The impact of climate change on the forest ecosystems of Krasnodar Region

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Abstract. Modern anthropogenic warming changes all climatic characteristics: temperature, precipitation, cloudiness, duration of snow cover, etc.The article analyzes the impact of global climate change on the forest ecosystems of Krasnodar region. The conclusion about the moderately negative contribution of the climatic factor to the forecast dynamics of forestry is substantiated.

1 Introduction

The uniqueness of natural resources of Krasnodar region has a direct potential value for the present and future of the entire country [1, 9]. Due to its natural features, the Kuban plays an important role both in the country and in the world in terms of preserving global public goods.It provides significant environmental services to the entire planet. The Caucasian Biosphere Reserve is in Krasnodar region, It is a World Heritage Site. The ecological situation in Krasnodar region is determined by the anthropogenic load, natural and climatic factors, and man-made and natural emergencies.

Forests have the active properties of a living organism and are regulators and stabilizers of the natural processes of the Biosphere, exhibit soil-protective and water-protective properties, and are inextricably linked with human life.

Forests have a stabilizing effect on climatic conditions in terms of temperature, light, precipitation, and wind. The water-protective, water-preserving and water-regulating effects of forests are manifested in strengthening banks, maintaining the level of soil water, forest water sources, retaining moisture, regulating surface runoff, preventing floods, etc.

Forest climatic conditions are a set of factors associated with weather conditions that affect the development and characteristics of forest ecosystems. Climate is a major factor in determining forest types and their distribution around the world.

The climatic conditions of forests include parameters such as temperature, precipitation, humidity, solar radiation and wind. These factors interact with each other and create certain conditions for the growth and development of vegetation in forests.

Temperature plays an important role in determining forest types. Some forests thrive in cold climates, while others prefer warm and humid conditions. Rainfall is also an important factor as it provides water for plants and maintains soil moisture.

Humidity and solar radiation also affect the growth and development of forests. High humidity promotes the formation of fertile soils and provides sufficient water for plants. Solar radiation, in turn, provides energy for photosynthesis and plant growth.

Wind can also have an impact on forests. Strong winds can damage trees and change their shape. However, moderate winds can be beneficial as they promote air circulation and help ventilate forest ecosystems.

Climate is one of the main factors determining the characteristics and development of forest ecosystems. It affects plant growth, species distribution, soil fertility and much more [17].The strategy of the current state of forest resources in Krasnodar region assumes an increase in profitability from the forest fund in the next decade, within the Forest Plan of Krasnodar region, through the development of multi-purpose use of forests (recreational, raw material component, infrastructure development, etc.). This is determined by the geographical location of the region.

All forests located on the lands of the forest fund are protective. The share of coniferous plantations is 4.9% (56.7 thousand ha), hardwood – 88.8% (1017.7 thousand ha), softwood – 6.3% (71.2 thousand ha). The total forest area of Krasnodar region is more than 1,685 thousand hectares, which is about 20% of the region's territory. High-value species (oak, hornbeam, fir) predominate here, while beech and edible chestnut grow only in the North Caucasus [8, 9, 11].

The role of trees and shrubs in the protection of the soil cover is invaluable. Trees, shrubs and undergrowth hold back rainfall, break it into small streams, favor the absorption of these waters by soils and reduce the impact of erosion processes. On the slopes, forest plantations reduce the intensity of surface runoff by two or more times. Soils accumulate more moisture, which ensures

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large yields [2]. Forest belts create a favorable climate, protect crops from dry winds, which also increases the productivity. A large area is occupied by floodplain forests, whose role in the biosphere is irreplaceable. Unfortunately, floodplain and ravine forest formations have been changed due to human activities and are secondary broad-leaved and small-leaved forests, woodlands and shrubs. Floodplain forests, located on the ancient bottoms of river valleys with fertile alluvial soils in the basin of the tributaries of the Kuban River and the Black Sea rivers, are multi-layer plantations with a developed shrub-liana layer. In terms of their importance, many forests belong to the first group and perform important sanitary, recreational and protective functions [8, 9].

Communities of herbaceous plants occupy river floodplains and bottoms of gullies. Unfortunately, the forb steppe vegetation has not been preserved, and many steppe species have become extinct. Of great interest are wild medicinal plants, of which there are over 100 species; among them there are many species from Asteraceae, Fabaceae, Lamiaceae, Malvaceae, Rosaceaefamilies and a number of others which are of great practical importance. Unfortunately, the raw material base of many medicinal plants has been destroyed due to the destruction of many natural habitats and pollution of landscapes [5].

