What determines the area of impact around campsites? A case study in a Finnish national park

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Abstract
This study investigates the impacts of tourism on vegetation and soil on campsites in Pallas-Yllästunturi National Park, Northern Finland. Altogether, 19 campsites were surveyed to estimate the current condition of campsites and to specify factors affecting the amount of disturbance. Our results indicate that the location of campsite structures is the most important factor determining the size of disturbed area on campsites. Distance between wilderness huts and campfire sites explained the size of disturbed area, whereas the age of the campsite and number of visitors had no impact. The total disturbed area on campsites varied between different vegetation types, mountain biotopes being the most sensitive. Our results suggest that the disturbed area can be minimized by locating campsites in trampling tolerant environments and by building the structures compactly within each campsite.

Keywords: tourism, camping site, trampling, vegetation change, national park

1 Introduction

Negative impacts of recreation on nature are inevitable. The major and most visible impact of recreation is wear on vegetation and soil caused by trampling. Even low levels of trampling can induce negative ecological changes (e.g. Frissell and Duncan 1965; Grabherr 1982; Cole 1995a; Marion and Cole 1996; Tolvanen *et al.* 2001, 2004). Trampling causes physical damage to vegetation, diminishes total cover, changes species composition and reduces species richness (e.g. review by Cole 2004). The original vegetation can be replaced by trampling-tolerant species (e.g. Hammitt and Cole 1998), but if the disturbance is rapid and very intensive, even the trampling-tolerant species may not be able to establish in the area (Hoogesteger and Havas 1976; Nylund *et al.* 1979). The impacts of continuous trampling, e.g. erosion and compaction of soil, can hinder the establishment of vegetation (e.g. Hammitt and Cole 1998; review by Cole 2004). The tolerance of plant communities to disturbance varies between different vegetation types (e.g. Cole 1995a, 1995c; Monz 2002; Gallet and Rozé 2001; review by Cole 2004) and is dependent on the community's capability to resist initial trampling and to recover from the disturbance (Cole 1995a, 1995c).

Nature-based tourism and recreational use are often concentrated in environments with conservational value such as national parks. In Finland, the number of visitors in national parks has multiplied in the last few decades (SAARINEN 2005; METSÄHALLITUS 2006). The rapid increase of tourism may threaten the conservational value of the national parks: hiking trails and areas around wilderness huts and campsites are exposed to more extensive wear and erosion, and increased environmental impacts such as littering, noise pollution and waste water. An important indicator of recreation induced impacts in national parks is the wear of campsites as it is a relatively clear and visible impact. Only one night of camping can be sufficient to cause visible impacts on vegetation (COLE 1995b). According to a study conducted in Saariselkä, in northern Finland, the area of transformed vegetation surrounding the wilderness huts has expanded substantially over a 25 year period (RAUTIO *et al.* 2001). Mineral soil is exposed due to the erosion around the most extensively used wilderness huts. Wear of vegetation and soil inevitably reduces the visual value of the landscape. An increased number of visitors may result in a greater amount of different recreational services offered inside and in the proximity of national parks, causing the environmental impacts to spread out over a wider area. To preserve the conservational and recreational value of the national parks it is essential to monitor and control the environmental impacts caused by recreation. Impacts of recreation on campsites have been studied rather widely, particularly in North America (e.g. COLE 1992, 1995b; HAMMITT and COLE 1998; review by COLE 2004). In Finland, a few studies have been conducted concerning the impacts of recreation on vegetation on campsites (e.g. HOOGESTER and HAVAS 1976; RAUTIO *et al.* 2001). However, while the focus has been mainly on vegetation type and amount of use, the effect of location of campsite structures is less studied. There is a need for more detailed studies at campsites in a variety of environments to determine the factors affecting campsite deterioration for controlling and minimizing the negative impacts of recreation.

We studied the effects of tourism on vegetation in campsites in Pallas-Yllästunturi National Park in Northern Finland. The main focus of the research was to quantify the current state of the campsites in terms of disturbance impact and the major factors affecting the amount of disturbance. The main questions were: 1) What is the size of the areas with visible changes in vegetation and soil? 2) Are the number of visitors, campsites' age, vegetation type and distance between campsite structures related to the impacts on vegetation?

