Trampling Effects of Hiking and Mountain Biking in a Grassland Park

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Abstract Targeting the cause of trail degradation can be a challenging role for park managers if more than one user group frequents the trails. This study compared the effects of hiking and mountain biking across seasonal California grasses to determine the trampling that could occur just prior to the onset of the rainy season. Hiking and mountain biking traffic were experimentally applied to undisturbed grasses in thirty 6ft-long by 1-ft wide test lanes at Mullholland Ridge Open Space in Moraga, California. The traffic was applied in both pulse (one 40-pass treatment applied on a single day) and press (four 10-pass applications applied at biweekly intervals) forms along with a no-traffic control. Measurements of percent cover and vegetation height were taken to measure disturbance, and data on each were taken before treatments, immediately after treatments, and at two-week intervals thereafter to determine the initial impact and vegetative recovery. Hiking and mountain biking both caused a significant but statistically indistinguishable decrease in vegetation height, and, consistent with pre-wet season conditions, no significant recovery in the height of dormant grasses was observed for either treatment type. The two treatment types did not produce statistically significant differences in the percent plant cover, and neither appears to curb the emergence of new springtime grasses. These results indicate that the short-term effects of hiking and mountain biking may not differ significantly on undisturbed grasses.

Introduction

One significant challenge facing park management is determining how to prevent the degradation of an area's ecology. In particular, park managers must balance park recreation with natural resource preservation. In addition to determining the extent to which recreation can occur in a given area while simultaneously preserving natural resources, park managers face the challenge of distinguishing the impacts from different kinds of recreational users. This responsibility can become quite complicated (Knight and Gutwiller 1995) because of the difficulty in distinguishing whether a particular group is causing more extensive damage to an environment than others. One such example of coincident recreation is the use of parklands by both hikers and mountain bikers. In addition to the social conflicts that may arise between these groups from sharing trails (Morey et. al. 2002), park managers must distinguish the environmental degradation resulting from trail use by other groups. Managers often attempt to resolve both issues by closing trails to mountain bikers (Morey et. al. 2002), usually on the grounds of excessive trail damage (Sprung 2004).

To date, however, results from the existing published studies examining comparative impacts of trail user groups are inconsistent or inconclusive in showing that mountain biking is more harmful to park health than hiking, or visa-versa. Mountain biking is an increasingly popular activity (Morey et. al. 2002) with an estimated 13.5 million cyclists visiting public trails each year (BLM 2002). As the number of mountain bikers increases, so too will the demand for trail use. Further scientific information comparing the impacts of hikers and mountain bikers in different areas and across different land types is needed to create sound policy decisions independent of conflicting biases (Sprung 2004).

A few studies suggest that while both groups may cause enough damage to limit their uses, there is no consistent significant difference between the effects caused by each group to soil compaction and erosion, wildlife[1], and vegetative trampling. By measuring sediment displacement along an experimental piece of trail, Chiu and Kriwoken (in press) found that there

[1] Effects on wildlife have been studied for a number of different species with varying results. Most of these studies used measurements of behavioral response to the trail user, such as flushing distance and frequency, to determine the disturbance levels from hikers and mountain bikers. Studies involving male alpine chamois (Gander and Ingold 1996) and antelope (Taylor 2002) found that there was no significant difference between impacts of the two trail user groups. Studies involving bighorn sheep (Papouchis et. al. 2001) and bald eagles (Spahr 1990) found that hikers caused the most disturbance. A study examining where golden-cheeked warblers made their habitats before and after the construction of trails found that neither hiking nor mountain biking activity impacted warbler territory density, return rates, or age structure (Stake 2000).

was no significant difference in trail erosion caused by hikers and mountain bikers. Goeft and Alder (2001) show that factors such as slope and the age of the trail also influence general human impacts on erosion, but no clear trend regarding a particular user group's relative influence could be established.

A little-examined aspect of comparative disturbance is vegetative trampling, which results from travel off established trails or along the trail's outer edge. Bjorkman (1996) reports that vegetation loss along a trail's centerline occurs most rapidly, and a study by Goeft and Alder (2001) adds that the wear along a trail's outermost edges is typically significantly less than in the center. Weaver and Dale (1978) suggest that a non-linear relationship exists between the numbers of passes made by any user group and the amount of damage inflicted on the vegetation. That is, earlier trail users will cause a greater per-capita amount of trampling than later trail users. These studies all provide insight into how a trail user will cause disturbance to a trail, but do not examine differences between hikers and mountain bikers. Only a study by Thurston and Reader (2001) compares the trampling effects of hiking and mountain biking. Using a controlled experimental design, they examined plant stem density, species richness, and soil exposure were used as measurements of pre- and post-trampling vegetation wellness in the experimental test lanes. A wide range of trampling intensities was used in order to analyze the highly variable amount of trail use that can occur in parks. Thurston and Reader were unable to detect a significant difference between the mountain biking and hiking plots; furthermore, full vegetation recovery within the study period was documented for both plot types.

This study further explores the vegetative trampling aspect of user group influence begun by Thurston and Reader (2001). Using methods similar to theirs, my study analyzes the relative ecological disturbance from vegetative trampling by hikers and mountain bikers in a grassland park. Thurston and Reader studied a deciduous forest, and this study applies their methods to another vegetation type (grasslands), to determine whether general patterns might be recognized across different land types.

Through a comparison of the immediate effects of trampling, the rates of recovery of vegetation after trampling, and the appearance of new growth following trampling, this study examines the relative ecosystem disturbances of hiking and mountain biking in a grassland park. In addition to this substantive contribution, this study also makes a methodological contribution. By examining the difference in the apparent effect of applying treatment all at once (pulse) or over a span of several weeks (press), this study explores equal amounts of disturbance whose magnitudes are distributed differently over time.

I hypothesize that, consistent with Thurston and Reader's (2001) results, no significant difference will be detected in the disturbances caused by hiking and mountain biking from the pulse treatments. However, due to the added recovery time between trampling intervals in the press treatment, results may differ for this second treatment type.

The goal of this study is to produce results which will be helpful to park managers make sound management choices regarding access of trails to hikers and mountain bikers.

Methods

Experimental Design I conducted my research at Mullholland Ridge Open Space in Moraga, California. The vegetation at Mullholland Ridge typifies the grass species and variety commonly found in the San Francisco Bay Area. I did my research project experimentally in the field rather than observationally along an actual recreation trail; this approach allowed me to control for the amount of trampling applied to the vegetation and measure the specific effects of it.

