effects on wildlife is complex and varied. These effects are the function of both the internal and external structure of the corridor itself. Jalkotzy et al. (1997) state that interior structure is characterized by three elements:

- Width Characteristics - The environmental gradient from one edge to the other.
- Internal Entities - such as roads and ditches.
- Plant And Animal Community Structure

When looking at the external structural elements of a linear corridor and their effect on wildlife there are many factors that must be taken into account with regards to its surrounding matrix. Jalkotzy et al. (1997) felt the most important were:

- The corridor's relationship to its surroundings. This includes the corridor length, patchiness, distribution of attached nodes, adjoining patches or matrix.
- The curvilinearity and width of the corridor which refers to the variability in width, distribution of narrows.
- The connectivity and gaps in the corridor which describes the degree to which an ecosystem is connected or joined together and gap sizes, gap frequency, habitat suitability in and around gaps.

Corridors act in five different ways pertaining to wildlife. Jalkotzy et al. (1997) found that the functioned, dependent on the external and internal structure, as:

- **Habitats** - when they provide wildlife with some requisites for survival such as food or shelter (e.g., grazing habitat for ungulates).
- **Conduits** - when wildlife moves along it (e.g., a wolf traveling along a packed seismic line in winter).
- **Filters or barriers** - when wildlife movements across or along them are hindered or blocked (e.g., roads with high traffic volumes).
- **Sources** - if wildlife living in the corridor spreads out into the surrounding habitat (e.g., mice).
- **Sinks** - if wildlife is attracted to the corridor and die as a result (roads and wildlife-vehicle collisions).

Jalkotzy et al. (1997) also found that these corridors also had six major categories of effects on wildlife, again is dependent on the internal and external structure of the corridor. These categories are:

- **Individual disruption** - the corridor itself or activities associated with the corridor often disturb wildlife resulting in wildlife leaving the corridor area or altering patterns of use, responses that carry with them costs in terms of energy expenditure and possibly lost opportunities.

- **Social disruption** - refers to any changes to the social structure of a population as a result of the disturbance corridor. This disturbance may take several forms such as the displacement of wildlife from the corridor into adjacent habitats that are already occupied by other individuals of the same species, changes in group structure for gregarious species, or differential mortality of classes as a result of the disturbance corridor. Disturbance corridors may remove or provide additional habitat for wildlife.
- **Habitat avoidance** - corridors and activities associated with them may lead to wildlife avoiding habitats close to the corridors. Habitat in the vicinity of the corridor is effectively lost. Fragmentation of the landscape may occur if avoidance of disturbance corridors prevents wildlife from fully using land on either side of a corridor.
- **Habitat disruption or enhancement** - Disruptions include the construction of all types of road or entire road rights-of-way if they are fenced. Enhancements include features for wildlife if new habitat features are created were not present prior to the construction of the corridor.
- **Direct and indirect mortality** - Activities associated with disturbance corridors may result in mortalities. Examples of direct sources of mortality are wildlife-vehicle collisions or powerline strikes and electrocutions. Disturbance corridors may also be important contributors to indirect mortality. Indirect mortality is typically associated with human access. Human access generally leads to additional mortality due to hunting, trapping, poaching, and management actions.
- **Population effects** - Predators such as wolves may benefit from the presence of the disturbance corridor in a similar way. Behavioural responses to disturbance may lead to population effects, typically a reduction in the population. Population effects don't necessarily follow even from significant behavioural responses. Conversely, it is possible that population effects may occur even though no behavioural response to a disturbance was detected. To confirm the presence of a population effect, the demographics of the population must be studied.

HABITAT FRAGMENTATION

Certain species of wildlife, or perhaps even certain individuals in a local population will use a remnant corridor but others may not. The degree of connectivity of a remnant corridor, will often dictate which species and individuals will use it. The degree of movement that this corridor allows is referred to as the corridor's permeability. According to Jalkotzy et al. (1997), when a disturbance corridor has low permeability, then habitats and wildlife populations on either side of the corridor may become functionally separated. These habitats and wildlife populations that are functionally separated are termed to be fragmented. This process is referred to as fragmentation. Succinctly, fragmented landscapes have poor connectivity.

