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Executive Summary

Wildlife and Traffic in the Carpathians

Guidelines how to minimize impact of transport infrastructure development on nature in the Carpathian countries

2019

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1 Introduction

These Guidelines are one of the main outputs of the TRANSGREEN project. They are in general aimed to support finding solutions to minimize negative impacts of transport infrastructure development on wildlife in the Carpathians and are recommended to be used in combination with other TRANSGREEN outputs:

- Policy recommendations on integrated road and rail transportation planning in the Carpathians
- State of the Art Report and Gap Analysis in the field of environmentally-friendly transport infrastructure development
- Keeping Nature Connected - Environmental Impact Assessment (EIA) for Integrated Infrastructure Planning - Training package
- Scheme for stakeholder participation related to transport infrastructure development
- Tool for registering animal-vehicle collisions

The Guidelines can be used at all levels of sustainable linear transport infrastructure development - from the initial planning and design through the construction to the operation and maintenance. This initiative represents a particular step towards fulfilling the goals of the Carpathian Convention Protocol on Sustainable Transport in the Carpathians. It is based on the European COST 341 Handbook (Wildlife and Traffic) on how to avoid Habitat Fragmentation due to Linear Transportation Infrastructure and other guidelines and handbooks with special focus and adaptation meant to support ecological connectivity in the Carpathians.

Development of transportation brings extensive impacts on nature and landscape. Most visible is undoubtedly animal mortality in collisions with vehicles. Motorways and other intensively used arterial roads and major railways create impassable barriers for animals. Such barriers then separate originally continuous distribution areas into smaller and mutually isolated islands that are no longer able to ensure conditions for long-term survival of populations. This process, called fragmentation of the environment, becomes more and more a serious threat.

Migration makes it possible to compensate for fluctuations in numbers caused by a temporary worsening of habitat, epidemics, and natural disasters or by anthropogenic impacts. The Carpathians are an area with exceptionally well-preserved landscape and unique nature within Europe.

