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Monitoring of anthropogenic load, recreational safety of the Arctic tourism objects in Russian Arctic National Park

A C Chekmareva¹, D V Dobrynin², A G Kirilov³ and N M Byzova⁴

¹Leading Researcher at Russian Arctic National Park. Arkhangelsk

²Chief investigator of the Department of Engineering Surveys and Monitoring at the Center for Marine Research, Moscow State University. Moscow

³Director of Russian Arctic National Park. Arkhangelsk

⁴Head of the Department of Geography and Hydrometeorology at NArFU. Arkhangelsk

E-mail: ann-192@yandex.ru

Abstract. The article discusses one of the important environmental problems of the high-latitude Arctic - the anthropogenic impact on the species composition of the communities and their ecological state. The paper proposes an experiment to assess the capacity of the Arctic communities to recreational effects. The research was conducted in Tikhaya Bay, Hooker Island, Franz Josef Land archipelago. In the course of the experiment, five test paths were made with a load imitating the real impact. During two seasons, test paths were assessed at the beginning and the end of the season using three parameters: botanical diversity, turf disintegration process, and soil processes. Diagnostic indicators for assessing the disturbance of the state of the paths with assigned points of negative consequences were developed. According to the results of the research, the permissible anthropogenic load on typical communities of this territory was determined.

1. Introduction

Arctic tourism is attractive because of its uniqueness in several aspects at once. These are ecological, geographical, historical, cultural and natural components. Due to the high cost and complexity of logistics, the availability of such recreational services is limited, but the demand for them is increasing every year. Annual cruises have been taking place on the territory of Franz Josef Land archipelago since the 1990s.

With a steadily increasing interest in tourist visits to the Arctic region and the associated anthropogenic and recreational impact, it is necessary to design and implement measures to reduce the negative effect of the presence of a large number of people on the sites of excursion routes [2]. This requires the development of scientifically-based indicators for assessing the level of permissible impact on natural complexes, compliance with which will ensure the sustainable functioning of natural ecological systems.

Tikhaya Bay, Hooker Island, Franz Josef Land was chosen as the place of research. At present, the territory of Franz Josef Land archipelago and the northern tip of Severny Island of Novaya Zemlya archipelago, in total 8.8 million hectares, belong to the Federal State Budgetary Institution Russian Arctic National Park [1]. After cleaning the Arctic, which was carried out manually on Hooker Island, Tikhaya Bay station has been one of the main tourist visiting points, since 2014 the world's



northernmost post office has been operating there. Since 2015, the station has a souvenir shop of the national park, and since 2018, an alternative energy system have been operating.

2. The scheme of the experiment

Test paths were made 250 meters northeast of Tikhaya Bay polar station. The place for making the paths was chosen in such a way as to exclude external anthropogenic impact and to work with the maximum variety of typical communities. The paths are located in three positions of the relief. The upper part is at the foot of the plateau, on boulder-pebbly soils with a significant slope. The lower part of the paths passes through accumulative terraces with loamy soils experiencing strong water logging due to surface and internal groundwater flow. The middle part of the paths lies in the transition zone with a slight slope, on soils with normal humidity. The place for paths making was chosen with the maximum horizontal homogeneity of plant communities. However, due to the high mosaic pattern characteristic of the Arctic groups, it was not possible to find a place for the location of completely identical paths. In total, 18 plant species belonging to 10 families were described at the site selected for research. The intensity of the load was distributed in such a way as to imitate a recreational press, similar to the effects at disembarkation of tourists from cruise ships, movements of employees of the national park. As a result, five paths with a length of 23 meters were made; the distance between the paths was 1.5 meters. At the beginning of the season, the paths were traced in 1 meter increments, and at the end of the season, a description of the state of the vegetation and soil cover of every meter of the paths was performed. The work was carried out from July 11, 2017 to August 10, 2017 and from July 11, 2018 to August 9, 2018.

Table 1. Frequency and intensity of recreational impact on the paths of sample plots.

Path No.	Load (passes)	Intensity (passes per day)
1	2	daily
2	50	1 in 5 days
3	20	1 in 5 days
4	6	daily
5	6	1 in 5 days

Scheme 1. Distribution of plant communities on the paths.