2 Materials and methods

2.1 Study areas

The study sites were located in Pallas-Yllästunturi National Park (former Pallas-Ounastunturi NP), in Northern Finland (68º05'N, 24º04'W). The study area is located near the northern limit of the boreal zone. Annual mean temperature during the year 2003 was –0.4 °C with –38 °C minimum and +29.5 °C maximum (Finnish Meteorological Institute 2003). In the previous winter the snow cover lasted approximately six months from late October/early November to the beginning of May, with a maximum mean snow depth of 57 cm (Finnish Meteorological Institute 2002, 2003). In 2005 the Pallas-Ounastunturi National Park was dissolved and simultaneously new Pallas-Yllästunturi National Park was established, containing the Ylläs-Aakenus Natura 2000 area, the old Pallas-Ounastunturi NP and some side areas. The park has a high recreational value. The Hetta-Pallas hiking trail, which leads through the park, is among Finland's oldest and most popular trails. There are approximately 350 km of marked summer-time trails in the Pallas-Yllästunturi area. During the study year 2003 the total visitor number was over 125 000 (SULKAVA *et al.* 2004). About

40 % of the use activities occur in the summer season and 60 % in winter (SULKAVA *et al.* 2004). Within the Pallas-Yllästunturi National Park and just outside of its boundaries, there are twenty open and four reservable wilderness huts for one to two night stays, nine day trip huts for brief stops and one rental wilderness hut, which is rented to one group at a time. There are also four campfire sites, six lean-to shelters and 18 Lapp pole tents, which can be used to shelter from bad weather. In the recreation zone of the National Park camping is permitted in the vicinity of wilderness huts and campfire sites. In the wilderness zones camping is permitted everywhere, but campfires can only be built near bodies of water.

Altogether 19 campsites were surveyed in summer 2003. Campsites can be divided in three groups by the use type; mainly day visitors (nine campsites), day and overnight visitors (7) and mainly overnight visitors (3). User groups are mainly small; most common group size was two persons in 2003, but campsites are used regularly also by bigger groups with mean group size of six persons in 2003. The vegetation types at surveyed campsites were mesic boreal forest, semi-dry boreal forest, mountain birch forest and mountain heath. Mesic boreal forests are dominated by *Picea abies,* more rarely by *Betula pubescens* and the ground layer by dwarf shrubs *Vaccinum myrtillus, V. vitis-idaea* and some herbs *(Solidago virgaurea, Trientalis europaea)* (5 campsites). Semi-dry boreal forests are dominated by *Pinus sylvestris* and the ground layer by *V. vitis-idaea, V. uliginosum* and *Empetrum nigrum* (5 campsites). Mountain birch forests are dominated by *Betula pubescens* ssp. *czerepanowii* included both a mesic type, dominated by *V. vitis-idaea* and *V. myrtillus* and a herb *Cornus suecica* (5 campsites) and a dryer type dominated by dwarf shrubs *E. nigrum, V. vitis-idaea* and *V. myrtillus* (1 campsite). The treeless mountain heaths similarly included mesic type dominated by *V. vitis-idaea* and *V. myrtillus* and *E. nigrum* (2 campsites) and dryer type characterized by *E. nigrum* and lichens (1 campsite).

2.2 Field survey

Campsite measurements

At the first phase of the survey the total campsite area affected by trampling was estimated. The area with visible changes in soil or vegetation was considered as the total disturbed area. The total disturbed area was measured and separated into two zones: (I) zone with destroyed vegetation cover, i.e. non-vegetated area and (II) zone with continuous vegetation cover but clearly affected by trampling. Zone I was characterized by exposed humus layer or mineral soil, containing not more than a few scattered small patches of vegetation. Zone II included areas with trampled original vegetation (visible injuries in plants; bent or broken stem, leafs ripped off etc.) and areas consisting of secondary trampling-tolerant vegetation. To study the size and construction of the campsite, the campsite area with different zones was drawn on a graph paper as accurately as possible. The structures and their distances were measured and drawn to scale. As the use on the campsites in the study area often concentrates around main structures of a campsite, like campfire site and wilderness hut, it is difficult to specify a centre point of a campsite area. Thus, instead of using one centre point with 16 transects (e.g. COLE 1982, 1989b; HAMMITT and COLE 1998), in this study two of the main structures on each campsite were chosen as midpoints for transect lines to obtain an accurate measure of campsite area. From each of these main structures eight transect lines (16 transect per campsite in total) were directed to cardinal and half-cardinal points. In every transect line the distance to the edge of zone II and to the undisturbed control area were measured. The size of the total disturbed area, a combination of zone I and zone II was further calculated from the graph paper. If there were islands of original vegetation inside zones I and II their area was estimated and subtracted from the size of total disturbed area.

In this study we did not include the “satellite” areas, i.e. the disturbed areas which are situated further from the main campsite area, such as extra tent sites. At each campsite the amount of official and unofficial paths leading from the campsite was counted. On one campsite there were no trails at all, as the campsite is only in winter use and thus accessible along ski tracks.

Vegetation measurements

The species composition and percentage of vegetation coverage were visually estimated from 50 × 50 cm study squares in different zones of the campsite area and in control areas. The study squares were placed in each zone on the transect lines radiating from the chosen campsite structures. In zone I, which most often was the predominant zone surrounding the main structures, the study square was placed directly at the beginning of the zone at the edge of the facility. Similarly in zone II the study squares were placed at the beginning of the zone. The control square was situated on undisturbed area approximately five metres from the campsite edge. The occurrence of different zones varied around the chosen main structures (e.g. zone I and/or zone II were absent from some sides of the structure) and thus a different number of squares could be studied from each zone on each campsite.

