Impacts of Experimental Hiking and Mountain Biking in Deciduous Forest*

E. Thurston and R. J. Reader
Department of Botany, University of Guelph, Guelph, Ontario N1G 2W1

Abstract

Hiking and mountain biking were experimentally applied in a deciduous forest in Boyne Valley Provincial Park, near Orangeville, Ontario. This study compared the impacts of each activity, at a variety of use intensities (0-500 passes) on vegetation and soil in 4 m by 0.6 m treatment plots. Measurements were made before, two weeks after, and again one year after treatment application. Two weeks following 500 passes of both activities, over 85% of above-ground vascular plant stems were dead or damaged. In addition, the amount of soil exposed increased by 30%. One year later, these immediate treatment effects were no longer detectable. In most cases, at two weeks and one year following treatment there were no significant differences between the effects of hiking and biking activity on the measured variables. These results imply that, at similar use intensities, the short-term impacts of hiking and mountain biking should not be expected to differ greatly in a deciduous forest habitat. While the immediate impacts of both activities can be severe, rapid recovery should be expected (for the range of use intensities employed here) if initial trails are not allowed to persist.

Introdution

- Managers of wilderness areas consider recreational impacts along trails and on campsites to be their most common management problem (Washburn and Cole, 1983).
- The field of recreation ecology has developed to respond to this issue. However, it has traditionally focused on the impacts of hiking, and less so on the effects of other trail activities.
- Since impacts on trails can be user-group dependent, it may not be prudent to extrapolate known impact/use relationships from previous studies (re: hiking) to a new form of recreational use, namely mountain biking.
- The presence of mountain bikes on trails of recreational areas has caused considerable controversy about the amount of resource degradation they cause. To date, the discussions and debates associated with mountain biking issues have been mainly confined to subjective magazine articles, anecdotal accounts, and advocacy arguments both for and against mountain bike access (Cessford, 1995).
- Since the addition of mountain bikes to trails, hikers have used the bikers' potential to do environmental damage, due to the nature of bicycles and their lugged tires, as reason enough to exclude biker access to existing trails (Cessford, 1995).

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- Almost no research has been done on the actual impact of mountain biking on vegetation and soil to help resolve this debate. To date, only one study appears in the literature. Wilson and Seney (1994) compared the erosional impact of off-road bicycles to that of hikers, as well as horses and motorcycles, using an experimental approach on Montana trails. No vegetation analysis was included, however, as the experiment was conducted on an existing trail with a history of multiple use. Changes were not monitored as use intensity increased, to a maximum of only 100 passes. Therefore, this study cannot answer questions about how mountain bikes impact vegetation and soils at the early stages of trail formation and how those impacts change with level of use.
- Consequently, additional studies are needed to answer questions about the relative impact of biking versus better understood trail activities (e.g. hiking), and whether the relationship between the amount of activity and amount of impact is similar to, or different from biking.

Study Objective and Approach

- The purpose of this study was to compare the effects of hiking and mountain biking at various use intensities on the understory vegetation and soil of an undisturbed deciduous forest. By measuring selected soil and vegetation parameters before and after experimentally applied biking and hiking passes, we determined whether the effects of biking were significantly different from those of hiking, free from the problems of user-group behaviour differences and unknown traffic levels.
- Deciduous forest was selected because it typically has a ground-layer vegetation type that is among the most susceptible of all terrestrial habitats studied (Kuss, 1986). A forest habitat was also chosen because it is the preferred environment of mountain bikers (Ruff and Mellors, 1993) and is therefore a likely setting for future bicycle paths.

Study Significance and Application

- In areas with established trail systems, a common problem reported by managers is the tendency of users to go off-trail, creating impromptu paths (Cole 1985). Because it becomes difficult to discourage use of obvious impromptu trails, managers need to know how many off-trail passes are needed to create a trail, and if this threshold differs for hiking or biking passes (Neal Switzer, Conservation Areas Planner, Halton Region Conservation Authority, personal communication).
- Before constructing any new biking trails, or attempting to manage current biking use, managers need to know if they can rely on the accumulated knowledge of hiking impacts (i.e. effects in different vegetation types) when making decisions about location and course, or if mountain bikes are so unique that new research is warranted (Brian Huis, Park Planning Specialist, Ontario Parks, personal communication). If mountain biking activity has effects similar to those of hiking then managers can make use of the hundreds of human trampling studies that currently exist to predict where and when biking impacts are likely to occur.

