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ASSESSMENT OF THE IMPACT OF RECREATIONAL ACTIVITIES ON THE NATURAL ENVIRONMENT OF THE KARKARALY STATE NATIONAL NATURE PARK OF THE REPUBLIC OF KAZAKHSTAN

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Abstract: The article considers the results of assessment of recreational impact on the natural environment within Karkaraly SNNP (State National Nature Park). The purpose of this study is to assess the impact of recreational activities on the natural environment of Karkaraly SNNP using remote sensing data. The proposed methodology for assessing the impact of recreational activities on the natural environment using remote sensing data includes several steps from the selection of indicators for assessing recreational load to obtaining the integral value of recreational load on the natural environment. The most visited recreational sites were selected as objects of the study. The study showed that the natural environment near the sanatorium "Sosnovy Bor" in the area with high attendance of vacationers is in a relatively disturbed state. The key site has a dense network of paths, the stand of trees is weakly closed, groups of trees are limited by paths, roads and glades.

Key words: recreational activity, recreational load, natural environment, integral assessment, Karkaraly State National Nature Park

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INTRODUCTION

In society, it is commonly believed that recreation has a positive impact on nature, however, like all human activities it has its negative consequences. As a result of recreational activities, anthropogenic transformation of the natural environment occurs. This contributes to the degradation of natural complexes due to the direct human impact on nature. Uncontrolled flows of vacationers visiting natural objects, its pollution due to vehicles are the main causes of degradation of nature. Accumulation of recreational waste on the coasts of reservoirs, rivers, seas leads to degradation of drive complexes. As a result of dirty waste water discharge from recreation sites into water bodies, the quality of rivers, lakes, etc. deteriorates. Trampling of ground cover and plants in protected areas leads to impoverishment of the species composition and reduction of the number of individuals of the species. Soil compaction leads to disruption of soil structure, air permeability and water holding capacity, water and wind erosion. This negatively affects forest phytocenoses. Atmospheric pollution by exhaust gases of transport in parking areas worsens the ecological situation in places where recreationists congregate (Canteiro et al., 2018; Çakir et al., 2016; Benson et al., 2022).

Construction of tourist and recreational facilities leads to changes in the composition of vegetation and ground cover. Natural vegetation cover is destroyed in the immediate vicinity of recreational facilities. The degree of transformation depends primarily on the intensity of use. Evaluation of the impact of recreation activities on the natural environment is a worldwide concern, and there are many works devoted to this topic (Kuwabe and Ohashi, 2023; Hnaung et al., 2023). Therefore, the organization of regulated recreation is very important, it can become a means of preserving elements of the

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cultural landscape, large ecosystems, despite the damage caused to the natural environment by tourists and recreationists (Baloch et al., 2023; Schafft et al., 2021). The integrated system of environmental monitoring in the tourist-recreational zone allows to obtain information about the state of the environment: assessment of changes occurring in it; forecasting of phenomena and processes; providing information support and management decision-making. Thus, the conducted studies on recreational areas allow scientists to conclude that, such factors as the ratio of involved landscapes in recreational use and part of the unchanged area of landscapes, are different for different landscapes (Wolf and Green Ronda, 2019). The recreational actions of a single person can lead to irreversible effects on the environment. The strength of a recreational impact depends on the vector of influence it has. Thus, direct impact entails a decrease in species diversity of flora and fauna of the territory, especially when the latter is included in the economic activity; the emergence of diseases by contamination of flora and fauna with wastes of recreational and economic life activity of people; disruption of the course of natural processes of development of flora and fauna of the territory subjected to recreation (disruption of regenerative succession, destruction of species habitats, noise pollution, etc.) (Hermes, 2018; Arif et al., 2023; Ozgeldinova et al., 2022; Keukenov et al., 2022). The presence of even one person does not pass without a trace for the environment. There are direct environmental impacts of tourism and indirect impacts of tourism (Papiryan, 2000). Direct impacts include:

1) extermination of representatives of flora and fauna in the process of hunting, fishing; destruction of natural habitats by including territories in economic activities, etc;

2) introduction and spread of infections, diseases through products of human activity (excrement, organic food waste); economic activities (deforestation, soil disturbance, etc.);

3) interference in natural processes of life activity of plants and animals by feeding them, breeding them in artificially created conditions; observation of them; noise impact; destruction of nests, dens, etc.