At my study site I set up thirty experimental test lanes at my study site. Each test lane was a 1ft by 6ft strip of undisturbed grasses that could be treated either by walking over it, biking over it, or leaving it undisturbed (as a control). The 1ft width dimension was chosen so that the lane would be narrow enough that grasses along the entire width of the lane would have as close to an equal chance as possible to being trampled. The 6ft length dimension was chosen so that the test lane would be short enough to sample an equal trampling style. (For example, a bike would not be moving significantly faster at the end of the 6ft lane than at the beginning of it). Additionally, each lane was surrounded by a buffer area of at least 3ft on all sides, which allowed ample room for moving between lanes or starting and stopping on the bike. Each test lane was randomly assigned one of five treatment types addressing the type of trampling and whether or not it would be applied all at once (pulse) or over a period of several weeks (press). The five treatment types are control, pulse hike, pulse bike, press hike, and press bike. In this study I collected data from six lanes of each treatment type (Table 1).

Table 1: Treatments assigned to experimental test lanes

	Pulse treatment	Extended treatment
Bike	6 lanes	6 lanes
Foot	6 lanes	6 lanes
Control	6 lanes	

The control lanes are used to monitor natural changes in the vegetation, and no trampling is applied in these areas. Any changes in grasses are recorded to assure that observed changes in the vegetation in the treatment areas are due to trampling.

The pulse treatment lanes mimic the experimental design employed by research found in the literature, such as Thurston and Reader (2001). Treatment was applied all at one time in the form of passes by foot or by bike at one time. After some preliminary test runs, I chose to use 40 passes as my treatment intensity because I determined it should provide a sufficient and realistic level of trampling. Thus, for the pulse treatment lanes, I first took preliminary measurements of the grasses, then applied 40 passes by foot or bike, then took measurements again immediately after to quantify the immediate effects of the trampling. Additionally, because I am also interested in the recovery and growth of the vegetation, I continued to take measurements of the grasses at two-week intervals for eight weeks after the treatment was applied.

Condensing reality into a very short time frame in order to generate an experimental simulation is convenient, but not very realistic. It is more likely that trail users will travel on a given section of path over the course of a longer time period, rather than all at once. The press treatment creates a more realistic scenario by distributing the 40 pass treatment over a longer period of time. Instead of applying the passes all at once, as in the pulse treatment, I applied 10 passes on four weekends spaced two weeks apart (Table 2).

Table 2: Measurements and treatments through time for control, pulse, and press test lanes

	Week 1	Week 3	Week 5	Week 7	Week 9
Control	take measurements	take measurements	take measurements	take measurements	take measurements
Pulse	take measurements apply 40 passes take measurements	take measurements	take measurements	take measurements	take measurements
Press	take measurements apply 10 passes take measurements	take measurements apply 10 passes take measurements	take measurements apply 10 passes take measurements	take measurements apply 10 passes take measurements	take measurements

Data Collection To measure the effects of trampling on the grasses, I used two measurements: percent cover and vegetation height. I Monitored the percent cover of the test lanes with the intention of determining the extent to which treatment is removing vegetation from the ground. Percent cover is the most relatable measurement to biomass or plant production (Elzinga et al. 2001). To measure the percent cover, I used 10 in by 6 in quadrats (Fig. 1) which I systematically placed in three different locations within each test lane (Fig. 2). I visually 'eyeballed' the percent cover within the quadrat and recorded this value.

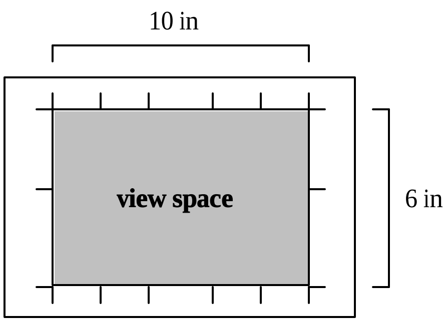


Figure 1: Quadrat used

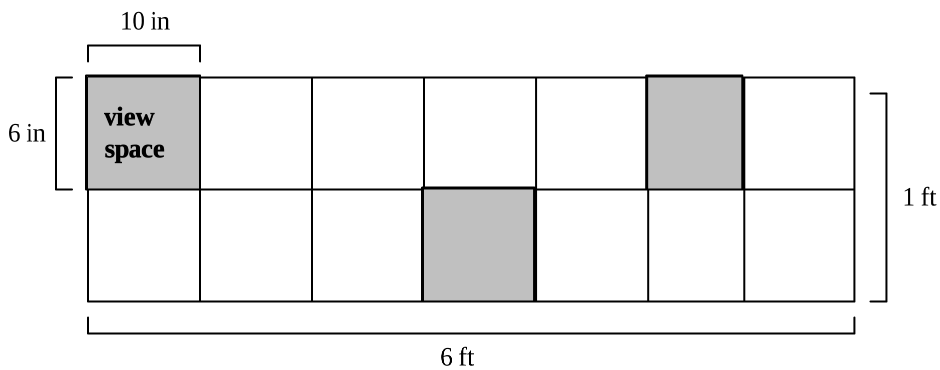


Figure 2: Example schematic of qudrats placed within a test lane

To measure the vegetation height, I used the same quadrats used for the percent cover. I visually estimated the level at which about 80% of the vegetation fell beneath and measured with a ruler from the ground to this level (Fig. 3). The 80% mark represents a level commonly used in the methodology of scientific literature (Stewart et al 2001). This approach allowed me to assess the height of most the vegetation without having grasses in the upper 20% which may have escaped trampling skew the measurement.