2 Problem statement

Adverse weather conditions and soil and climatic factors in the Krasnodar Territory have a significant impact on the sanitary condition of forests. This applies, first of all, to catastrophic phenomena such as ice, floods, floods on mountain rivers, tornadoes and atmospheric moisture deficiency in combination with high air temperatures.

Forests play a significant role in stabilizing the ecological situation in the Kuban region. The climate-regulating, water-regulating and soil-protective properties of mountain forests are of great importance. The forest serves as a "procurer" of fresh waters and a regulator of their flow from the mountains to the plains, it feeds the Azov-Kuban artesian basin.

The geographical position of Krasnodar region and the complex surface topography determined the most important properties of the climate: a large amount of hours of sunshine, pronounced continentality, aridity, and the manifestation of altitudinal climatic zonality. There are two patterns: 1) continentality and aridity increase in the flat part of the region from the northwest, west and southwest (from the Azov and Black Seas) to the northeast and east (towards the eastern borders of the region); 2) in the foothill and mountainous zones of the Greater Caucasus, there is an altitudinal distribution of heat and moisture [3,4,6].

Deforestation, grazing in floodplains, fires and other adverse factors, such as global climate change, lead to significant disruptions in the natural forest systems.

Modern anthropogenic climate warming changes all climatic characteristics: temperature, precipitation, cloudiness, duration of snow cover. Regional climate trends may differ from the global ones, and the territory of Russia is a good example.

There are conflicting opinions among climatologists. Meteorological observations in Krasnodar have been carried out for about 120 years. This is a very short period in order to make climate generalizations. The temperature in Russia has increased by approximately 2.5 degrees in January and by 1.5 degrees in July. This corresponds to the global trends [8].

Scientists from the Institute of Global Climate and Ecology named after Yu.A. Izrael claim that The Krasnodar region is in the orange zone, where the effects of climate change will also be felt and the region will soon face serious consequences of climate change.

Most climatologists believe that global warming has occurred in recent decades. Over the past 100 years, this warming is expressed in an increase in temperature by one and a half to two degrees. Precipitation, humidity, pressure, solar radiation indicators affect the climate. It is believed that following a slow increase in temperature due to an increase in the surface heating temperature, water evaporation increases. Consequently, the processes of water exchange intensity increase in the atmosphere, which is expressed in a change in the precipitation regime in comparison with climatic norms [6, 7, 9].

Increasing average temperatures may change the distribution of plant and animal species in forests. Some species may not cope with higher temperatures and become vulnerable to extinction. In addition, temperature change can also influence the phenology of forest plants, such as the timing of flowering and leaf fall.

Changes in precipitation can have serious consequences for forest ecosystems. Increases or decreases in precipitation can change the availability of water for plants and animals. Lack of water can lead to droughts and increased vulnerability of forests to fires. On the other hand, excess precipitation can lead to flooding and changes in the composition of vegetation in forests.

Climate change can also influence the spread of pests and diseases in forests. Changes in temperature and precipitation can create more favorable conditions for pests such as insects and fungi to breed and spread. This can lead to increased tree mortality and changes in the composition of forest communities.

Climate change may also change the geographical distribution of forests. Increases in temperature and changes in precipitation may create more favorable conditions for forest growth in some regions, while other regions may become less suitable for the development of forest ecosystems. This could lead to shifts in forest boundaries and changes in biodiversity in different regions.

Overall, climate change poses a serious threat to forest ecosystems. Understanding these changes and their impact on forests will help develop adaptation and management strategies for forest resources to preserve their biodiversity and ecological integrity.

Since the distribution of forests is closely related to the climate, the stable climatic trends cause shifts in the boundaries of forest distribution and changes in the

forest-forming species composition. As temperatures rise, forests begin to occupy spaces that were previously unsuitable for the growth of certain biological species.

In the forests of Krasnodar region, the areas of some dominant tree species have changed, and these changes can be compared with climate trends. Климатические изменения имеют значительное влияние на леса и их экосистемы. Изменение температуры, осадков и других климатических факторов может привести к серьезным последствиям для лесных экосистем.

The southern border of forest distribution is also related to climate and coincides with the ratio of the amount of evaporated moisture from the water surface to the amount of precipitation [15, 16].

