

NON-FOREST WOODY VEGETATION AS A SIGNIFICANT ELEMENT IN INCREASING ECOLOGICAL STABILITY IN CULTURAL LANDSCAPE

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<https://doi.org/10.11118/978-80-7701-087-0-0265>

Abstract

The aim of the contribution is to present the importance of the functions of non-forest woody vegetation (NFWV) in increasing ecological stability in the cultural landscape of Slovakia. Since NFWV fulfils several functions in the cultural landscape, it is important to determine the regions in which this vegetation will help improve the overall ecological state of ecosystems and of the environment quality. We defined the regions based on conflicts of interest and specified landscape-ecological problems such as problems of threat to ecological stability, problems of threat to natural resources and the environment (i). In the proposals, we also took into account the ecological stability value calculated for 2,927 cadastral territories of urban and rural settlements in Slovakia (ii). Based on the criteria defined in this way, we determined the regions with proposed functions of NFWV that will contribute to increasing ecological stability and at the same time to solving problems related to the negative impacts of stress factors on humans, soil, water, forest and biotic resources (iii). The research results can be used in landscape planning for the optimal use of natural capital and the preservation of heritage features and the traditional character of the territory of Slovakia.

Key words: conflicts of interest, landscape ecological problems, vegetation functions

Introduction

The spatial demands of human economic activities carried out in the cultural landscape often lead to conflicts of interest and the emergence of landscape-ecological problems. Very often these problems are associated with threats to ecological stability, threats to the quantitative and qualitative indicators of natural resources, and threats to the quality of the environment. Since ecological stability is considered the basis for assessing all conditions and prerequisites for the use of the cultural landscape by humans, it is important to know where its threat occurs. The landscape-ecological research we carried out in the cultural landscape of Slovakia was focused on evaluating the impacts of human activities on the stability of the landscape, its components and elements, and subsequently on proposing green measures to mitigate the negative impacts of stress factors on humans, biota, water, forest and soil resources. The aim of the assessment was therefore, in the specified regions of landscape-ecological problems, to propose specific functions of NFWV to increase ecological stability and biodiversity and to support green infrastructure. Trees as solitaires, lines or areal elements in the cultural landscape fulfil several functions. To a significant extent, they contribute to the formation of the character of the territory and are an essential part of many processes that take place in the landscape. They are closely linked to many natural and anthropogenic elements in the territory and create with them a connected polyfunctional whole, shaped by cultural development, the method of use and natural conditions. The functionality of trees and stands depends mainly on their location and spatial arrangement in the territory, species and age composition, height structure, quality and quantity (SNC SR, 2024). Non-forest woody vegetation (NFWV) also belongs to landscape elements with a high ecostabilising effect (Špulerová, 2006; Múdry, 1989). It represents a characteristic part of the landscape structure with which it co-creates the image of a specific territory. NFWV affects the microclimatic regime, air quality parameters, hygienic conditions, biotic and recreational potential of the territory, but also the occurrence and consequences of water and wind erosion, etc.

Materials and methods

The basis of the methodological procedure was analyses, syntheses and interpretations, assessments and proposals. The methodological procedure was applied to the territory of the Slovak Republic.

Within the analyses we carried out:

- Specification of selected positive socio-economic phenomena (PSEP) of the character of nature protection, protection of natural and cultural-historical resources and health resources, which increase ecological stability and support green infrastructure.
- Specification of selected negative socio-economic phenomena (NSEP) of the character of primary and secondary stress factors, which by their negative action and barrier effect against

elements of nature and landscape protection disrupt the natural development of ecosystems, threaten ecological stability and biodiversity and threaten green infrastructure.

Syntheses and interpretations were focused on:

- Creation of a territorial system of positive phenomena and a territorial system of stress factors (SF). To define conflict areas between PSEP and SF that threaten humans, the landscape and its individual components and negative effects on elements with a high ecostabilising effect.

Assessments included:

- Calculation of ecological stability values (CES) for cadastral territories of urban and rural settlements in the SR. Definition of regions with different ecological quality and different landscape-ecological problems necessary to define for the proposal of “green” measures implemented to increase ecological stability.

Proposals:

- In regions of specified landscape-ecological problems, propose such a function of non-forest woody vegetation (NFWV) that will support the functionality of the existing green infrastructure (GI) and increase ecological stability especially in areas of intensively agriculturally used land (Fig. 1 and 2) as well as in areas with manifestations of natural risks and hazards and negative impacts of stress factors on the stability of the landscape and human health (Map 1, Tab. 1).

