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Environmental Assessment of Recreation Areas: a Case Study in Wilderness of Kamchatka (Russian Far East)

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Abstract: The paper describes assessment and monitoring program, which has been designed and initiated for monitoring recreational impacts in some wilderness of Kamchatka. The framework of recreational assessment was tested through an application to a case study, conducted in summer 2008 in Kronotskiy State Biosphere Preserve (Kamchatka peninsula, Russia). The overall objective of case study was to assess the existing campsite and trail recreational impacts and to establish a network of key sites for subsequent long-term impact monitoring. The detailed assessment of different components of natural complexes of Kronotskiy State Natural Preserve and obtained maps of ecological conditions showed that some sites were highly disturbed (over 20 % of the total area of some key sites was identified as highly disturbed).
Findings of our initial work corroborate the importance of basing a wilderness management programs on knowledge about trail and campsite impacts and emphasize the necessity of adopting of recreational assessment and monitoring framework to the practice of decision-making.
Keywords: environmental assessment, recreation impact, monitoring, protected areas, wilderness, Kamchatka

1 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 visitation is increasing.

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

However, the studies of some authors show that there is no direct relationship between amount of use and level of impact, especially in protected areas with established trail systems [1]. Besides, although the term carrying capacity suggests that the number of users is the main concern, carrying capacity is also a function of other use conditions, such as type of use, timing and location of encounters between visitors, and visitor behavior [2].

Therefore, it is necessary to turn to another approach, which is based not on establishment of the number of visitors but on long-term planning and analysis of recreation opportunity spectrum, forms and types of recreation activities, different models of development of recreation [3]. This approach is realized in the LAC (Limits of Acceptable Changes) framework [4, 5, 6, 7, 8], which was developed to address the issue of recreation carrying capacity and to manage recreation impacts [9, 10].

An initial impact assessment and monitoring programs provide an essential element for the LAC recreation resource planning and management framework [11] and offer managers the most objective tool for documenting natural conditions, processes, the extent of human influence and for evaluation of subsequent success of implemented actions [12, 13, 14]. The capabilities and management utility of such programs are receiving increased international attention due to dramatic expansions in ecotourism worldwide [15].

In conditions of rapid growth of the stream of tourists the adopting of the LAC methodology and developing recreation monitoring programs, providing the information to assess the state of conservation resources, the severity of threats and the success of management responses [16], becomes very actual for the Russian environmental practice, requiring effective tools and programs for recreational management.

The LAC methodology and programs of recreation monitoring have been already applied and effectively utilized in some Russian natural areas [3, 17, 18, 19].

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

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

2 Study area

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

The Preserve is located on the Eastern part of Kamchatka (Fig. 1) and is notable for various types of volcanic activity: active and extinct volcanoes, geysers and thermal sources. It harbors such unique nature monuments as the Valley of Geysers, the Caldera of Uzon Volcano, the Death Valley, Burlyashiy (Bubbling) Volcano, Lake Kronotskoye, the Semyachikskiy Estuary, glaciers of the Kronotsky Peninsula and the unique Sakhalin fir grove.

The area under our study lies in Uzon-Geyzer region of the Kronotskiy Preserve and is located along the former all-Union tourist route to the Valley of Geysers through Burlyashiy Volcano and the Caldera of Uzon Volcano. The region corresponds to 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; alder elfin wood and mountain pine.

Fig. 1 Geographical position of Kamchatka area

Development of unplanned and unmanaged recreation in 1960-s and the operation of 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 a 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 activities in the Preserve is concentrated in the Valley of Geysers and in the Caldera of Uzon Volcano in strict compliance with the requirements of preserving the natural landscapes. The fulfillment of these requirements is controlled *only* in the Valley of Geysers by 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.

3 Methods

In 2007-2008, using the methodologies of different authors [13, 15, 20, 21, 22, 23], a multiparameter campsite and trail condition assessment system was developed for monitoring the resource conditions of the routes in Kronotskiy State Natural Preserve.