External and internal attributes of disturbance corridors can be altered to reduce their filter or barrier effect whenever possible, corridor width should be minimized. Curvilinearity should be increased where possible. In addition, Roads and trails should be developed and maintained to the minimum standard necessary for their stated purpose. Such low standards deter use, and promote lower bicycle speeds and reduce the likelihood of encounters.

SOCIAL IMPACTS

There are two main types of social impacts from outdoor recreation: user conflict and interference with the goals of non-recreationists. User conflict occurs primarily among recreationists.

Since the late 1980's much work has been conducted in the realm of social conflict between the various user groups on multiple-purpose trails. These groups include mountain bicyclists, hikers, trail runners and equestrians in the non-motorized class of trail users, and motorcyclists, ATV drivers, jeepers, and other motorized users. Conflict that is endemic between these groups is largely due to perceptions of goal interference. The statements of Moore, 1996, summarize this:

> *Trail conflicts can occur among different user groups, among users within the same user group, and as a result of factors not related to trail user activities at all. Conflict has been found to related to activity style, focus of trip, expectations, attitudes toward and perceptions of the environment, level of tolerance for others, and different norms held by different users.*

The conflicts outlined in the above statements are at the core of social impacts of trail use. As mountain bicycling is seen as the new kid on the block it often becomes the target of those who see the activity infringing upon their own view of appropriate behaviour in the backcountry or city park.

RECREATION TRENDS

With increases in human population, shifts in activity levels and an increase in the utilization of recreational resources, competition for recreational facilities and spaces is increasing.

In Edmonton Frost, 1995 stated that trail use has risen from an estimated 2.1 million in 1991 to an estimated 2.8 million in 1995 with individual use becoming more significant. Between 1991 and 1995 user group percentages have changed, with mountain bicycling and roller balding showing the greatest increase The percentage change in activities such as mountain bicycling demonstrates a cultural shift in the use of trails to more active use.

As this cultural shift in activity level and style becomes more pronounced further competition for trail resources will become focused between user groups and within groups.

SOURCES OF SOCIAL CONFLICT AND COMPETITION

Conflict among recreationists occurs when a person experiences a special type of dissatisfaction related to a perceived action or inaction by another person. In the case of conflict on trails, this conflict is defined as "goal interference attributed to another's behaviour" (Jacob and Schreyer 1980, 369; Jacob 1977). Competition is usually the result of vying for a scarce resource. Moore, 1996, distinguishes conflict and competition:

> *For example, when a trail user fails to achieve the experiences desired from the trip and determines that it is due to someone else's behaviour, conflict results and satisfaction suffers. As defined by Jacob and Schreyer (1980), conflict is not the same thing as competition for scarce resources. If people attribute not getting a parking place at a trailhead to their own lack of planning, there is no conflict. If they blame the lack of parking places on horseback riders whom they feel have parked their trucks and trailers inconsiderately (whether or not this is truly the case), conflict will likely result. In both cases, users did not achieve their goals, and dissatisfaction resulted, but only one was due to conflict as defined here.*

Conflict is not an objective state but depends on individual interpretations of past, present, and future contacts with others and is therefore a subjective judgment. Jacob and Schreyer, 1980, theorized that four factors cause conflict in outdoor recreation:

- Activity style - the various personal meanings attached to an activity, intensity of participation, status, range of experience, and definitions of quality;
- Resource specificity - the significance attached to using a specific recreation resource for a given recreation experience;
- Mode of experience - the varying expectations of how the natural environment will be perceived;
- Tolerance for lifestyle diversity - the tendency to accept or reject lifestyles different from one's own.

Competition most often occurs when the carrying capacity of a trail is exceeded, according to Jacobi, 1997. Carrying capacity is a complex idea and it depends on physical, biological, and personal factors. Personal factors are especially relevant when recreationists perceive crowding by a newcomer group, which often becomes the target of hostility.