Indirect impacts include:

1) anthropogenic impact on the components of the geographic environment (soil and surface water pollution, deforestation and erosion development, global climate change, atmospheric pollution, etc.);

2) alteration of natural habitat;

3) artificial breeding of animals, creation by man of animals and plants with specified properties (genetically modified, mutants), the impact of which on natural nature and on man himself has not yet been studied.

The purpose of this study is to assess the impact of recreational activities on the natural environment of the Karkaraly State National Nature Park. The territory of the national natural park belongs to the second category of specially protected natural territories. This place has the status of a nature protection and scientific institution of Republican significance, intended for the preservation of biological and landscape diversity, as well as use for nature protection, ecological-educational, scientific, tourist and recreational purposes. The Karkaralinsk-Kent Mountain junction consists of five relatively isolated mountain groups: Buguly, Shankoz, Maten, Airtau and Kent. The landscape of the Karkaraly Mountains and the Kent massif is characterized by marked asymmetry. The northern slopes of these mountains are steeper and greener due to numerous springs and diverse vegetation, while the southern and western slopes of the mountains are much less pronounced in this respect. The ridges form rocky crests and peaks separated by deep gorges, intermountain valleys and gently rolling plains.

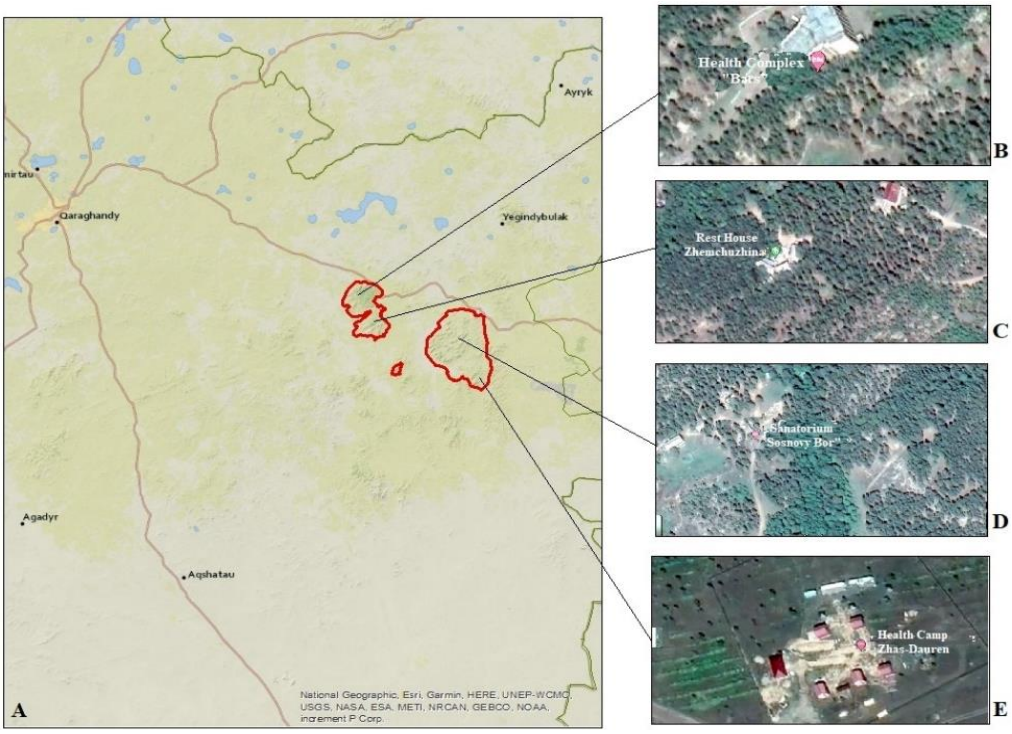

Figure 1. Recreational complexes of the Karkaraly State National Nature Park (Source: Google Earth, 2023; Created by the authors in ArcGIS.10.8 program using "National Geographic World Map") A) Territory of Karkaraly SNPP; B) Tourist and Sports Health Complex "Bars"; C) Rest House "Zhemchuzhina"; D) Sanatorium "Sosnovy Bor"; E) Health Camp "Zhas-Dauren")