Path 1	Path 2	Path 3	Path 4	Path 5	Legend
1	1	1	1	1	Willow-moss community with scarce total projective cover due to boulder-pebbly soil. The projective cover of vascular plants is also not dense.
2	2	2	2	2	
3	3	3	3	3	
4	4	4	4	4	
5	5	5	5	5	
6	6	6	6	6	Various grasses and moss community with scarce projective cover of vascular plants and dense total projective cover.
7	7	7	7	7	
8	8	8	8	8	
9	9	9	9	9	
10	10	10	10	10	
11	11	11	11	11	Various grasses and moss community on moist loamy soils with scarce projective cover of vascular plants and dense total projective cover; buttercup dominates among the vascular plants.
12	12	12	12	12	
13	13	13	13	13	
14	14	14	14	14	
15	15	15	15	15	
16	16	16	16	16	The cereal and moss community with dense total projective cover and dense projective cover of vascular plants.
17	17	17	17	17	
18	18	18	18	18	
19	19	19	19	19	
20	20	20	20	20	
21	21	21	21	21	The willow and moss community with dense total projective cover and dense projective cover of vascular plants.
22	22	22	22	22	
23	23	23	23	23	
23	23	23	23	23	
23	23	23	23	23	
23	23	23	23	23	Moss and lichen community.

The impact on the paths was recorded according to three leading degradation factors:

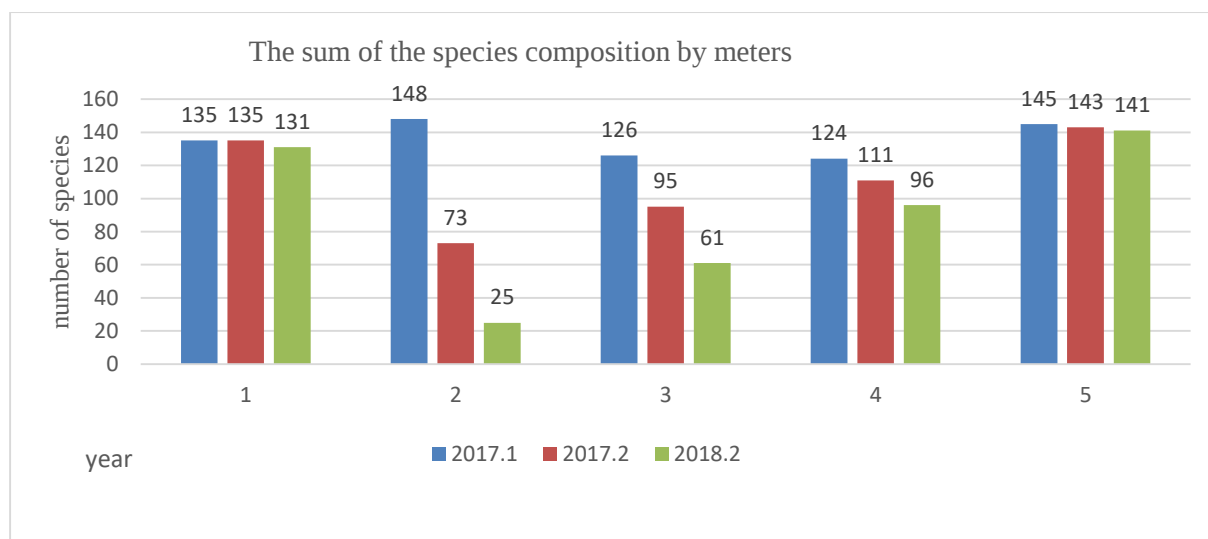
- Botanical diversity, violation of certain species on each specific meter of the path.
- The process of turf disintegration, changing the total projective cover and the projective cover of vascular plants.
- Disruption of the natural structure of the water and physical properties of the mineral horizons of tundra soils.

3. Botanical diversity, impact and resistance of certain species.

The sustainability of each particular species is influenced by the peculiarity of its life form, the features of the root system and the preferred position in the nanorelief. Thus, the optimum position will be occupied by vegetation, grouped in beds with a well-developed root system.

At the beginning and at the end of the season, a description of the species composition was carried out on each meter of the path, the graph below shows the sum of the species before the experiment (2017.1), after the completion of the experiment stage in 2017 (2017.2) and after the completion of the second field season (2018.2).

Chart 1. The sum of the types of vegetation on the paths at different stages of the experiment.



