

ASSESSMENT OF RECREATIONAL LOAD ON FOREST LANDSCAPES OF THE KOSTANAY REGION IN THE REPUBLIC OF KAZAKHSTAN

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Abstract: The purpose of the study is to assess the recreational load on forest landscapes within the Kostanay region. In this study, a landscape-dynamic basis is used to identify the relationship of recreational load in various types of natural complexes. An integral indicator of recreational load was calculated for each studied forest landscape and the stages of recreational digression were determined. The surveyed forests are located in an area with high attendance and are characterized by stages III and IV of digression. Especially high loads are carried by the forests of Arakaragai, which has a very dense network of paths.

Key words: forest landscapes, Kostanay region, recreational activity, recreational load, recreational digression

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INTRODUCTION

Currently, various forms of forest recreation have become a powerful factor of anthropogenic impact on the forest. The forests of the Kostanay region are characterized by uniqueness and favorable conditions for tourism and the organization of various forms of recreation. As the city grows, the population increases the recreational load on the forests of the region. With the growth of recreational loads, natural renewal is disrupted, the process of digression increases. To maintain a stable balance while simultaneously performing sanitary-hygienic and environmental functions by forests, it is necessary to know the levels and duration of recreational exposure. Thus, there is a typical contradiction between the use of this territory for the needs of the local population and the need to preserve forests. To prevent further deterioration of the condition of this facility and reduce environmental risk, it is necessary to give a comprehensive assessment of its condition, determine the degree of its degradation. The works of Dmitriyev, Mustafayev and Agybetova are devoted to the study and assessment of the recreational load on the studied objects with a view to their possible rational use and development. The results obtained characterize the degree and demand for natural and recreational facilities and allow us to identify objects already used or recommended for use as objects of the tourism industry (Dmitriyev et al., 2021; Mustafayev et al., 2023; Agybetova et al., 2023).

Recreational loads are increasing and cause deterioration of the quality condition of the forest, in some cases, it completes irreversible degradation naturally. In suburban forests, sanitary and hygienic, water protection, and soil protection functions are reduced, and their aesthetic value is lost. In places used for recreation, the vegetation cover is damaged, the renewal of forest-forming species is disrupted, the soil is compacted, the forest litter is destroyed, etc.

This has an impact on the quantitative and qualitative composition of forest flora and fauna and leads to a violation of the existing consort relationships. Recreational loads affect forest phylogenies as a complex factor (Canteiro et al., 2018; Asmelash and Kumar, 2019). The presence of a forest area affects the quality of the natural environment and the extent to which this natural environment is suitable for a comfortable and healthy human existence. Issues of forest fund protection are dealt with all over the world and there are many works that are devoted to this topic (Kuwabé and Ohashi, 2023; Hnaung Aye and Shibata, 2023; Sato and Shuin, 2023).

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The most noticeable effect is the compaction of the topsoil, increasing its bulk weight and hardness. Hence, various violations of the water-air regime arise. Strong compaction of the soil creates conditions close to anaerobic in the root layer and provides great resistance to root growth. In the upper layers of the soil, the number of intensively working parts of the root system – thin roots that absorb water and nutrients – decreases 2-3 times. Trees often have the phenomenon of «lifting the roots up» with a lack of air, while they, rising, are subjected to mechanical destruction.

Due to the compaction of the soil in the forest, the growth of trees in height is inhibited and the increase in trunk thickness decreases, as well as the drying of trees (the phenomenon of «dryness»). Pine and birch are the most resistant to recreational loads, relatively low-demand for soil moisture and aeration. Oak, linden and others suffer more.

Soil compaction slows down the activity of soil microorganisms, violates the conditions of mineral nutrition, reduces the number of nitrates, reduces the amount of total noise, gross and mobile nitrogen, and phosphorus (Zakamsky, 2012).