The flora of Karkaraly National Park includes more than 200 species of covered plants, 3 species of holosemum plants, 2 species of ferns, 27 species of mosses and 14 species of lichens that have been recorded so far. According to literature sources, the number of plant species in the park can reach about 800 species. This is significantly higher than the number of species in the adjacent steppe zone. Of all these species, 5 are listed in the Red Book of the Republic of Kazakhstan, including *Karkaraly barberry*, *smooth sphagnum*, *Kyrgyz birch*, *slender poppy* and *spring adonis*. The Karkaraly and Kent mountain-forest massifs are home to many endemic and boreal plants. Within the territory of Karkaraly State National Nature Park there are 18 recreation centers and children's camps. One of the main reasons for the decline in the quality of recreational resources in the use of natural landscapes for recreation is a significant excess of the actual number of vacationers over the maximum permissible. The following most visited recreational facilities of various purposes were selected as objects of the study (Figure 1):

Tourist and sports recreation complex "Bars" with an area of 7.9471 ha and a capacity of 80 people per day, operates only in summer.

Rest house "Zhemchuzhina" with the area of 0.3793 hectares and a capacity of 70 people per day, operates all year round.

Sanatorium "Sosnovy Bor" with the area of 18.2569 hectares with the capacity of 200 people per day, operates all year round (Figure 2).

Health camp "Zhas-Dauren" with the area of 10.1021 hectares with a capacity of 250 people per day, operates all year round.

Figure 2. Sosnovy Bor Sanatorium (Source: the study was conducted by the authors in Sosnovy Bor, fall 2023)

MATERIALS AND METHODS

Using the scheme of the impact of recreational activities on the natural environment (Figure 3), we determined the main indicators for assessing the impact of recreational activities on the natural environment. In addition to the types of impact listed in the scheme, there are also behavioral (damage to tree bark, breaking of branches, etc.), noise, and others. But even despite the large degree of generalization of the scheme data, it is clear how complex and multifactorial the problem of preserving natural nature in recreation areas is (Chizhova, 2011).