Materials and Methods

Study Design

- The study was conducted in Boyne Valley Provincial Park (44°05'N, 80°08'W), located 60 km northwest of Toronto, Ontario. The selected site satisfied the following criteria: (1) mature deciduous forest habitat (dominated by sugar maple—*Acer saccharum*) with a continuous canopy; (2) gently sloping land (10-15°) with a common aspect; and (3) absence of current human use (e.g. timber harvesting, recreation, or other field research).
- The experiment consisted of two treatments: activity type (hiking or biking) and number of passes (0, 25, 75, 200, 500), resulting in ten treatment combinations overall.
- Each combination was then randomly assigned to ten treatment lanes within an experimental plot, or block. Lanes were 5 m long by 0.6 m wide, and were separated by 5 m buffer zones. Ten blocks were prepared overall. Each was 50 m in length by 5 m in width and was positioned on a slope so that treatment lanes ran parallel to it (downhill).

Treatment Application

- Biking and hiking treatments were applied by the same four participants, weighing between 57 and 73 kg. Participants wore similar lug-soled hiking boots and used standard 13.5 kg, 18-inch frame mountain bikes. Total weights of bikes plus riders ranged from 70.5 to 86.5 kg.
- Treatments were applied from June to early August 1997. The total number of passes required for an individual block (1600) was scheduled to be completed over a one week period.
- A pass was a one-way walk or bike trip down a lane following a pre-marked centreline path. Hikers moved at a natural gait, while bikers traveled at a moderate speed, applying brakes as needed. Uphill passes were prohibited by the terrain, due to slope. Therefore, passes were made downhill only, in one direction.

Response Variables

- Two variables commonly used to assess recreational impacts were measured. First, loss of vegetation was measured by the change in vascular plant stem density in a full lane. Second, the increase in exposed soil (A-horizon) was measured by visually estimating the percentage surface area of each lane free from macroscopic organic material (i.e. litter, twigs, and moss).
- The entire sampled portion of each lane was 4 m by 0.6 m. A 1 m by 0.6 m wooden frame quadrat, placed over the lane centreline, was used in series to accomplish sampling.
- Measurements were made during three sampling periods: pre-treatment (immediately before biking and hiking passes were applied); post-treatment (two weeks after treatments); and one-year post-treatment (one year after treatments).

Two-week Post-treatment Calculation:

Loss of vegetation:

$$\frac{\text{\# original stems found absent, dead, or damaged } after}{\text{\# original stems present } before} \times 100\%$$

Increase in soil exposure:

% soil exposed *after* - % soil exposed *before*

One-year Post-treatment Calculations:

Absence of vegetation:

$$\frac{\text{\# original stems present } before \text{ - \# stems present } 1\ year\ after}{\text{\# original stems present } before} \times 100\%$$

Increase in soil exposure:

% soil exposed *after 1 year* - % soil exposed *before*

Statistical Analysis

- Data for each response variable, for each post-treatment period, were analyzed with a two-factor ANOVA for a randomized-complete-blocks design, using the PROC GLM procedure of SAS (SAS Institute Inc., 1996). The two treatment effects were activity-type (biking and hiking) and pass-intensity (0, 25, 75, 200, 500). Data were transformed as needed to improve normality.
- Whenever ANOVA indicated a significant ($P<0.05$) treatment effect, Tukey's HSD test was used to determine which treatment means differed significantly.

