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RECREATION MONITORING OF RESOURCE CONDITIONS IN THE KRONOTSKY STATE NATURAL BIOSPHERE PRESERVE (KAMCHATKA): AN INITIAL ASSESSMENT

ABSTRACT. The paper describes assessment and monitoring program which has been designed and initiated for monitoring recreational impacts in some wildernesses areas of Kamchatka. The framework of the recreational assessment was tested through its application in a case study conducted during the summer 2008 in the Kronotsky State Natural Biosphere Preserve (the Kamchatka peninsula, Russia). The overall objective of the case study was to assess the existing campsite and trail recreation impacts and to establish a network of key sites for the subsequent long-term impact monitoring. The detailed assessment of different components of natural complexes of the Kronotsky State Natural Preserve and the obtained maps of their ecological conditions showed that some sites had been highly disturbed. The results of these works have given rise to a concern that the intensive use of these areas would make an unacceptable impact on the nature. Findings of our initial work corroborate the importance of founding wilderness management programs on knowledge about the trail and campsite impacts and emphasize the necessity of adopting the recreational assessment and monitoring framework to the practice of decision-making.

KEY WORDS: recreation impacts, environmental assessment, monitoring, wilderness

INTRODUCTION

One of the most pressing problems facing wilderness managers in the ecologically fragile ecosystems of the Kamchatka peninsula is that of recreational impacts. The loss of vegetation, soil erosion, and associated aesthetic degradation of sites is a significant management concern, particularly when usage is increasing.

In the Russian traditional works devoted to recreational impacts and in the practice of wilderness management, a normative approach is applied for solving the problem of resource conservation when the area is used for different types of recreation. This approach focuses on the search of precise quantitative standards for carrying capacity or the level of use, e.g., the "safety" length of a route correlated with the total land area, or the number of visitors per day (per month, season, year) that can be received on the route without damage to nature.

However, some authors show that there is no direct relationship between the amount of use and the level of impact, especially in the protected areas with established trail systems [Chizhova 2002]. Besides, although the term *carrying capacity* suggests that the number of users is the main concern, the carrying capacity is also a function of other use conditions, such as a type of use, timing and location of encounters between visitors, and visitor behavior [Stankey and Manning 1986].

Therefore, it is necessary to turn to another approach, which is based not on the establishment of the visitor number, but on the long-term planning and analysis of the recreation opportunity spectrum, forms and types of recreation activities, and different models of development of recreation [Chizhova 2007]. This approach is realized in the LAC (Limits of Acceptable Changes) framework [Eagles et al. 2002; Lucas 1985; Stankey 1998; Stankey et al. 1984; Watson and Cole 1992] developed to address the issue of recreation carrying capacity and to manage recreation impacts [Cole and Stankey 1998; Stankey and McCool 1984].

The initial impact assessment and monitoring programs provide an essential element for the LAC recreation resource planning and management framework [Marion 1998]. They offer the managers the most objective tool for documenting natural conditions and processes and the extent of human impact and for evaluation of the subsequent results of implemented actions [Cole 1983, 1989; Marion 1991]. The capabilities and management utility of such programs are attracting the increased international attention due to dramatic expansions of ecotourism worldwide [Marion 1995].

In conditions of rapid growth of the stream of tourists, the adoption of the LAC methodology and development of the recreation monitoring programs and the provision of the information on the assessment of the state of conservation resources, on the severity of threats, and on the success in the management responses [Buckley et al. 2008], become very relevant to the Russian environmental practice requiring effective tools and programs for recreational management.

The LAC methodology and programs of recreation monitoring were already applied and effectively utilized in some Russian natural areas [Chizhova 2007; Ivanov and Labutina 2006; Ivanov et al. 2006; Kalikhman et al. 1999].

This paper describes our attempt to design and implement such program for the Kronotsky State Biosphere Preserve (the Kamchatka peninsula, Russia). It discusses one aspect of the developed recreation-monitoring program – the monitoring of resource conditions. The framework of the recreational impact assessment and monitoring was tested through its application in a case study conducted during the summer of 2008 in Uzon-Geyzer region of the Preserve.