On paths 2 and 3, 50 and 25% of species are lost, respectively.

Different groups of plants belonging to different genera and families had an ambiguous reaction to the modulated effect. First of all, on the paths, even with minimal impact, lichens wear down to the loss of the thallome integrity. The fragility of lichens is due to their structure. Next, plant species with single organization and relatively large shoots disappeared from the paths. Here we can name such species as Alpine clustered saxifrage, drooping bulbous saxifrage, and arctic poppy. Plants growing in groups have greater resistance; tufted saxifrage and hypoarctic tormentil can be named. Also, plants with a hard, waxy shoot are more resistant species: Alpine clustered saxifrage and, to a lesser extent, sulfur-yellow buttercup. One of the ways to preserve the plants with fragile shoots, observed by the example of cerastium and scurvy grass, is their inclusion into dense moss mats. This is only possible due to the small size of the plants. Mosses, willows and grasses were the most stable. Grasses and willows remained in areas with significantly damaged turf thanks to a tough shoot and a highly developed root system. The willow root system is stiff and much larger than the above-ground part. The presence of this plant ensures the stability of the whole community. Out of grasses, *Phippsia concinna*, forming dense beds on the paths, is the most stable.

Summing up, the plant communities involved in the experiment can be divided into three groups on the basis of resistance to recreational disruption:

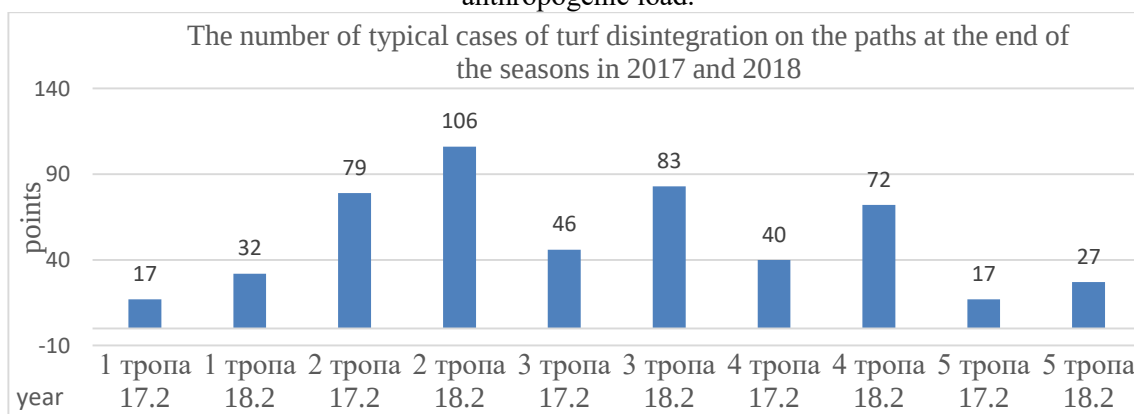
- The least sustainable, within the limits of distribution of which particularly strict forms of controlling the movement of groups along artificial paths are required.
- Medium degree of stability, within which individual non-observance of movement of groups along artificial paths are permissible.
- Highly resistant, within which the creation of artificial paths may not be economically feasible due to the extremely high cost of delivery and construction works, compared with minimal damage to Arctic vegetation and landscapes.

4. Botanical diversity, damage to certain species on each specific meter of the path

The process of turf disintegration, the change in the total projective cover and the projective cover of the vascular plants was also recorded on each meter section of the paths. With a decrease in vegetation cover, the ability to drainage decreases, which in the Arctic conditions characterized by the excess of moisture leads to a disturbance of the water regime, that is, flooding. Abrasion and fragmentation of the aboveground part reduces the ability of vegetation to bond the soil, which, in turn, leads to the emergence of the soil organic and mineral horizon to the surface, triggering a number of associated negative processes, such as erosion and weathering. The process was divided into 9 types, each of which was assigned negative impact scores. The type list is as follows:

