Study experiment on the way forest plantation microclimate influences human hemodynamic parameters

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Abstract. In recent years, the flow of vacationers in the forests of cities' green areas has significantly increased. In this regard, it raises the question about the influence of various forest plantations, or rather the "microclimate" of various types of forest conditions, on hemodynamic parameters of a healthy person. In everyday life, for example, there are cases when people's staying in a pine plantation causes malaise, dizziness, weakness, and even fainting. The research was carried out in various forest plantations, the most typical for the green zone of Voronezh city according to meteorological conditions. Studies of the state of vital organs and systems of a healthy person show that the "microclimate" of various forest stands is not indifferent to a person and causes him a number of changes in hemodynamics. The noted changes in hemodynamics suggest that mixed plantings, multi-tiered, do not cause drastic changes in the body of a healthy person. The main criterion for the training of new cities' green areas and the reconstruction of existing ones should be the creation of complex, multi-tiered plantings, especially for short-term recreation.

1 Introduction

The expansion of urban areas and the reduction of green areas in cities leads to an acute human need for a rest. Therefore, the recreational role of forests at the present stage is very important. The limited area of green areas of cities dictates the need for their maximum optimization in terms of combining high environmental protection, sanitary, hygienic, aesthetic properties of biocenoses with their resistance to anthropogenic impact. Research on recreation problems is mainly carried out in the field of socio-economic and human influence on forest phytocenoses. During socio-economic research, a survey of vacationers is conducted, issues of organization and planning of recreation in recreational forests and their economic assessment are studied [1]. There is a large amount of information in the references on the study of sanitary and hygienic properties of plantings [2].

It has been established that forest stands have high gas resistance and gas absorption capacity, which depends on the composition, completeness, shape, height of phytocenosis [3,4], they reduce various kinds of noise, increase environmental attractiveness [5], give up

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to 5-8 tons of phytomass per 1 ha, absorb up to 18.3 tons of carbon, while releasing up to 13.2 tons of oxygen. The use of recreational forests for mass recreation leads to the degradation of soil and vegetation cover, and this leads to a change in the species composition of the flora and fauna of green zones [3,6,7].

The question of the influence of forest phytocenoses on the human body has been marginally studied. There is information about the influence of coniferous forests on patients with tuberculosis, cardiovascular diseases, oak forest on patients with hypertension [8], the influence of flowering plants on the human body [9].

The objective of our research was to find out the influence of various phytocenoses on the body of a healthy person and the human influence on the studied cenoses in areas that are most typical for the Voronezh Green Zone.

### 2 Material and methods

The object of our research were four main types of forest plantations, the most characteristic of the Green zone of Voronezh: grass pine - A (pinery), grass pine with oak - B (subor), oak-shrub pine - C (oak grove), snytevo-sedge oak - D (oak grove).

As a result of the reconnaissance survey, 16 test areas were laid in 4 types of forest plantations in the areas most visited by recreants and in areas of protected areas. The distribution of pathological signs by categories of tree condition was carried out on the basis of the classification recommended by the "Rules of Sanitary Safety in the Forests of the Russian Federation" of 2007.

Observations were carried out in June-July, during the period of the most massive visits to forest plantations by vacationers.

The state of hemodynamic parameters of a healthy person was studied according to the indications: pulse (frequency, filling, tension and rhythm), respiration, saturation of arterial blood with oxygen, arterial pressure (systolic and diastolic), as well as, for every third participant, a general blood test. A survey of recreants about their subjective feelings was conducted. The studies were conducted before the beginning of human contact, with a certain "microclimate", on the 1st, 2nd, 3rd, 5th, 7th and 10th days of a person's stay in various forest cenoses. 200 people aged 18-25 years (100 women and 100 men) were under observation.

On the days of the research, measurements of air temperature and humidity, atmospheric pressure, wind speed, illumination were carried out, the presence of precipitation was noted as well.

### 3 Results and discussion

The condition of plantings on permanent test areas according to forestry and taxation characteristics sharply decreases from the 1st stage of degression to the third. Especially in clean plantings (pinery and oak forests). All qualitative and quantitative changes in the state of undergrowth are directly dependent on recreational loads (Figure 1). The study of the sanitary condition of the stand is also one of the characteristics of the recreational use of the plantation. There is a clear decrease in the number of healthy trees from protected trial areas to areas with intensive visits by recreants.

Moreover, the number of trees conditionally healthy in the types of growing conditions B2 and C2 is significantly greater than in the type of growing conditions A2 and D2. As the surveys of the trial areas showed, the largest number of damaged trees as a result of recreational load was observed in plantings A2 and D2. In the sample areas most visited by recreants, more than 60% of the trees had shrunken skeletal branches, stripped, flat-headed
growth (Figure 2), hollow of tree trunk (Figure 3), fungal fruits (Figures 4, 5, 6), bark blaze, mechanical bark damage (Figures 7, 8, 9), frostcracks and thunderstorm cracks.

Fig. 1. Trampled down topsoil. Fig. 2. Flat-headed growth. Fig. 3. Hollow of a tree trunk.