Results

Treatment Effects on Vegetation

After 2 weeks:

- Pass Intensity: Vegetation loss was significantly affected by the pass intensity applied by both activities ($F=42.19$, $P<0.001$). Mean loss values increased significantly from 15% on the control lanes (0 passes), to 59-89% on the treated lanes (25-500 passes), but did not increase significantly from 25 to 500 passes, with the exception of the hiking 25 pass treatments (Figure 1).
- Activity Type: Mean vegetation loss did not differ significantly between biking and hiking treatments at any pass intensity ($F=1.59$, $P>0.05$; Figure 1).

After 1 year:

- No treatment effects were detectable after 1 year ($F_{\#\,passes}=0.78$, $P>0.05$; $F_{H\,vs.\,B}=0.04$, $P>0.05$). Absence of initial stems was not associated with use intensity or activity type (Figure 2).

Treatment Effects on Soil

After 2 weeks:

- Pass Intensity: Soil exposure was significantly affected by the pass intensity applied by both activities ($F=52.74$, $P<0.001$). Mean exposure values increased gradually from the biking (0.6%) and hiking (1%) control lanes to the 500 pass biking (39%) and hiking lanes (32%) (Figure 3).
- Activity Type: Mean soil exposure did not differ significantly between biking and hiking treatments at any pass intensity ($F=2.22$, $P>0.05$; Figure 3).

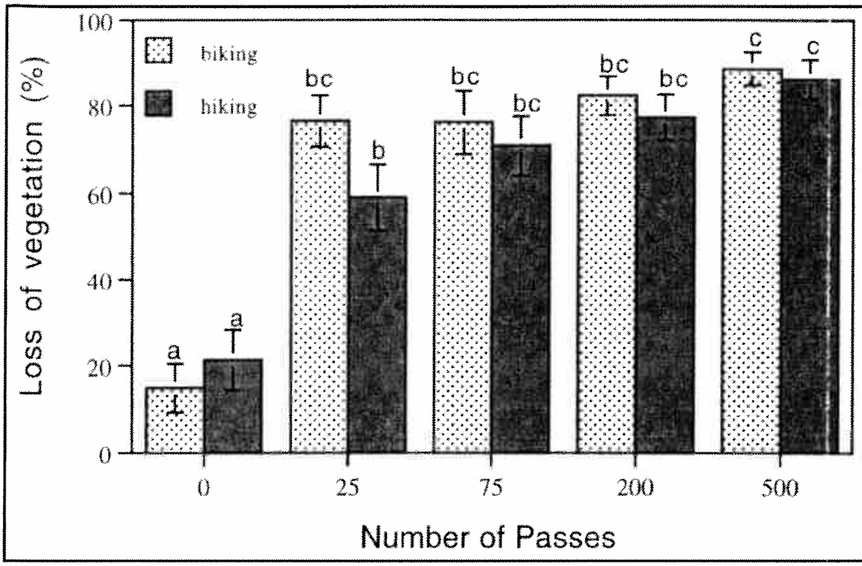

Figure 1: Treatment effects on deciduous understorey vegetation two weeks after experimentally applied hiking and mountain biking passes. Shared letters indicate no significant difference between bars.