In the research we used data from field research and statistical data, which we subsequently analysed, quantified, statistically evaluated and visualised in a GIS environment. We worked with SEP that represent material and immaterial manifestations of human activities in the landscape and express the demands of society and individual economic sectors on a certain space, ecological and natural conditions (Ružička, 1985; Miklós et al., 1985; Miklós, 1992; Forman, Godron, 1993; Jongman, 1995; Drdoš, 1992; Demek, 1974). To assess the degree of ecological stability we used the coefficient of ecological stability (CES) (Miklós et al., 1985), which we calculated for two time periods – 2018 and 2023. We differentiated settlements on the basis of specified conflicts of interest between PSEP and selected point, line and areal SF. By gradual superposition of individual SEP we obtained a varied mosaic of conflict areas on the territory of Slovakia. On each area we precisely determined which socio-economic phenomena meet there. Some of them mutually excluded, limited, others supported or were neutral. Subsequently we grouped settlements into regions with the same conflicts of interest and specified landscape-ecological problems and proposed “green” measures to increase ecological stability. We precisely spatially localised the problem of threat to ecological stability and proposed such a meliorative function of non-forest woody vegetation so that the ecological state of individual ecosystems is improved and the risks of their threat are minimised. For assigning vegetation functions we proceeded from valid legislation, expert assessment and from the classification of NFWV functions by several authors (Jurko, 1990; Špulerová, 2006; Zachar, 1986; Sláviková, 1987; Supuka et al., 1991; Rakovská, 1998; Rózová, 1994; Múdry, 1990; State Nature Conservancy of the SR, 2024; Ružička, Ružičková, Múdry, 1979 and others). According to authors from various scientific fields who dealt with vegetation functions in the years 1974–2004, up to 58 partial functions of vegetation were recorded (Reháčková, Pauditšová, 2006). Since the understanding of vegetation functions is very broad and depends on the evaluator and the purpose for which the vegetation functions are examined (Reháčková, Pauditšová, 2006), by the function of NFWV we understood the sum of real or potential possibilities of using its effects.

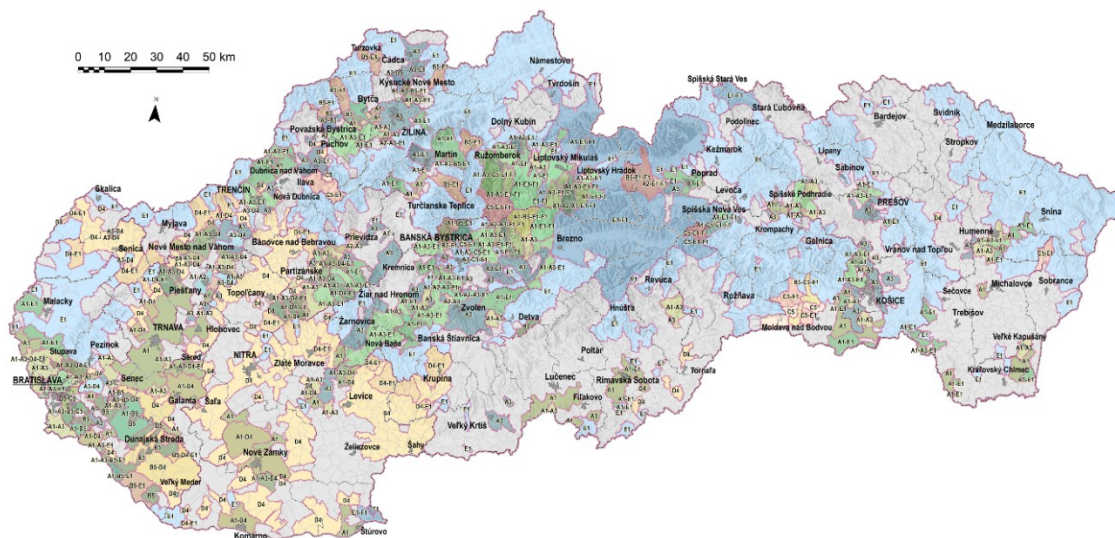
Results

In total we specified 50 types of conflicts of interest within the SR, each of which had its own specificity and required a special measure. The resulting assessment is projected in Map 1: Regions of Slovakia with proposals of NFWV functions according to conflicts of interest and specified landscape-ecological problems. Based on the CES value we classified 2,927 Slovak settlements into 5 stability categories. Subsequently we also classified 79 districts of Slovakia into five quality categories. We also identified settlements in which the CES value increased or, on the contrary, decreased during the years 2018 and 2023. According to a CES value lower than 0.2, 9.74 % of settlements were classified among significantly unstable areas. In these areas it is necessary to implement ecostabilising measures in the form of planting areal and line elements of green infrastructure. The proposed planting should be supplemented by engineering-technical and technological measures. More than 22 % of settlements with a CES value in the interval from 0.2 to 0.4 were classified among unstable areas, 19 % of settlements with a CES value in the interval from 0.4 to 0.6 were classified among partially stabilised areas, 32 % of settlements with a CES value from 0.6 to 0.8 were classified among stabilised areas. The last fifth category with a CES value higher than 0.8 was achieved by a total of 492 settlements,