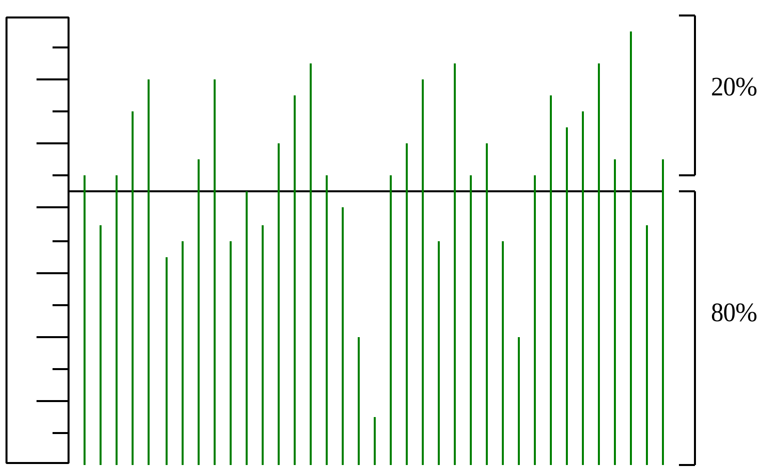
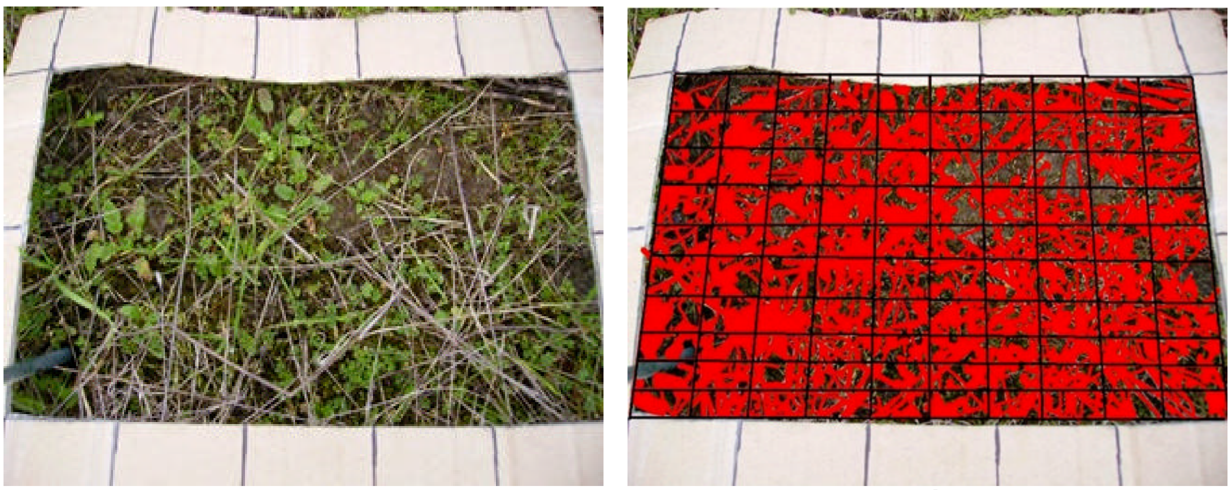


Figure 3: Vegetation height was measured at the level under which 80% of the vegetation fell

Measurement Error and Uncertainty The largest potential source of error in visually estimated percent cover is observer bias. However, because I was the only individual to take measurements, this source of error refers to my intertemporal inconsistencies, not inconsistencies arising from different observer bias. To help in recording a more precise percent cover, I segmented my quadrat into tenths (Fig. 1).

I also took digital photographs of each quadrat from above at the time of measurement. Of these photographs, I selected six; one of a low recorded percent cover, medium recorded percent cover, and high recorded percent cover from both week 1 and week 9 of the experiment. Using a paint program, I colored all of the vegetation red, segmented the photo into one-hundredths, and



(a) (b)

.3	.3	.25	.5	.5	.7	.7	.8	.7	.5
.25	.8	.65	.7	.8	.85	.5	.45	.5	.6
.65	.9	.55	.7	.9	.4	.2	.15	.75	.75
.7	.8	.65	.85	.75	.5	.75	.55	.5	.75
.4	.8	.6	.75	.75	.5	.6	.5	.6	.55
.6	.6	.6	.8	.45	.6	.7	.6	.8	.45
.65	.65	.9	.7	.5	.75	.75	.8	.75	.65
.6	.75	.85	.55	.55	.65	.65	.6	.85	.6
.35	.85	.55	.5	.5	.6	.65	.85	.6	.8
.7	.8	.9	.7	.65	.7	.75	.65	.55	.55

(c)

Figure 4: Digital photographs of quadrats (a) were gridded into one-hundredths and coded with red vegetation (b), then re-evaluated for measurements of percent cover (c)

visually estimated the percent cover of each hundredth (Fig. 4). I then added together these percents to calculate a more precise measurement of percent cover for the entire quadrat. This calculated percent cover could be compared to the recorded percent cover to assess the error in eyeballing the measurement.

Statistical Analysis In order to test whether or not the average effects from the treatments differ significantly from one another, I first transformed my data into a more appropriate format. Rather than raw heights and percents cover, I used the changes in height and cover between treatments and recovery times. I also subtracted the control quantities from the treatment data so that all differences in height and cover are normalized against an unchanging control for easier comparison.

Using the statistics software JMP, I performed ANOVA tests to compare treatment types at each time of data collection. If significant ($p \leq .05$) differences were found, a Tukey test was run to analyze which treatments differed. These analyses allowed me to examine the differences in height and percent cover from each treatment within a single time slot (for example, between the first and second tramplings). I then set up a table summarizing the results of the ANOVA and Tukey tests at each week (Tables 3 & 4). I was able to use this table to examine whether or not significant differences were consistent from week to week.

Results

Control Over the 11-week experiment, the control plots were measured biweekly a total of six times. There was a great deal of variability in the overall trends of each quadrat for both percent cover (Fig. 5) and height measurements (Fig. 6). The mean percents cover at each week show an increasing trend over the 11 weeks while the mean heights at each week show a decreasing trend over the course of the study (Fig. 7).

