

Space-functional role of consortiums of ecotones of protective type to ensure the environmental safety on railway lines

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Abstract – *A multi-factor analysis of the impact of the Lviv Railway transport on the environment takes into account the properties of natural systems: multiple connections, stability, commutability, additivity, invariability as well as multivariable correlation of nature components. One of the important steps towards ensuring environmental safety in the railway transport is the formation of ecologically balanced system of nature management on the basis of environmentally clean technologies. A fundamentally new model of environmental safety in railway transport is of great polyfunctional importance as this enables, on the basis of the landscape-ecological methods, to form consortiums of protective ecotones that will provide the maximum spatial-temporal efficacy.*

Key words – ecotone, geoeotone, railway, protective forest plantations.

I. Introduction

The railway transport of Ukraine is part of the integrated transport system, it is an industrial technological complex of organizations, enterprises of public transport designed for the needs of public production and the country's population in domestic and international transportation as well as provision of other transport services.

However, along with the benefits offered by the railway transport, there arise acute issues of environmental safety during its use, which is caused by its negative and even destructive impacts on the environment. That is why ensuring a high level of safety on railway transport in Ukraine is one of the main objectives of transition to a harmonious development, while the development and implementation of innovative methods to provide environmental safety, based on cumulative function of established florocoenotic systems along railway lines, is relative and timely.

II. Results and discussion

One of the most important steps toward minimization and elimination of environmental impact, in accordance with the National Environmental Strategy of Ukraine and the pan-European strategy of conservation of biological and landscape diversity, is the formation of an ecologically balanced system of nature management on the basis of environmentally clean technologies in transport sector. That is

why an important role in the mechanism for reduction and neutralization of such impacts in future should belong to the formation of highly productive phytocomplexes with powerful potential for phytostabilization and phytoextraction of contaminated soils. Forest plantations are designed, first and foremost, to protect railway lines against adverse aerodynamic effects and ensure regular and uninterrupted rail traffic at any time of the year. Today, the protection from snow and sand drifts, mudrock flows, snow avalanches, landslides and rockslides, soil erosion, acoustic and radioactive contamination is fulfilled by protection forest plantations along the railway lines.

Since ecotones, as distinct from ordinary protection plantations, have specific autotrophic and heterotrophic blocks, edatope and climatope, we can propose a hypothesis that ecotones should be viewed as border ecosystems with inherent biotic cycles and flow of energy, and which are able to perform more efficiently than usual railway protective forest plantations a variety of functions to ensure environmental safety.

The spatial-functional role of protective ecotones on railway lines is dominant in the optimization of their components because the arrangement and size of the plantation should be governed by the windbreak effect as well as direction of turbulent air flows that are harmful to railway lines and adjacent agrocoenoses. From the aerodynamic standpoint, the windbreak effect of forest shelterbelts as spatial grids consists in the speeding down and transformation of latency of wind flows at a distance of 5 H (H – protective height of the plantation) on the windward side and 25 H – from leeward side. However, such design of protective plantations leads to deterioration of other functions performance.

On erosion-prone lands (steepness of more than 200), the arrangement of protective plantations must be performed according to the principles of contouring-reclamation organization of the territory with application of relevant soil-conservation agricultural techniques and waterworks which reduce the risk of soil erosion to a minimum.

That is why, at present time, railway protective forest plantations should be considered not only from the point of view of their utilitarian value as a means of railway lines protection against adverse natural and anthropogenic factors but primarily as a system of forestry measures to optimize the spatial infrastructure of railway landscapes, i.e. as a system of protective ecotones which have a strong potential to ensure environmental safety on the lines of railway transport.

Years of research on the spatial functional characteristics of the protective forest plantations on the Lviv Railway lines have shown that these plantations have acquired traits of ecotone because they have seen a dramatic increase in the number of coenopopulations, which confirms the general ecological principle of life diversity at the phase boundary or environment interface according to V.Vernadsky.

As a result, a kind of parademe system is formed along the Lviv Railway lines, consortium, that significantly differs from natural one due to overlapping ecological niches. This consortium has much in common with conserved

(ecological) corridors because the integrated assessment shows increasing species diversity of agrosystem flora by 7 – 73 %, entomofauna – by 27 – 62.5 %, zoofauna – by a factor of 2.7 times.

In the consortiums of protective ecotones along the Lviv Railway lines, one can observe the effect on trophotopes and geochemical processes along the railway lines and adjacent agrosystems. Thus, along the railway lines Lviv – Sambir, Lviv – Stryi, and Stryi – Mukachevo, there is evidence of the reduction in run-off of up to 1.3 %, annual average temperature by 3-80, dissipation of acoustic flux – by 15.2 dB, also a high cumulative ability of plantations is observed.