2.3 Estimation of visitor number

The survey for estimating the visitor number in different campsites of Pallas-Yllästunturi National Park was conducted from January 2003 to October 2003. Visitor numbers were estimated with electronic counters and visitor questionnaires. There were a total of 17 electronic counters (Telco SMR 5525 NG 5 and Trailmaster TM 1500) on the main tracks, which were checked every week for service and weekly visitor number information. Counters were installed and calibrated according to used method (HORNE *et al.* 1998). Visitor survey (n = 1100) was completed simultaneously with electronic counting. In the questionnaire, with a help of a map of the area, visitors were asked for which trails they had or were going to use during their visit. Comparison of visitor number data gained from electronic counters to data from visitor survey of the same trail gave a ratio of exact number of visitors in each trail. Number of visitors in each campsite is the total number of visitors coming from every trail heading to the campsites. Number of visitors was not counted electronically in all tracks heading to campsites. At these sites the number of visitors was estimated according to the information gained from visitor survey questionnaires together with information of nearest counters; presumably, this ratio was equal in each track near the campsite.

2.4 Statistical analyses

In the statistical analysis we used four response variables indicating the disturbance level of the campsites: sizes of the zone I, zone II and the total disturbed campsite area as well as the number of trails leading from the campsite (hereafter disturbance variables). We used the number of visitors, campsite age, the distance between wilderness hut and campfire site and the distance between wilderness hut and woodshed as explanatory variables (hereafter campsite use variables). We used a stepwise linear multiple regression to investigate the relative importance of campsite use variables in explaining variation in each disturbance variable. Pearson’s correlation was used to study the possible relationships between each of the campsite use as well as disturbance variables. Bonferroni corrections were calculated for correlations between disturbance variables and for campsite variables. There tended to be positive correlation between the number of visitors and the distance between wilderness hut and campfire site ($r = 0.419$, $N = 19$, $p = 0.074$, 2-tailed). As the correlation was not significant both variables were included in the multiple regression analyses.

We compared the average size of zone I, zone II and total disturbed area as well as the mean number of trails between different vegetation types with one-way ANOVA. Pairwise comparison between the vegetation types was done using Tukey's post hoc test.

The differences in species composition and vegetation coverage of functional plant types (dwarf shrubs, grasses, herbs, shrubs, lichens and mosses) between zone II and the control area were studied with Wilcoxon Signed Ranks Test.

If the data did not fulfil the requirements of normality and homogeneity of group variances, square root or log transformed values were used. Parametric tests were applied, if appropriate; otherwise we used the corresponding non-parametric tests. All analyses were performed using SPSS 14.1. (SPSS Inc. 2003).

3 Results

3.1 The size of the disturbed campsite area

The mean size of zone I was 88.26 ± 26.096 S.E. m^2 ($n = 19$, $CV = 1.289$) and zone II 245.2 ± 42.450 m^2 ($n = 19$, $CV = 0.755$) with ranges from 16 m^2 to 492 m^2 and from 0 m^2 to 582 m^2, respectively. Non-vegetated zone I occurred mainly around the main structures with the most intensive use, and formed on average 24 % of the total disturbed area. Zone II was absent on only one campsite. This campsite was the only site exclusively in winter use. The size of total disturbed area was on average 333.4 ± 48.1 m^2 ($n = 19$, $CV = 0.755$) with a range from 22 m^2 to 665 m^2. None of the campsite use-variables was significantly related to the size of the zone I or zone II. However, there were positive correlations between different disturbance variables (Table 1). The size of the total disturbed campsite area correlated positively with the size of zone II and the number of trails leading from the campsite. Furthermore, the size of zone II correlated positively with the number of trails.

The size of the disturbed area was best explained by the distance between wilderness huts and campfire site (Table 2). In the stepwise multiple regression model, only hut-campfire site-distance variable was included, explaining 34.8 % of the variation of the total disturbed area. Age of the campsite, hut-woodshed distance and the visitor number had no significant impact on disturbed area and were thus excluded from the regression model.

Table 1. P-values of correlation matrix (r) for the disturbance variables. The correlations which were significant after Bonferroni correction are presented with bold font.

	Total area	Zone I	Zone II
Zone I	0.123		
Zone II	**<0.001**	0.626	
Number of trails	**<0.001**	0.079	**0.016**

Table 2. Summary of results from stepwise multiple regression investigating the predictive value of different campsite use variables to disturbance variables. The chosen models and their significance (ANOVA) presented. HC = distance between wilderness hut and campfire site, HW = distance between wilderness hut and woodshed, VN = visitor number.