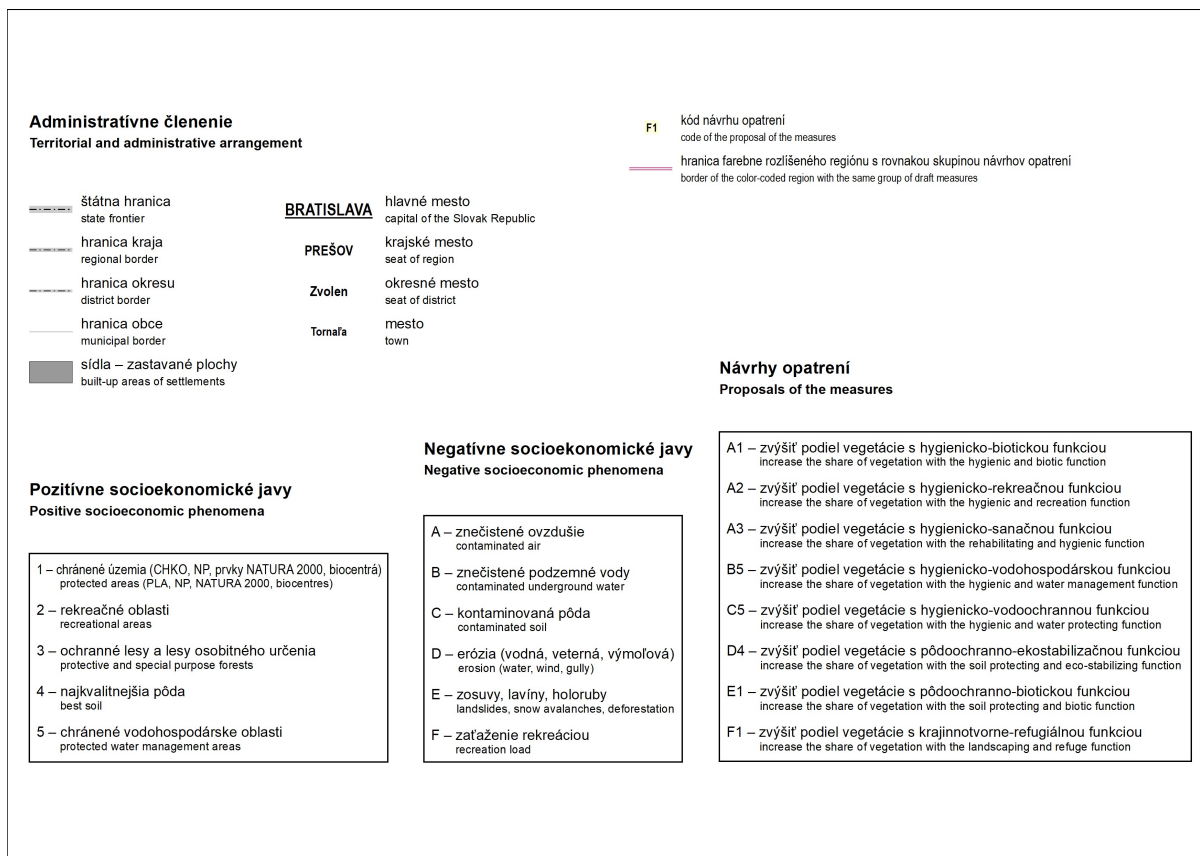
which is almost 17 % of the total number of settlements in Slovakia. The cadastral territory of these settlements was characterised as significantly stabilised without the need to implement ecostabilising measures. From the landscape-ecological point of view, in all settlements where CES was lower than 0.6 it is necessary to implement measures to increase ecological stability. From the point of view of assessing the degree of ecological quality of the districts of Slovakia, out of the total number of 79 districts the highest percentage of districts (33 %) had a high degree of quality, 22 % of districts had a very low degree of ecological quality, 20 % of districts had a low degree of ecological quality, 15 % of districts had a medium degree and 10 % of districts had a very high degree of ecological quality. In 57 municipalities, which is almost 2 % of the total number of municipalities, a decrease in CES by more than 0.5 % occurred during the 5 assessed years. In 144 municipalities, which is almost 5 % of the total number of municipalities, an increase in CES by more than 0.5 % occurred during the assessed period.