The overall objective of the case study was to inventory all camping areas and trails along the route, to assess the existing recreation impact, and to establish a network of key sites for the subsequent long-term impact monitoring. This paper discusses the preliminary findings of our initial assessment work. Future re-evaluation of these sites will allow us to examine changes in campsite and trail conditions over time and to attempt to relate these trends to changes in the amount, type, and distribution of visitor use.

THE STUDY AREA

The Kronotsky Preserve is recognized for its importance in the conservation of the Earth's natural resources. It has Biosphere Reserve status and is in the List of the World Heritage sites.

The Preserve is located in the Eastern part of Kamchatka and is known by various types of volcanic activity: active and extinct volcanoes, geysers, and thermal sources. It contains such unique nature monuments as the Valley of Geysers, the Caldera of Uzon Volcano, the Death Valley, Burlyaschiy (Bubbling) Volcano, Lake Kronotskoye, the Semyachikskiy Estuary, glaciers of the Kronotsky Peninsula, and the unique Sakhalin fir grove.

The area in our study is in the Uzon-Geyzer region of the Kronotsky Preserve and is located along the former all-Union tourist route to the Valley of Geysers through Burlyaschiy Volcano and the Caldera of Uzon Volcano (Fig. 1). The region is in the volcanic-tectonic depression with heights from 350 m to 1000 m above the sea level and has vulnerable types of vegetation coverage: swamps and areas of geothermal communities; lichen, lichen-shrub, and shrub tundra; and alder elfin wood and mountain pine.