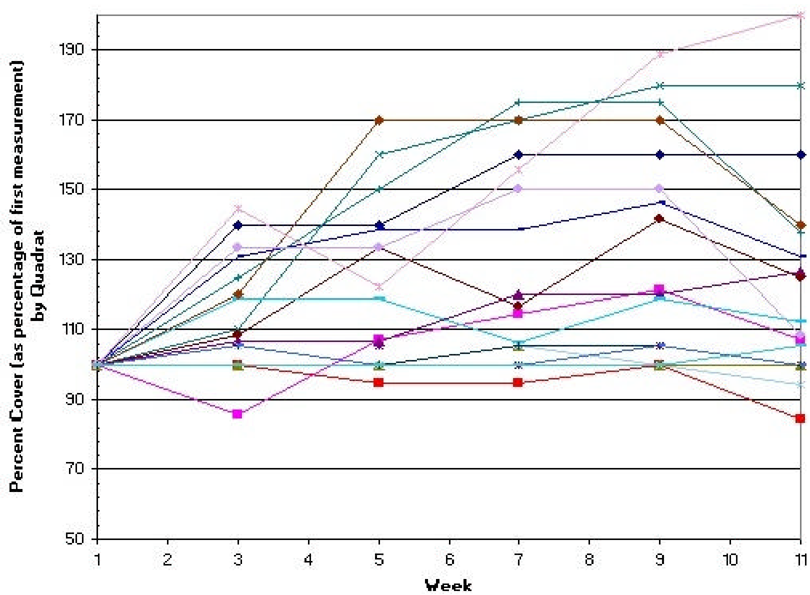


Figure 5: Percent cover measurements varied a great deal between control quadrats

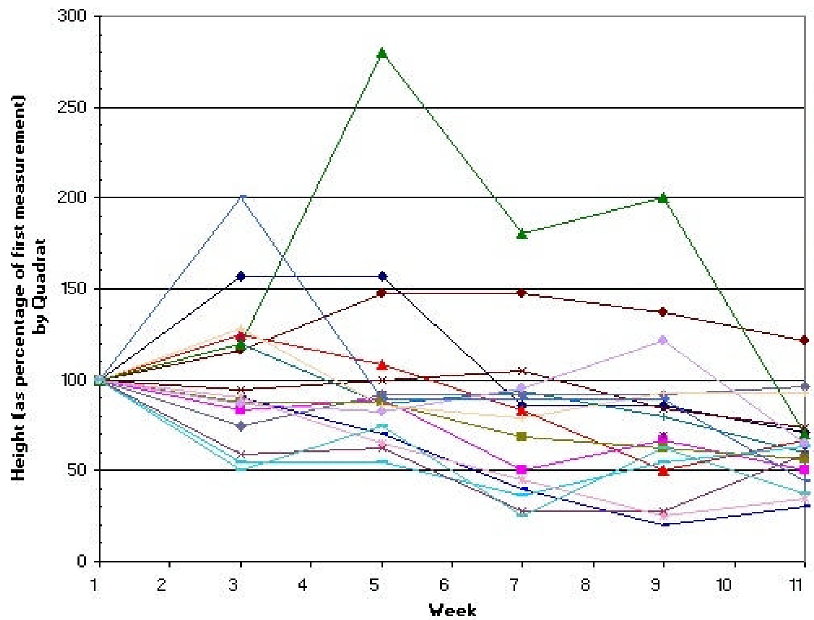


Figure 6: Measurements of height varied a great deal between control quadrats

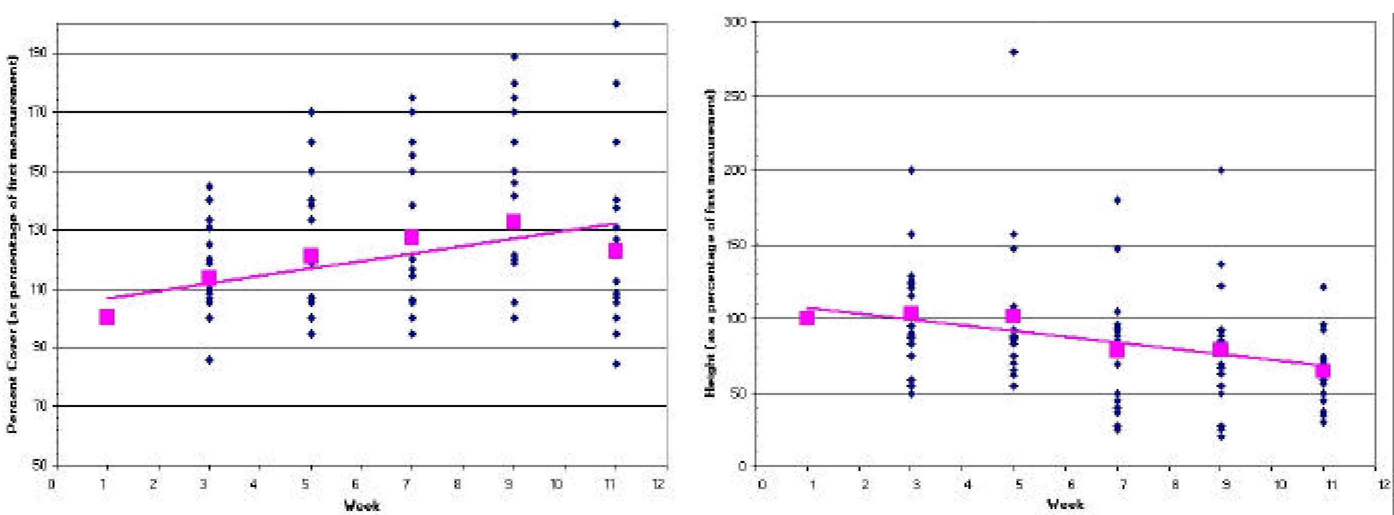


Figure 7: In the control plots, the mean percent cover from all quadrats showed a general increasing trend over the 11-week period of study while the means of all height measurements showed a decrease

Pulse Treatments The pulse treatment plots were measured biweekly at the same times as the control plots, with an additional measurement taken on the day of the 40-pass treatment passes after they were applied. Like the control plot measurements, the pulse foot and pulse mountain bike plot measurements also displayed a great deal of variability between quadrats at each time of measurement-taking.

The pulse foot treatment did not cause a significant difference in percent cover as compared to the control plots. The initial treatment did not cause a significant change, nor did the subsequent recovery period. Figure 8 graphically depicts the change in normalized percent cover for the pulse hiking treatment from week to week. The change in percent cover from the control plots is subtracted from the change in percent cover from the pulse foot plots. This normalizes the treatment for background changes in the grasses. Neither the treatment nor the recovery caused an average change in percent cover that is significantly different from the control.

