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Illuminance under canopy in different types of forest in the northern taiga

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Abstract

The illumination under the canopy in different types of pine and spruce forests is considered. The research was carried out in different points of the Northern taiga of the Arkhangelsk region. Illumination was measured using a luxmeter in different directions: at the level of the moss-lichen layer, at the level of the grass-shrub layer and at a height of 1.3 m; at different distances from the tree trunk; at different distances from the edge of the forest.

Illumination in pine forests at the level of the moss-lichen layer is 2.3 times higher than in spruce forests. Under the canopy of spruce forests, it is 1–3%, and in the pine forests, 3–9% of the illumination in the open. Illumination from tree trunks to the edge increases in pine and spruce forests equally. The lowest illumination is observed at the level of the moss-lichen layer, then it increases to the grass-shrub layer, and then practically does not change. However, the difference between pine and spruce forests is consistently high 47%. The decrease in illumination in the tree stand as it moves away from the edge in blueberry pine forests is observed up to a distance of 10 m from the edge, and in blueberry spruce forests up to 6 m.

Key words

illumination, forest type, spruce forests, pine forests

Introduction

The light regime within plant communities is very important in the life of the forest and is considered in all the important works for forest science (Morozov 1949; Sukachev 1964). At the same time, as noted by Melekhov (1980), there are conflicting information in the literature on this subject and the illumination under the forest canopy is influenced by numerous factors related to the breed composition, structure, presence of tiers and such others, and is largely determined by climatic conditions. Weather conditions at the time of light measurement are also important, such as the presence of clouds, their number and nature, time of day and so on. Information on this issue is present in the literature, but more often in other regions (Molchanov 1973; Alek-

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seev 1975), as well as in North-taiga forests (Feklistov and Sobolev 2013), which of course do not exhaust the problem. The study of patterns and processes in forest ecosystems is very important from the point of view of the main species conservation and their occurrence in plant communities (Bormann and Likens 1979).

Material and methods

The material was collected at different points in the Northern taiga (Fig. 1). To measure the illumination, test areas were laid out and the taxational characteristics of the stand were determined (Anuchin 1982; OST 56-69-83). Taxation parameters of forest stands are given in Table 1.

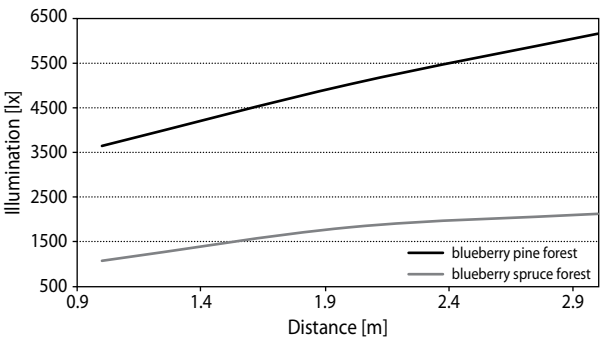

Figure 1. Illumination under a tree in different forest types

Illumination was measured at different points in the sample area. The work was carried out in cloudless weather in July. Before the measurements in the tree stand, the light was measured in an open area. The choice of measurement locations was either made randomly or according to a specific plan. For example, measurements were made at tree trunks, then in the direction of the window in the canopy to the North and South, as well as at different heights from the surface. The number of measurements was determined based on a preliminary trial study of the variability of this feature and the calculation of the corresponding number of measurements.

In total, 15 test areas were laid and about 1,600 light measurements were made. Statistical analyses were performed using the Python software (ver. 2.7.12, 2016), package SciPy (ver. 0.18.1, 2016).

Result

Measurement of illumination at the level of the moss-lichen layer showed the following. All the calculated illumination indicators are reliable. The student's criterion ranged from 7 to 26 (with a critical value of 3–4 for different probability levels). The illumination in spruce forests is lower than in pine forests. In spruce forests at different sites, the illumination ranged from 1033 lx to 2364 lx, with an average of 1664 lx (Tab. 2). Slightly higher illumination in bilberry spruce, where there are 2 units of birch in the composition.

Illumination in pine forests varies from 1985 lx to 6300 lx, and on average it was 3754 lx. This is higher than in spruce forests, but only 3–9% of the illumination of the open area.

