The current state assessment of pine forests in the central part of the Kola Peninsula

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Abstract. The problem of restoring disturbed pine forests in the European part of Russia is one of the main directions not only in the forestry sector, but also in the study and development of various segments of environmental management. This paper presents modern data on the vitality structure of the stand of various types of pine forests in the central part of the Kola Peninsula, which are at a different stage after catastrophic violations of natural and anthropogenic origin (cutting, fire).

1. Introduction
Boreal forests are one of the largest terrestrial ecosystems on the planet, covering approximately 1.4 billion hectares, or 38% of the world's total forested area. 46% of the area of these forests is located in the Russian Federation. For the north of the European part of the country, these communities are mainly formed by species of Scotch pine (Pinus sylvestris L.) and Siberian spruce (Picea obovata Ledeb.). Communities formed by Scots pine in the north of the European part of Russia are plantations of natural origin of relatively low productivity due to climatic and natural features.

For these communities growing in the background (that is, not affected by the aerotechnogenic emissions of industrial enterprises), the main violations are cutting and fires. It should also be noted that forest fires can be both natural and man-made. Forest fire is a form of catastrophe common for boreal forest communities, leading to disruption of the natural composition of plantations [1, 2]. Such fires may accompany clear cutting, and, in this case, the consequences of one form of violation may overlap with another. There is an opinion that differences in violations of natural coenopopulations can lead to different scenarios of restoration and the formation of various types of communities in the area subjected to catastrophic violations [3].

In this paper, the main types (formations) of pine forests are considered:

- Lichen pine - Pinetum cladinosum (the share of lichens is more than 70%). Communities are characterized by a large predominance of bushy lichens of the genus Cladina in the moss-lichen layer. These communities are confined to dry, low humus or coarse humus, surface-podzolic soils.
- Green-moss-lichen pine - Pinetum cladinoso-hylocomiosum (proportion of lichens 30–70%). Communities are distinguished by the co-domination of bushy lichens of the genus Cladina and green mosses, such as Pleurozium schreberi, Dicranum spp. and others. It is believed that
these communities are intermediate in the succession series of disturbed pine forests between lichen and green-moss communities. However, these communities can be very stable for a long time and in some cases stand out as a separate type of pine forestes [4].

Green-moss pine - Pinetum hylocomiosum (the proportion of lichens is less than 30%). This type of pine community is found in normally drained habitats with moderate soil moisture. This type is confined to various elements of the relief - gentle slopes, mountain shelves and flat areas of the earth's surface (including river valleys). The moss-lichen layer is represented by Pleurozium schreberi, Dicranum spp. and Hylocomnium splendens. Lichens are absent completely or their participation is insignificant.

2. Materials and methods
The studies were performed on the basis of material obtained on the territory of the Kola Peninsula in the Kvodorsky, Appatitsky, Monchegorsky and Olenegorsky districts of the Murmansk region. Trial plots were laid in pine trees with a violation of 80 years (at least 2 test plots for each type of community). The duration of the violation was established on the basis of the analysis of cuts and cores of living trees. In these communities, trial plots (PP) of 0.1–0.25 ha were established (the number of trees of the forest-forming species should be at least 200 individuals) [5]. On the PP data, model objects were selected in accordance with the steps of the trunk diameter thickness: 8, 12, 16, 20, 24, and 28 cm, from which cores and saw cuts (4 cm) were taken. It should be noted that all individuals of the forest-forming species with a trunk diameter of 4 cm at an altitude of 1.3 m were assigned to the stand stand. Also, a condition category was determined for all stand stands to analyze the vitality structure of the tree stand. We also calculated the index of the vital state of the stand by the formula:

\[
I_n = \frac{n_1 + 0.7n_2 + 0.4n_3 + 0.1n_4}{n}
\]

где \(I_n\) – life condition index;
\(n_1\) – the number of individuals classified as “healthy”;
\(n_2\) – the number of individuals classified as “defoliated”;
\(n_3\) – the number of individuals classified as "severely defoliated”;
\(n_4\) – the number of individuals classified as "withered";
\(n\) – total number of individuals.

It should be noted that in assessing the vitality of trees there is a fifth category - “dead” individuals. However, in the case of determining the index of living conditions, the number of such individuals is not taken into account (in the formula, this can be represented as 0 times \(n_5\)).

The first two categories (“healthy” and “defoliated”) of trees were considered as one cluster, uniting individuals that do not experience strong oppression in growth and development, but experience some competition normal for such communities.

3. Results
The study showed that the vitality structure can noticeably change in various types of communities (respectively, depending on the growing conditions).

In middle-aged pine forests recovering from a fire, the proportion of healthy and defoliated trees was about 40% for moss communities. At the same time, a large number of severely defoliated and withered individuals (about 50%) are observed in these communities. For moss-lichen and lichen communities, the total number of healthy and defoliated individuals is approximately the same - 70-80%. It should also be noted that the distribution of categories within this group is not the same: about 10% of healthy individuals in the moss-lichen community and about 20% in the lichen community. At the same time, the proportion of severely defoliated and dead individuals is much smaller than in the moss pine — about 20–25%. And dead trees are almost completely absent (figure 1). This may
indicate stronger competition in moss communities, where there is a higher density in the tree layer.

In communities recovering from cutting, the proportion of healthy and defoliated trees is about 40% for moss communities. The proportion of severely defoliated and withered individuals can reach 60% (more than half of the community members are in a depressed state). For moss-lichen communities, the number of healthy and defoliated individuals is about 70%. In lichen communities, this indicator is slightly higher - an average of 70-80%. As in communities recovering from fires, the ratio of healthy and weakened individuals shifts to the “healthy” category from moss-lichen to lichen communities (on average 15% in moss-lichen communities and more than 30% in lichen). Also similar to the situation with post-fire restoration, in lichen forests recovering from cutting, the number of severely defoliated and withered trees will be minimal (only 13%). Also, dead individuals are almost completely absent (figure 2).

As in the previous case, pine forests recovering from cutting and belonging to the green-moss type will have the highest density. Therefore, it can be assumed that in such communities the strongest competition between individuals of the tree layer will be observed.

When comparing the living condition index in the presented communities, the highest indicator will be observed in lichen communities in both cases of catastrophic disturbances. However, for communities recovering after cutting, this indicator is higher (0.75) than for post-fire communities.
A similar situation will be observed for moss-lichen communities: 0.59 for post-fire communities and 0.63 for post-cutting communities. In moss communities, this indicator, regardless of the type of violation, remains the same (0.49). It can also be noted that, as in the case of analyzing the distribution of pine forests by the categories of living conditions, in both cases there is a tendency to increase the living conditions index when moving from green to lichen communities (table 1).

|       | Moss | Moss-lichen | Lichen |
|-------|------|-------------|--------|
| Fire  | 0.49 | 0.59        | 0.68   |
| Cutting | 0.49 | 0.63        | 0.75   |

4. Conclusion
Thus, in the vitality structure of north-taiga pine forests with a violation of 80 years, a tendency is observed to increase the number of healthy and defoliated and the life condition index during the transition from moss to lichen communities. This is typical for communities recovering from both cutting and after a fire. One of the possible reasons for this change may be a decrease in competition between individuals of the tree layer, associated with a decrease in the stand density with an increase in the total projective cover of lichens in the moss-lichen layer.

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