Dependent variables	Model	Regression equation	df (regression, residual)	R^2	F	p
Total disturbed area	1	y = 0.216xHC+155.350	1, 17	0.348	9.081	0.008
Number of trails	1	y = 0.53xVN+5.191	1, 17	0.278	6.543	0.020
	2	y = 0.048xVN+0.003xHW+1.683	2, 16	0.502	8.074	0.004

The number of trails in campsites varied from 0 to 18 with a mean of 9.737 ± 1.011 (n = 19) trails. In the stepwise multiple regression, a model with the number of visitors and hut-woodshed distance had the best predictive value on the number of trails in the campsites (Table 2), explaining 50.2 % of the total variation. The distance between wilderness hut and campfire site and campsite age were excluded from the model.

The number of visitors in campsites ranged between 318 and 32802 with an average of 9286 ± 2002 visitors. The correlation between the number of visitors and the size of disturbed area was positive (r = 0.488, n = 19, p = 0.034). However, the correlation was not significant after being controlled by the hut-campfire site distance in a partial correlation test (r = 0.329, p = 0.183).

3.2 Differences between vegetation types

The total disturbed area differed significantly between campsites in different vegetation types (ANOVA F = 6.307, p = 0.006). Mountain biotopes were more affected by trampling than boreal forests (Fig. 1). The total disturbed area around campsites was significantly smaller in mesic boreal forests than in mountain heaths (Tukey HSD, p = 0.020) and mountain birch forests (Tukey HSD, p = 0.036), and slightly but not significantly smaller in semi-dry boreal forests than in mountain heaths (Tukey HSD, p = 0.062) and mountain birch forests (Tukey HSD, p = 0.078). The number of trails in the campsites differed significantly between the vegetation types (F = 3.889, p = 0.031), although Tukey's post hoc test could not detect pairwise differences between the vegetation types. The vegetation type had significant impact on the size of the zone II (F = 6.415, p = 0.005), which was significantly larger in mountain heaths than in semi-dry boreal forests (Tukey HSD, p = 0.018) and in mesic boreal forests (Tukey HSD, p = 0.011). Vegetation type had no impact on the size of zone I (F = 0.351, p = 0.789).

3.3 Changes in vegetation characteristics

The cover of all studied plant groups, except herbs, differed significantly between zone II and the control area (Fig. 2). Only grasses had a higher cover in zone II, all the other plant groups having higher covers on control areas. At all campsites there were trampling-tolerant species, e.g. *Poa annua, P. pratensis* and *Plantago major,* which are alien to the original biotope. These secondary species were mostly found in disturbed areas of the campsites (zone I and zone II).

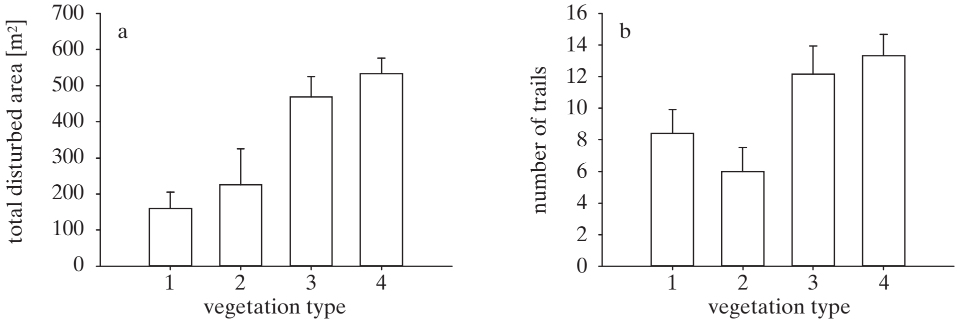

Fig. 1. The mean (+ S.E.) size of the total disturbed area (a), and the mean number of trails at campsites (b) in different vegetation types. Vegetation types 1= mesic boreal forest (n = 5), 2 = semi-dry boreal forest (n = 5), 3 = mountain birch forest (n = 6) and 4 = mountain heath (n = 3).