There is a reduction in the areas of spruce forests, sometimes taking on the character of mass drying up. The sensitivity of spruce to climate warming is associated with the superficial nature of its root system. Warming against the background of precipitation variations reduces moisture availability, which weakens tall older trees. Weakened areas of spruce forests are attacked by bark beetle-typographer and other pests, which leads to mass death of trees. Young spruce forests are not so sensitive to the lack of moisture. The areas of spruce forests are increasing in the middle zone of the European part of Russia due to forest plantations in the areas of clearings. Against the background of warming, the density of forests increases; in addition, other conifers will gradually appear [8].

A large number of global and regional models have been developed to predict the spatial distribution of vegetation cover under known climatic conditions [9]. But these conditions are precisely unknown, since future climate change will depend on anthropogenic emissions of greenhouse gases. Therefore, forecasts are usually given for a set of scenarios that assume different options for the dynamics of emissions and global temperature growth [13, 22, 23].

According to Pogorelov A.V., one of the indicators of climate change is glaciation. A glacier is the result of accumulation of snow that does not melt, crystallizes and turns into ice. In Krasnodar region there are glaciers that are decreasing [8, 10]. The westernmost one in the Caucasus is a glacier located on Mount Fisht. According to the observations, it was stationary and did not change much. But since 2010, it has sharply retreated by tens of meters. This is a typical response to the climate change due to an increase in temperature at an altitude of 2500 m and a decrease in the amount of solid precipitation.

3 Conclusion

Based on the results of the analysis of forest pathological monitoring materials, all forestries have been assigned to three forest protection regions: the first forest protection region (Gelendzhik) is a zone of strong forest pathological threat; the second forest protection region (Absheron) is a zone of medium forest pathological threat; the thord forest protection region (Otradnensky) is a zone of weak forest pathological threat. On average, on 72.6% of the areas of plantations covered by forest pathological monitoring in 2016-2022, factors that adversely affect the state of the forest stand were identified.

The main reasons for the weakening of forest plantations are as follows:

- forest diseases – 32.4%;
- damage to plantings by non-pathogenic factors – 21.7%;
- unfavorable weather conditions, soil and climatic factors – 17.5%;
- insect damage – 16.5%;
- forest fires – on the area of 175.8 ha.

Unfavorable weather phenomena and soil and climatic factors in Krasnodar region have a significant impact on the sanitary condition of forests. This applies to catastrophic events, such as rainfall (in 1994, 2001, 2010, 2016, 2021), floods (2002, 2010, 2012, 2021), floods on mountain rivers (in 2011, 2012, 2018, 2019, 2020, 2021), tornadoes (1991, 2000, 2010, 2019) and atmospheric moisture deficit combined with high air temperature (2007, 2010, 2012, 2016, 2019, 2020, 2021) [8, 9, 11, 12, 14].

The total area of federal forests weakened by this group of negative factors is 8653.7 ha. The total area ofplantations that died under the influence of unfavorable weather conditions and soil and climatic factors by the end of the reporting year amounted to 845.0 ha (7%).

In the conditions of mountainous terrain, a large amount of precipitation (often stormy) in mountainous areas, it is necessary to preserve forests and reduce the industrial cutting area.

The result of the impact of climate change on the sustainability of forest ecosystems is the identification of vulnerabilities and risks in the area under study, while understanding the cause-and-effect relationships between impact factors and the result is the basis for developing a strategy that would allow in the future to avoid the negative consequences of climate change both in forest ecosystems, and in forestry.

The conservation of biodiversity, the organization of a monitoring system for the development of individual systems, rational environmental management and other conditions should become the norm, which will make it possible not only to establish the causes of the destruction of natural systems, but also to develop technologies for their restoration. In every district of the Krasnodar Territory, in every natural economic zone, it is advisable to create genetic reserves of valuable plant species in order to use them for reforestation. It is also extremely necessary to carry out certification of meadows and pastures, establish the areas of unproductive lands and develop technologies for their radical or superficial improvement [16,19,20,21].

The conservation of biodiversity, the creation of a monitoring system indented to develop individual systems, rational environmental management and other conditions will establish causes of the destruction of natural systems and contribute to the development of technologies for their restoration [24, 25]. In each

district, natural and economic zone, it is advisable to create genetic reserves of valuable plant species in order to use them for reforestation.

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