According to the field studies, we have classified the protective ecotones of the Lviv Railway by characteristics of profile, i.e. the structure and composition of plantations by their origin. Full-profile protective ecotones are plantations where the structure of shelterbelts (ecotones) can be clearly seen, they can be found in all sections of the Lviv Railway where the protective forest plantations were artificially created (Fig. 1). Predominantly, they consist of one or, less common, three strips. Ecotone is formed at the boundary of two different anthropogenic tracts in a railway precinct. Across the study sections of the railway lines, only mixed stands were observed, no pure stands were found.

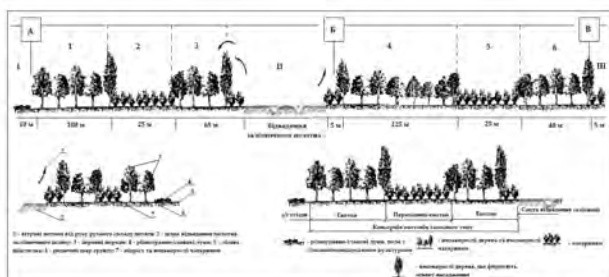


Fig. 1. Diagram of the vertical structure of the full-profile consortiums of protective ecotones at the Lviv Railway: A – herb-grass strip, field of crop plants; B – railway precinct; C – consortium of protective ecotones; 1, 3, 4, 6 – ecotones; 2, 6 – transition ecotones; I – agrocoenosis; II – anthropocoenosis; III – primary stands.

Partial-profile protective ecotones are predominantly the remains of natural forests where it is impossible to distinguish well-defined strips – actually ecotones (Fig. 2).

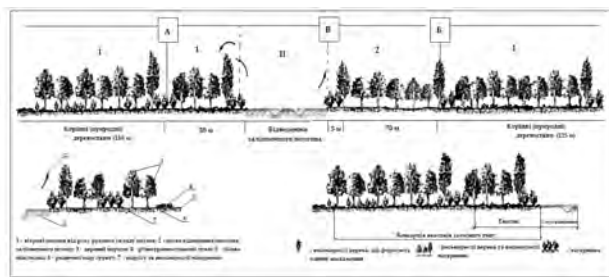


Fig. 2. Diagram of the vertical structure of partial-profile consortium of protective ecotones at the Lviv Railway: A – primary (natural) stands; B – consortium of protective ecotones; C – railway precinct; 1, 2 – ecotones; I – agrocoenosis; II – anthropocoenosis; III – primary stands

The complex and differentiation characteristics of cumulative function of protective ecotones depends on the morphology and composition of forest communities – edificator. The water regime of the soil under the forest shelterbelts is characterized by greater amplitude because of the accumulated snow and increased consumption during the growing season. The trophotopes in the forest shelterbelts tend to change toward intensive accumulation of humus and nutrients in the soil profile. In the affected area, they are characterized by increased moisture in the first meter depth of the soil on average by 30-55 mm and a higher content of humus and nutrients as a result of increased input of organic substances and intensification of humification processes.

In the structure of vegetation in the consortium of protective ecotones, there is a significant amount of synanthropic and acclimatized species. Active processes are currently observed of human-induced changes in primary stands to form natural-anthropogenic stands in a wider array.

The aggregate of protective ecotones at the Lviv Railway is functioning as a single system or forest reclamation complex that serves as the ecological framework where elements and subsystems interact providing a synergistic effect. Proceeding from the necessity of shifting to landscape-ecological principles of management and ensuring the maximum possible protective effect, the creation of a system of protective ecotones is one of the most innovative ways of ensuring ecosystem sustainability, in particular, enhancing their buffering capacity due to partial renewal of forest ecosystems as an integral component of natural landscape, which will provide for environmental safety on railway lines using only natural mechanisms of environmental protection.

Conclusion

Successful operation and development of rail transport is dependent on the condition of natural systems and availability of natural resources, infrastructure development of the built environment, socio-economic environment of society. In this case, between each of the rail transport system there is a direct and backward linkage, as well as certain limitations in the use of natural systems, labor and financial resources.

The difference between the parameters of ecological factors of ecotones and those of related protective forests is a prerequisite for formation of specific coenoses and changes in their population structure. Particularly, ecotones can see the formation of their unique specific populations of plants and animals or there may arise a situation where part of a population is in the same community, the other part – in another community, while the third is found in the ecotone.

The cumulative capacity of consortiums of protective ecotones is determined by comprehensive impact on the environment and has environment-forming and environment-stabilizing functions. A systemic and balanced spatial arrangement makes it possible to achieve significantly positive impacts on the adjacent areas.

That is why, it is of importance to form consortiums of ecotones on the basis on landscape-ecological methods, which will provide for the maximum spatial and temporal efficacy and will have a significant synergistic effect in ensuring environmental safety on railway transport lines.