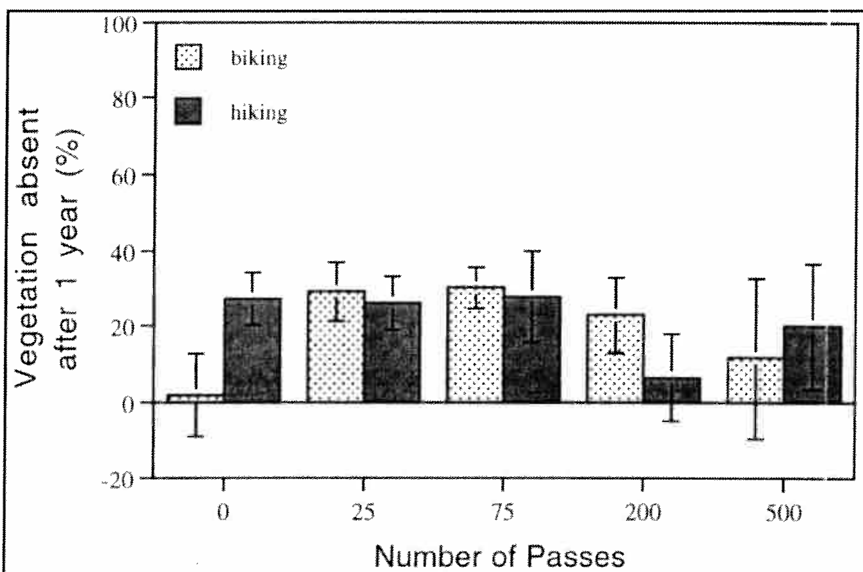

Figure 2: Treatment effects on deciduous understorey vegetation one year after experimentally applied hiking and mountain biking passes. No significant difference between treatment effects.

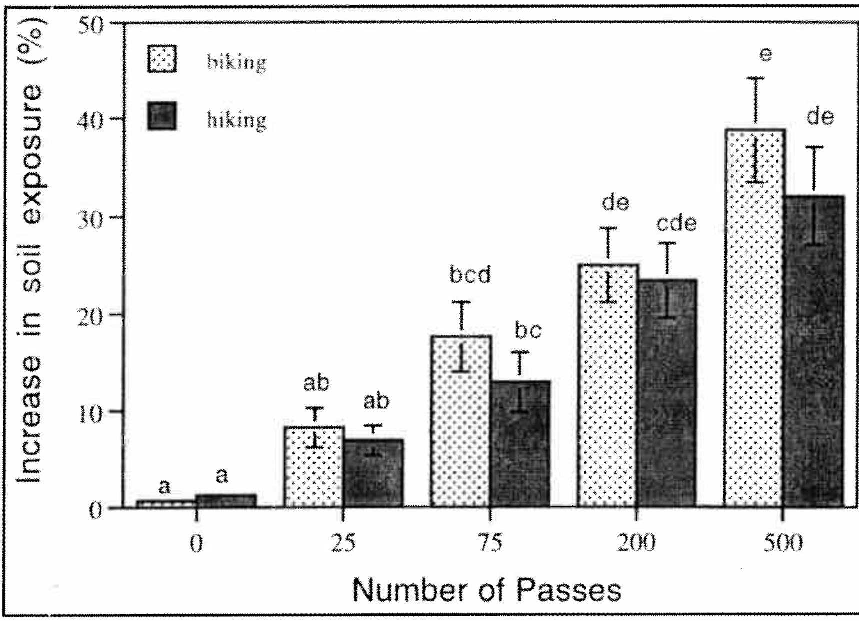

Figure 3: Treatment effects on deciduous forest soil exposure two weeks after experimentally applied hiking and mountain biking passes. Shared letters indicate no significant difference between bars.

After 1 year:

- No treatment effects were detectable after 1 year ($F_{\#\,passes}$=2.14, P>0.05; $F_{H\,vs.\,B}$=0.04, P>0.05). Amount of soil exposed was not assoceated with use intensity or activity type (Figure 4).

Discussion

Pass Intensity Effects—Vegetation

- Vegetation loss occured rapidly with increasing intensity of either activity. After only 25 passes of a hiker or biker, the majority of plant stems present were affected enough to show signs of observable damage and sometimes death after only two weeks.
- The asymptotic pattern of vegetation loss with increasing activity found here is characterisitc of deciduous forests with forb-dominated understoreys (Kuss, 1986). Forbs that grow in the shade of full canopy forests have adaptations to low light conditions, such as tall stems and broad, thin leaves, that make them highly susceptible to trampling damage (Cole, 1979).
- One year following treatments, the proportion of stems still absent were not significantly associated with either biking or hiking activity. Nearly all stems had returned to their initial locations, even where they had been apparently removed the season before. Forbs are often perennials with perennating buds located below the soil surface (Kuss, 1986). If these structures are not too severely damaged by activity, and use does not persist, new stems should appear the following season. For this reason, deciduous forest understoreys are characterized with low resistance (same season impact) to recreational