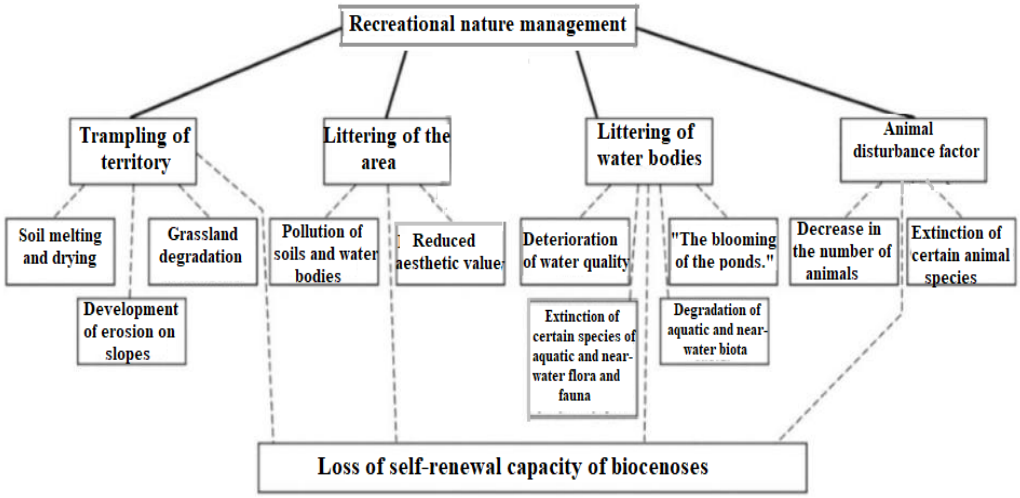

Figure 3. Scheme of influence of recreational activities on the natural environment:
1 - impact on the natural environment; 2 - reaction of the natural environment (according to Chizhova V.P,2011)

Assessment of the impact of recreational activities on the natural environment consists of the following steps:

- selection of assessment indicators and key areas of recreational pressure;
- determination of the values of the selected indicators using remote sensing data and field studies;
- development of gradations of the selected indicators taking into account local peculiarities of the study region (maximum and minimum values of the indicators);
- integral assessment of the recreational load on the natural environment of the study region;
- analyzing the results obtained, reflecting the influence of each indicator of recreation in different types of natural complexes (Figure 4).

To assess recreational pressure at each key site, the following indicators were recorded:

1. Soil compaction (density, soil resistance when Wile SOIL was introduced into the soil, kg/cm²);
2. Degree of erodibility (NDVI index value);
3. Littering of the area (total amount of litter in kg/ha);
4. Share of the area (%) occupied by secondary vegetation groups with predominance of trampling-resistant, mainly ruderal herbaceous species (dandelion (*Taraxacum officinale Wigg. s. l.*), plantain (*Plantago major L.*), creeping clover (*Trifolium repens L.*), common glade (*Agrostis capillaris L.*), annual bluegrass (*Poa annua L.*), fragrant lepidotheca (*Lepidotheca suaveolens (Pursh) Nutt.*), slender grass (*Juncus tenuis Willd*);
5. Damage to woody vegetation (% of damaged trees out of their total number);
6. Number of stumps of cut and felled trees (pcs./ha);