Fig. 4. Fungal fruits. Fig. 5. Fungal fruits. Fig. 6. Fungal fruits.

Damage to the crown and the outer part of the tree trunk can result in either the formation of a secondary, thinner bark, or the formation of a dry shoulder.

Fig. 7. Bark blaze, mechanical bark damage. Fig. 8. Bark blaze, mechanical bark damage. Fig. 9. Frostcracks and thunderstorm cracks.
In forests with a large anthropogenic load, trees suffer not only from mechanical damage leading directly to bark blaze, mechanical bark damage, flakes or broken ends of the trunk and crown, but also by ingrowing into the tree trunk of various foreign bodies, which to some extent limit the viability of the tree (Figures 10,11,12).

**Fig. 10.** The result of anthropogenic impact.  
*Fig. 11.** The result of anthropogenic impact.  
*Fig. 12.** The result of anthropogenic impact.

Plantings that have been subjected to a high recreational load have less completeness, sometimes critical for forest plantations, more than 80% of trees with mechanical damage of varying intensity. With an increase in illumination, as a result of the destruction of undergrowth and undergrowth, meadow-curtin complexes with a grassy cover of meadow and weed annual plants are formed.

However, the plantings are complex in their composition, multi-tiered, formed from local ecotypes have fewer damaged trees, the herbaceous cover in them is more abundant with representatives of forest species, there is undergrowth and underwoods. That is, we can talk about a higher resistance to recreational loads, compared with pure plantings in their composition. And from an aesthetic point of view, they are more attractive.

As a result of the conducted studies of the influence of various forest plantations on the body of a healthy person against the background of meteorological conditions, we found certain trends: already in the first days of a person's stay in the forest, he has changes in hemodynamics that are of a functional nature.

There is a quickening of the pulse (Figure 13). In the fresh forest (A2 Green), the pulse rate in the first days is less pronounced, compared with fresh oak (D2 Red), but persists for a longer time. Changes in the pulse rate in fresh oak grove (C2 Blue) and the fresh subor (Pine forest with an admixture of spruce, birch and other tree species growing on sandy loam or clay sands) (B2 orange) are smoothed and return to the level of the original data in B2 on the third day, and in C2 on the fifth day.
Dynamic changes in the respiratory rate (Figure 14) shows that the respiratory rate in the first days in all types of forest stands is reduced, only in the fresh forest (green) there is a sharp increase in respiration in the first days and only on day 10 the respiratory rate is restored. In the remaining plantings, the reduction of respiration is smoothed out and returns to the level of initial data for 3-5 days of research. Red–pinery, blue–sudubrava (oak forest), orange–subor (pine forest with an admixture of spruce, birch and other tree species growing on sandy loam or clay sands)

Blood pressure begins to decrease for the first few days, and then returns to the level of the initial data. In the fresh oak grove, a decrease in blood pressure was observed during the first two days, and then by the 7th day of stay in this cenosis, it returned to the level of the initial data (blue). In the fresh forest (green), we observed a sharp change in blood pressure, and in men it rises by the third day of stay in, and in women it decreases, then stabilizes within 10 days (Figure 15).
Measurements of blood oxygen saturation were carried out by an oxyhemometer and here we also observe an increase in blood oxygen saturation, for the first time the days of a person's stay in a forest plantation, only by day 5-7 these indicators are stabilized and kept at a high level.

A blood test showed that an increase in the number of red blood cells was observed in the forest, subori, oak grove. There was no change in the number of erythrocytes in the sudubrava.
4 Conclusion

Based on the conducted research, the following conclusions can be drawn:
- not all sections of the Voronezh Green Zone carry the same recreational load. Plantings are complex in their composition, multi-tiered (subor and sudubrava) have more resistant properties to high recreational loads, compared with pure plantings (oak and forest)
- the conducted complex of hemodynamic studies shows that the first changes in the body of a healthy person are observed in the first days of staying in a particular forest plantation. Then these changes stabilize and return to the level of the initial data, that is, a certain period of time is needed to adapt to qualitatively new conditions of the "microclimate" of the forest plantation, in certain meteorological conditions. Changes in hemodynamic parameters under the influence of the "microclimate" of fresh boron, fresh oak, subor and sudubrava are of a short-term, functional nature. These changes disappear in fresh subori and fresh sudubrava for 3-5 days, in fresh forest and fresh oak grove for 7-10 days, which indicates a longer period of adaptation. Subjective sensations are also of great importance, if in clean plantings (oak and forest) the majority of the surveyed complained of headache, light dizziness and drowsiness, which persisted for 5-7 days, then in fresh sudubrava only a few people had slight dizziness and drowsiness, the rest of the study participants, as in fresh subori, complaints not presented. The subjects felt a surge of energy, an increase in mood and efficiency.
- the main criterion for the formation of new green spaces around the city or the reconstruction of existing ones should be the creation of a complex in its composition. multi-tiered plantings, especially for short-term rest.

References

and anthropogenic impact on forest ecosystems