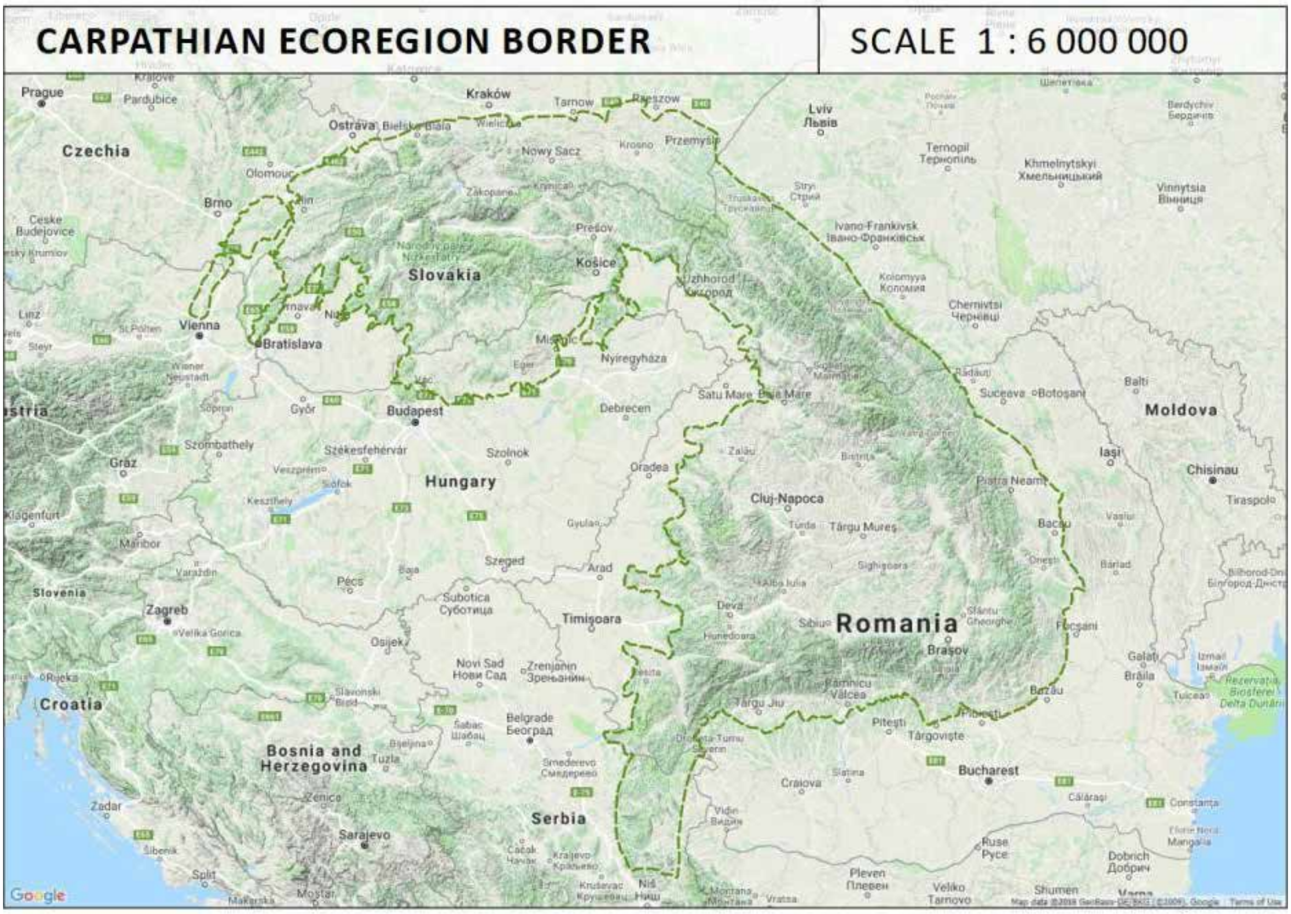


Figure 1: © The Carpathian Eco region spreads across eight countries - Austria, the Czech Republic, Slovakia, Poland, Ukraine, Hungary, Romania and Serbia. (www.ccibis.org)

2 Primary ecological effects

These Guidelines are primarily focused on motorways, roads and railways. Some recommendations can be applied to inland waterways as well, especially in case of artificial canals that can also create barriers limiting free movement of animals in the landscape. The effects of transport infrastructure on nature are typically divided into two groups: primary (directly bound to the construction and further operation of a given piece of infrastructure) and secondary (effects that do not directly fall into the transport sector, but are likely induced by it). The main effects are listed in the in the following table:

PRIMARY	***Loss of wildlife habitats:*** physical loss of natural habitats as it is replaced with or significantly altered by the transport infrastructure
	Habitat fragmentation: the consequence of impermeability of roads or railways for animals
	Fauna traffic mortality: mortality caused by collisions on the roads and railways is the most evident and well-known impact
	Disturbance and pollution: the consequence of construction and operation of transport generates various changes in environment
	Creating new habitats on transport verges: the construction brings also creation of new habitats, especially in the form of road verges
SECONDARY	Represented by changes in land-use, human settlement or industrial development that originate as a result of new road and railway construction. As these secondary effects fall under the responsibility of many different sectors, not just the transport one, they should always be carefully considered in SEAs and EIAs. Building of new transport infrastructure in natural areas brings the development of recreational and sport facilities, as well as new possibilities of industrial use of natural resources.
IMPACT OF PARTICULAR COMPONENTS OF ROADS AND RAILWAYS	Road construction contains a number of components that can have a significant impact on wildlife. It is not just the road itself, but the construction also includes junctions (interchanges), fences, crash barriers, local road relocation, drainage, noise barriers, reservoirs to catch contaminated water, bridges, etc. All these parts must be taken into account when assessing the effects of the construction on nature.
LIFECYCLE STAGES OF ROAD AND RAILWAYS	Effects of roads and railways on nature change during their life cycle and therefore all phases have to be included in a proper evaluation. From the life cycle point of view four basic phases can be distinguished: planning, construction, operation and removal.

Table 1: Primary ecological effects.

3 Particularities of the Carpathian contries

The Carpathian Mountains, or the Carpathians, form roughly a 1,500 kilometres-long arc across Central and Eastern Europe. They cover an area of about 209,000 km2 and stretch through the territories of eight countries (from west to east and south-east.). The region is most commonly divided into three main geographic areas/divisions referred to as:

WESTERN CARPATHIANS	SOUTHERN CARPATHIANS	EASTERN CARPATHIANS
▪ Austria ▪ The Czech Republic ▪ Poland ▪ Slovakia ▪ Hungary	▪ Romania ▪ Ukraine ▪ Eastern Slovakia ▪ South-eastern Poland	▪ Serbia ▪ Romania

Figure 2: Geographic areas in the Carpathian region.