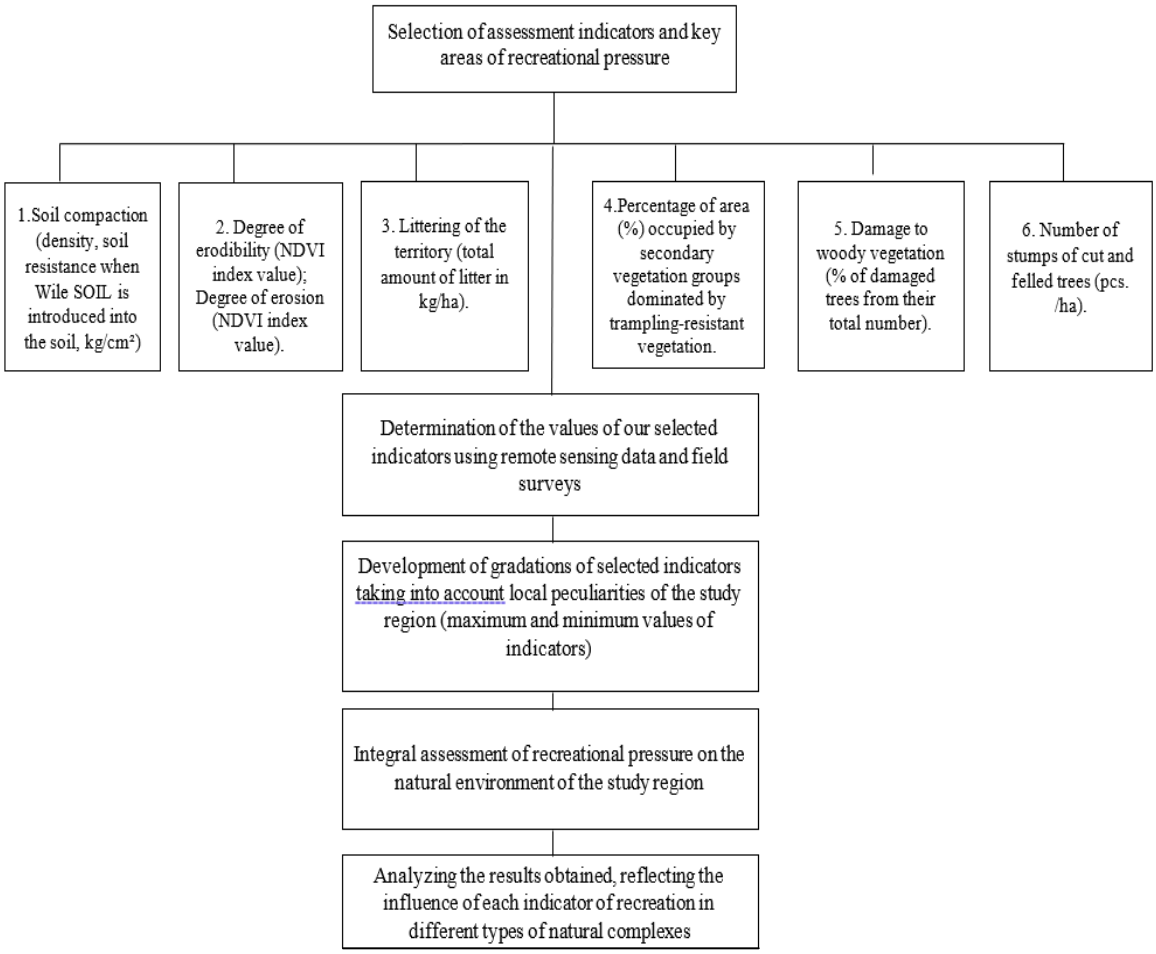

Figure 4. Block diagram "Assessment of the impact of recreational activities on the natural environment" (Source: Authors)

The most used spectral indices in determining soil erodibility are NDVI (Normalized Difference Vegetation Index) and GNDVI (Green Normalized Difference Vegetation Index). In our research we used NDVI index using nonparametric Mann-Whitney criterion. NDVI is calculated according to the formula:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Where: NIR - reflection in the near infrared region of the spectrum.
RED - reflection in the red region of the spectrum.

For each group, average index values were calculated for the whole series of images. Comparison using the Mann-Whitney criterion showed that there is no significant difference between highly eroded and moderately eroded, as well as between slightly eroded and non-eroded soils. Significant differences ($p<0.01$) are observed in case of grouping key sites into 3 categories: no soils (open soils); strongly and moderately eroded -0 soils; weakly eroded and non-eroded soils.

In the course of the work, each NDVI index value was assigned to classes of eroded soils according to Table 1. NDVI index calculations were carried out using Landsat-9 data for 2023.

Table 1. Classification of soils by NDVI index value

Soil classification	NDVI index value
Very highly washed out soils	0,0 – 0,2
Highly washed out soils	0,2 – 0,5
Medium washed out soils	0,5 – 0,7
Weakly washed out soils	0,7 – 0,9

When assessing the impact of recreational activities on the natural environment, quantitative indicators for each parameter were converted into scores (from 0 to 4), which were then summarized. The result of summation is the integral indicator (U) proposed by K.M. Petrov (1998), formula (1):

$$U = \frac{1}{n} \Sigma \text{ xi ki}, \quad (1)$$

where: n - number of factors;
xi - score of i factor;
ki - weight coefficient of i factor.