RESULTS OF CONFLICT

Conflict will change the behaviour of individuals. Kuss et al., 1990 observed three strategies individuals and groups have used to cope with conflict. Each strategy forced a change upon the experience of the individual or group:

- Users re-evaluate the normative definition of what is acceptable (i.e., they adapt and accept the conditions they find);
- Users change their behaviour (e.g., use less frequently, use at off-peak times, etc.);
- Users are displaced altogether (i.e., conditions are unacceptable to them, so they stop the activity or stop visiting that area).

ECONOMIC IMPACTS

The economic impacts of an activity are those that affect the material and social wealth of a society. When a community expends resources to manage the economic growth and impacts these expenditures fall into two broad categories:

- Wealth sustaining expenditures; and
- Wealth creating expenditures.

These expenditures are used to maintain quality of life and to facilitate economic development, respectively.

In the case of trails expenditures these costs can fall into both categories. The costs of trail maintenance sustain the wealth of a community by maintaining recreational opportunities thereby strengthening the social fabric of the community.

Trail construction and development can be wealth sustaining and wealth generating. First by creating a healthier quality of life and second providing tourism opportunities that can create economic spin-off effects for the local economy.

Two examples of places where mountain bicycling on trails have generated considerable wealth are Moab, Utah and the Rossland-Trail-Castlegar-Nelson area of British Columbia. These areas each have experienced more than 50,000 mountain bike-related visitor days. This translates to $5,000,000.00 annual benefits to each area based on the model created by Fix and Loomis (1996).

RESEARCH, MONITORING AND HABITAT DELINEATION REQUIREMENTS

The current state of practice dictates that any study, defining management strategies and monitoring of impacts in natural areas follows a clearly defined systematic process. These steps are:

1. Pre-assessment Data Base Review.
2. Review of Management Objectives.
3. Selection of Key Impact Indicators.
4. Selection of Standards for Key Impact Indicators.
5. Comparison of Standards and Existing Conditions.
6. Identify Probable Causes of Impacts.
7. Identify Management Strategies.
8. Implementation and Continued Environmental Monitoring.

MANAGEMENT STRATEGY OPTIONS

Management strategies fall into two categories. The first are those that deal with indirectly influencing the behavior of the visitor. The second category is that of direct strategies and involves direct involvement by the land management officials in discouraging use.

INDIRECT STRATEGIES

As the term implies indirect strategies attempt to influence the behavior of the visitors to an area in order to meet the management objectives. These include but are not limited to:

- Physical Alterations
    - Improve or neglect an area.
    - Improve or neglect campsites.
- Information Dispersal
    - Advertise area's attributes.
    - Identify surrounding opportunities
    - Provide minimal impact education.
- Economic constraints
    - Charge constant fees.
    - Charge differential fees.

DIRECT STRATEGIES

Direct management strategies include direct approaches that regulate or restrict visitor activities in order to minimize impacts. Some direct management strategies include:

- Enforcement
    - Increase Surveillance.
    - Impose Fines.

- Zoning
    - Separate visitors by experience level - User Preference Profiles.
    - Separate incompatible uses.
- Rationing of use intensity
    - Limit use via access points.
    - Limit use via campsite.
    - Rotate use.
    - Require reservations.
- Restricting activities
    - Restrict type of use.
    - Limit size of group.
    - Limit length of stay.

LEGAL RAMIFICATIONS

As a result of judgments by the various appellate courts in Canada, the United States and the House of Lords in the United Kingdom:

> *"Each practitioner of a profession or those persons professing to be expert must show a duty of care to their client and other principals (which include the practitioner's client and the public) and maintain a standard of care in their relevant area of expertise."*

Failure to comply has resulted in many costly judgments against professed experts. To prevent further recurrences of legal disputes professions regulated by legislation (engineers, geologists, physicians, architects, et cetera), practitioners must pursue continuing education to remain current and to be continue to be licensed to practice.

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