The illumination at the level of the lower tier of vegetation is extremely low. In relation to the illumination of an open area, it is 1–3% in spruce forests, and 3–9% in pine forests. How low this illumination is can be judged by the data given by Veretennikov (1987). He notes that the minimum light for the existence of pine is 3300 LX, and for spruce 1000 lx. When we received the illumination under the canopy, the undergrowth of pine and spruce will be in the region of the light compensation point where photosynthesis is equal to the intensity of respiration. All the created organic substances will be immediately spent on breathing. This light regime was significantly complicated by the emergence under the canopy of the undergrowth of conifers and especially pines. Other researchers have paid attention to shadow resistance (Niinemets and Valladares 2006). It was stated that light is a condition of survival for certain species (Čater and Batič 2006). Light is also important for the grass-shrub and moss-lichen layer, for example, for blueberries (Jaakola et. al 2004). Examples of drawing up ontogenetic scales of the relationship of trees to light have appeared (Evstigneev 2018), but for a different region.

Discussion

It is interesting to compare the light intensity in different phytocoenoses at different distances from the tree and in the gaps between the trees. Numerous measurements show that the lowest illumination is observed near the

trunk in both blueberry pine and blueberry spruce forests (Fig. 1). In trees, the average illumination was 3650 lx in blueberry pine, and 1080 lx in blueberry spruce. As you approach the lumen, the illumination increases and reaches a maximum. However, this maximum is only 9% of the illumination of the open space in pine and 3% in spruce. The difference between the illumination in different places in relation to the trunks in blueberry spruce and blueberry pine trees is very significant and stable at different distances from the tree. In pine forests, the illumination is always higher by 65–70%.

The change in illumination in height from the surface of the moss-lichen cover increases sharply to the level of the grass-shrub layer (Fig. 2). In blueberry spruce, the illumination increases by 60%, and in blueberry pine by 36%. Further up to a height of 1.3 m, the increase in illumination is extremely insignificant, especially in blueberry spruce. The differences between blueberry spruce and blueberry pine are very significant, 1.3 m difference is 47%.

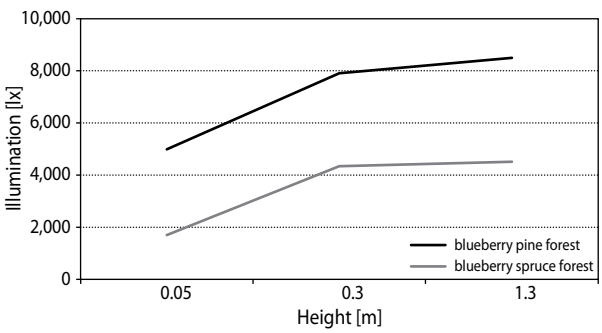

Figure 2. Illumination at different heights in different forest types

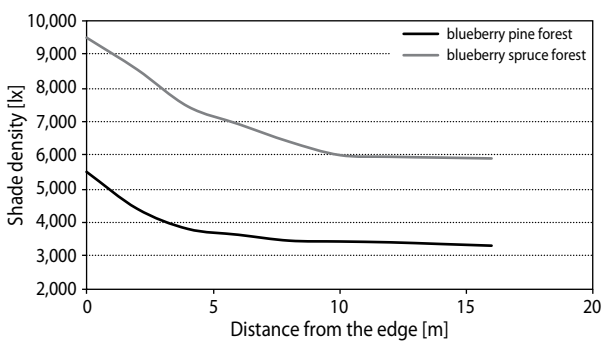

Figure 3. Illumination at different distances from the edge of the forest.

The change in illumination in phytocoenoses also depends on the distance to the edge of the forest. Both in blueberry pines and in blueberry spruce forests, there is a natural decrease in illumination as the distance from the edge of the forest deep into the forest (Fig. 3). In blueberry spruce and blueberry pine, the decrease in illumination occurs in parallel, but with a difference of about 30%. In pine forests, the illumination decreases to a distance of 10 m, and in spruce forests to a distance of about 6 m, after which the illumination remains constant.

Conclusion

- Illumination in pine forests at the level of the moss-lichen layer is 2.3 times higher than in spruce forests. Illumination under the canopy of spruce forests is 1–3%, and in pine forests 3–9% of the illumination in the open.
- Illumination over the area in pine and spruce forests is uneven. Increases from tree trunks to the window equally, but in pine trees it is 65% higher.
- The lowest illumination is observed at the level of the moss-lichen layer, then it increases to the grass-shrub layer, and then practically does not change. However, the difference between pine and spruce forests is consistently high at 47%.
- Decrease in illumination in the stand as it moves away from the edge of the forest in blueberry pine forests is observed up to a distance of 10 m from the cannon, and in blueberry spruce forests up to 6 m.

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