The weighting coefficients are established by the expert method based on the ranking of indicators by the degree of recreational impact on the natural environment. In the formula for calculating the integral indicator the most stable and significant characteristics of digression - compaction index and the share of secondary vegetation groupings - were introduced with a weighting factor of 2. Indicators characterizing these factors formed the basis for ranking the territory of Karkaraly SNNPP on the degree of recreational load. According to the obtained integral indicator (U), were defined the following gradations of the degree of recreational pressure on the natural environment: <1 - little disturbed; 1-2 - disturbed; 2-3 - heavily disturbed, 3-4 - degraded.

Low-disturbed condition: trampling is not observed even in the form of a weakly expressed trail network; recreational impact is limited to felling of trees, whose diameter (meaning diameter at the level of cutting or felling) rarely exceeds 10-15 cm; secondary vegetation is practically absent; soil density is characterized by favorable conditions for growth (2-9 kg/cm2), slightly eroded soils (NDVI index value 0.7-0.9).

Disturbed condition: there is a distinct trail network with an area not exceeding 10%; ruderal plant species are present on trails and old fire pits; soil density is characterized by acceptable conditions for growth (14-19 kg/cm2), moderately erodible soils (NDVI index value 0.5-0.7).

Highly disturbed condition: stand is poorly closed, groups of trees are limited to paths, roads and glades; higher proportion of damaged trees (up to 50%); secondary groupings of plants occupy a noticeable area; soil density is characterized by unfavorable conditions for growth (21 kg/cm^2 and more), highly eroded soils (NDVI index value 0.2-0.5).

Degraded condition: area of secondary vegetation groupings is often more than 50 %; undergrowth is almost completely absent; undergrowth is preserved in a small number of clumps; number of damaged trees reaches 100 %, tree roots are often exposed; soil density is characterized by extreme conditions for growth (24 kg/cm2 and more), very strongly eroded soils (NDVI index value 0.0-0.2).

RESULTS AND DISCUSSION

The research was conducted in 2023 in the territory of Karkaraly SNNP. For each key site 3-4 sampling points were identified and the recreational load was calculated. Taking into account the objectives of the study and the peculiarities of the territory, calculations were made and indicators for each key site were determined. All these indicators were taken into account and then recorded. Thus, a set of indicators of recreational load for each key site was obtained (Table 2).

Table 2. Recreational pressure indicators for key sites (Source: Authors)

Key area	Tourist and sports health complex "Bars"			Holiday home " Zhemchuzhina"			Sanatorium "Sosnovy Bor "			" Zhas-Dauren" recreational camp			
Selection points	1	2	3	1	2	3	1	2	3	1	2	3	4
Soil compaction (density, kg/cm²)	9	7	2	8	6	9	20	19	24	14	15	19	18
Degree of erosion (NDVI index value)	0,7	0,8	0,8	0,7	0,7	0,8	0,2	0,8	0,7	0,7	0,6	0,6	0,5
Littering of the territory (kg/ha)	-	-	-	-	-	5	7	-	6	-	7	-	-
Area occupied by secondary vegetation groups (%)	2	3	2	8	9	17	50	54	52	40	35	42	38
Damage to woody vegetation (%)	5	7	4	15	11	10	51	45	20	16	-	18	35
Number of days (pcs/ha)	2	6	3	-	5	1	15	23	15	-	13	11	10

Recreational activities have a multifaceted impact on the natural environment of the SNNP and are reaching such a scale that they are beginning to threaten the condition and preservation of protected green areas. According to the assessment results, no key sites belonging to the fourth group "degraded state" were identified. The pine forests of the "Sosnovy Bor" sanatorium we studied are located in an area with high visitor traffic and are characterized by a highly disturbed state. The key site "Sosnovy Bor" has a dense network of paths, the stand is weakly interlocked, groups of trees are limited by paths, roads and glades; a large proportion of damaged trees (20-51%). The structure of vegetation cover is represented by various herbaceous groupings with a significant share of secondary vegetation groupings. Soil density is characterized by unfavorable conditions for growth (19-24 kg/cm2 and more), in terms of erodibility soils vary from slightly to strongly eroded soils (NDVI index value 0.2-0.8) (Figure 5). Exposure to recreational pressure significantly alters the natural mosaic of living ground cover. The study revealed that the horizontal structure of this cover is an alternation of areas with different degrees of disturbance. It was also found that the total area of trails and trampled areas in pine plantations directly depends on the number of visitors to these forests.