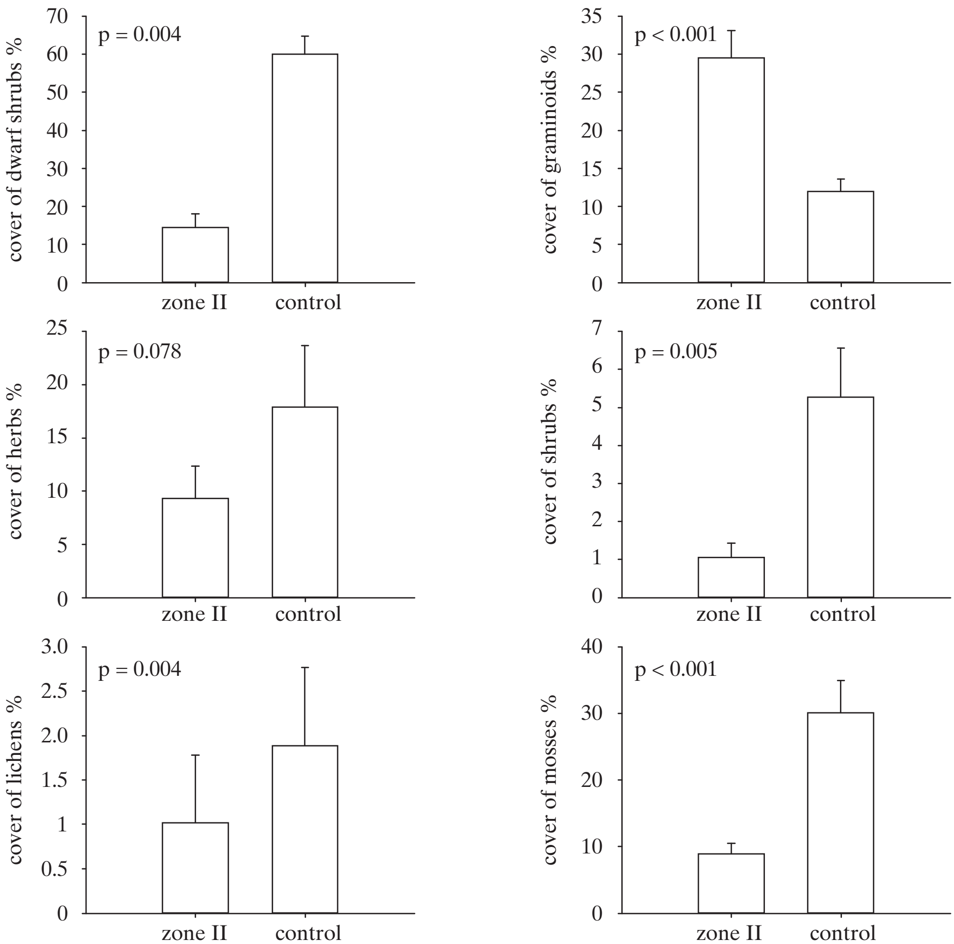

Fig. 2. Estimated covers of plant groups in zone II and undisturbed area (control). Statistical comparison with the Wilcoxon signed ranks test, n = 19. All surveyed vegetation types were included in the analyses.

4 Discussion

Our results show that the location of campsite structures is the most important factor determining the size of disturbed area in campsites in Pallas-Yllästunturi National Park. The total disturbed area was best explained by the distance between wilderness huts and campfire sites. Furthermore, the number of trails seems to be related both to the distance between wilderness hut and the woodshed and visitor numbers of the campsites. It is known that several factors including the amount, type and behaviour of the use, season, environmental factors and spatial distribution of use have an effect on the amount of impact on campsites (review by COLE 2004). Since these factors interact, the effect of any single factor is difficult to separate.

The empirical results of this study corroborate the modelling results and predictions by COLE (1992). He found that the degree of concentration of camping activities affects the significance of other factors and determines the amount of vegetation loss. The vegetation fragility and the amount of use are equally important factors given that the use is not concentrated, and thus any increase in these variables increases the amount of vegetation loss. However, if the degree of concentration of camping activities is raised, the influence of the amount of use and vegetation fragility declines. Thus in campsites with highly-concentrated use neither the amount of use nor vegetation fragility have much effect on the amount of impact on vegetation (COLE 1992). The relationship between the amount of use and the amount of impact is curvilinear indicating that a substantial amount of impact occurs already at low levels of use, whereas increases in amount of use have only slight additional impact (e.g. HAMMITT and COLE 1998; review by COLE 2004). According to COLE (1992), one explanation for this relationship can be the tendency of activities to become increasingly concentrated as the amount of use increases.

Contrary to earlier investigations (e.g. HOOGESTEGER 1976; MARION and COLE 1996), we found no relationships between the size of disturbed area and the number of visitors or with the age of the campsite. This is probably explained by the fact that all campsites studied in Pallas-Yllästunturi National Park are relatively old (mean 28 years), and the increase in the number of visitors has been gradual. Hence other factors such as the location of campsite structures may have become more important in determining the size of the disturbed area. According to a schematic presentation on a typical life history of a campsite (review by COLE 2004), most of the campsites in Pallas-Yllästunturi National Park are in a "stable phase" in which there are changes in the amount of impact only if there are dramatic changes in the amount of use.