Fig. 1 and 2: Line NFWV vegetation in agricultural landscape (Moyzeová, M., 2025).



Map 1: Regions of Slovakia with proposals of NFWV functions according to conflicts of interest and specified landscape-ecological problems.



In the proposals of NFWV functions as measures to increase ecological stability in the specified regions of Slovakia, we proceeded from the set goals and needs of building green infrastructure (Tab. 1 Proposals of the measures).

Tab. 1: Proposals of the measures.

A) Problems of threat to ecological stability and biodiversity
A1 – threat to protected areas by polluted air occurred in 23 combinations in 213 areas and in 424 settlements within the SR.
Goal: In protected areas preserve the diversity of plant and animal species, the subject of protection and the traditional character of the territory.
Measure: Areas with nature protection threatened by negative impacts of polluted air revitalise by planting NFWV with hygienic and biotic function, with the ability to remove polluting and dust particles from the air.
E1 – threat to protected areas by clear-cuts, landslides and avalanches occurred in 29 combinations in 216 areas and in 963 settlements within the SR.
Goal: In protected areas preserve the diversity of plant and animal species, the subject of protection and the overall character of the territory.
Measure: Revitalise areas of nature protection threatened by clear-cuts, landslides and avalanches by planting NFWV with soil protecting and biotic function. By planting vegetation whose root system stabilises the territory and protects the soil from external destructive processes, create conditions for the existence of biota and its food chain.
F1 – threat to protected areas by excessive recreation occurred in 11 combinations in 29 areas and in 101 settlements within the SR.
Goal: In protected areas primarily preserve the subject of protection and the character of the territory and an attractive environment for recreational purposes.
Measure: Protected areas threatened by excessive recreation revitalise by planting NFWV with landscaping and refuge function. Vegetation with the ability of rapid regeneration will create conditions for the preservation of the gene pool, species diversity of animals, plants and microorganisms and at the same time preserve the recreational character of the territory. Vegetation adjustments should be supplemented by regulation of visitor

numbers in the visiting order of protected areas.
B) Problems of threat to the quality of the environment and human health
A2 – threat to recreational areas of spa towns by polluted air occurred in 10 combinations in 16 areas and in 17 settlements within the SR.
Goal: In recreational areas of spa towns preserve a quality environment for the physical and mental well-being of humans.
Measure: Areas of spa towns threatened by the negative impact of polluted air revitalise by planting NFWV with hygienic and recreation function. Prefer planting biologically rich and aesthetically pleasing vegetation with the ability to remove polluting and dust particles from the air.
C) Problems of threat to natural resources
A3 – threat to forest ecosystems by polluted air occurred in 21 combinations in 164 areas and in 306 settlements within the SR.
Goal: In purpose forests preserve their anti-erosion, water-management and anti-avalanche function.
Measure: Improve the current state in forest ecosystems threatened by the negative impact of polluted air by planting NFWV with rehabilitating and hygienic function, with the ability to remove polluting and dust particles from the air.
B5 – threat to significant water resources by polluted groundwater occurred in 15 combinations in 46 areas and in 96 settlements within the SR.
Goal: In protected water-management areas (PWMA) preserve a quality environment and ensure the protection of qualitative and quantitative indicators of the water resource primarily intended for supplying the population with drinking water.
Measure: In PWMA threatened by polluted groundwater, for improving the current state designate areas for planting vegetation with hygienic and water management function. To improve the qualitative indicators of waters plant vegetation with the ability to filter and capture polluting substances from groundwater. Improve quantitative indicators by vegetation that positively affects water management, the water regime, the regulation of infiltration of atmospheric precipitation and the balancing of the overall water balance in nature.
C5 – threat to significant water resources by polluted soils occurred in 11 combinations in 19 areas and in 26 settlements within the SR.
Goal: In protected water-management areas preserve a quality environment and ensure the protection of qualitative indicators of the water resource primarily intended for supplying the population with drinking water.
Measure: In PWMA threatened by polluted soil, for improving the current state designate areas for planting vegetation with hygienic and water protecting function, with the ability to filter and capture polluting substances from the soil and thereby improve the quality of water primarily intended for drinking purposes.
D4 – threat to the highest-quality soils by erosion occurred in 12 combinations in 110 areas and in 365 settlements within the SR.
Goal: In areas with the occurrence of the highest-quality soils stabilise the territory and preserve the quantity of topsoil, bonity and soil fertility.
Measure: On agriculturally large-scale cultivated soils threatened by external destructive processes caused by water and wind erosion designate areas for planting vegetation with soil protecting and eco-stabilizing function. Increase the stability of the agricultural landscape with a low representation of TSES elements by planting areal and line tree vegetation, whose root system positively affects soil drainage and recultivation. At the same time preserve bonity and soil fertility by using crops with anti-erosion effect.