Vacationers in the forest violate the composition of the forest floor, destroying and grinding its components: branches, cones, needles, leaves, and other organic residues. With the increasing recreational load on the forest, the stocks of forest litter are decreasing. Its destruction leads to a change in the temperature regime of the soil, the litter fertilizes and improves the physical properties of the soil. The collection of litter or its absence leads to impoverishment, compaction, and drainage of the soil. The natural renewal of tree species is also associated with the forest floor because there are tree seeds there (Avila-Robinson and Wakabayashi, 2018). Thus, in the territory experiencing a high recreational load, there is a change in the species composition of the animal and plant world. This can lead to partial or complete changes in the biocenosis and the ecosystem as a whole (Dyrenkov, 1978). One of the tasks of the complex determination of the geocological state of recreational facilities in the Kostanay region was to assess the recreational loads on their components. The state forest fund of the Kostanay region is 1 million 146,087 hectares (official website of the Akimat of Kostanay region). Pine and birch forests of the most widespread mixed-grass group of forest types growing in the Kostanay region («Borovskoye », «Amankaragai», «Arakaragai») were selected as objects of research (Akbar et al., 2020).

«Borovskoye». The area of the territory of KSU «Borovskoye Forestry Institution» is 93.00 hectares, including:

- protection category - green zones of settlements and health-improving institutions - 56.0 hectares;
- protection category - restricted lanes along the banks of rivers, lakes, reservoirs, canals, and other water bodies - 24.0 hectares;
- protection category - field- and soil-protective forests - 13.0 hectares.

The territory of forestry is represented by mixed forests, mainly pine forests. The most common are variegated, bracken, cherry, bone, and horsetail pine forests. The relief forms wide cliffs and sandy hills with gentle slopes.

The sanatorium complex of the municipal-state enterprise «Kostanay Regional Rehabilitation Center named after M.Karabayev» is deployed in a pine forest on the shore of a lake with mineral water. Borovskoeskoye Lake is located in the vicinity of the forest, which is located at an altitude of 167.2 m above sea level. According to the topographic survey of 1958, the surface area of the lake is 1.9 km². The largest length of the lake is 2.4 km, the largest width is 1.3 km (Ozgeldinova, 2022). «Amankaragai». The Amankaragai pine forest is the largest island forest of the Kostanay region – the habitat of one of the oldest animals on the planet – the moose. Trees of mixed breeds grow here: poplar, pine, birch. The forest alternates with small lakes. The Amankaragai forest stretches in the southern part of the Kostanay (North Turgai) plain (45 km long and 14.5 km wide). The area covered by forest is more than 60 thousand hectares. Mostly pine grows here, but significant areas are occupied by birch and aspen. Here, in the Karagash tract, there is a small, 5-hectare, botanical nature monument of regional significance. This boron grows on an array of Aeolian sands (a type of continental geological deposit represented by material brought by the wind). This sand is wavy in places, and bumpy. In the interstitial basins, there are swampy birch and aspen-birch spikes. At the entrance to the pine forest, there are many small lakes, both fresh and salty. It is surrounded by grass-grass steppes (Kropinova et al., 2023).

«Arakaragai». Arakaragai (Arakaragai pine forest, Kaz. Arakaragai) is a mixed forest area, which is located in a steppe zone with dark chestnut soils. The length from north to south is 40 km, and the width is about 20 km. The total area is 616 km², including 271 km² covered with forest. Wood composition: pine, birch, aspen, rosehip, black dogwood, meadowsweet. The most common are early-sedge, early-sedge-ground-collar, spiraling-cherry, mixed-grass-ground-collar, and fescue-lichen pine forests. The relief forms shallow-bumpy dunes and sand hills with gentle slopes.

On the territory of Arakaragai there is a climatobalneological sanatorium «Sosnovy Bor». The main therapeutic factor of the sanatorium is mineral water. By its composition, the mineral water of the sanatorium «Sosnovy Bor» is close to the mineral springs of the famous resort «Pyatigorsk», it is also an analog of the water «Morshin», «Karlovy Vary» and «Essentuki 17» (Chazdon et al., 2016; Cutler et al., 2018; Tokpanov et al., 2021).