None of the investigated campsite use variables were related to the size of the non-vegetated area (zone I). This is an opposite result to earlier studies (e.g. HOOGESTEGER 1976; MARION and COLE 1996). It is likely that the size of the non-vegetated area in campsites of Pallas-Yllästunturi National Park is determined by other factors (e.g. the type and behaviour of the use and natural constraints of the use), which affect the distribution of most intensive use. For example, back-country campsites with long hiking distances generally get fewer visitors per year than more easily accessible campsites. However, as the short-distance sites get more one-day trip visitors, the back-country sites are used for over-night camping with more intensive use of the site per visitor. Natural constraints such as rough vegetation and topography also affect the spatial distribution of use (COLE 1989a; LEUNG and MARION 1999; MARION and FARRELL 2002).

Our results emphasize that the concentration of use within campsites is an effective management tool for controlling campsite impacts (COLE 1989a, 1992; MARION and COLE 1996; COLE and MONZ 2004). Indeed, some positive results accomplished by concentrating the use have already been reported (MARION 1995; SPILDIE *et al.* 2000; MARION and

FARRELL 2002). The number of trails indicates off-site disturbance and thus about potential for campsite expansion (LEUNG and MARION 1999). In our study unofficial trails were most common in campsites with a higher number of visitors and a longer distance between wilderness hut and woodshed. Hence spatial configuration of campsite structures is important in limiting the formation of unofficial trails (review by MARION and FARRELL 2002). The formation of unofficial trails can be reduced by, for example, linear arrangement of campsite structures (MARION and FARRELL 2002).

Mountain biotopes were more sensitive to disturbance than boreal forest types. Alpine and sub-alpine vegetation and soil are known to be sensitive to trampling due to their low resistance and re-growth ability after disturbance (STOHLGREN and PARSON 1986). Even low trampling pressure can reduce significantly the cover of vegetation and the above-ground biomass on arctic and alpine heaths (GRABHERR 1982; TOLVANEN *et al.* 2001, 2004; MONZ 2002; TÖRN *et al.* 2006), and unofficial trails emerge quickly, even after 25 passes (TOLVANEN *et al.* 2001; TÖRN *et al.* 2006). HOOGESTEGER (1984) discovered many plant species to be more sensitive to trampling above the tree-line than in forest. Furthermore, the vulnerability of the mountain heaths to disturbance can be partly explained by low and open vegetation, which probably makes it more passable for visitors than forests with denser vegetation.

In this study, from the studied plant forms only the graminoids had higher cover in zone II than control areas, thus supporting the earlier findings that graminoids are more trampling tolerant plant form (e.g. STOHLGREN and PARSONS 1986; YORKS *et al.* 1997). The native dwarf shrubs, mosses and lichens were sensitive to trampling and disappeared from the most intensively used areas (see also HOOGESTEGER 1976). Tolerance of herbs varies depending plant characteristics, matted, caespitose and rosette growth forms being more tolerant than erect herbs (COLE 1995c; COLE and MONZ 2002), which partly can explain the non-significant result in the cover of the herbs between zone II and control areas.

At present the invasion of ecosystems by alien species is considered one of the major threats to global biodiversity (VITOUSEK *et al.* 1997; SALA *et al.* 2000) and has also in increasing extent become one of the major issues confronting the managers of national parks and other nature reserves (e. g. MARION *et al.* 1986; COWIE and WERNER 1993; MARLER 2000; LLEWELLYN and RICHARDSON 2003). In Pallas-Yllästunturi NP, the alien plant species were mostly detected in disturbed areas and thus their impacts on the original vegetation seem to be quite minor. In fact, most of the alien species observed were trampling tolerant species which can prevent erosion (HOOGESTEGER 1976). However, regular monitoring of alien species is needed in order to detect and prevent possible invasions.

To conclude, our results suggest that the disturbed area can be minimized by locating campsites in trampling tolerant environments and by building the structures compactly within a campsite. Constructing new campsites in mountain heaths should be avoided as they are sensitive to trampling. They also reduce the scenic value of the landscape due to disturbed non-vegetated areas that can be seen from a distance. The spatial extent of the disturbance in a landscape level can be minimized by establishing new campsites along existing hiking trails. Within campsites, natural constraints, such as dense, high, or rough vegetation or topographical factors, can be used in minimizing the size of the disturbed area (COLE 1989a; LEUNG and MARION 1999; MARION and FARRELL 2002). In the absence of natural constraints the use can be channelled by marking the campsite area by e.g. rocks and logs (MARION and FARRELL 2002) or with artificial structures like duck-boards, stairs or cover by gravel. Channelling the use in established campsites can prevent the further expansion of the disturbed area and formation of unofficial trails. The success of channelling and preventive methods in preserving the conservational and recreational value of national parks needs regular monitoring to assess the environmental impacts of recreational use.