The current profile of the mountains was then finalized during the Quaternary period by shifting of glaciers in the interludes between the glacial periods. The landscape was shaped by volcanic activity as well, its remnants can be found in the Southern Carpathians, in southern parts of Slovakia and Hungary. The average annual temperature ranges from more than 10 °C in the Romanian foothills to -2 °C in the Tatras. The amount of precipitation is also quite variable, from more than 1,800 mm per year to 600 mm per year and except for the alpine zone, most of it falls as rain, peaking either in June (in the South) or in July (in the North).

Based on elevation, there is typically a well-pronounced zonation of the vegetation in the Carpathians, with the following main zones (Table 2):

FOOTHILLS	Below 600 m, mostly covered by mixed decidusous forests
MONTANE ZONE	600 - 1,000 m in the North and 650 - 1,450 m in the South
SUBALPINE ZONE	1,100 - 1,400 m in the North and 1,400 - 1,900 m in the South, with Norway Spruce forests or Stone Pines
KRUMMHOLZ ZONE ABOVE TIMBERLINE	1,400 m in the North-West, 1,900 m in the South, with Mountain Pine, Dwarf Juniper and Green Alder
LUSH ALPINE MEADOWS OR ROCKY	With very sparse Alpine vegetation

Table 2: The Carpathian vegetation zone.

The types of habitats that occur in the Carpathians are also extremely rich and overall high in biodiversity. A study done as part of the BioREGIO Carpathians project in 2011-2013 (Appleton et al. 2014) focused on forest, grassland and wetland habitats, has described 9 main different forest types, 6 main ecological groups of high nature value grasslands with 38 different vegetation types, and 7 simplified ecological groups of wetland habitats.

Road system:

The Carpathian region is located at the crossroads of East–West (from South-Eastern Europe/Asia towards Western Europe) and North–South ("Amber road" Baltic-Adriatic). Their directions followed the deep narrow valleys of main rivers embedded in mountain ranges, which resulted in increased possibility for pairing the infrastructures to create multiple linear barriers increasing fragmentation level for several terrestrial species.

There were only 1,118 kilometres of discontinuous motorway network in operation around 1990.

Railway system:

Especially the Czech Republic has advanced far and has already completed the rehabilitation of nearly two-thirds of the network of European importance. On the other hand, Romania has just started and has completed only about 5% of the network by 2015. These railways are upgraded but still not real high speed railway (HSR) lines with speeds exceeding 220 km/h.

In Hungary recently announced plans to build new connections between Vienna and Budapest, Budapest and Bucharest via Cluj (Bendre 2018), the Czech Republic published a policy document (MD ČR 2017) to open the discussions on the future of HSR.

Settlement and traditional life in the Carpathian countries :

Fertile lowlands and hillsides along main rivers in the Outer Carpathian Depressions have attracted inhabitants from prehistoric times and were always the core settlement regions (Hrnčiarová 2009).

The second world is represented by hilly parts of the Carpathian Range, which was - relatively intact by humans for ages - colonized as the last area of Central Europe as late as in the 16th and 17th century. Generally less favourable conditions forced people to adapt their farming and whole life to the natural conditions.

In modern post-socialistic times, the demand for quality of life has increased, causing the process of suburbanization - the rapid expansion of villages in the hinterland of cities, where people sought quiet living in the womb of nature, but with all the achievements of urban life.

Figure 4: Demands of various groups (categories) of animals on permeability of transport infrastructure.

4 Biota and ecological connectivity, demands of different groups of fauna on infrastructure permeability

Building new transport infrastructure threatens different habitats to a different degree and measures aimed at reducing negative impacts of transportation on these habitats will have to be different as well. Each species has different requirements on connectivity and distinct behaviour with respect to transport infrastructure. However, it is possible to find species with similar requirements on permeability of linear barriers in individual habitats, or to select species that generally represent a wider group with similar requirements (so called umbrella species).