- 1 Vegetation is slightly trampled - 1 point
- 2.2 Loss of natural form by most plants, inhibition due to loss of physiological integrity of the most sensitive plants - 2 points
- 3 Fragmentation and death of the moss cover - 3 points
- 3.1 Irreversible change of microrelief shape (hummocks, ridges) - 3 points
- 4 Compaction of a layer of grassland litter and tundra mat due to the remains of plants that died during trampling. Violation of the natural composition and compaction of the upper soil horizons. Surviving plants, mainly cereals and shrubs, are forced to change the morphology and life forms to increase resistance to trampling - 4 points
- 4.1 Appearance of open areas of organic and organic and mineral soil horizons between groups of disturbed vegetation - 4 points
- 4.2 Death of mechanically damaged plants and moss cover, in combination with overwetting foci, and formation of a stable structure of soaking spots (ground areas with unfavorable water conditions) - 4 points
- 5 The vegetation is destroyed on the most part of the area, open ground prevails - 5 points

Chart 2. The number of negative manifestations of turf disintegration on paths with different anthropogenic load.



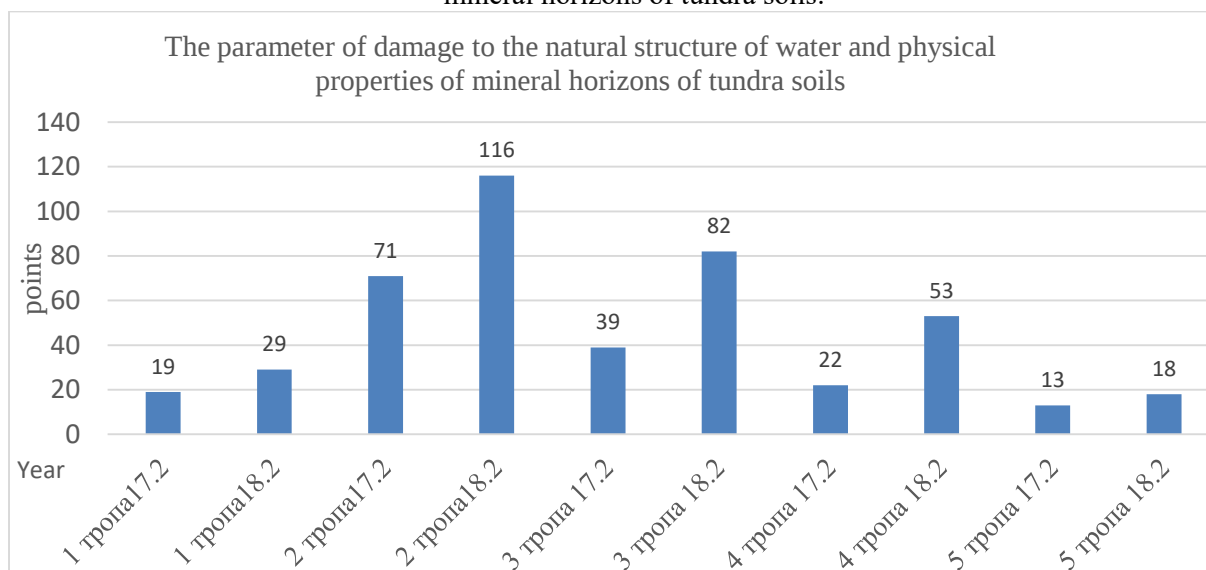
The speed and the fundamental possibility of the restoration of vegetation cover will depend on the degree of impact on the turf.

5. Damage to the natural structure of water and physical properties of mineral horizons of tundra soils

The leading factor influencing the general condition of the site is the damage to the natural structure of water and physical properties of mineral horizons of tundra soils. These include the destruction of peaty soil horizons, accompanied by the deterioration of their water-physical properties, the development of surface water logging. Such processes can lead to the activation of soil heaving processes and contribute to the spread of erosion processes. When describing the paths, attention was drawn to the following diagnostic parameters:

- 2.3 Minor areal violation of the turf integrity, the release of organic matter takes up to 10% of the paths surface - 2 points
- 4.1 Areal turf disintegration, the release of organic matter takes up to 10-30% of the paths surface - 4 points
- 5 Significant areal turf disintegration, the release of organic matter takes up to 30-50% of the paths surface - 5 points
- 6 Extensive areal turf disintegration, the release of organic matter is more than 50% of the paths surface - 6 points
- 1.1 Linear violation of turf integrity up to 5 centimeters - 1 point
- 2.1 Linear violation of turf integrity up to 20 centimeters - 2 points
- Linear violation of turf integrity up to 30 centimeters - 3 points
- 3.1 Multiple linear violation of turf integrity - 3 points
- 1 Formation of grooves in soil and moss cover - 1 point
- 1.2 Cracks, grooves in soil and moss cover around stones - 1 point
- 2.2 Complete loss of soil and vegetation from stones - 2 points

Chart 3. The parameter of damage to the natural structure of water and physical properties of mineral horizons of tundra soils.