MATERIALS AND METHODS

An indicator of the recreational impact on the biocenosis of factors caused by the type of forest recreation, determined through the basic values. The influence of recreational loads was studied using the evaluation scales of recreational digression. As a rule, in the zone of influence of large settlements, intensive recreational load combined with the negative impact of man-made pollution of the air basin inevitably suppress the vital activity of forest landscapes, which leads to the appearance of various stages of digression, determined by the state of living ground cover. And so recreational loads act not only on individual plants but also on the plant community as a whole (Figure 1).

The distribution of recreants within the territory depends on many factors: the landscape structure and characteristics of elementary landscape allotments (locations), the presence or absence of water bodies, accessibility, and landscaping of the territory. In this study, a landscape-dynamic basis is used to identify the relationship between recreational load in various types of natural complexes (Isachenko and Reznikov, 2011).

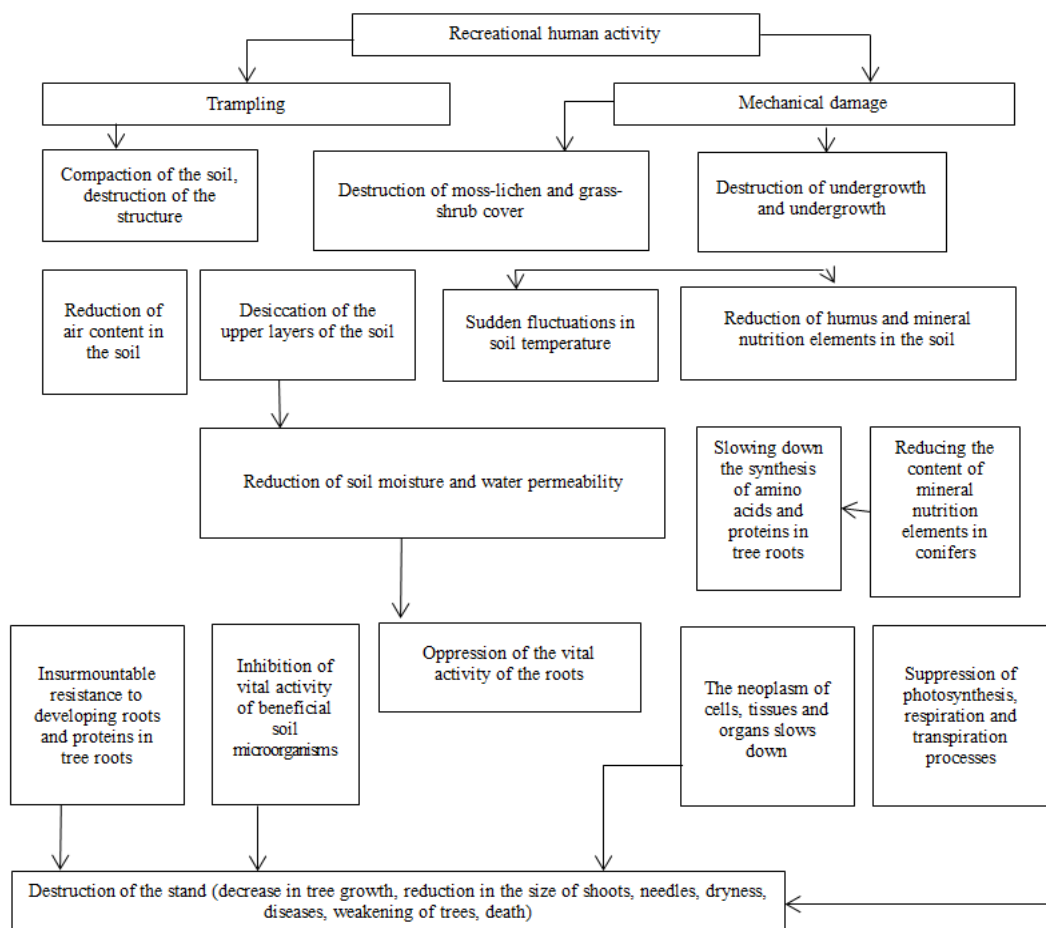


Figure 1. Scheme of conjugate processes occurring during recreational forest degradation (Source: Dyrenkov S.)