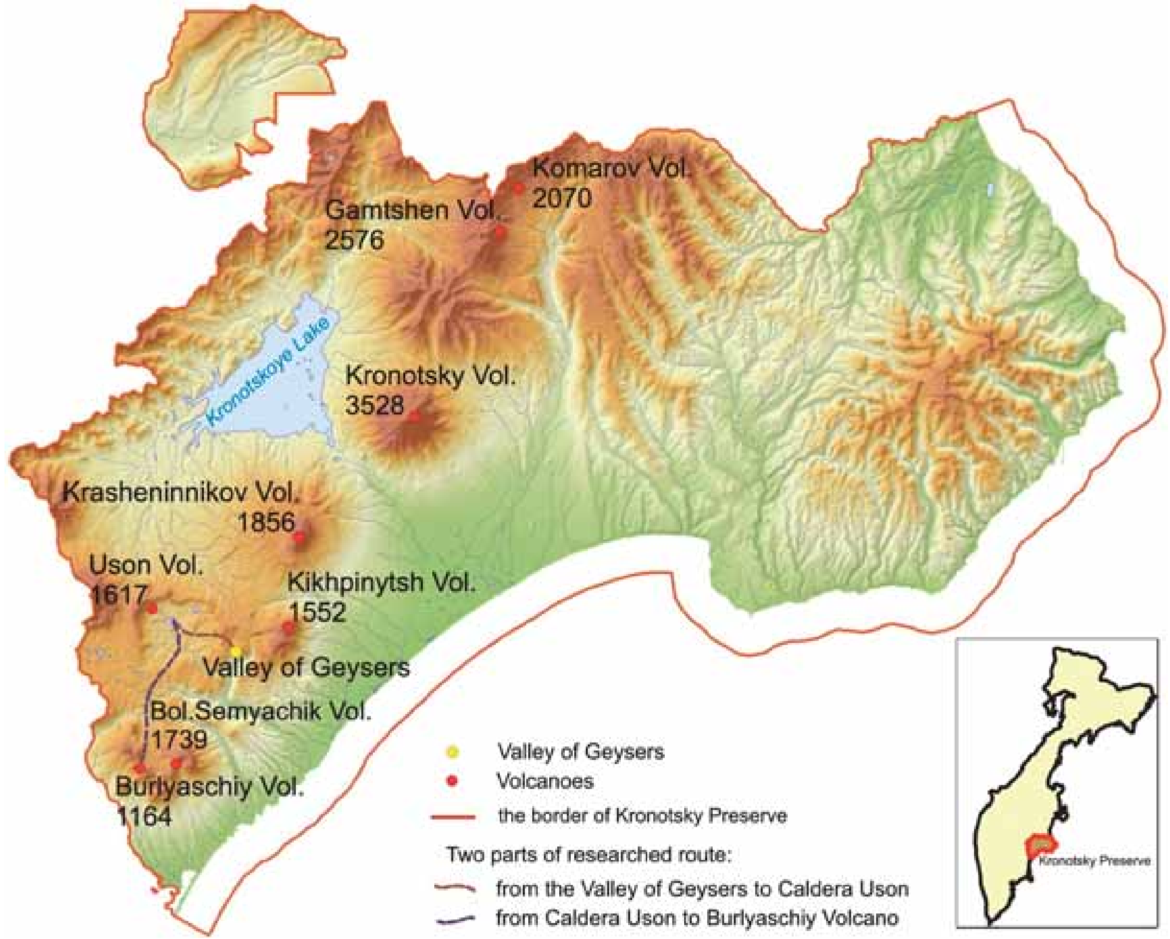

Fig. 1. Location of the study area

The development of unplanned and unmanaged recreation in 1960-s and the operation of the all-Union tourist route in 1962–1976 produced a heavy negative impact on different components of natural complexes along the route. The annual visitation of the route was about 3 000 persons per year, but in conditions of extremely fragile ecosystems of the region and the absence of any recreational planning and visitor management, this has become a threat to the safety of the unique natural objects.

The route has been closed and, nowadays, the tourist activity in the Preserve is concentrated in the Valley of Geysers and in the Caldera of Uzon Volcano in strict compliance with the requirements for preserving the natural landscapes. Compliance with these requirements is controlled ***only*** in the Valley of Geysers by the Preserve scientists through annual ecological monitoring. Today, the other part of the Preserve, including the former all-Union route, is sometimes visited for the purposes of ecological education and scientific tourism. The state of its resources has not been assessed and managed yet.

METHODS

In 2007–2008, using the methodologies of different authors [Cole 1989, 1991; Cole et al. 2008; Manning et al. 2006; Marion 1995; Marion et al. 2006], a multi-parameter campsite and trail condition assessment system was developed for monitoring the resource conditions of the routes in the Kronotsky State Natural Preserve.

Procedures and protocols for assessing inventory and resource condition parameters were developed. The resource condition parameters (e.g., campsite size or trail width, exposed soil, etc.) documented the site conditions, while the inventory parameters (site number and name, site location (GPS coordinates), landscape, type of vegetation cover, soil type, relief, character of boundaries, distance from river) documented the site location or the resource attributes.

The study involved detailed examination of trails and campsites along two parts of once integrated tourist route, stretching from the famous Valley of Geysers to Burlyaschiy Volcano (see Fig. 1).

The campsites were assessed on 12 resource condition parameters and 9 inventory parameters, the trails – on 5 resource condition parameters and 8 inventory parameters.

Measurement accuracy and precision were enhanced through training and supervision of qualified field staff and the use of specially developed protocols.

Campsite impact assessment

Along the route, we searched for the campsites which were marked by the evidence of a campfire. Campsite boundaries were defined by pronounced changes in vegetation cover, vegetation height/disturbance, vegetation composition, or, more rarely, topography. In case when the understory vegetation in some campsites was sparse and it was difficult to establish an accurate border, the boundary was defined hypothetically.