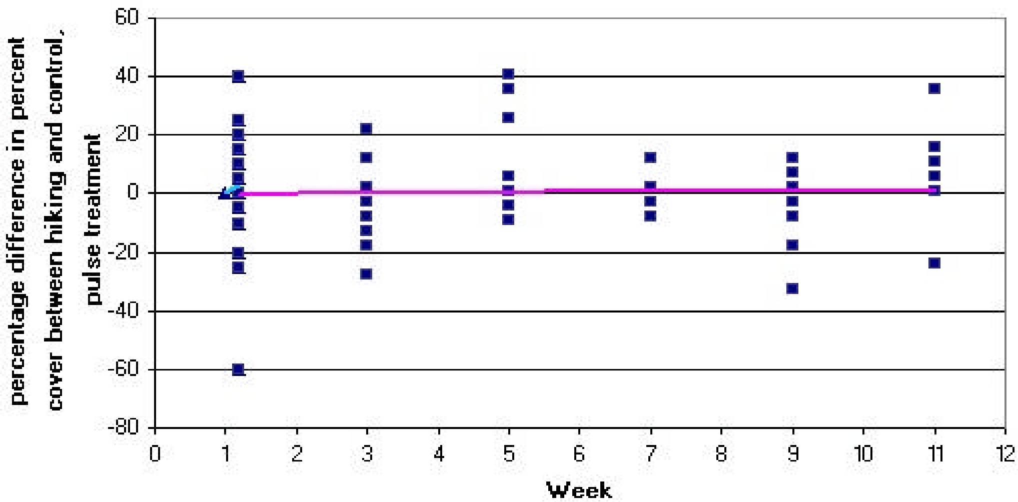


Figure 8: The pulse foot treatment did not lead to a statistically significant change in percent cover at any point throughout the study.

Figure 9 displays the normalized change in plant height from the pulse foot treatment plots. As in Figure 8, eighteen data points were collected in weeks 1, 3, 5, 7, 9, and 11. A logistical trend line was fit through the data points in the recovery phase. This shows that the vegetation height data in the pulse foot plots shows a significant depression from the 40-pass treatment. In the recovery phase, the vegetation initially shows a height recovery rate that is slower than in the control plots. However, the vegetation reaches and maintains the rate of recovery of the control plots by week three (Fig. 9). Because the recovery rate of the treated plots would have to had significantly exceeded that of the control plots in order for the grass height to have completely recovered, this means that the 40-pass treatment caused a significant depression from which the grasses could not recover their original height.

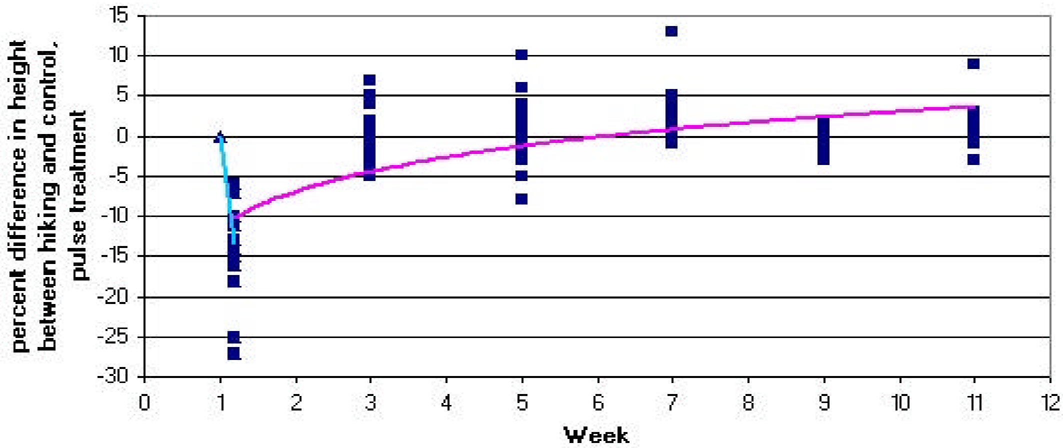


Figure 9: The 40-pass pulse foot treatment causes a significant decrease in the growth rate of the vegetation. The recovery phase shows a return to the growth rate of the control plots

Figure 10 displays the normalized change in percent cover from the mountain biking pulse treatment plots. Unlike the pulse foot treatment, which showed no significant change in percent cover, the pulse mountain bike treatment caused a statistically significant increase in percent cover. During the recovery phase however, the percent cover increases and decreases with no clear trend. By the end of the study period, the change in percent cover of the treated plots does not differ significantly from that of the control plots.

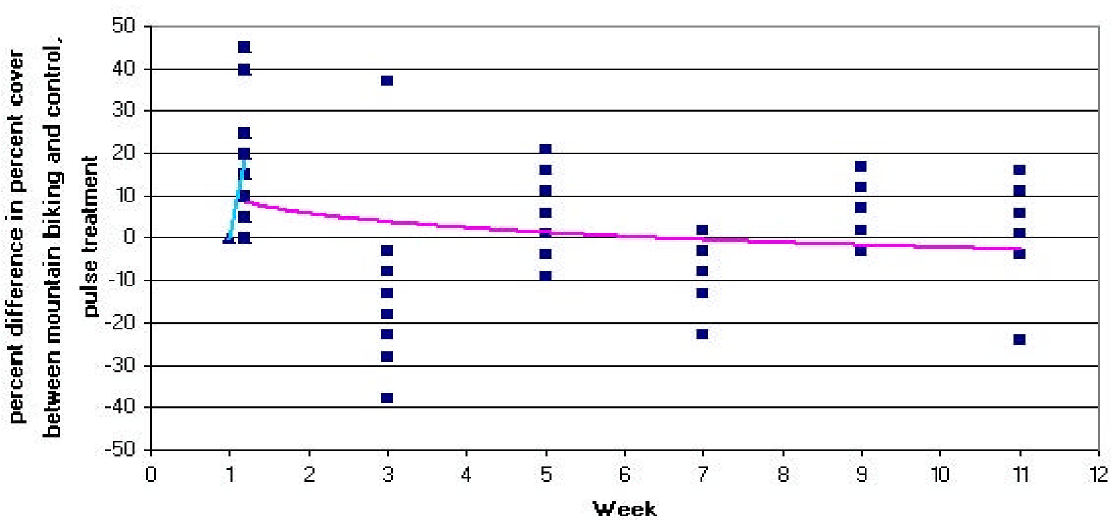


Figure 10: The pulse mountain biking treatment causes an initial increase in the change in percent cover from week to week, but the recovery phase allows the grasses to return to the same rates of change as the control plots

The vegetation in the pulse mountain biking plots is significantly depressed by the 40-pass treatment. However, like in the pulse foot treatment plots, the vegetation quickly recovers to the same growth rate as the grasses in the control quadrats (Fig. 11).

