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ECOLOGICAL RECONSTRUCTION MEASURES OF SOME LENDS AFFECTED BY ROAD INFRASTRUCTURE

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Abstract. *Restoring degraded land following road construction is essential both for protecting the environment and for ensuring the sustainability of infrastructure projects. Road construction activities can significantly affect soil, vegetation, water resources and biodiversity, and the restoration of these lands is a crucial step in reducing the negative impact and reintegrating affected ecosystems. The studied area includes a variety of natural habitats, which harbor a significant diversity of flora and fauna, some of which are sensitive to environmental changes caused by construction activities. In the framework of ecological restoration measures in the case of road construction, it involves the choice of ecological solutions depending on the terrain, biodiversity and estimated impact, and the development of ecological compensation plans and post-construction monitoring. Following the mapping, the maps were prepared that provide the scientific basis for correct decisions regarding the route, technical solutions and ecological restoration measures. The identification of ecological corridors guides the optimal route of the highway to avoid sensitive areas and informs decisions regarding the placement of ecological tunnels, Eco ducts and wildlife crossings. The practical implementation of ecological recovery measures materialized by introducing green works in technical plans and supervising the execution of protection and restoration measures. Monitoring and maintenance include monitoring biodiversity in the years following construction and adjusting measures based on the results*.

Keywords*: biodiversity, ecological reconstruction, degraded lands*

INTRODUCTION

The motorway section is located in the western part of the country, in the Banat region, belonging to the administrative territory of Timiș and Hunedoara counties.

The importance of restoring degraded lands following road construction is essential both for protecting the environment and for ensuring the sustainability of infrastructure projects.

Road construction activities can significantly affect soil, vegetation, water resources and biodiversity, and the restoration of these lands is a crucial step in reducing the negative impact and reintegration of affected ecosystems. Road construction works often involve excavations, cutting of slopes and material deposits that lead to the loss of fertile soil and land degradation.

Their restoration prevents erosion, landslides and desertification, protecting essential resources such as soil and water.

Land degradation affects the natural habitats of local species. Restoring vegetation and soil conditions allows for the restoration of biodiversity and supports the rebalancing of ecological processes.

Rapid restoration of affected lands minimizes adverse effects on neighboring areas and reduces the risks of water pollution, slope collapse, or watercourse blockage.

National and European legislation requires environmental restoration measures after the completion of infrastructure works. Restoration of degraded land is necessary to obtain environmental permits and to avoid sanctions.

Land restoration contributes to the visual and functional reintegration of affected areas into the natural or agricultural landscape and reduces the risk of conflicts regarding future land use.

MATERIAL AND METHODS

Within the framework of ecological restoration measures in this case, it involves the choice of ecological solutions depending on the terrain, biodiversity and estimated impact and the development of ecological compensation plans and post-construction monitoring.In the first phase, a mapping of habitats and species was carried out, which is a key tool for the ecological integration of motorway projects.

Following the mapping, maps were drawn up that provide the scientific basis for correct decisions regarding the route, technical solutions and ecological restoration measures Without this stage, the risks of irreversible damage to biodiversity increase significantly The practical implementation of ecological restoration measures is materialized by introducing green works in the technical plans and supervising the execution of protection and restoration measures.

Monitoring and maintenance include monitoring biodiversity in the years following construction and adjusting the measures according to the results. Within the framework of ecological restoration measures in this case, it involves choosing ecological solutions depending on the terrain, biodiversity and estimated impact, and the development of ecological compensation plans and post-construction monitoring.

To ensure the efficiency and sustainability of the ecological restoration measures for degraded lands, a systematic monitoring plan is essential in the medium (5 years) and long term (10 years). This plan allows for the evaluation of the evolution of restored habitats, the detection of ecological deviations, and the application of adaptive corrections

Table 1

Main monitoring indicators in the study area

Domain	**Indicators**	**Method**	**Frequency**
Vegetation	Survival and development of planted species	Vegetation relevées	Anually (spring)
	Survival and development of planted species	Inventory / fixed photos	Bianually
	Presence of invasive species	Visual inspection	Semiannual
Soil	Soil fertility (NPK, pH, organic matter)	Laboratory analysis	Anually
	Soil compaction	Penetrometer	Every 2 years
	Erosion degree	Field observations	After major rainfall
Water	Surface water quality	Physico-chemical analysis	After major rainfall
Biodiversity	Presence of fauna (birds, amphibians, insects)	Ecological observations	Annual / seasonal
	Pollinator activity	Flower-insect transects	In season (May–August)
Structural	Slope stability	Geotechnical inspections	Annual + post-

			weather events
	Functioning of wildlife crossings	Photo/video monitoring	Semiannual