For assessment of the campsite condition and measurement of the campsite areas, we employed the radial transect method [Cole 1982; Marion 1991, 1995]. A point was established near the center of the disturbed area of the campsite. The distances from this point to the first significant difference in vegetation were measured along 16 cardinal directions. This defined the central disturbed area. Within this area, four 1 m^2 quadrates were located along north, south, east, and west transects, halfway to the edge of the core [Cole et al. 2008]. These procedures were applied to all selected, within the campsite, areas with different degree of disturbance (defined by difference in vegetation).

Approximately 18–20 1 m^2 quadrates were randomly located along transects in the campsite perimeter. Within each quadrate, the following parameters were estimated or counted:

- the percent cover of vegetation, medium height of plants, and the number of sick and oppressed plants of each vascular plant species;
- the number of shrubs rooted in each quadrate;
- the total number of species;
- the total percent cover of live vascular vegetation;
- the number of ruderal species;
- organic litter;
- various soil parameters (bulk density, penetration resistance, infiltration rate, and moisture).

All these parameters were also estimated for the adjacent, environmentally similar, but undisturbed control sites selected to represent conditions in the absence of the campsite influence.

Within each campsite boundaries, we also counted the number of trees with scars clearly caused by humans; the number of trees with roots exposed by trampling; the number of social trails that connected the campsite to the trail, to other campsites, or to water. The extent of the development (for example, seats and fire rings) and the cleanliness of the site were also noted. Finally, we took photos of each site to document impacts and mapped the total site area (total impacted area) and selected areas with defined difference in vegetation, mineral soil exposure, and other visible characteristics.

Trail impact assessment

Trail impact assessment included both the assessment of the trail conditions and the assessment of components of natural complexes in the zone of trail impacts.

As one of the purposes of this study was to inventory trails, we have carefully examined the entire complex of trail conditions. Each 10 m, we recorded the width and depth of the trail and its vegetation cover; along the entire route, we identified and investigated eroded areas, as well as highly disturbed areas on or near the trail (so-called "windows of trampling" [Chizhova and Sevostianova 2007]) confined mainly to the points of sightseeing and intersections with other trails.

As in the case with assessing the campsites, when the trail lied in lapilli and it was difficult to establish its accurate boundary, the width was defined hypothetically.

Assessment of soil at eroded sites included the following parameters: coordinates of the site, soil texture, slope length and steepness, average width and depth of the main gully, and the total area of the eroded site.

To assess the influence of "windows of trampling", we used the same methodology as for the campsites.

For detailed assessment of different components of natural complexes in the zone of trail impacts and for the subsequent long-term monitoring of their dynamics, several permanent key sites were established on the trail in every natural complex, using the methodology by Chizhova V.P. and Sevostianova L.I. [Chizhova and Sevostianova 2007]. Several transects, 10 m long each, were located on both sides of the trail, perpendicularly to it. By analogy with the campsite impact assessment methodology, the distances from the middle point of the trail to the first significant difference in vegetation were measured and 1 m^2 quadrates were located in the areas with different degree of disturbance along these transects. The list of estimated parameters and characteristics was the same as in the evaluation of the campsite impacts (see above).

Data analysis

The GIS based methodology was developed for analysis and mapping of recreational impacts and condition classes of campsites and trails in Kronotsky State Natural Preserve.

As a measure of the level of impact on different components of natural complexes in the zone of the trail and campsite influence, we used the level of their disturbance, estimated by comparison of the results of the field studies in the disturbed areas with those in the control sites. The main indicators of such disturbance were the following impact parameters: absolute vegetation cover loss, loss in species composition, vegetation depression, total number of sick and oppressed plants, tree damage and root exposure ratings [Monz 1998], mineral soil exposure, depletion of organic litter, number of social trails and fire rings, and changes in soil parameters. These characteristics were used for the campsite and "windows of trampling" impact assessment, as well as for the assessment of the components of the natural complexes on the key sites in the zone of trail impacts. For evaluation of the trail disturbance, we estimated its total length, average and maximum depth, the development of soil erosion (average width and depth of main gully; total area and length of eroded site), the total number and the area of the "windows of trampling" and the total vegetation cover.