THE CARPATHIANS

- Alpine and sub-Alpine grassland
- Forest
- Dry grasslands and pastures with shrubs
- Wetlands
- Watercourses
- Agricultural landscape
- Urbanized area

Figure 3: The main habitats from this point of view are:

Terrestrial invertebrates (especially insects): Many species are able to fly as adults, but the ability to overcome longer distances is very different. Habitats with a high invertebrate species diversity - full linkage of habitats on both sides of transport infrastrucutre.

Fishes and other aquatic animals: This group includes not only fish species but also other aquatic animals such as crayfish, dragonflies, freshwater clams, snails, and many more. Free movement through the watercourses in both directions is the condition for their existence.

Amphibians: This is not a very numerous group that includes so called caudal species (newts, salamander) and acaudal species (frogs). This group is specific by migration between reproduction sites (bound to water) and wintering sites. During their migration time, they often must overcome roads.

Reptiles: This is a diverse group that include lizards, snakes and two species of turtles - aquatic European pond turtle (*Emys orbicularis)* and terrestrial Hermann´s Tortoise (*Testudo hermanni*). Most reptile species are bound to warm grasslands with hiding places (shrubs, fallen wood, rocks or vegetation verges).

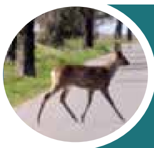
Birds: Some small species from forest environment (goldcrest, some tit species) overcome wide busy motorways only reluctantly and prefer underpasses or overpasses for these situations.

Terrestrial mammals up to the size of fox and badger: This is a diverse group including small rodents, insectivores, lagomorphs, mustelids, fox and wildcat. The group in general includes mobile animals that frequently cross roads while searching for food.

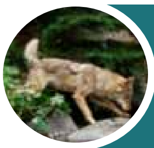
Otter and other semiaquatic animals: Typical representatives are Eurasian otther and Eurasian beaver, but many other species move along watercourses as well. These species can swim and dive, most of them do not use bridges wothout existing dry banks.

Mammals living on the trees: The doormouse, Eurasian red squirrel, European pine marten use passages where connectivity of the forest environment is ensured. Tey can use special overpasses interconnecting tree tops.

Bats: Some of the species could overcome long distances high above ground, while others avoid free space and move predominantly in the forest environment. For such species busy roads create barriers. Fana passages should be solves as well.



Medium sized mammals: These species are widely spread and inhabit both forest and agricultural landstape. While the roe deer are usually restricted to their permanent home ranges, the wild boar often make long distances. The requirements of these two species are considered as a standard to ensure permeability of roads in common landscape.



Large mammals: The wold, the lynx and the bear belong to endangered and protected species. The red deer is widespread species in the Carpathians. European Bison was reintroduced in some areas. Connectivity between different parts of their populations at supranational scale is crucial for their long-term survival.

Figure 4: Demands of various groups (categories) of animals on permeability of transport infrastructure.

5 Connectivity of different types of habitats

When planning a new transport infrastructure it is necessary to ensure connectivity of populations of all species typical for the given habitat and for species, which are not permanently present but would use this habitat as a linkage area. Three main questions usually have to be addressed while doing so:

- What kind of fauna passages (with what kind of parameters) to build?
- What should be the density and placement of such fauna passages?
- How should the fauna passages be integrated into the landscape in order to ensure their functionality?

In order to reach sufficient permeability of transport infrastructure for animals, it is in first step recommended to verify the possibility of multipurpose use of bridges (culverts) that are originally proposed on the planned route for other uses. Setting the recommended mutual distance between fauna passages is a complicated expert task. The following recommendations take into account the size of local species home ranges but also the existence of migration corridors even for species that are not "local" in the area.

TYPE OF HABITAT	TYPE OF FAUNA PASSAGE: Large mammals	Roe deer	Fox badger	Other types	Recommended proportion of functional fauna passages from the total lenght of the infrastructure
Alpine and subalpine grasslands	on migration corridors	2-5 km	1-2 km	tunnels, large overpasses and underpasses connecting mountiang ecosystems	20-30 %
Forests	3-5 km (1) on migration corridors (2)	2-5 km	1-2 km	according to local conditions: tree tops overpasses, special passages for bats, amphibians and other groups of species	2-3 %
Dry grasslands and pastures with shrubs	on migration corridors	3-8 km	1-2 km	multifunctional or special overpasses for invertebrates, reptiles, ground squirrel - 3-5 km	2-3%
Wetlands	on migration corridors	3-8 km	1-2 km	measures connecting wetland ecosystems, measures for amphibians, the European pond turtle, the dice snake, the Eurasian otter, connecting wetland ecosystems	10% depending on the conditions
Watercourses				measures preventing collisions with birds and bates	100% all watercourses should be kept, permeable, dry banks preferably bulit on both sides
Agricultural landscapes	on migration corridors	5-10 km	1-2 km	permeability for aquatic and semiaquatic species	1%
Urbanised areas	on migration corridors		1-2 km	adaptation for other groups of animals	depending on the conditions