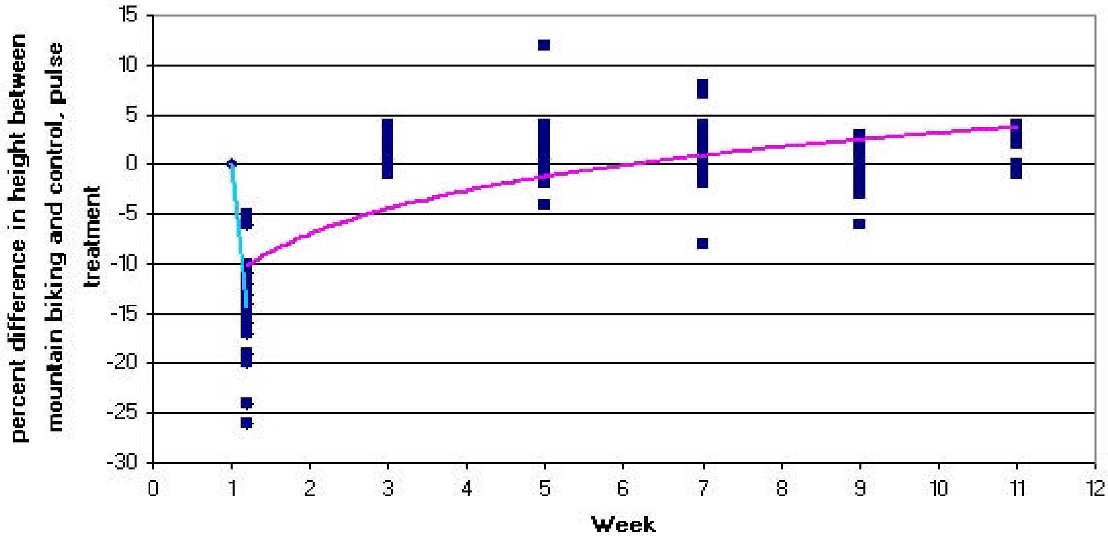


Figure 11: The 40-pass treatment causes a significant decrease in grass height in the pulse mountain bike quadrats, but the vegetation returns to control plot growth rates by week three.

The pulse foot and pulse mountain biking plots do not consistently significantly differ from each other in either measurements of percent cover or vegetation height. While the pulse mountain biking treatment caused a significantly greater increase in percent cover from the 40 passes, by week three there was no significant difference detected. The two treatments did not produce differentiable changes in height.

Press Treatments Trampling was applied to the press treatment plots at four biweekly intervals, with measurements taken before and after trampling and again two weeks after all treatment was complete.

Figure 12 graphically displays the normalized change in percent cover from the press foot treatment plots. While the graph shows that each 10-pass treatment resulted in an increased measure of percent cover, these differences were not statistically significant as compared to the control plots. However, height was significantly reduced from the first 10-pass treatment, and the subsequent treatments prevented the recovery phases from allowing the grasses to return to normal growth rates until all treatments were over (Fig. 13).

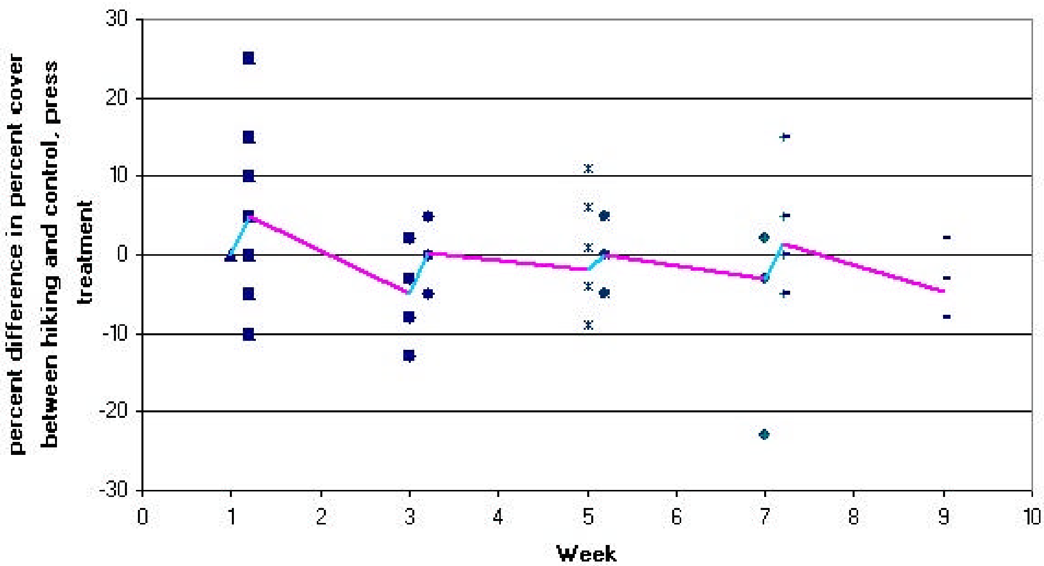


Figure 12: While each 10-pass press hiking treatment led to an increase in the measured percent cover, the change was not significantly different from the changes in percent cover in the control plots