At present, the key site of the health camp "Zhas-Dauren" is less exposed to recreational loads and according to the results of our research is characterized by disturbed condition. The key site has a very moderately dense network of trails; the proportion of damaged trees ranges from 16 to 35%. Secondary plant groupings occupy up to 40% of the area at individual observation points. Soil density is characterized by acceptable conditions for growth (14-19 kg/cm2); in terms of erodibility, soils belong to the group of moderately eroded soils (NDVI index value 0.5-0.7) (Figure 5).

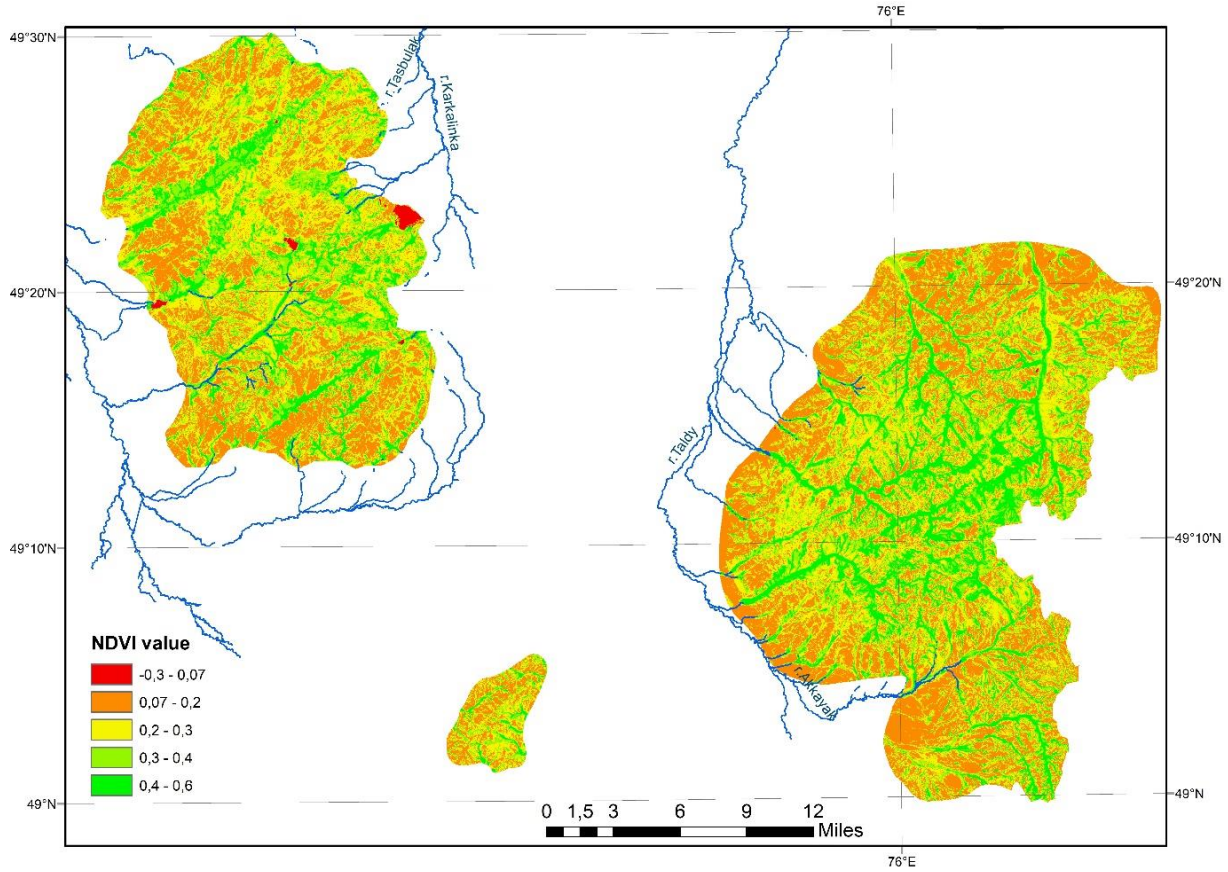

Figure 5. NDVI index value for the territory of Karkaraly SNNP (Source: Created by the authors in ArcGIS program.10.8)

As a result of the survey, the key sites of the recreation center "Zhemchuzhina" and tourist and sports recreation complex "Bars" are characterized by intact condition. Trampling is not observed even in the form of a weakly expressed trail network; recreational impact is reduced to cutting down trees, the diameter of which (meaning the diameter at the level of cutting or felling) rarely exceeds 10-15 cm; secondary vegetation is practically absent; soil density is characterized by favorable conditions for growth (2-9 kg/cm^2), slightly eroded soils (NDVI index value 0.7-0.9).

CONCLUSION

In general, the analysis of recreational loads and the response of plants of living ground cover to their various impacts in the studied plantations showed: under the influence of recreation in areas with recreational load index from 1 to 2 the grass cover is strongly changed; with recreational load index from 2 to 3 and more the grass cover is completely changed, its structure is destroyed, some forest and forest-meadow species are preserved only at the bases of trees. The grass cover in these areas should be considered degraded. Given the above, we can conclude that the natural environment in Karkaraly SNNP is under the influence of recreational activities, which every year becomes more active and leads to the transformation of the natural environment. The increase in recreational load affects the species diversity of pine and birch forests, and this negatively affects both the overall productivity of the grass-shrub layer and the productivity of individual grass species. The recreational impact leads not only to changes in the composition of the vegetation cover, but also to changes in its coverage and productivity of the lower tiers. In pine forests under high recreational load, mainly mosses experience degradation, which allows using them as indicators of the state of the cover of areas disturbed by recreation.

