

## DETECTION OF THE MOUNTAIN ECOSYSTEM DYNAMICS IN THE Khibiny BY TECHNIQUE OF COMPARISON OF MODERN AND OLD PHOTOGRAPHS AND ITS RELATION WITH CLIMATE CHANGES

V.I. Demin<sup>1</sup>, Yu. L. Zyuzin<sup>2</sup>

<sup>1</sup>*Polar Geophysical Institute, Apatity, Russia*

<sup>2</sup>*Centre of Avalanche Safety, Kirovsk, Russia*

**Abstract.** The natural changes of the landscapes in the Khibiny Mountains during last 120 years have been studied by the comparison of the modern and old photographs. The obvious landscape changes were detected. There are the expansion of the forest-tundra in the tundra zones and the rise of the tree-line upper. Most likely that it is response of the landscape on warmer conditions of growing season of 20<sup>th</sup> century in comparison with 19<sup>th</sup> century. The meteorological measurements are evidences of the warming too. At the same time the reaction of the landscapes on the climatic change is considerably more complex. The landscape dynamics has not agreement with short-term (interdecadal) climate changes. For example, the overgrowing of the valley Malyi Vudyavr took place even during the 1940-1970s, when temperature trend was negative. The wide range of tolerance of the forest ecosystem on the short-term climatic changes shows the limited use of the landscape methods for diagnostics of the climate changes.

### Introduction

The global climate changes of the last decades should cause the shift of the climate and Nature boundaries and the variations of the landscape processes. However the observed climate changes have not caused any noticeable forest ecosystems response in the plain European part of Russia yet [3]. Most scientists agree that ecosystem changes are most pronounced in the Subarctic and the mountain regions at the forest boundaries. It is suggested that the forest will shift to the tundra zones and the tundra will occupy the district of arctic desert in conditions of the Global Warming.

### Objects and methods of the research

The purpose of this paper was to find out the landscape changes in the Khibiny mountains and the forest ecosystems reply on the on-going climate changes by method of the comparison of the modern and old photographs.

### Results and Discussion

The first photos of the Khibiny have been made during the research expedition of V. Ramsay in the 1890-1891 and have been published in the "Fennia" magazine (№ 2, 1891). In 2007 the repeat photography at the same districts has been made. There are the significant changes.

At the end of the 19<sup>th</sup> century the valley has been occupied by the sparse second growth wood and tall-grass meadows. In present time the valley is overgrown with birches and spruces which have a height of 10-12 m. The increase of the closing of leaf canopy is visibly. The rocky slopes of valley are overgrown with birches and spruces too. The upper tree-line raised about 100-150 m on mountainside which has top-soil or melkozem.



**Fig. 1** Valley of the Yumegorr river in June of 1891 (left) and of 2007 (right)

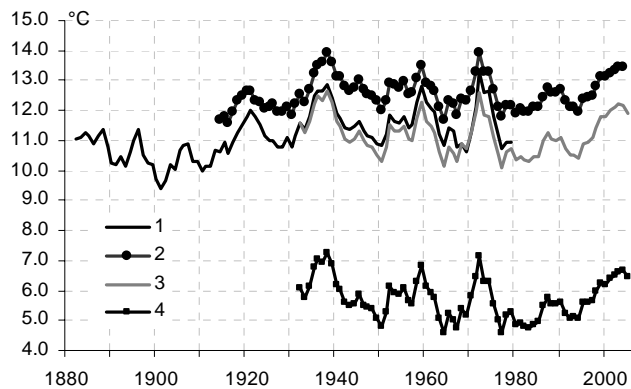
The similar landscape changes are observable throughout the Khibiny. The districts of tundra vegetation are replaced by forest-tundra, and forest-tundra is replaced by forest.

It is known, that the temperature of the summer period is main factor for growth of wood vegetation in the Subarctic region [5]. For this reason we can assume that the expansion of forest-tundra, the rise of the upper tree-line on the mountain slopes, the increase of height and diameter of trees, the presence of straight-boled underwood within district of old crooked forest shows warmer conditions of the 20<sup>th</sup> century in comparison with the 19<sup>th</sup> century.

The meteorological measurements are evidence this regional warming too. The average summer temperatures in 4 sites in the Khibiny for period of 1961-2007 are about 0,5C higher than climatic norms of 1881-1960 years. The durations of the period when the mean daily air temperature is higher than 0 and 5°C have increased by a week approximately.

However whether we can unambiguously concludes that these changes of the natural environment are caused by the climate changes only and no changes of the other landscape components? For example the expansion of the forest-tundra to districts of tundra could be caused by the soil evolution too [1].

As discussed above, the 20<sup>th</sup> century is warmer than 19<sup>th</sup> century. However this fact demonstrates the long-term variations only, while the temperature variations during 20<sup>th</sup> century have a different sign (Fig. 2). The period of warming of 1920-1940s was followed with a period of air cooling between 1950s and 1970s. The modern warming began with the later half of 1980s. The 1930s were approximately as warm as the 1990s.



**Fig. 2.** 5-years running average summer temperatures in the Kola Peninsula (1– Kola, 2– Kandalaksha, 3– Khibiny (350 m asl), 4 – Khibiny (1090 m asl)).

However these interdecadal variations have not an impact on the dynamic of the Natural Zones in the Khibiny.