Assessment of the recreational load of the territory on a landscape-dynamic basis consists of the following stages:

- selection of recreational load indicators;
- determination of the actual values of the selected indicators;
- development of gradations of selected indicators in relation to the study area;
- calculation of the total recreational load indicator and determination of the stages of recreational digression;
- analysis of the effects of recreation in different types of natural complexes (Figure 2).

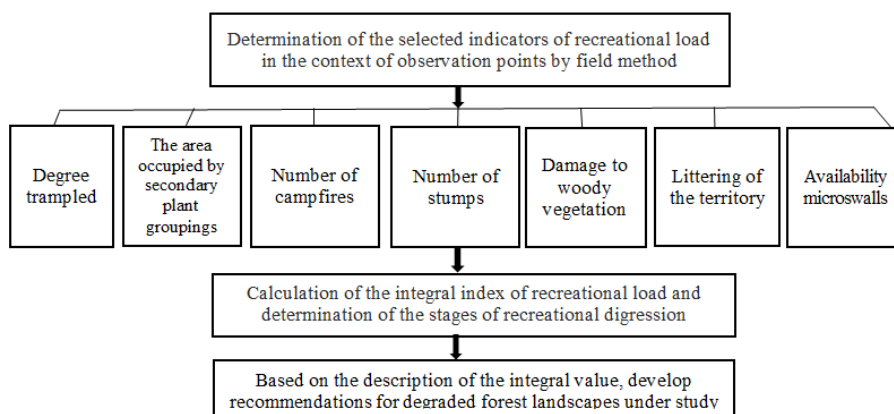


Figure 2. Flowchart «Assessment of recreational load on forest landscapes» (Source: Authors)

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

K_1 — the degree of trampling of the ground cover (the proportion of the area with exposed soil or soil, %);

K_2 — the share of the area (%) occupied by secondary plant groupings with a predominance of trampling-resistant, mainly ruderal herbaceous species (*Dandelion vulgaris* (*Taraxacum officinale* Wigg. s. l.), plantain large (*Plantago major* L.), creeping clover (*Trifolium repens* L.), common vole (*Agrostis capillaris* L.), annual bluegrass (*Poa annua* L.), lepidotheca odoriferous (*Lepidotheca suaveolens* (Pursh) Nutt.), thin Juncus (*Juncus tenuis* Willd.), yarrow ordinary (*Achillea millefolium* L.), kulbaba autumn (*Leontodon autumnalis* L.) and others.) and some pioneer species of mosses (*Pohlia nutans* (Hedw.) Lindb. and others.);

- K_3 — number of fire pits (pcs./hectares);
 K_4 — the number of stumps of cut and felled trees (pcs./hectares);
 K_5 — damage to woody vegetation (% of damaged trees from their total number);
 K_6 — littering of the territory (total amount of garbage in kg./hectares);
 K_7 — the presence of microswalls of garbage (pcs./hectares).

Based on the comparison of the results obtained with the work on the study of recreational digression of forest communities (Rysin and Lepeshkin, 2011:283), a total indicator of the recreational load of the natural complex (K) was introduced, which was calculated by summing up the scores of partial load indicators for each landscape allotment:

$$K = 2K_1 + 2K_2 + K_3 + K_4 + K_5,$$

where K_1, K_2, K_3, K_4, K_5 are the point gradations of recreational loads.