Procedures and protocols for assessing inventory and resource condition parameters were developed. Resource condition parameters (e.g., campsite size or trail width, exposed soil, etc.) documented site conditions, while inventory parameters (site number and name, site location (GPS coordinates), landscape, the type of vegetation cover, soil type, relief, the character of boundaries, distance from river) documented site location or 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 Burlyashiy Volcano (Fig. 2).

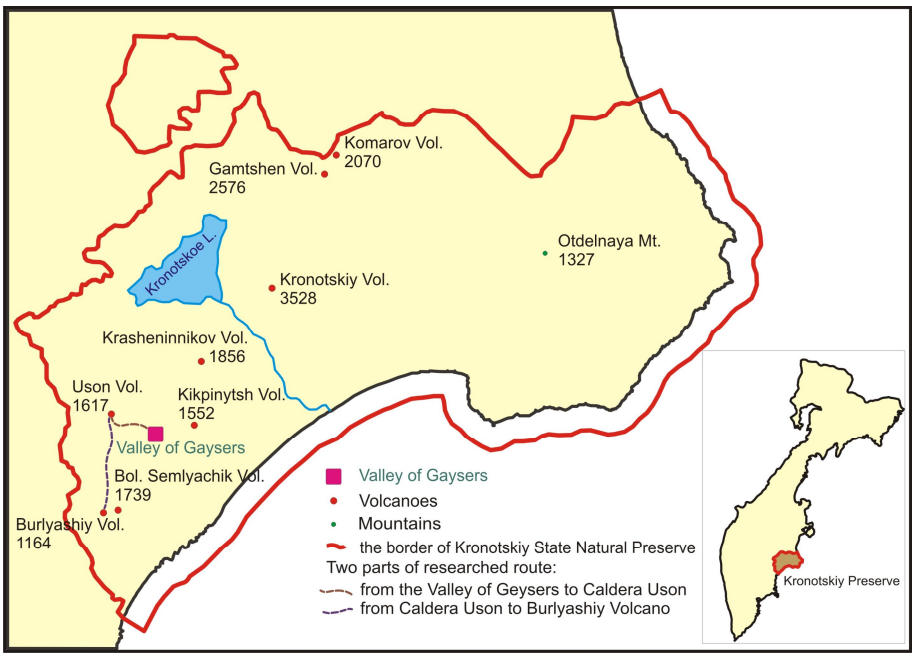

Fig. 2 Location of the study area

Campsites were assessed with 12 resource condition parameters and 9 inventory parameters, trails – with 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.

3.1 Campsite impact assessment

Along the route we searched for campsites, which were defined by 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 accurate border, the boundary was defined hypothetically.

For assessment of campsite condition and measurement of campsite areas we employed the radial transect method [14, 15, 24]. 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 quadrats were located along north, south, east, and west transects, halfway to the edge of the core [21]. These procedures were applied to all selected within campsite areas with different degree of disturbance (defined by difference in vegetation).

Approximately 18-20 1-m^2 quadrats were randomly located along transects in the campsite perimeter. Within each quadrat the following parameters were estimated or counted:

- the percentage cover of vegetation, medium height of plant and the number of sick and oppressed plants of each vascular plant species;
- the number of shrubs rooted in each quadrat;
- total number of species;
- total percentage 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 an adjacent, environmentally similar but undisturbed control sites, selected to represent conditions in the absence of 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 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.

3.2 Trail impact assessment

Trail impact assessment included both the assessment of trail condition 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 trail condition. Each 10 m we fixed width and depth of the trail and its vegetation cover; along all the route we identified and investigated eroded areas, as well as highly disturbed areas on or near trail (so-called “windows of trampling” [25]), confined mainly to the points of sightseeing and intersections with other trails.