To improve the efficiency of ecological restoration measures and ensure a minimal impact on the environment within similar projects, the following are recommended: monitoring key species (bear, wolf, lynx, amphibians, etc.) and the efficiency of ecological passages in facilitating habitat connectivity; Maintenance and adaptation of ecological restoration measures through periodic verification and maintenance of ecological corridors, wildlife passages, and replanted areas; Adapting technical solutions based on the results of monitoring (e.g., adding additional fencing or modifying the vegetation used).

RESULTS AND DISCUSSIONS

The studied motorway area is located in a transition territory between the western plain and the hilly area of the Poiana Ruscă Mountains. This location includes a variety of natural habitats, which harbor a significant diversity of flora and fauna, some of which are sensitive to environmental changes caused by construction activities. The flora in the studied area is representative of plain and hilly regions, and the ecological characteristics of the land influence the vegetation types.

The terrain is characterized by a predominantly hilly relief, unstable in certain areas, with varied geotechnical compositions, which required special engineering works. This area marks the transition from the low plain of Banat to the hilly and mountainous relief from the east.

The degree of erosion is moderate to severe, depending on the slope and vegetation cover, we have areas affected by slope cutting and excavations that are the most exposed, accelerated surface erosion during periods of heavy rainfall and the possibility of ravine formation or local landslides in the absence of consolidation works.

Construction interventions (embankments, temporary soil deposits) have led to the compaction of the superficial layer, the destruction of the fertile horizon and the need for works to restore the vegetation layer and control erosion (through grassing, terracing, hydroseeding, etc.).

The area includes natural grasslands and meadows on clay and loamy soils, with grass and herbaceous plant species: *Festuca pratensis*, *Dactylis glomerata*, *Plantago lanceolata*. Higher areas and those on slopes are covered with deciduous forests (oak, hornbeam, ash), and in some places, rose hips or willows are found along the banks of brooks and rivers. Tree species such as *Quercus robur*, *Fraxinus excelsior*, and *Carpinus betulus* are characteristic of this area. In areas with less permeable soils, the vegetation includes species resistant to more extreme soil conditions, such as: *Rubus idaeus*, *Salix alba*, *Ulmus minor*, *Corylus avellana* (hazelnut).

Protected species such as *Orchis macula*, *Fritillaria meleagris*, and *Crocus sativus* are also identified in the area. The fauna in the studied area is diverse and includes both species typical of plain and forest regions, as well as species more sensitive to habitat modifications. Several mammal species are found in this area, including: *Vulpes vulpes* (fox), *Mustela putorius* (European polecat), wild goats (in hilly areas), the wolf, and the marten, which may occasionally transit the area from nearby forests. The area is an important habitat for various bird species, both migratory and sedentary, such as: *Buteo buteo* (buzzard), *Accipiter gentilis* (northern goshawk), *Corvus corax* (common raven), *Passer domesticus* (house sparrow), and waterfowl species, such as *Anas platyrhynchos* (mallard) on nearby watercourses.

Birds are exposed to risks generated by construction works and habitat changes (road division can lead to isolation). Reptiles and amphibians The area is also inhabited by various species of reptiles and amphibians, including: *Bufo bufo* (common toad), *Anguis fragilis* (slow

worm), *Natrix natrix* (grass snake).These species can be vulnerable to rapid habitat changes and the appearance of physical barriers. The area has a high diversity of insects, including butterfly species (e.g., *Iphiclides podalirius* – scarce swallowtail), which are ecologically important for pollination. Bee and wasp species are essential for pollination, and the alteration of their habitat can reduce the efficiency of these natural processes.

Habitat fragmentation has a significant impact on biodiversity, especially when large infrastructure projects such as highways are built. In the case of the present study, this can affect both flora and fauna in the area, creating obstacles to species migration and interaction.

Habitat fragmentation can lead to the isolation of animal populations and the loss of biological diversity, and its effects can be observed in the long term on local ecosystems.In the first stage of reconstruction works, controlled embankment works are carried out, which are particularly important to maintain the long-term integrity of the infrastructure and to protect the environment.