In the formula for calculating K , the most stable and significant characteristics of digression — the trampling index (K_1) and the proportion of secondary plant groupings (K_2) — were introduced with a weighting factor of 2. Indicators of littering of the territory and the presence of micro-landfills (respectively K_6 and K_7) were not taken into account when calculating K , since these characteristics are subject to changes even during one season and the violations described by them are most easily eliminated. The obtained values of the total recreational load index K (in points) were ranked according to 4 stages:

I (0-9 points) - intact condition: trampling is not noted even in the form of a weakly expressed path network; recreational impact is reduced to cutting down trees whose diameter (meaning the diameter at the level of cutting or felling) rarely exceeds 10-15 cm, and the appearance of single fires; secondary vegetation is practically absent;

II (10-14 points) - disturbed condition: there is a distinct pathway network, the area of which does not exceed 10%; there are single campfires; ruderal plant species are present on the paths and old campfires;

III (15-19 points) - severely damaged condition: the stand is poorly closed, groups of trees are limited to paths, roads, and clearings; the trampling of the contour area is up to 50%; increased density of fire pits (up to 100 pcs./ hectare); a large proportion of damaged trees (up to 50%); secondary plant groupings occupy a noticeable area;

IV (≥ 20 points) - degradation of vegetation cover: trampling of the original plant ground cover up to 100%; the area of secondary plant groupings is often more than 50%; there is almost no undergrowth; undergrowth persists in a small number of curtains; the number of damaged trees reaches 100%, tree roots are often exposed; abundance of fire pits (more than 100 pcs. /hectare) (Haris et al., 2020).

RESULTS AND DISCUSSION

At the initial stage, the objects of research were selected, which included the following forest landscapes within the Kostanay region: «Borovskoe», «Amankaragai» and «Arakaragai» (Figure 3).