1 - areas with permanent occurrence of large mamals

2 - areas outside the permanent occurrence of large mammals

Table 3: Recommended mutual distances between fauna passages for main animal categories in different types of Carpathian habitats.

6 Legislative aspects

6.1 European directives and strategies, relevant conventions

Nature and biodiversity legislations and strategies

Nature and biodiversity in the Carpathians are protected through several directives and strategies at the EU level, which have to be taken into account when transport infrastructure is being planned, designed, constructed and then gets in operation:

At the EU level, two important strategies have been issued in order to enhance protection of biodiversity:

I. The EU Biodiversity Strategy to 2020 (COM (2011) 0244), which aims at halting the loss of biodiversity and ecosystem services by 2020.

II. Strategy on Green Infrastructure. It promotes the deployment of green infrastructure across Europe as well as the development of a Trans-European Network, so-called TEN-G, equivalent to the existing or planned parts of the European Transport Network (TEN-T).

At the EU level, important conventions have been issued in order to enhance management of landscape and protecting biodiversity:

I. European Landscape Convention of the Council of Europe. This convention promotes the protection, management and planning of landscapes and organises international cooperation on landscape issues.

II. ESPOO Convention in place is the UNECE Convention on Environmental Impact Assessment in a Transboundary Context.

III. The Convention on Biological Diversity (CBD). Its objectives are: protecting biodiversity at all levels, sustainable use of its components, access to genetic resources and fair and equitable sharing of benefits from their use.

IV. The Framework Convention on the Protection and Sustainable Development of the Carpathians. It is the only multi-level governance mechanism covering the entire Carpathian area.

V. Other Conventions. They supporting conservation and management of migratory species, their habitats and migration

The European Union's international legislation on nature and landscape conservation aims primarily at protecting selected species and habitats of the European interest through the Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) and the Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds).

The following main pillars are relevant to protecting habitats and implementation of transport infrastructure:

- The Habitats Directive (92/43/EEC)
- The Birds Directive (2009/147/EC)
- The Environmental Impact Assessment (EIA) Directive (2014/52/EU)

Transportation legislation ad strategies

The Trans-European Transport Network (TEN-T) is a European Commission policy directed towards the implementation and development of a Europe-wide network of roads, railway lines, inland waterways, maritime shipping routes, ports, airports and rail-road terminals. Altogether 4 TEN-T corridors are under consideration in the Carpathian region: the Rhine-Danube, the Baltic-Adriatic, the Orient/East-Mediterranean and the Mediterranean.

Road Transport Strategy for Europe is aiming at promoting mobility that is efficient, safe, secure and environmentally friendly.

White paper 2011 is an EU roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.

6.2. National level legislation in respective the Carpathian countries

National law on nature conservation that applies to habitat fragmentation

Legislation related to nature conservation in the Carpathian countries is summarized in Table 4.

Country name	Ecological network/ connectivity in the Constitution	Legislation
Czech Republic	*No*	Law no. 114/1992 Coll. on Nature and Landscape Protection - Territorial System of Ecological stability
Slovakia	*No (ecological balance/active care of the environment)*	Law no. 543/2002 Coll. on Nature and Landscape Protection - Territorial System of Ecological stability
Poland	*No (sustainable development)*	The Nature Conservation Act of 16 April 2004 (maintain ecological processes and ecosystems' stability)
Ukraine	*No (ecological security/balance)*	- Law of Ukraine on Ecological Network of Ukraine, 24 June 2004 Law on Protection of Natural Environment, 25 June 1991 - Law on Natural Protected Areas of Ukraine, 16 June 1992
Hungary	*No (biodiversity protection)*	The Act No. 53 of 1996 on Nature Protection - contains general provisions for creating/implementing ecological corridors and networks
Romania	*No*	- The Law on Environmental Protection (no. 195/2005) -Emergency Government Ordinance no. 57/2007 regarding the regime of protected areas, conservation of natural habitats and of wild flora and fauna.
Serbia	*No (protection of natural heritage and limitation to land use due to environmental protection)*	- Decree on the ecological network, 102/2010 (ecologically significant areas and ecological corridors of international importance) - Law on Nature protection, 2009

Table 4: Nature conservation related legislation in the Czech Republic, the Slovak Republic, Poland, Ukraine, Hungary, Romania and Serbia.