Increased impact without a set of environmental protection measures can lead to weakening of environment-forming and protective functions of plantations and their degradation. Exceeding the allowable norm of recreational load per unit area can lead to excessive soil compaction, disturbance of water-air regime and forest pollution, which in turn leads to the depletion of the natural environment in the study region. Increased recreational pressure also affects natural regeneration, intensifying the process of recreational degradation. Under such conditions, information on the state of the natural environment and its components under different recreational loads, necessary for predicting the dynamics of recreational facilities and choosing the optimal management, becomes especially important and requires a comprehensive approach.

1. the indicators of the impact of recreational activity on the natural environment (soil compaction; degree of erosion, littering of the territory; the proportion of the area (%) occupied by secondary vegetation groups with a predominance of resistant to trampling; damage to woody vegetation; the number of stumps of cut and felled trees) were determined;

2. Within the objects of study the stages of influence of recreational activities on the natural environment are defined for individual key areas under study. Weighting coefficients are established by the expert method based on the ranking of indicators by the degree of recreational impact on the natural environment. According to the results of the assessment, no key sites were identified as belonging to the fourth group "degraded state".

3. Of the four key sites, two are characterized by low-disturbed condition (recreation center "Zhemchuzhina" and tourist and sports recreation complex "Bars"). The study showed that the natural environment in the vicinity of the Sosnovy Bor sanatorium in the area with high visitation is in a relatively disturbed state. The key area has a dense network of paths, the stand of trees is weakly interlocked, groups of trees are limited to paths, roads and glades; there is a high proportion of damaged trees. Studies have established that the total area of trails and trampled areas in pine plantations directly depends on the attendance of these massifs.

4. The results of this study can be used to develop recommendations for restoration of damaged recreational areas.

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