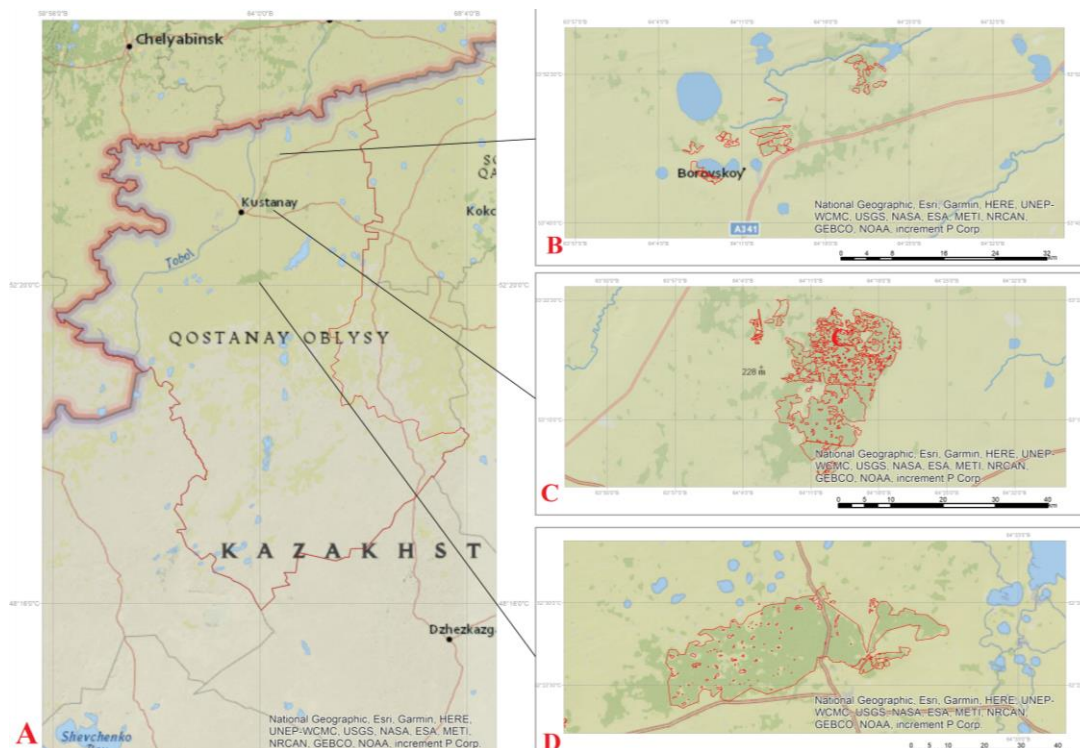


Figure 3. Forests of Kostanay region (Source: Author, created in the program ArcGIS.10.8 using the «National Geographic World Map») A) Kostanay region; B) Forest «Borovskoe»; C) Forest «Arakaragai»; D) Forest «Amankaragai»

Forest plantations perform many protective and recreational functions, therefore, the problem of their conservation is crucial to ensure the sustainable development of the natural environment. With the growth of cities, the recreational impact

increases, causing negative changes in the state of forest parks and suburban forests, which are essential to detect at an early stage. Most of the forest areas of the studied key areas are covered with pine trees and shrubs (Figure 4).

Recreational activities have a negative multilateral impact on forest landscapes and acquire such a scale that they begin to threaten the condition and existence of preserved green areas, especially those located in the vicinity of reservoirs. On the territory of the Arakaragai forestry there is a sanatorium «Sosnovy Bor», which also affects the state of forest landscapes. The sanatorium's wellness procedures use mineral water from healing springs and therapeutic mud (Figure 5, 6).



Figure 4. Amankaragai pine forest (Source: Author, created in the program ArcGIS.10.8 using the «National Geographic World Map»)



Figure 5. Arakaragai pine forest (Source: Author, created in the program ArcGIS.10.8 using the «National Geographic World Map»)

The research was carried out in 2022 in key areas of the forests of the studied region. Within the key area, three selection points were allocated for each of which the recreational load was calculated. Based on the objectives of the study and taking into account the characteristics of the study area, indicators were allocated for each key site, and calculations were carried out. All the above-mentioned indicators were taken into account and then the data obtained were recorded. Thus, a set of recreational load indicators was obtained for each key site (Table 1).

The pine and birch forests surveyed by us are located in an area with high attendance and are characterized by stages III and IV of digression. Especially high loads are carried by stands of Arakaragaya Pine forest, which has a very dense path network. In it, under the influence of recreational loads, the natural mosaic of the living ground cover is strongly transformed. The horizontal structure of the living ground cover is an alternation of different degrees of disturbed and undisturbed areas. The structure of the cover is represented by various grass groupings with a significant share of weed species. Recent studies have established that the total area of trails and trampled areas in pine plantations directly depends on the attendance of these arrays. Currently, the pine forests of the Borovskoe forest area are less susceptible to recreational loads than the plantations of Amankaragai and Arakaragai, the III and IV stages of recreational digression have been identified here.

At the same time, the array is used as a landfill for household and construction waste. As a result of the survey of pine plantations of the Amankaragai and Arakaragai botanical and geographical areas, it was found that the attendance at



Figure 6. Sanatorium «Sosnovy Bor» (Source: the research was conducted by the authors in «Sosnovy Bor», autumn, 2022)

the trial areas is significantly higher than normal. The identified stages of recreational digression in pine forests vary from III to IV, where, as a result of trampling, there is almost no living ground cover.