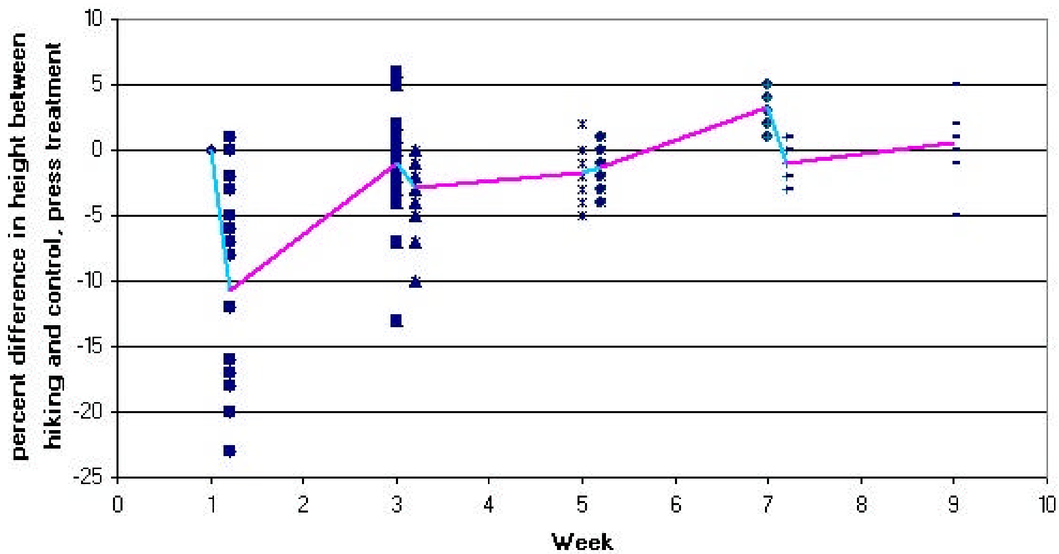


Figure 13: Grasses in the pulse foot plots experienced a significant reduction in vegetation height and did not begin to return to normal heights until week 9, two weeks after all treatment had been completed

The pulse mountain biking plots resulted in a similar trend with no significant difference in percent cover detected, but with a significant reduction in vegetation height throughout the entire treatment phase.

There was no difference in percent cover or height detected between the press hiking and press mountain biking treatments at any week.

Pulse versus Press The changes caused to percent cover from the pulse and press hiking treatments were not significantly different. The changes caused to percent cover from the pulse and press mountain biking treatments were also not consistently differentiable. However, the changes caused to vegetation height from the pulse and press hiking treatments were detectably different at certain times of measurement. Although the changes to vegetation height were not significantly different after the 40-pass pulse treatment and first 10-pass press treatment, the pulse foot treatment plots were detectably taller in vegetation height than the press foot plots, after the pulse treatment grasses had recovered for two weeks and the press treatment grasses had been trampled again. The mountain biking plots showed similar results, with the pulse treatment plots being significantly less flattened at the end of the study.

All Treatments Figure 14 shows that all plot types, including the controls, display an increase in percent cover. However, the rate of increase in the press treatment plots was consistently less than the control plots, and the rate of increase in the pulse treatment plots was generally higher than the control. There is no distinguishable difference in the reactions of the percent cover to hiking and mountain biking.

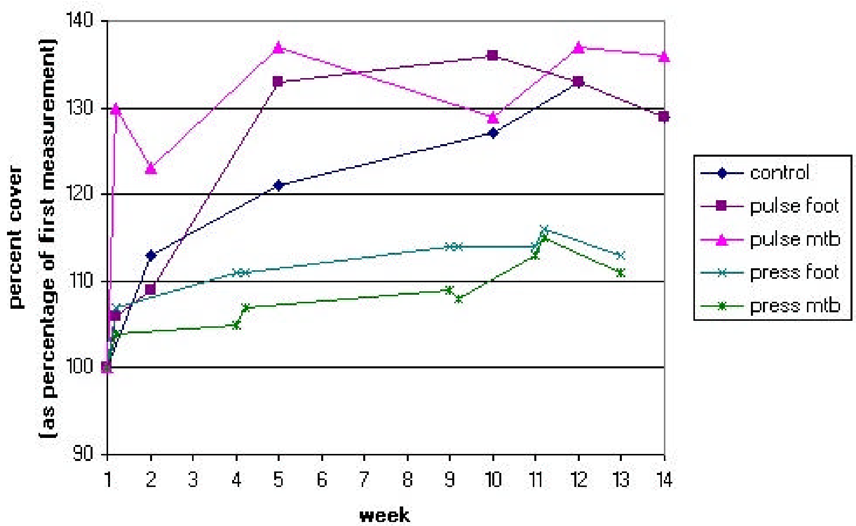


Figure 14: All plots show an increasing trend in percent cover, but the rates of change of the press plots are less than the control, and the rates of change of the pulse plots are generally higher than the control

Figure 15 shows that all plot types, including the controls, display an overall decrease in vegetation height. However, the treated plots show a sharp depression of grass height which remains well beneath the height of the control plots throughout the period of the study.

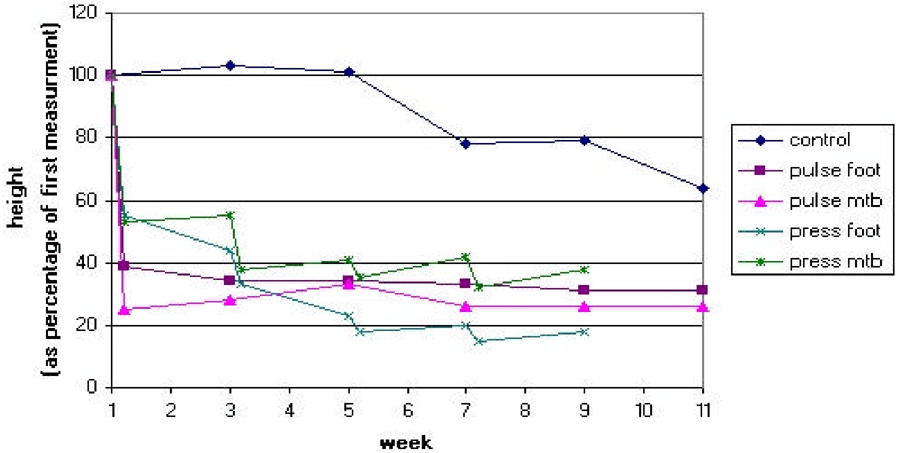


Figure 15: All plots show an overall decrease in vegetation height, but the treated plots are significantly more depressed than the controls

Table 3 summarizes the results of the study for percent cover comparisons. The "Bike – Control" columns represent the amount of percent cover which the mountain biking treatment caused over the control plots for that time period. Similarly, the "Hike – Control" columns represent the amount which hiking caused a change to the percent cover as compared to the control plots. The "Bike – Hike" column specifically addresses whether biking or hiking caused a greater difference to the percent cover of the plots. If the amount is positive, the mountain biking treatment caused a greater measurable effect. If it is negative, the hiking treatment did.

Table 3: Results are summarized in terms of differences through time (in percentage).

