Evaluation of the state of the "Yauza River Valley" landscape reserve

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Abstract: Specially protected natural areas within large cities provide not only their main nature protection function, but also have an important recreational and educational value for people. At the same time, these ecosystems are affected by different kinds of man-made impacts of the urban environment, the excessive pressure of which may disturb the balance in the ecosystems. In order to minimize such impacts and maintain sustainable existence of specially protected natural areas, it is necessary to perform regular monitoring that can help analyze the state of these ecosystems and predict future changes in them. There are four main types of anthropogenic impacts that are mostly associated with high visitor attendance of protected areas: trampling and littering, contamination of water bodies and animal disturbance. Usually, the natural environment has a response to the negative impact on it. Methods of environmental control are based on this principle and can help to identify such impacts more accurately. In this work, the state of the “Yauza River Valley” landscape reserve was analyzed using various environmental control methods. A particular attention was paid to methods related to bioindication of natural ecosystems and based on the study of recreational pressures in the area.

1. Introduction
The "Yauza River Valley" landscape reserve is a natural complex of territories surrounding the Yauza River, which are part of an ecological corridor that runs from the regional part of the Losiny Ostrov national park to the Ostankino natural-historical park [1, 2]. Such lands are intended to help migrate animal and plant species and maintain the ecological balance of the territory. Also, due to its location inside the city, the reserve is intended to provide recreational services to the population. For the successful implementation of both nature protection and recreational services, it is necessary to maintain the reserve's territory in good condition and continuously assess its condition to identify any changes. For a more accurate assessment of the state of the area, there is a large number of different methods and instruments of environmental control, aimed at analyzing certain factors of this environment, which together can provide an overall assessment of the state of the ecosystem under consideration [3].

The creation of urban protected areas is designed to slow down the rate of degradation, or even to keep it at an appropriate level. The existing forms of nature management in Moscow's natural reserves
only slow down the degradation of natural complexes at best, since it is practically impossible to completely relieve the pressure of people activity on their territories. In addition, the most important function of protected areas is recreational, which increases degradation [4, 5].

Therefore, it is necessary to conduct continuous monitoring using various methods aimed at controlling the state of the natural environment, followed by the formation of an overall ecosystem assessment.

2. Analysis of the road and path network (RPN) of the "Yauza River Valley" landscape reserve

The road-path network (RPN) is an essential element in landscape planning of parks. They make it easier to move around a park site. Studies of design solutions for park areas show that the road network can take from 10% to 20% of the total area of the park, and the length of roads is 300-400 m per 1 ha.

The method of analysis is based on the work of Yu. A. Nasimovich [6, 7]. It is a compilation of RPN territory and calculation of its area from the total area of the park.

The RPN obtained with the help of GPS tracker was built and displayed on the map of RPN of the "Yauza River Valley" landscape reserve. The boundary of the park and its RPN were marked on the map. Each of the roads was measured in width. According to GPS tracker data, the total length of the road-tropin network for the "Yauza River Valley" reserve was 19.45 km.

Having summed up the area of all roads, the area of the road and path network of the "Yauza River Valley" landscape reserve was 4.98 ha. The area of the investigated territory is 49.07 ha.
The share of the area occupied by the road and path network from the whole investigated area for the "Yauza River Valley" landscape reserve was 10.15%. These figures exceed the norm.

3. Recreational impact on the territory of the "Yauza River Valley" landscape reserve

The density of the road and path network (RPN) reflects the attendance of the park area by visitors and is used as an indicator of recreational disturbance of the area. This method consists in counting the number of intersections of secondary roads and paths with the main RPN [8, 9].

To determine the functional zoning of recreational forests used for recreational purposes, often used as an indicator of attendance (number of visitors for a certain period). In this case, the attendance is evaluated not only the entire area, but also its individual sections. However, this is a very long and laborious procedure, so often the attendance of the forest judged by the consequences - the state of the grass cover, the formation of undergrowth and many other signs. That is why the density of RPN is used as an indicator of the intensity of visits to forests and parks. Therefore, the higher the attendance, the denser is the spontaneous road and path network [10, 11].

A table of trampling windows and unauthorized bonfires was created.

**Table 1. Area of bonfires and trampling windows.**

| №  | Bonfire site | Fire pit area, sm² | Area of trampling windows around the fire pit, m² | The presence of litter |
|----|--------------|--------------------|-----------------------------------------------|-----------------------|
| 1  |              | 3000               | 220                                           | +                     |
| 2  |              | 1500               | 174                                           | +                     |
| 3  |              | 500                | 248                                           | -                     |
| 4  |              | 1500               | 326                                           | +                     |
| 5  |              | 2000               | 270                                           | +                     |
| 6  |              | 3000               | 648                                           | +                     |
| 7  |              | 1500               | 270                                           | +                     |
| 8  |              | 2000               | 350                                           | +                     |
| 9  |              | 800                | 276                                           | -                     |
| 10 |              | 1500               | 320                                           | +                     |
| 11 |              | 1000               | 344                                           | +                     |
| 12 |              | 2000               | 276                                           | +                     |
| 13 |              | 1500               | 354                                           | +                     |
| 14 |              | 1500               | 170                                           | +                     |
|    | Subtotal     | 23300             | 4246                                          |                       |
Figure 2. Map of intersections of the main roads (green) with secondary paths (red).