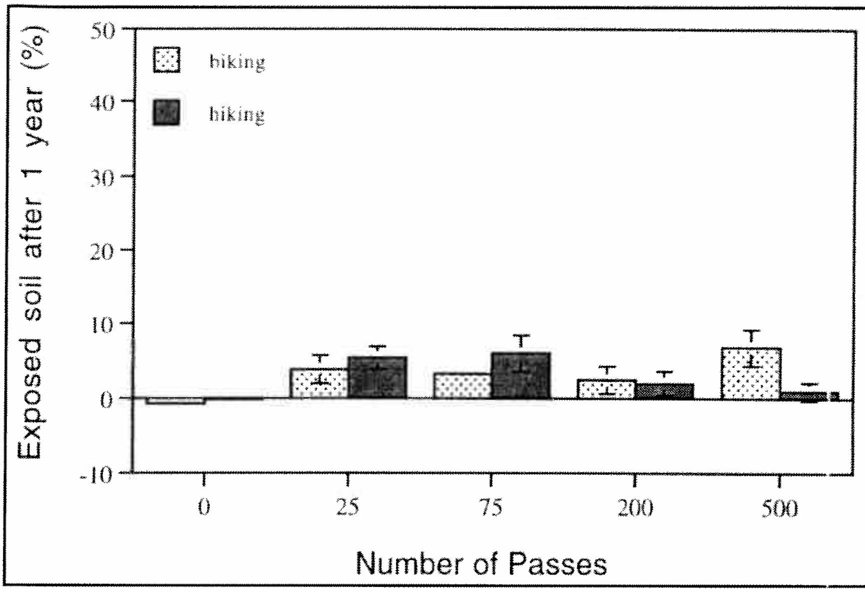

Figure 4: Treatment effects on deciduous forest soil exposure one year after experimentally applied hiking and mountain biking passes. No significant difference between treatment effects.

damage, but high resilience (later season recovery) if use is not continuous (Cole, 1995).

Pass Intensity Effects—Soil

- Increase in soil exposure occurred more gradually with increasing activity than did vegetation loss, suggesting a more linear relationship between use and impact for this soil parameter.
- A higher use threshold for soil impact than vegetation impact is explained by the fact that bare soil can not become exposed until vegetation is removed. This is especially true of those habitats with thick leaf litter layers, such as deciduous forest (Cole, 1987).
- One year following treatments, the amount of soil still exposed was essentially undetectable. This is expected in habitats with full deciduous canopies that add a new layer of litter every fall, usually completely covering evidence of low levels of impact, such as those used here (Hammitt and Cole, 1987).

Activity-type Effects

- There was no significant difference between the effects of mountain biking and hiking on vegetation or soil, after either two weeks or one year following activity.
- The lack of difference here suggests that these two activities are essentially the same in terms of the way they contact the ground surfaces over which they move. Weights between bikers and hikers amounted, of course, to the weight of the bikes (13.5 kg). Where vulnerable plants are contacted, the difference between a 60 kg hiker and 75 kg biker may be irrelevant. As well,

contact pressure may be more important than weight alone. This was calculated as 0.29 kg/cm^2 for hikers balanced on one foot, and 0.35 kg/cm^2 for bikers resting on both tires, a difference of only 0.06 kg/cm^2.

Conclusion and Study Significance

- The principal finding of this study is that direct vegetation and soil impacts from short-term experimentally applied passes of mountain biking are no different from those of hiking, either immediately following use or after one year of recovery.
- This finding suggests that, at similar use intensities, the short-term impacts of these activities should not be expected to differ greatly in a deciduous forest habitat. Managers should be able to make use of the accumulated knowledge of hiking impacts when addressing off-road biking management, instead of repeating research for this new user-group.
- Reports of greater biking impacts on trails may derive from differences in user behaviour between bikers and hikers, or from cumulative use impacts on already over-used trails that this new activity has contributed towards.
- While the immediate impacts of both activities can be severe, creating visible impromptu trails after less than 100 passes, rapid recovery should be expected (at least for the range of use intensities employed here) if initial trails are not allowed to persist.

Acknowledgements

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