The analysis of the data for these separate impact parameters, using ArcGIS 9.3 (ESRI), allowed us to improve delineation of the boundaries of the sites with different degrees of disturbance, selected in the field, to calculate the level of impact, and to give an integral campsite and trail condition assessment.

For obtaining an integral evaluation of the intensity of impacts (level of impact) and the ecological condition of trails and campsites, we developed a rating scale, including 5 points, and simultaneously introduced 0 through 4 condition-class scale.

Condition-classes for the disturbed areas and trails were as follows: (1) light impact – site is barely discernible, but is distinguishable as a campsite or trail; (2) moderate impact – significant change (approximately 20–50%) of the natural characteristics; (3) heavy impact – high degree (50–80%) of changes; (4) severe impact – the highest possible impact and changes of the natural characteristics (>80%). For areas with no apparent impact we used the "0" Class

RESULTS

The campsites and trails, along the route the Valley of Geysers – Burlyaschiy Volcano, were assessed in September, 2008. We found a large range of campsite and trail conditions with the median condition class being 1 for campsites, 3 for trails, and 1 for trail's key sites (Table 1). This indicates that the sites tend to be lightly to highly impacted.

We assessed six separate camping areas in two parts of the route (Table 1). The campsites were found mainly in lichen and lichen-shrub tundra. The impacted area of the campsites ranged from 181 to 526 m^2 with the median campsite size of 297 m^2 and the prevalence of moderate and light impacted areas.

The inventory and the condition-class assessment were conducted for trails with the total length of 42 km. While 18.3 km (43.6% of the total) were classified as having no impacts or being in a lightly impacted condition and barely distinguishable (Class 0 or 1), 17.8 km (42.4%) were classed as heavily and severely impacted with highly eroded treads (Class 3 and 4) (Table 1).

For assessment of the components of natural complexes in the zone of the trail impacts, we developed seven key sites. The detailed assessment of the key areas revealed a surprisingly restricted spread of the trail impacts on adjacent areas. At most key sites, the impact zone was only 1.5 m wide with the prevalence of lightly impacted areas (Class 1 conditions).

At the same time, the research of "windows of trampling", at the most popular and interesting sights on the route, showed substantial detioration. Thus, over 40% of the area of the key site near the mud hole "Sculptor" in the Uzon Caldera were identified as heavily and severely disturbed (Fig. 2).