National law on transport infrastructure

Transport related legislation in the Carpathian countries is summarized in Table 5.

All Carpathian countries, both EU and non-EU Member states (Ukraine and Serbia) have already adopted the most significant Acts on Environmental Impact Assessment (SEA/EIA), which regulate the procedures and processes of selected projects including linear infrastructure.

Country name	Transport legislation
Czech Republic	- Act 100/2001 Coll. on Environmental Impact Assessment - Technical Conditions of the Ministry of Transport TP 180 "Fauna passages for Reinsurance of the motorways and roads for wildlife" - National road safety strategy 2011-2020
Slovakia	- Act No. 24/2006 Coll. on Environmental Impact Assessment (SEA, EIA) - Strategic Transport Development Plan of the Slovak Republic up to 2030 – Phase II - National road safety plan of the Slovak Republic 2011 – 2020
Poland	- Act on Making Available Information about the Environment and its Protection, the Public's Participation in Environmental Protection, as well as on Environmental Impact Assessments of 3 October 2008 - The Act of 13 April 2007 on preventing the damages to nature and their compensation - Act on special rules for the preparation and implementation of investments in the field of public roads, 10 April 2003 - Transport Development Strategy until 2020 (from the perspective until 2030), 22 January 2013 - Program of Construction of National Roads for the years 2014 - 2023 (with a prospect until 2025), 4 September 2015 - National road safety programme 2013-2020
Ukraine	- Law "On Environmental Impact Assessment", 23 May 2017 - Law "On Strategic Environmental Assessment", 20 March 2018 - State Construction Norms (DBN B.2.3-4:2007). Motorways., 2007 - Branch Construction Norms (GBN B.2.3-218-007: 2012). -Ecologic Requirements to Motorways, 2012. - Law 'On Transport', 10 November 1994 - Law 'On Railway Transport', 4 July 1996 - Law "On Automobile Transport', 5 April 2001
Hungary	- Government Decree 314/2005 (XII.25.) on Environmental Impact Assessment - Act No. LIII of 1996 on Nature Protection - Sec. 7, Subsec. 2, para. g) - Hungarian Transport Policy
Romania	- Ministerial Order no.
Serbia	- Law on Environmental Impact Assessment, 2004 - Law on Strategic Environmental Assessment, 2004. - Law on public roads, 2005

Table 5: Transport related legislation in the Czech Republic, the Slovak Republic, Poland, Ukraine, Hungary, Romania and Serbia

7 The phases of linear transport infrastructure planning and recommended implementations of environmental measures

Planning and preparation of transport infrastructure is a long-term process. In general, each new construction of transport infrastructure goes through several phases, which can be described by the following scheme:

Many of these processes are given by international legislation and are performed as mandatory in all Carpathian countries. This is represented mainly by two directives of the European Union regarding assessment of impacts on the environment: Strategic Environmental Assessment (SEA Directive 2001/42/EC) and Environmental Impacts Assessment (EIA Directive 2014/52/EU).

EIA shall identify, describe and assess in an appropriate manner, in the light of each individual case, the direct and indirect significant effects of a project on the following factors:

(a) Population and human health;

(b) Biodiversity, with particular attention to species and habitats protected under Directive 92/43/ EEC and Directive 2009/147/EC;

(c) Land, soil, water, air and climate;

(d) Material assets, cultural heritage and the landscape;

(e) The interaction between the factors referred to in points (a) to (d).

Nine specific tools (T1 – T9, see also Table 6) to apply ecological requirements are described in this chapter. Their use is recommended for individual preparation phases and related processes, so that requirements to minimize fragmentation of the environment are applied in a complex way in the entire process of preparing the construction.