A map of the intersection of temporary and secondary paths with the main roads in the study area was drawn up. All roads and paths are taken into account, except for the barely visible paths. Such paths differ from the rest by a good preservation of vegetation cover.

Most crossings of the main roads with secondary paths take place in the north part of the investigated territory. This is especially true for the left-bank part of the reserve, as it is almost completely lacking any infrastructure and it is the least viewed by visitors of the park, resulting in the most trampling windows, unauthorized fires and secondary paths.

The total area of trampling windows was 4246 m², which is 0.85% of the investigated territory of the reserve. This parameter is very big. It is recommended to take measures to rehabilitate the north-eastern part of the reserve.

While mapping the area, it was noted that the undergrowth was cut off. The closer to the path, the less often new trees grow. In some places, where the paths are especially frequent, there was no undergrowth at all or only a few specimens were found. Only weed species of grass grow along the paths that are trampled. Plants inherent to this type of forest parks, are found only under trees with a wide crown, where there is very little light. On many trees you can see traces of mechanical damage.
Further on, by the method of Yu. A. Nasimovich at the intersections of the main roads with secondary paths are allocated zones at the stages of recreational digression.

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Then, following the intersections of major roads with secondary paths zones in the stages of recreational digression were identified.
Working according to this method, it should be taken into account that the stages of recreational
degression do not always correspond to the allocated zones in the density of the road and path network. 
These stages depend not only on the attendance of the park, but also on the stability of the grass (ground) 
cover, which in turn depends on the grain-size composition of the soil, its moisture, surface slope, 
ilumination (the lighter, the more resistant the forest herbs to trampling).

Based on the data analysis, it was found that the northern part of the park is most exposed to 
anthropogenic impact, which can be explained by its proximity to the Moscow Ring Road. The territory 
of the park is not fenced off the road in any way, so that various negative impacts can affect the state of 
the ecosystem in question.

According to the results of noise measurement in the landscape reserve it was found that the noise 
level inside the park reaches values from 45 to 55 dB, while at the border with the Moscow Ring Road 
the values exceed the mark of 70 dB.

![Figure 6](image)

**Figure 6.** The result of noise impact measurement on the territory of the "Yauza River 
Valley" landscape reserve on the border with the Moscow Ring Road.

Such high noise levels can have a negative impact on visitors and the wildlife of the reserve. It is 
recommended to install acoustic screens on the border of the reserve with the Moscow Ring Road.

4. **Assessment of the state of the trees of the "Yauza River Valley" landscape reserve**

Due to the growth of anthropogenic pressure in recent decades (increase in the amount of exhaust gases 
in the surface atmosphere, recreational impact, etc.) the resistance of tree plants to abiogenic stresses is 
significantly reduced, which leads to anatomical and morphological fluctuations of their vegetative and 
generative organs [12, 13]. Therefore, the study of fluctuation asymmetry (non-directional differences 
between the right and left sides of different morphological structures, normally having bilateral 
symmetry) is an important and promising criterion in determining the ecological state of urban park 
ecosystems [14].

One of the most promising methods for bioindication of the quality of the natural environment is the 
assessment of the stable development of Betula pendula, calculated by the magnitude of fluctuating 
asymmetry (FA) of leaf plates [15]. Correlations of this indicator with various anthropogenic impacts, 
including chemical and radioactive contamination, have been revealed.

The methodology of bioindication of the quality of the natural environment by FA consists of the 
collection of assessment materials, analysis of the data set and the subsequent conclusion of the results 
of the environmental quality study.
After that, the obtained indicator is estimated on a five-point scale of deviations from the norm developed by V.M. Krysanov, in which 1 point is a conventional norm and 5 point is a critical state.

On the basis of the stages described above, samples of Betula pendula were collected and analyzed. Two tables were compiled, differing from each other by the place of data selection for analysis (near the road, near the River). This was done in order to further compare the values obtained and to find out where the situation with the FA is best.

The average relative difference per sign for Betula pendula near the River was 0.054, which can be estimated at 1 point (conditional norm).

The average relative difference per sign for Betula pendula near the roads was 0.066, which can be estimated at 4 points (almost critical condition). From these values it can be concluded that trees near roads are indeed subject to strong anthropogenic impact.

5. Conclusion
The state of the "Yauza River Valley" landscape reserve cannot be called satisfactory. The road and path network covers a large area of the park, in some places there is trampling and littering of the territory. The northern part of the park, bordering the Moscow Ring Road, suffers from high noise impact. Evidence of the negative impact of the area's adjacent to the Moscow Ring Road can also be traced in the fluctuating asymmetry of tree leaves and the general condition of the stand. It is necessary to take measures to minimize the negative impact of the Moscow Ring Road on the territory.

It is recommended to continuously monitor the state of the park to control the processes occurring in the park. This can be helped by various environmental monitoring devices and methods, some of which have already been presented in this work. The methods based on the analysis of the trees and RPN of specially protected natural areas are distinguished by the clear visualization of their results, which means that their application makes the assessment of the park areas more understandable, convenient and effective.

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