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5 References

COLE, D.N., 1982: Wilderness Campsite impacts: Effects of amount of use. Res. Pap. USDA For. Serv. INT-284. 34 pp.
COLE, D.N., 1989a: Area of vegetation loss: a new index of campsite impact. Research note INT-389. Ogden, UT, U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 5 pp.
COLE, D.N., 1989b: Wilderness campsite monitoring: a sourcebook. General technical report INT-259. Ogden, UT, U.S. Department of Agriculture, Forest Service, Intermountain Research Station.
COLE, D.N., 1992: Modelling wilderness campsites: Factors that influence amount of impact. Environ. Manage. 16, 2: 255–264.
COLE, D.N., 1995a: Experimental trampling of vegetation. I. Relationships between trampling intensity and vegetation response. J. App. Ecol. 32, 1: 203–214.
COLE, D.N., 1995b: Disturbance of natural vegetation by camping: Experimental applications of low-level stress. Environ. Manage. 19, 3: 405–416.
COLE, D.N, 1995c: Experimental trampling of vegetation. II. Predictions of resistance and resilience. J. Appl. Ecol. 32, 1: 215–224.
COLE, D.N.; MONZ, C.A., 2002: Trampling disturbance of high-elevation vegetation, Wind River Mountains, Wyoming, U.S.A. Arct., Antarc., Alp. Res. 34, 4: 365–376.
COLE, D., 2004: Impacts of hiking and camping on soils and vegetation: a review. In: BUCKLEY, R. (ed) Environmental Impacts of Ecotourism. CABI publishing, UK. 41–60.
COLE, D.N.; MONZ, C.A., 2004: Spatial patterns of recreation impact on experimental campsites. J. Environ. Manage. 70, 1: 73–84.
COWIE, I.D.; WERNER, P.A., 1993: Alien plant species invasive in Kakadu National Park, Tropical Northern Australia. Biol. Conserv. 63, 2:127–135
Finnish Meteorological Institute 2002: Ilmastokatsaus No. 1-12/2002.
Finnish Meteorological Institute 2003: Ilmastokatsaus No. 1-12/2003.
FRISSELL, S.; DUNCAN, D., 1965: Campsite preference and deterioration. J. For. 63, 4: 256–260.
GRABHERR, G., 1982: The impact of trampling by tourists on high altitudinal grassland in the Tyrolean Alps, Austria. Vegetatio 43: 209–217.
GALLET, S.; ROZÉ, F., 2001: Resistance of Atlantic Heathlands to trampling in Brittany (France): influence of vegetation type, season and weather conditions. Biol. Conserv. 97, 2: 189–198.
HAMMITT, W.E.; COLE, D.H., 1998: Wildlife recreation: ecology and management. 2nd ed. New York, Wiley.
HOOGESTEGER, M., 1976: Changes in vegetation around the refuge huts in Koilliskaira forest area. Silva Fenn. 10: 40–53. [In Finnish with English summary]
HOOGESTEGER, M.; HAVAS, P., 1976: Ecological capacity and the planning of recreational activities in the proposed new national parks of northern Finland. Terra 88, 1: 31–34. [In Finnish with English abstract]
HOOGESTEGER, M., 1984: The effect of trampling on vegetation at four cottages in Torne Lapland, northern Sweden. Reports from the Kevo subarctic research station. 19: 25–34.
HORNE, P.; SIEVÄNEN, T.; ALENIUS, V.; IISALO, H.; FRIMAN, T., 1998: Kävijälaskenta-opas. Metsähallituksen luonnonsuojelujulkaisuja. Sarja B 45: 68 pp. [in Finnish]

LEUNG, Y.-F.; MARION, J.L., 1999: Characterizing backcountry camping impacts in Great Smoky Mountains National Park, USA. J. Environ. Manage. 57, 3: 193–203.

LLEWELLYN, C.F.; RICHARDSON, D.M., 2003: Managing alien plant invasions in the Kruger National Park, South Africa. In: CHILD, L.E.; BROCK, J.H.; BRUNDU, G.; PRACH, K.; PYSEK, P., WADE, P.M.; WILLIAMSON, M. (eds) Plant invasions: Ecological Threats and Management Solutions. Leiden, Backhuys. 385–403.

MARION, J.L., 1995: Capabilities and management utility of recreation impact monitoring programs. Environ. Manage. 19, 5: 763–771.

MARION, J.L.; COLE, D.N.; BRATTON, S.P., 1986: Exotic vegetation in wilderness areas. Gen. Tech. Rep., USDA For. Serv. 114–120.

MARION, J.L.; COLE, D.N., 1996: Spatial and temporal variation in soil and vegetation impacts on campsites. Ecol. Appl. 6, 2: 520–530.

MARION, J.L.; FARRELL, T.A., 2002: Management practices that concentrate visitor activities: Camping impact management at Isle Royale National Park, USA. J. Environ. Manage. 66, 2: 201–212.