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

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

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

For detailed assessment of different components of natural complexes in the zone of trail impacts and for subsequent long-term monitoring of their dynamics several permanent key sites have been established on the trail in every natural complex, using methodology by Chizhova, V.P. and Sevostianova, L.I. [25]. Several transects were located on both sides of the trail part 10 m length, perpendicularly to it. By analogy with campsites impact assessment technology the distances from the middle point of the trail to the first significant difference in vegetation were measured and 1-m^2 quadrats were located in areas with different degree of disturbance along these transects. The list of estimated parameters and characteristics was the same as that in the evaluation of campsites impacts (see above).

3.3 Data analysis

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

As a measure of level of impact on different components of natural complexes in the zone of trail and campsites influence we used the level of their disturbance, estimated by comparison of the results of field studies in disturbed areas with those in control sites. The main indicators of such disturbance were the following impact parameters: the absolute vegetation cover loss, the loss in species composition, vegetation depression, total number of sick and oppressed plants, tree damage and root exposure ratings [26], mineral soil exposure, depletion of organic litter, number of social trails and firerings, changes in soil parameters. These characteristics were used for campsite and "windows of trampling" impacts assessment, as well as for assessment of components of natural complexes on the key sites in the zone of trail impacts. For evaluation of 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), total number and area of "windows of trampling" and total vegetation cover.

The analysis of data for these separate impact parameters, using ArcGIS 9.3 (ESRI), allowed us to improve the boundaries of 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 getting an integral evaluation of the intensity of impacts (level of impact) and 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 disturbed areas and trails were the following: (1) light impact – site is barely discernible but is distinguishable as a campsite or trail; (2) moderate impact – significant change (approximately 20-50%) of natural characteristics; (3) heavy impact – high degree (50-80%) of changes; (4) severe impact – the highest possible impact and changes of natural characteristics (>80%). For areas with no apparent impact we introduced the Class (0).

4 Results

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

Table 1 Summary of campsite and trail impacts in two parts of the route Valley of Geysers – Burlyashiy Volcano

Impact characteristic		Part of the route	
		Valley of Geysers – Caldera Uson	Caldera Uson – Burlyashiy 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 observed in parentheses. The percentage of different class areas for campsites and trail's key sites is estimated with no account taken of the areas without impact.

We have assessed 6 separate camping areas in two parts of the route (Table 1). Campsites were found mainly in lichen and lichen-shrub tundra. Impacted area of campsites ranged from 181 to 526 m^2 with the median campsite size being 297 m^2 and the superiority of moderate and light impacted areas.

The inventory and condition class assessment was fulfilled for trails with 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 assessed as being heavily and severely impacted substantially with highly eroded treads (Class 3 and 4) (Fig. 3).

For assessment of components of natural complexes in the zone of trail impacts we developed 7 key sites. The detailed assessment of key areas revealed a surprisingly restricted spread of trail impacts on adjacent areas. In the major number of key sites the impact zone was only 1,5 m width with the superiority of lightly impacted areas (1st Class condition).

At the same time the research of "windows of trampling" at the most popular and interesting sights on the route showed perilous results. 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. 3).

The detailed assessment of different components of natural complexes of Kronotskiy State Natural Preserve along the researched route and utilization of GIS-methodology allowed us to compose maps of ecological conditions, on which we separated areas with different levels of recreational impacts (see Fig. 4).

5 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 Valley of Geysers – Burlyashiy Volcano. There was no any significant recreational activity on the most part of the route for more than 30 years, but in spite of this fact the general conclusion of our research is that the examined system of trails and campsites in Kronotskiy Preserve is moderate and heavily disturbed. We have revealed some long stretches of highly eroded trails, developed numerous severely disturbed "hot points", and considerable areas of key sites at the most popular sights along the route have been identified as heavily and severely disturbed.