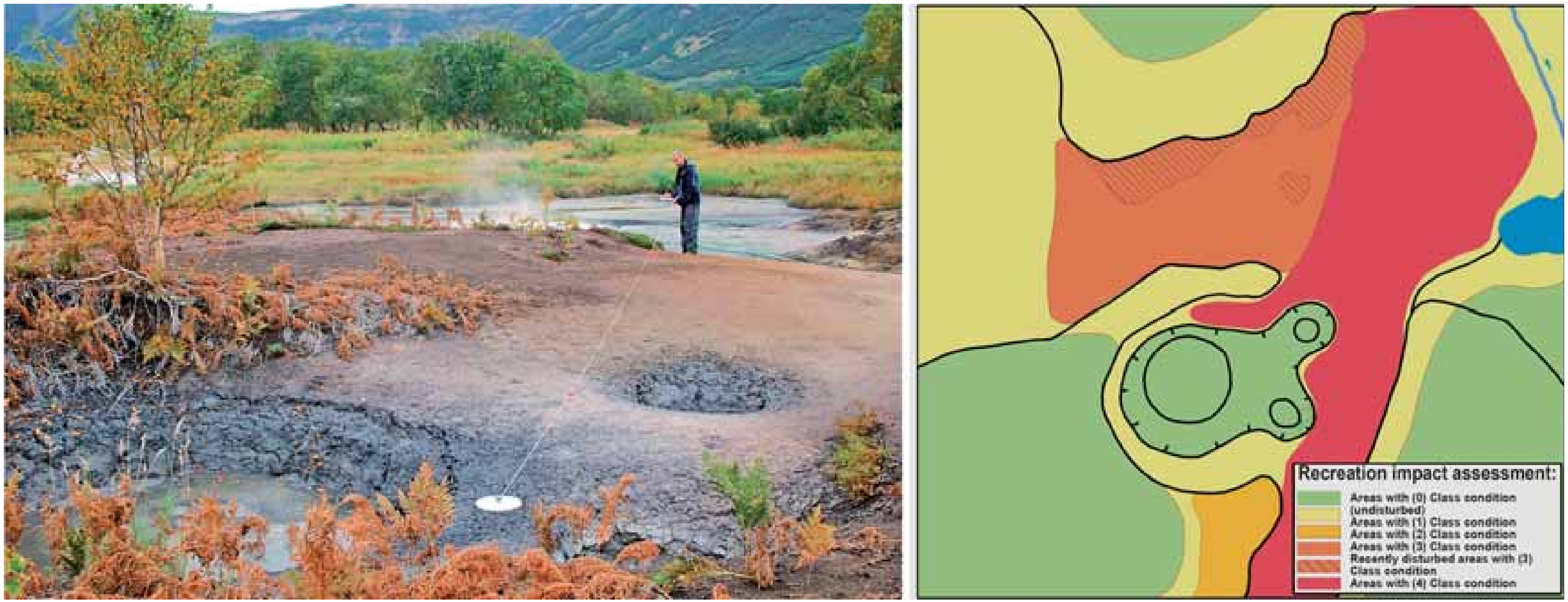

Fig. 2. The key site near the mud hole "Sculptor" in the Uzon Caldera.

Photo of the area and a fragment of the map of the ecological condition of the site

Table. The summary of the campsite and trail impacts in two parts of the route the Valley of Geysers – Burlyaschiy Volcano

Impact characteristic		Part of the route: Valley of Geysers – Caldera Uson	Part of the route: Caldera Uson – Burlyaschiy Volcano
Campsites	Number of sites inventoried	2	4
	Total area of all sites, m^2	363.05	1418,03
	Condition Class	1	1
	Percentage of 4th class areas	1.2 (0.4–2.0)	4.75 (0.0–18.0)
	Percentage of 3rd class areas	9.4 (1.0–17.8)	13.75 (5.0–24.0)
	Percentage of 2nd class areas	22.5 (13.0–32.0)	23.75 (8.0–33.0)
	Percentage of 1st class areas	62.0 (49.8–75.0)	57.25 (53.0–68.0)
Trails	Total length of the trail, km	16	27
	Average width of the trail, cm	32.0	28.6
	Average depth of the trail, cm	18.5	15.3
	Condition Class	3	3
	Percentage of 4th class trails	13.2	12.6
	Percentage of 3rd class trails	26.7	29.6
	Percentage of 2nd class trails	18.4	14.8
	Percentage of 1st class trails	23.0	24.1
	Percentage of 0 class trails	18.7	18.9
Trail's key sites	Number of sites developed	3	4
	Total area of all sites	180.03	243,18
	Condition Class	1	1
	Percentage of 4th class areas	1.1 (0.0–2,1)	3.8 (1.4–4.6)
	Percentage of 3rd class areas	7.5 (2.8–14,5)	4.2 (3.6–8.2)
	Percentage of 2nd class areas	25.1 (15.3–34,6)	32.3 (14.5–40.1)
	Percentage of 1st class areas	66.3 (48.5–82,1)	59.7 (52.8–61.4)

Note: Values are medians followed by minimum and maximum values shown in parentheses. The percentage of different class areas for the campsites and the trail key sites is estimated without the areas of no impact.

The detailed assessment of different components of natural complexes of the Kronotsky State Natural Preserve along the researched route and the use of GIS allowed us to compile maps of the ecological conditions, where we delineated areas with different levels of recreational impacts (see Fig. 2).