Discussion

Many tree species, in addition to the hygienic function, also fulfil a number of other functions whose use we indicated in our research. Functions of vegetation, areas of action and forms of implementation necessarily merge, mutually combine and exclude each other (Špulerová, 2006). When designing plantings or interventions in existing stands, taking into account vegetation functions from this aspect is very important. Without their knowledge and use, landscape adjustments would not be comprehensive (Špulerová, 2006). Although various authors classify vegetation functions differently, Zachar (1986), Sláviková (1987), Jurko (1990), Rakovská (1998), Pagan (1996), Machovec, Hrubík, Vreštiak (2000) and others agree that when assessing NFWV functions it is necessary to take into account also the dendrological composition of stands and the structural and biochemical properties of

individual tree species. From the point of view of the results of our research, these statements need to be supplemented also by functions specified on the basis of conflicts of interest and specified landscape-ecological problems. We agree with the statements that from the point of view of NFWV functions in the urbanised environment of settlements, from the categories of natural functions the climatic and biotic function should be preferred in particular, and from the categories of anthropogenic functions – the group of social functions. At the same time, green areas in settlements should be linked to historical and symbolic urban structures such as city parks, monuments, etc., which form the skeleton of so-called intact green areas. On the contrary, in open, natural landscape, replacement planting should primarily supplement the skeleton of territorial systems of ecological stability, protected areas, NATURA 2000 elements and elements of already existing green infrastructure. In connection with the results of landscape-ecological research it is important that when planting NFWV the degree of anthropisation of the territory, conflicts of interest and specified landscape-ecological problems are also taken into account. Because precisely these research results can supplement the missing information on the localisation of NFWV planting with a specific function so that not only ecological stability is supported and increased but at the same time the negative impacts of stress factors on humans and their environment are mitigated.

Conclusion

By landscape-ecological research we assessed the ecological state of regions of Slovakia according to the current state of green infrastructure and its barriers. We specified settlements with different ecological quality and different needs for the implementation of measures to increase ecological stability. By proposing a specific function of NFWV with hygienic and biotic, hygienic and recreation, hygienic and rehabilitating, hygienic and water management, hygienic and water protecting, soil protecting and eco-stabilizing, soil protecting and biotic and landscaping and refuge functions we supported ecological stability in the areas of specified landscape-ecological problems. In 1,324 settlements no landscape-ecological problems were identified. In these settlements no conflicts of interest occurred that would directly threaten ecological stability, natural resources and the environment. When proposing the planting of new NFWV species in the cultural landscape it is important to plant species resistant to local conditions. Accept altitude, exposure and slope inclination as well as geological substrate and pedological conditions. For the territory of Slovakia it is important to prefer autochthonous species of trees and shrubs such as oak, beech, hornbeam, poplar, alder, maple, ash, willow, fir, hazel, elder and others. For the specific specification of tree species it is necessary to proceed from available literary sources focused on dendrology and ecology of trees (Benčať, 2009; Benčať, Modranský, Daniš, 2015; Čaboun, 1996). The results of landscape-ecological research will contribute to the expansion of knowledge where it is important and necessary to consider NFWV planting so that the ecological state of ecosystems is improved and at the same time ecological stability and biodiversity are supported. Tree species that fulfil one or more functions in the territory will also contribute to mitigating the negative impacts of climate change on humans, the landscape and living organisms.

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Acknowledgement

This paper has been prepared with the support of the Ministry of Education of the Slovak Republic and the Slovak Academy of Sciences, grants: No. 2/0125/25 Allotment gardens as a means of collective socio-ecological memory and an alternative to urban development frameworks of the „Slow City“.

Souhrn

Realizovaný krajinoekologický výzkum zhodnotil střety zájmů v katastrálních územích městských a venkovských sídel na Slovensku a specifikoval krajinoekologické problémy jejichž negativní účinky smírní návrh nelesní dřevové vegetace s funkcí která podpoří ekologickou stabilitu a biodiverzitu v daných ekosystémech a současně minimalizuje negativní vlivy stresových faktorů na člověka a jeho životní prostředí. Výzkum podpořil i celoevropskou iniciativu budování zelené infrastruktury, jejímž cílem je zachování fyzikálních vlastností a identity lokalit, ochraňování a zvelebování přírodního kapitálu a zmírňování rizik přírodních katastrof a negativních vlivů stresových faktorů.

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