Table 1. Recreational load indicators for key sites (Source: Authors)

№ selection points	Degree trampled (%)	The area occupied by secondary plant groupings (%)	Number of campfires (pcs./hectares)	Number of stumps (pcs./hectares)	Damage to woody vegetation (%)	Littering of the territory (kg./hectares)	Availability of microswalls (pcs./hectares)
The key section of «Borovskoye»							
1	2	1	3	5	3	-	-
2	2	2	4	4	4	2	-
3	1	2	5	4	3	4	-
Key section «Amankaragai»							
1	2	2	4	3	4	1	-
2	3	2	3	5	4	2	-
3	4	2	3	4	2	2	-
Key site «Arakaragai» («Pine forest»)							
1	3	1	3	4	4	2	-
2	2	3	4	4	5	3	-
3	4	4	3	4	4	2	-

The territory of «Borovskoe» is distinguished by a relatively dense path network (knocked-out areas occupy up to 10-15% of the entire area), light-loving species predominate in the herbaceous cover, meadow grasses begin to appear, the power of the litter decreases, the renewal of the forest is still satisfactory in extra-tropical areas.

Studies of the territory of Amankaragai have shown that the structure of the living ground cover in the plantings is represented by bumpy-ridge sandy landscapes with sandy-grass-sand-and-dust steppes on poorly formed dark chestnut soils and pine forests on poorly formed sod-podzolic soils (forested lands account for 40%). Of the pine forests, early-seeding reed-like-variegated, birch horsetail-bone, and mixed-grass ground-mulberry predominate.

CONCLUSION

In general, the analysis of recreational loads and the response of living ground cover plants to their various impacts in the studied plantings showed:

- under the influence of recreation in areas with a recreational load index from 52% to 65%, the grass cover is greatly changed. Therefore, it should be considered degrading, and the load should be higher.
- with a recreational load of over 70% or more, the grass cover has been completely changed, its structure has been destroyed, and some forest and forest-meadow species have been preserved only at the bases of trees. The grass cover in these areas should be considered degraded, and the anthropogenic load is very high.

Based on the above, it can be stated that the forest landscapes of the Kostanay region are influenced by recreational activities, which are growing every year and leads to the transformation of the natural environment. Pine and birch plantations have been exposed for a long time not only to recreational loads but also to a strong technogenic influence. With increased recreational loads, the species composition of both pine and birch forests changes, which affects both the overall productivity of the grass-shrub layer and the productivity of individual species of herbaceous plants. Under the influence of recreational influence, not only the species composition of the living ground cover changes but also the projective cover and productivity of the lower tiers of vegetation. In pine forests, under significant recreational loads, mosses degrade primarily as part of the ground cover so that they can be used as indicators of the state of vegetation cover of recreational and technogenic disturbed territories. With a continuous increase in the need for «near» recreation and, accordingly, recreational flows within forests, it is necessary to constantly monitor the state of the landscapes of recreational areas, primarily forest landscapes. Further strengthening the associated impact of these loads without carrying out a complex of environmental measures in plantings can weaken their environmental and protective functions and their degradation.

The free use of the territories of the Kostanay region and exceeding the permissible norm of visitors – load per unit area, leads to over-compaction of the soil, violation of the water-air regime, and pollution of the forest, and this, in turn, is the cause of starvation of trees and shrubs in the study region. With the growth of recreational loads, natural renewal is disrupted, and the process of recreational digression increases. In these conditions, complex qualitative and especially quantitative information about the state of forest ecosystems and their components under different recreational loads, necessary for predicting the dynamics of recreational forests and choosing optimal management, is of particular importance.

1. The selected indicators were determined (degree trampled, the area occupied by secondary plant groupings, number of campfires, number of stumps, damage to woody vegetation, littering of the territory, availability of microswalls) of recreational load in the context of observation points by field method;

2. Within the objects of study, the stages of recreational digression used to assess the recreational load of various types of natural components are determined.

3. For each studied forest landscape of Kostanay region, an integral indicator of recreational load was calculated and the stages of recreational digression were determined. The pine and birch forests examined by us («Arakaragai», «Amankaragai») are located in a zone with high attendance and are characterized by stages III and IV of digression. Especially high loads are carried by plantations of Arakaragaya Pine forest, which has a very dense path network.

4. The result of the study developed recommendations for the restoration of damaged areas for each stage of recreational digression of forest landscapes.

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