For example, the comparison of photos of the south-west slopes of the Kukisvumchorr mountain of 1936 and 2006 years has shown the rise of the upper tree-line limits by 100 m approximately during last 70 years (Fig. 3). [5]. However the temperature conditions in the region have not become better during this period. Further still the rise of the upper tree-line limits and even its acceleration during last 40 years were detected in the beginning of 1960s [4], while the summer temperatures decreased during this period. (Fig. 2).

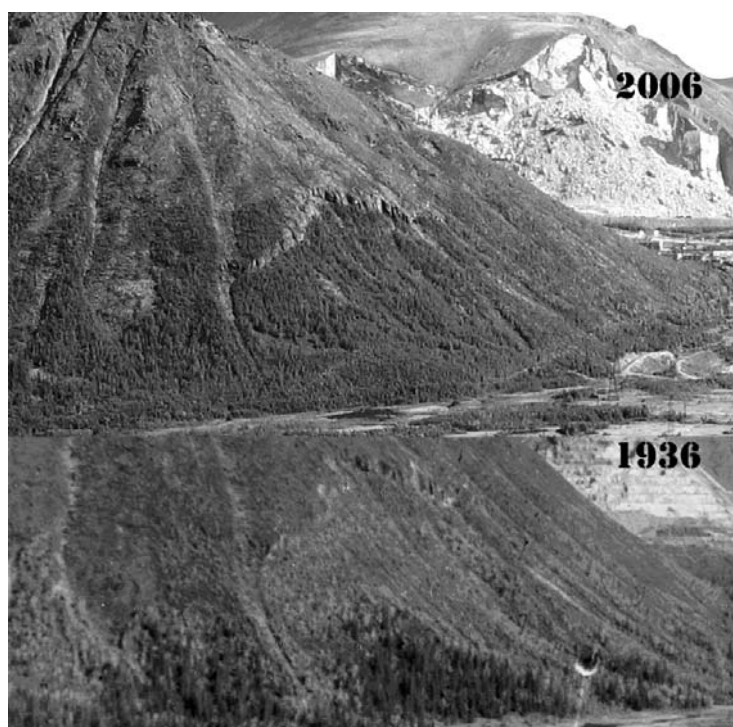
The valley around lake Malyi Vudjavr was occupied with tundra vegetation according to the results of studies of vegetative and soil covers in the 1930s. At that time the valley looked like “a wide plain licked of trees, which was covered with lichen, dwarf birch and reindeer moss”. A. E. Fersman has named this site as reserve of the Khibiny tundra. However the valley has already overgrown with birches by the early 1980s. These changes have formed the basis of conclusion that areas of tundra in the Khibiny Mountains are replaced with forest-tundra, and the forest-tundra areas are replaced with the forest [4]. Thus the tundra in the valley around the Malyi Vudjavr lake was replaced by the forest-tundra during 1920-1970 years while the thermal resources of the growing season worsened. In other words, the cooling of 1940-1970 years has not caused the response of the dynamic nature zones.

It is evident that reaction of vegetable on the climatic changes is complex by reason of wide adaptative range which helps them to withstand negative influence of the environment [3]. For example, the contribution of modern warming in the total dispersion of summer temperature is not exceed 5%, while the phytocenosis had gained the adaptation properties on the much greater variations meteorological conditions during evolution processes.

In conclusion we also should mention the fact that forest ecosystems are slow to respond to climate changes which is noticed by many authors [2, 3, 5]. They believe that forests may respond after dozen and even hundreds of years.

The wide range of tolerance of the forest ecosystem to the short-term climatic changes is indicative of the limited use of the landscape methods for climatic problems.

It is impossible to separate the effect of the climate change on the dynamics of nature zones from the effect of evolution another landscape component (for example, soils).



**Figure 3.** The south-west slope of the Yukspor mountain in August, 2006 and August, 1936.

### **Conclusion**

The natural changes of the landscapes in the Khibiny mountains during last 120 years have been studied by the comparison of the modern and old photographs.

The comparison old and modern photographs indicate on the obvious landscape changes. There are the expansion of the forest-tundra in the tundra zones and rise of the tree-line upper. Most likely it is response of the landscape on most warm conditions of growing season of XX in comparison with XIX. The meteorological measurements evidences of the warming too. The average summer temperatures for period of 1961-2007 are 0.5°C higher than ones for period of 1880-1960. At the same time the landscape dynamics is not agreement with short-term (interdecadal) climate changes.

We assume that the rise of the tree-line upper and expansion of forest-tundra in the Khibiny are reaction on the overall warming of 20<sup>th</sup> century in comparison with 19<sup>th</sup> century, while the interdecadal climatic variability is not reflected in landscape dynamic.

The wide range of tolerance of the forest ecosystem to the short-term climatic changes is indicative of the limited use of the landscape methods for diagnostics of the climate changes.

### **References**

1. Aleksandrovskij A.L., Aleksandrovskaja E.I. Soil evolution of soils and the geographical environment. Moscow. Nauka. 2005. 224 p (in Russian).
2. Gorchakovskiy P.L., Shijatov S.G. Phitoindication of environmental condition and the natural mountain processes. M. Nauka. 1985. 208 p. (in Russian)
3. Kozharinov A. V., Minin A. A. Modern tendencies in Nature of the Russian Plain // Registered nature territory of the Russia: analysis of long-term observations. Moscow. 2001. 184p. (in Russian).
4. Nature of the Khibiny educational centre. Moscow. MSU. 1986. 169 p. (in Russian).
5. Vaganov E.A., Shijatov S.G., Mazepa V.S. Dendroclimatoly researches in the Ural and Siberian Subarctic. Novosibirsk. Nauka. 1996. 246 p. (in Russian).