DISCUSSION AND CONCLUSION

The primary objective of this study was to assess the level of impact on a system of trails and campsites along the route the Valley of Geysers – Burlyaschiy Volcano. There was no any significant recreational activity on the most part of the route for more than 30 years, but despite this fact, the general conclusion of our research is that the examined system of trails and campsites in the Kronotsky Preserve is moderate or heavily disturbed. We have revealed some long stretches of highly eroded trails (Fig. 3), numerous severely disturbed "hot points"; a significant number of areas of the key sites at the most popular sights along the route have been identified as heavily or severely disturbed.

The condition of the trails and campsites depends on some factors: their immediate environment, design and maintenance, and the amount, type and timing of the use they receive. There is abundant evidence that use characteristics are the least important out of these influential factors [Cole 1991; Helgath 1975; Tinsley and Fish 1985]. This is vividly illustrated by the results of our research.

Main problems on the route are: absence of any engineering arrangement at some popular sights; wide spread of wet and muddy areas (geothermal areas, swamps, valleys of streams); high vulnerability of tundra and geothermal communities along the trails and in campsites; easily washed sandy soils provoking the development of scour erosion even on small slopes.

Probably, in most cases, the changes in the condition of the natural complexes in the Kronotsky Preserve are caused not by the present amount of use, but by deterioration of ecosystem stability to withstand adverse impacts as a result of active use of the route in the Soviet period. Today, we are witnessing the processes of recovery of natural complexes at one site, as well as the processes of the erosion development and gully growing at other sites.

Consequently, the critical factors that influence the trail and campsite conditions are most likely to be related to the environment (for example, soil characteristics or slope steepness) rather than the use. This suggests that the principal solutions to trail and campsite impact problems involve the enhancement of the sites' resistance to negative impacts of their use (through improved design and engineering) or changes of their locations to more resistant [Cole 1991].

While describing the current condition at individual "problem" sites and quantifying the subsequent progression of the impact trends are beyond the scope of this paper, this work is the important preliminary work needed to accomplish this task in the future.

Fig. 3. More than 40 % of trails were assessed as being heavily and severely impacted with highly eroded treads

It is one of the first studies on the environmental assessment of the recreational areas of Kamchatka. But even preliminary findings of our initial work described in the paper corroborate the importance of founding wilderness management programs on knowledge about trail and campsite impacts and emphasize he necessity of adopting the recreation assessment and monitoring framework to the practice of decision-making.

The situation in the Kronotsky Preserve is a revealing example of the consequences of unplanned or poorly planned and implemented tourism and a striking demonstration of importance of the development of campsite and trail monitoring programs for the purpose of preserving resource conditions while simultaneously allowing for visitation.

Properly implemented, recreation impact monitoring programs provide a standard approach for collecting and analyzing resource condition data over time. Analysis of the data from periodic reassessments enables managers to detect and evaluate changes in resource conditions. Deteriorating conditions can be identified before severe or irreversible changes occur, which gives time for implementing the corrective actions. Analysis of the recreation impact monitoring data can also describe relationships between the resource conditions and the important use-related and environmental factors. Finally, a recreation impact monitoring program is indispensable to the new protected area planning and management frameworks, including the limits of acceptable change (LAC) [Stankey et al. 1984].

In conclusion, external land use practices, internal management activities, and the recreation use increasingly threaten protected natural areas. The values of these areas are inextricably linked to their undisturbed natural features. Disturbed vegetation and the proliferation of trails, campsites and fire rings have a potential to impair the ecosystem function and the quality of visitor experiences. Recreation impact monitoring programs offer managers a tool for assessing such changes and provide an essential basis for making resource protection decisions [Marion 1995].

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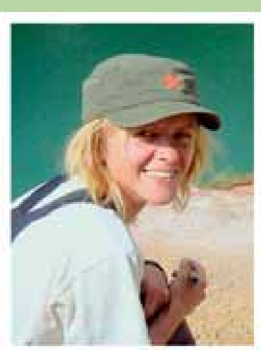

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