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

The condition of trails and campsites depends on some factors: their immediate environment, design and maintenance, and the amount, type and timing of the use they receive. Of these influential factors, there is abundant evidence that use characteristics are the least important [20, 27, 28]. This is vividly illustrated by the results of our research.

Most problems on the route are the 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 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 condition of natural complexes in the Kronotskiy Preserve are provoked not by the present amount of use, but by breaking of ecosystem stability and withstanding use ability in the Soviet period of active use of the route in the time. Today we are witnessing the processes of recovery of natural complexes in one sites, as well as the processes of erosion development and gully growing in other sites.

Consequently, the critical factors that influence trail and campsite conditions are more likely to be related to environment (for example, soil characteristics or slope steepness) rather than use. This suggests that the principal solutions to trail and campsite

impact problems involve increasing the ability of these sites to withstand use (through improved design and engineering) or changing of their location to those which are more capable of withstanding use [20].

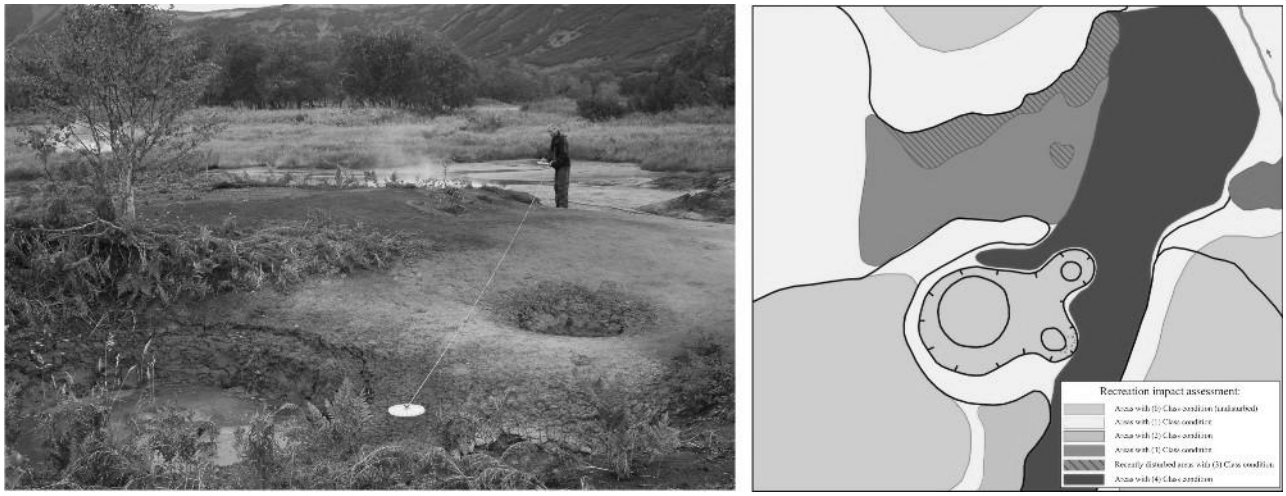

Fig 4 The key site near the mud hole "Sculptor" in the Uzon Caldera. Photo of the area and the fragment of composed map of ecological conditions of the site.

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

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

The situation in Kronotskiy Preserve is a revealing example of consequences of unplanned or poorly planned and implemented tourism and a striking demonstration of importance of development 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 data from periodic reassessments enables managers to detect and evaluate changes in resource conditions. Deteriorating conditions can be discovered before severe or irreversible changes occur, allowing time to implement corrective actions. Analysis of recreation impact monitoring data can also describe relationships between resource conditions and influential use-related and environmental factors. Finally, a recreation impact monitoring program is indispensable to the newer protected area planning and management frameworks, including the limits of acceptable change (LAC) [7].

In conclusion, external land use practices, internal management activities, and recreation use increasingly threaten protected natural areas. The values of these areas are inextricably linked to their naturalness. Trampled vegetation, the proliferation of trails, campsites and fire rings have the potential to impair 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 [15].

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