MARLER, M., 2000: A survey of exotic plants in federal wilderness areas. In: COLE, D.N.; MCCOOL, S.F.; BORRIE, W.T.; O'LOUGHLIN, J. (comps.) Wilderness science in a time of change. Conference Vol. 5: Wilderness ecosystems, threats, and management. May 23–27, 1999; Missoula, M.T. Proceedings RMRS-P-15-Vol-5. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Metsähallitus, 2006: Metsähallituksen luontopalvelut Vuosikertomus 2005. <http://www.metsa.fi/page.asp?Section=3015>

MONZ, C.A., 2002: The response of two arctic tundra plant communities to human trampling disturbance. J. Environ. Manage. 64, 2: 207–217.

NYLUND, M.; NYLUND, L.; KELLOMÄKI, S.; HAAPANEN, A., 1979: Deterioration of forest ground vegetation and decrease of radial growth of trees on camping sites. Silva Fenn. 13: 343–356.

RAUTIO, J.; HELENIUS, M.; SAARINEN, J., 2001: Urho Kekkosen Kansallispuiston kuluneisuus: luontomatkailun ympäristövaikutusten seuranta ja mittaaminen. In: JÄRVILUOMA, J.; SAARINEN, J. (eds) Luonnon matkailu- ja virkistykäyttö tutkimuskohteena. Metsäntutkimuslaitoksen tiedonantoja 796: 111–124. [in Finnish]

SAARINEN, J., 2005: Tourism in Northern Wildernesses: Nature-Based Tourism Development in Northern Finland. In: HALL, C.M.; BOYD, S. (eds) Nature-based Tourism in Peripheral Areas: Development or Disaster? Clevedon, Channelview Publications. 36–49.

SALA, O.E.; CHAPIN, F.S. III.; ARMESTO, J.J.; BERLOW, E.; BLOOMFIELD, J.; DIRZO, R.; HUBER-SANWALD, E.; HUENNEKE, L.F.; JACKSON, R.B.; KINZIG, A.; LEEMANS, R.; LODGE, D.M.; MOONEY, H.A.; OESTERHELD, M.; LEROY POFF, N.; SYKES, M.T.; WALKER, B.H.; WALKER, M.; WALL, D.H., 2000: Global biodiversity scenarios for the year 2100. Science 287: 1770–1774.

SPILDIE, D.R.; COLE, D.N.; WALKER, S.C., 2000: Effectiveness of a confinement strategy in reducing pack stock impacts at campsite in the Selway-Bitterroot Wilderness, Idaho. In: COLE, D.N.; MCCOOL, S.F.; BORRIE, W.T.; O'LOUGHLIN, J. (comps.) 2000: Wilderness science in a time of change. Conference Vol. 5: Wilderness ecosystems, threaths, and management; May 23–27, 1999; Missoula, M.T. Proceedings RMRS-P-15-Vol-5. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

SPSS 2003: SPSS base 12.0 user's guide. Chigago IL, SPSS Inc.

STOHLGREN, T.J.; PARSONS, D.J., 1986: Vegetation and Soil Recovery in Wilderness Campsites Closed to Visitor use. Environ. Manage. 10, 3: 375–380.

SULKAVA, P.; HATANPÄÄ, M.; OLLILA, E., 2004: Pallas-Ounastunturin kansallispuiston kävijät 2003. Raportti. Metsähallitus, Enontekiö. 103 pp. [in Finnish]

TOLVANEN, A.; FORBES, B.; RYTKÖNEN, K.; LAINE, K., 2001: Regeneration of dominant plants after short-term pedestrian trampling in sub-arctic plant communities. In: WIELGOLASKI, F.E. (ed) Man and the biosphere series: Nordic mountain birch ecosystems. Paris, UNESCO, and The Parthenon Publishing Group. 361–370.

Tolvanen, A.; Rämet, J.; Siikamäki, P.; Törn, A.; Orell, M., 2004: Research on ecological and social sustainability of nature tourism in northern Finland. In: Sievänen, T.; Erkkonen, J.; Jokimäki, J.; Saarinen, J.; Tuulentie, S.; Virtanen, E. (eds) Policies, Methods and Tools for Visitor Management. Proceedings of the Second International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas, June 16–20, 2004. Rovaniemi, Finland. Working Papers of the Finnish Forest Research Institute 2: http://www.metla.fi/julkaisut/workingpapers/2004/mwp002.htm.

Törn, A.; Rautio, J.; Norokorpi, Y.; Tolvanen, A., 2006: Revegetation after short-term pedestrian trampling at subalpine heath vegetation in Finnish Lapland. Ann. Bot. Fenn. 43, 2: 129–138.

Vitousek, P.M.; D'Antonio, C.M.; Loope, L.L.; Rejmanek, M.; Westbrooks, R., 1997: Introduced species: A significant component of human-caused global change. N. Z. J. Ecol. 21, 1: 1–16.

Yorks, T.P.; West, N.E.; Richard, J.M.; Warren, S.W., 1997: Toleration of traffic by vegetation: Life form conclusions and summary extracts from a comprehensive data base. Environ. Manage. 21, 1: 121–131.

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