The areas of vegetation on the moss cover in the process of impact formed specific stitches or scars that appeared when the orthogonal compression and the lateral shift of the soles were combined when walking along the microrelief inhomogeneities. Even with a limited impact, patches of stretching and displacement of vegetation cover were formed in areas of moss and moss-grass cover with formation

of sections of open soil of up to 10%. When the effect increased, displacement stitches widened, turf folds were formed and turned inside. At the same time, the areas of open soil expanded, occupying an area of up to 30%. With further enhancement of the impact, the gaping areas of lifeless soil reached 40-50% and more. In this case, the restoration of vegetation is no longer possible.

6. Discussion of the results

Summing up the experiment, in which the same sets of plant communities, located in a certain order along the slope of the catena, were of the same type but were exposed to the impact of different intensity, which imitated the recreational impact of tourist groups. We can draw the main conclusions:

The plant communities involved in the experiment had different reactions to the effects of the same duration and intensity. So, the most sensitive were the semi-hydromorphic communities with a significant participation of mosses. Community resistance increased with an increase in the projective cover of vascular plants. The most stable were communities with a large inclusion of willow and cereals. Communities with predominance of lichen require separate consideration. They undergo practically lethal damage even with a single load of low to medium intensity.

The role of the tundra microrelief turned out to be ambiguous. In case of the microrelief formation, the outcrops of stones showed partial preservation of vegetation between them. In case of the microrelief formed by loose sediments or peaty plant residues, an increase in the negative impact of trampling was observed in case of the soil spreading under pressure on the surrounding vegetation areas.

At the same time, the position of the paths in the relief adds additional factors affecting their stability, so we cannot but consider the gravitational processes at the foot of the plateau; similar communities in the middle part are more stable. The research has shown that the intensity of exposure leads to various violations of typologically identical plant communities.

According to the degree of disturbance as of the end of 2018, the paths can be divided into four types:

- Paths 1, 5 remain in good condition, practically not disturbed. It is characterized by the inhibited state of certain species. Rapid full recovery is predicted.
- Path 2 is in a catastrophic state, characterized by an almost complete loss of turf integrity and most of the species composition. The functioning of biotic and abiotic factors is impaired; the possibility and time for the restoration of such a path is planned in the second part of the experiment.
- Path 3 is in a state of crisis. The characteristics of the path correspond to path 2 at the end of the season in 2017: most of the species composition is lost, turf integrity is completely lost only on the lower part of the path. The ability of the path to recover requires additional study.
- Path 4 is in a satisfactory condition. There are negative changes in the individual elements of the ecosystem.

During the research in the season of 2017, snow fell on July 30 and did not melt for three days. There was no permanent snow cover on path 2, by that time the communities on the path had changed significantly. There are two versions explaining this phenomenon. First, because of the increase in energy production in the process of decomposition of organic compounds in the soil (soil respiration), the warming of the soil occurred. Secondly, the snow could melt faster because of the higher albedo on the dark path, from the numerous ground outcrops and color. In any scenario, this situation indicates a disruption in the functioning of areas in a critical and crisis state, changes in the microclimate, soil biota, and water regime.

7. Conclusions

The correlation of damage values in initial ecosystems with the values under model impact allows determining the level of negative changes in the system, the level of its degradation, as well as the level of additional allowable load at which the system does not lose the ability to self-repair. Territories planned for tourist visits should be equipped with information on the sustainability of

vegetation components and hazardous geological processes.

The experiment is not completed and provides for the second part of the vegetation cover restoration.

References

- [1] Boyarsky P.V., Baryshev I.B., Bolshiyarov D.Yu., Berger F.; Franz Josef Land - Paulsen 2013
- [2] Dobrynin D.V., Semikolennykh A.A., Chekmareva A.S.; Geoinformational assessment of the sustainability of natural complexes of the high latitude Arctic to recreational anthropogenic impacts. Contribution of specially protected natural areas of the Arkhangelsk region to the preservation of natural and cultural heritage. – Arkhangelsk, 2017, pp. 147 -153.