	Pulse			Press		
Week	Bike – Control	Hike – Control	Bike – Hike	Bike – Control	Hike – Control	Bike - Hike
Treatment 1 week 1 – 1.2	18*	3	17*	3	5	-2
Recovery 1 week 1.2 – 3	-14*	-7	-8	-7	-5	-2
Treatment 2 week 3 – 3.2				1	0	2
Recovery 2 week 3.2 - 5	5	6	-1	-3	-2	-2
Treatment 3 week 5 – 5.2				0	0	0
Recovery 3 week 5.2 - 7	-8*	-2	-6*	0	-3	3
Treatment 4 week 7 – 7.2				2	1	0
Recovery 4 week 7.2 - 9	2	-3	5	-8*	-5	-3
week 9 - 11	4	6	-1			

* indicates a statistically significant difference

Table 4 summarizes the results of the study for vegetation height comparisons.

Table 4: Results are summarized in terms of differences through time (in centimeters).

	Pulse			Press		
Week	Bike – Control	Hike – Control	Bike – Hike	Bike – Control	Hike – Control	Bike - Hike
Treatment 1 week 1 – 1.2	-14*	-13*	-2	-7*	-11*	4
Recovery 1 week 1.2 – 3	1	0	0	1	-1	-2
Treatment 2 week 3 – 3.2				-2*	-3*	0
Recovery 2 week 3.2 - 5	1	0	1	0	-2	2
Treatment 3 week 5 – 5.2				-1*	-1*	0
Recovery 3 week 5.2 - 7	1	0	-2	4*	3*	1
Treatment 4 week 7 – 7.2				-1*	-1*	0
Recovery 4 week 7.2 - 9	0	3*	0	1	1	1
week 9 - 11	2*	2*	0			

* indicates a statistically significant differ0ence

Uncertainty The analysis leading to the above results did not take into account the uncertainty in the measuring techniques that I used. In fact, this uncertainty may have been quite large. In the six-quadrat sample uncertainty analysis for percent cover using digital photographs and paint software, I found that quadrats recorded as having a low percent cover (i.e. 50% or below) may actually have been substantially more covered in vegetation. Quadrats recorded as having a high percent cover seemed to be more accurate (Table 5).

Table 5: Quadrats recorded as having low percent covers seemed to actually have higher percent covers

Quadrat	Week	Recorded % cover	Measured % cover	Off by
1a	9	30	47.8	-17.8
10c	1	50	76.8	-26.8
3a	1	60	63.3	-3.3
23f	9	70	73.55	-3.55
7b	9	90	84.9	+5.1
27e	1	90	89.6	+0.4

The high uncertainty associated with quadrats recorded as having a low percent cover means that were this taken into account in the analysis, percent cover results would be less likely to be significant. However, no significant differences in percent cover were found even without uncertainty of measurement techniques taken into the analysis.

Uncertainty in the height measurement technique was undoubtedly present, although probably less so than the percent cover measurement because using a ruler is more straightforward than eyeballing a percentage. If the uncertainty in vegetation height was assumed to be 2 cm, then the results associated with grass height would become insignificant, with the exception of the reduction in grass height from the 40-pass pulse treatments.

Discussion

Methods The measurement techniques used were found to be rather crude and measurement checks reveal that there is a high uncertainty associated with their use. Because this study was focused on detecting large degradation effects, a small change in grass height or percent cover that could only be detected with very sophisticated methods is presumed to be unimportant to park management.

Variability The high variability among quadrats in both percent cover and height could reflect an uneven distribution of trampling – a treatment distribution in conflict with my assumption that all quadrats within a treatment group are equivalent. While the test lanes were designed to be short and narrow so as to avoid having large portions of the lane left less trampled, it would have been impossible to assure that each part of a test lane receive equal trampling in a given pass. However, each section of the lane did have an equal *chance* of being trampled; thus, the variability reflects unequal trampling that would occur along a real trail as well.

Percent Cover When I designed the experiment, I intended to use percent cover as an indicator of how much grass had been ripped from the ground due to trampling. I expected trampling to lead to a decrease in percent cover. However, this measurement resulted in being a better indicator for the amount that grasses had been flattened due to trampling and the amount that new grasses began to emerge. Unfortunately, the measurement technique used did not allow me to differentiate between this flattening and new growth; rather, an increase in percent cover could be due to either factor. A measurement technique that allowed differentiation between these two factors would be helpful in future studies.

Height The height measurement, too, ended up serving a different purpose than intended. While I had intended for it to measure the ability of grasses to regrow, in actuality the grasses that were trampled were already dead. Due to the time of year when trampling was applied (right before the onset of the rainy season), the grasses were already dried and would not grow. Instead, a decrease in height indicated a flattening of grass, and an increase in height indicated that these grasses had “fluffed back up”, either through wind or natural resilience. In some quadrats where grasses were already very short, an increase in vegetation height that occurred in the later weeks could indicate that new grasses had sprouted and grown rapidly.

Hiking versus Biking Results suggest that neither hiking nor mountain biking causes greater degradation to California grasses during the onset of the rainy season. Furthermore, both hiking and biking plots generally returned to control plot levels of percent cover and height by the end of the experiment, suggesting that the grass’ natural ability to recover from trampling outweighs the disturbance. However, I suspect that the seasonality involved in this study played a large role in the outcome. Because the second half of the experiment occurred when new grasses were beginning to emerge, the appearance of “recovery” could actually be seasonal growth that would not have occurred had the study taken place at a different time of year. A similar study that takes place over a longer time frame (i.e. more than one year) would help to eliminate this seasonal variability and assess the long-term effects of trampling on grasses.

Pulse versus Press During the design of this experiment, I suspected that because the press treatment would allow the grasses a short period of time to recover between treatments, the pulse and press treatments may produce differing results. The results do not show this, except for isolated weekly cases pertaining to the height measurement. The chosen time interval between treatments (2 weeks) was chosen fairly arbitrarily and a different time interval may have influenced the project significantly to produce a different result. It is important when considering the results of this study to consider the specific intensity of trail use at the park in question, and whether or not 40 passes over an 8 week period seems to be a similar intensity.

Conclusion The results of this study are consistent with those found by Thurston and Reader (2001) and other comparative trampling studies. That is, no significant difference could be found between the degradation caused by hiking and that caused by mountain biking. Although these results do not change the knowledge base about recreation impacts, my study does suggest that park managers should take into account the time of year, trampling intensity, and vegetation type used in this study when considering how to regulate a specific park. Further studies integrating different land types, a longer time period, and other indicators of trampling would help to assess long-term effects and ecosystem variability.

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