BIOLOGICAL SCIENCES

PLANT INDICATORS FOR ASSESSING THE ECOLOGICAL STATE OF FOREST ECOSYSTEMS IN THE TALYSH-LANKARAN REGION OF AZERBAIJAN

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https://doi.org/10.5281/zenodo.19050734

Abstract

Forest ecosystems of the Talysh-Lankaran region represent one of the most valuable natural complexes of the South Caucasus, characterized by high biodiversity and the presence of relict Hyrcanian forests. The present study examines the role of plant communities as indicators of the ecological state of forest ecosystems in the Talysh-Lankaran region. The research focuses on the analysis of dominant plant species, vegetation structure, and ecological characteristics of forest phytocenoses. The results demonstrate that plant indicators provide reliable information about environmental conditions, soil properties, and anthropogenic impacts. The implementation of phytomonitoring programs based on vegetation analysis can significantly improve the assessment and protection of forest ecosystems in the region.

Keywords: phytoindication, ecological monitoring, Talysh–Lankaran region.

Introduction. One of the most effective approaches for evaluating the ecological state of ecosystems is the use of biological indicators. Living organisms react to environmental changes through physiological, morphological, and population responses. Among biological indicators, plants are considered particularly valuable because they are directly influenced by soil properties, climate factors, and environmental disturbances [1, 2, 3, 4, 5, 6].

The Talysh-Lankaran natural region of Azerbaijan is known for its unique Hyrcanian forests, which represent ancient relict ecosystems formed during the Tertiary period. These forests are characterized by high species diversity and include numerous endemic and relict plant species. However, increasing anthropogenic pressure, deforestation, and climate variability have led to noticeable transformations in forest ecosystems [7, 8, 9, 10, 11, 12].

Under such conditions, phytomonitoring and phytoindication methods become important tools for assessing ecological changes. Plant communities can reflect environmental conditions through changes in species composition, vegetation structure, and physiological characteristics. Therefore, the study of plant indicators provides valuable information about the ecological stability and functioning of forest ecosystems [13, 14, 15, 16, 17, 18].

The aim of this study is to analyze plant indicators used for assessing the ecological state of forest ecosystems in the Talysh-Lankaran region and to evaluate their role in phytomonitoring of Hyrcanian forests.

Materials and Methods. The research was conducted in forest ecosystems of the Talysh-Lankaran natural region located in southeastern Azerbaijan. The area includes mountainous landscapes of the Talysh Mountains as well as lowland forest zones. The region is characterized by a humid subtropical climate with high annual precipitation ranging from 1200 to 1600 mm.

Forest vegetation in the region belongs to the Hyrcanian forest system and is dominated by broad-leaved species such as: *P. persica*, *Q. castaneifolia*, *C. caucasica*, *A. subcordata*, *A. velutinum.* These species form complex multilayer forest communities with well-developed tree, shrub, and herbaceous layers. Vegetation surveys were conducted using standard geobotanical methods. Sample plots were established in representative forest areas to analyze species composition, vegetation structure, and ecological characteristics of plant communities. The following parameters were recorded: species composition of plant communities, dominance and abundance of species, structural characteristics of vegetation layers, ecological preferences of plant species, and indicators of environmental stress.

In addition, morphological and physiological parameters of selected plant species were evaluated as indicators of environmental conditions. The ecological condition of forest ecosystems was assessed using phytoindication methods based on the presence and distribution of indicator species. Special attention was given to species sensitive to changes in soil moisture, nutrient availability, and anthropogenic disturbance. Indicator analysis also included evaluation of vegetation diversity, dominance patterns, and ecological grouping of plant species [19, 20, 21, 22, 23, 24, 25].

Results and discussion. The studied forest ecosystems are characterized by complex vertical structure consisting of several vegetation layers. The tree layer is dominated by broad-leaved species typical of Hyrcanian forests. Among them, ironwood and chestnut-leaved oak play a particularly important role in the formation of forest communities.

The shrub layer includes species adapted to shaded and humid conditions, while the herbaceous layer contains numerous shade-tolerant plants. Several plant species were identified as important indicators of ecological conditions in the region. The presence of *P. persica* indicates well-preserved forest habitats with stable environmental conditions. This species is typically associated with fertile forest soils and high humidity. The species *Q. castaneifolia* serves as an indicator of fertile

mountain forest soils rich in organic matter. Oak-dominated forests often occur in areas with favorable ecological conditions. Moisture conditions are reflected by the distribution of *A. subcordata*, which usually grows along rivers and in wet forest habitats. Changes in the abundance of *C. caucasica* may indicate alterations in forest structure and light conditions. Meanwhile, *A. velutinum* is sensitive to microclimatic changes and forest canopy density.

In addition to species composition, several ecological parameters were identified as useful indicators of forest ecosystem condition: species diversity and richness; vegetation density and canopy structure; regeneration capacity of dominant tree species; morphological characteristics of leaves and shoots. Variations in these parameters can reflect environmental stress caused by anthropogenic activities or climate change.

The results demonstrate that plant communities provide valuable information about the ecological state of forest ecosystems in the Talysh-Lankaran region. Vegetation responds to environmental changes through shifts in species composition, structural characteristics, and physiological parameters. The use of indicator plant species is particularly effective for detecting early signs of ecosystem degradation. For example, changes in the abundance of dominant tree species may reflect alterations in soil fertility, moisture availability, or microclimatic conditions. Phytomonitoring based on vegetation analysis allows researchers to evaluate ecosystem stability and to identify potential threats to biodiversity. In the case of Hyrcanian forests, such monitoring is especially important due to their high conservation value and sensitivity to environmental disturbances. Furthermore, integrating vegetation analysis with soil and climatic data can provide a more comprehensive understanding of ecosystem dynamics.

Conclusion.

Forest ecosystems of the Talysh–Lankaran region represent unique natural systems characterized by high biodiversity and ecological importance. However, these ecosystems are increasingly affected by anthropogenic pressure and environmental changes. Plant indicators play a crucial role in assessing the ecological condition of forest ecosystems. The analysis of species composition, vegetation structure, and physiological characteristics of plants provides reliable information about environmental conditions and ecosystem stability. Implementing phytomonitoring programs based on plant indicators is essential for conserving Hyrcanian forests and sustainably managing forest resources in the Talysh-Lankaran region.

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