Table 2

Types of areas proposed for restoration/conservation in the study area

Area type	**Characteristics**	**Recommended Measures**
Longitudinal ecological corridors	Lanes parallel to the highway (on embankments, green ditches)	Replanting with native vegetation, anti-erosion barriers, maintaining vegetation continuity
Buffer zones between road and forests/meadows	Transitional areas with mixed vegetation	Planting native shrubs, restoring soil structure
Buffer zones between road and forests/meadows	Land temporarily affected by the construction site	Reprofilare, reintroducerea humusului, plantări controlate
Degraded marginal lands	Strips stripped or compacted	Hydroseeding, phytoremediation, natural grassing

One of the most common and environmentally friendly methods of controlled slope development is the planting of area-specific vegetation with species of grass, shrubs and trees that help to fix the soil.

In some cases, to prevent erosion and ensure long-term stability of slopes, geotextiles (resistant textile materials) and geogrids (rigid or semi-rigid structures made of plastic or other materials that allow drainage and protect the soil) can be used. These are placed on the slopes of the slope to support vegetation and prevent landslides

The native tree and shrub species identified and recommended in the studied area are: *Carpinus betulus* (Hornbeam), *Quercus petraea* / robur (Oak), *Cornus sanguinea* (Common Dogwood), *Corylus avellana* (Hazel), *Acer campestre* (Field Maple), C*rataegus monogyna* (Hawthorn), *Prunus spinosa* (Blackthorn) and perennial herbaceous plants *Festuca rubra* (Red Fescue), *Agrostis capillaris* (Common Bent), *Lotus corniculatus* (Bird's-foot Trefoil), *Trifolium pratense / repens* (Red/White Clover), *Achillea millefolium* (Yarrow), *Plantago lanceolata* (Ribwort Plantain);Grass species used for grass seeding are Festuca (Festuca spp.) and *Poa pratensis*, perennials that can easily stabilize slopes due to their ability to adapt to different soil types.

Table 3

Types of areas proposed for restoration/conservation in the study area

Benefit	**Explanation**
Local adaptation	They are resistant to the climatic conditions and soils of the area
Ecological stabilization	They quickly restore the natural habitat, attract specific fauna (birds, insects)

Maintenance efficiency	Requires less irrigation and fertilizer after establishment
Soil protection	Strong roots reduce erosion and stabilize slopes
Preventing biological invasions	Reduce the risk of non-native species expanding aggressively

Secale cereale (Rye) is also often used for hydroseeding, but also as a perennial plant for soil stabilization. Hydroseeding is a process that involves mixing plant seeds (usually species resistant to harsh conditions), water, and a binder (usually a mixture of organic or synthetic substances) in a specialized mixer.

This mixture is then applied to the surfaces affected by construction using specialized equipment, usually a hydraulic sprayer.

This method is particularly useful on slopes, hillsides or on land where the soil is not conducive to traditional planting.

Among the shrubs planted are the Bramble Tree (Rubus spp.), the Sea Buckthorn (Hippophae rhamnoides), a hardy evergreen shrub that can tolerate poorer soil conditions and helps stabilize the soil, and the Dogwood (Cornus spp.), an evergreen shrub that can be used on slopes to create a dense plant cover and prevent erosion.

Perennial plant species for biodiversity- Lavandula angustifolia (Lavender) In addition to its role as a soil stabilizer, lavender attracts pollinating insects and can contribute to habitat diversification. Corylus avellana (Hazelnut) Perennial shrub that can provide food and shelter for local fauna.

CONCLUSIONS

In the process of ecological restoration of degraded lands following the construction of the highway, the first stage is the stabilization of the soil and slopes through controlled embankment with adapted inclination to prevent landslides, hydroseeding with mixtures of native grasses for rapid coverage, the installation of anti-erosion barriers (geotextiles, fascines, gabions) and the reprofiling of the land and the reintroduction of the humus layer, is essentialReplanting with native species is an essential measure for restoring local biodiversity, stabilizing the soil and preventing invasion by alien species

To ensure the efficiency and sustainability of the ecological restoration measures of degraded lands, a systematic monitoring plan is essential in the medium (5 years) and long term (10 years).

This plan allows for the evaluation of the evolution of restored habitats, the detection of ecological deviations and the application of adaptive corrections.

The ultimate goal is to ensure sustainable ecological restoration, with the functional return of degraded lands and their integration into a stable, green and ecological landscape compatible with road infrastructure.

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