	Phase	Key topics	Processes	Tools
SCOPING	Transport policies	Transport concepts, analysis of the above-regional conflicts with protected areas and main migration corridors	SEA	Strategic migration study, map of protected areas, Natura 2000 (Special Protection Areas, Sites of Community Importance, Natura 2000 habitats), core areas and main migration corridors for target species, important and protected Species Action Plans and their distribution, etc. (T1)
PLANNING	Delimiting a transport corridor	Delimiting and survey of a wider transport corridor, selecting basic conflicts with protected areas and main migration corridors, starting a biological survey	SEA	
	Route selection	Assessment of proposed variants, basic proposal for placement and type of fauna passages, detailed biological survey, monitoring program	EIA	Biological survey (T2)
				Framework migration study (T3)
DESIGNING	Detailed project	Solving details in placement of fauna passages, technical parameters, surfaces of bridges and areas under them, connection to the surroundings, means of spatial protection of migration corridors	EIA	Monitoring program (T4)
				Detailed migration study (T5)
			Planning proceedings	Incorporation of migration corridor(s) near fauna passage(s) into spatial plan (T6)
			Building permit	Monitoring before construction (T4)
				Plan to protect biota during construction (T7)
CONSTRUCTION	Construction	Minimizing impacts on natural habitats, prevention of animals entering the construction site, building time schedule, protecting surrounding habitats of fauna from contamination and disturbance	Ecological construction supervision	Ecological supervision (T8)
			Final inspection	Monitoring during construction (T4)
OPERATION	Operation and maintenance	Assessing the effects of infrastructure operation and maintenance on fauna, functionality of mitigation measures (underpasses, overpasses), contamination and disturbance on habitats of fauna, animal mortality		Monitoring after construction, monitoring the impacts of operation (including maintenance) on fauna (T4)
				Post-project analysis (T9)

Table 6: Overview of basic phases, corresponding processes and recommended tools.

8 Fauna passes and other technical solutions

Classification of measures to reduce barrier effect and animal mortality. Measures to reduce barrier effect and animal mortality can be in general divided into several groups (see Figure 5):

MEASURES TO REDUCE BARRIER EFFECT AND ANIMAL MORTALITY

- Measures allowing safe srossing of infrastructure for animals (fauna pasages)
- Measures preventing aninals to enter infrastructure (fences, barriers)
- Measures warning animals of transport infrastructure or ofapproaching vehicles
- Measures warning drivers about approaching aninals or about accident risk sectors (warining signs, speed limitations, warning systems based on animal detection)

Figure 5: Groups of measures to reduce barrier effect and animal mortality.

General principles for proposing measures

The following general principles should form the basis for proposing measures to reduce barrier effect of roads, motorways and railways and should be applied to specific local conditions:

- The efficiency of a proposed measure is the function of ecological conditions and technical solutions. Required efficiency of a proposed measure can be reached only when both of the main requirements are met at the same time: (i) suitable ecological conditions and (ii) suitable technical solutions.
- Individual approach.
- Combination of fauna passages and fences or other barriers.
- Solving long-term sustainability of measures.
- Economic optimization of proposed measures.

First of all, in case of large and costly measures such as special fauna passages it is necessary to apply a complex approach, which lies in proper assessment of ecological and technical conditions, including conditions of the surroundings. The following sections are devoted to select most frequently used infrastructure components and give recommendations on how to best design them in order to minimise negative impacts of transport infrastructure on wildlife.

Fauna passages	Wildlife overpasses	Bridges over roads	Green bridges
			Multi-purpose overpasses
			Tree-top overpasses
		Tunnels	Bored tunnels
			Cut-and-cover tunnels
	Wildlife underpasses	Bridges on roads	Viaducts
			Underpasses for large and medium-sized animals
			Modified and joint-use underpasses
		Underpasses for small animals	Culverts
			Special passages (otter/badger/amphibian tunnels)
		Passages for fishes and other aquatic organisms	

Table 7: Basic classification of fauna passages.

OI interval	Examples of dimensions	Functionality for terrestrial mammals up to the size of fox and badger	Functionality medium sized mammals (roe deer, wild board)	Functionality for large mammals (red deer, moose, lare carnivores)
0,1 - 0,7	3 x 2 : 30	Minimum	NO/Blockage	NO/Blockage
0,7 - 1,5	10 x 3 : 30	Medium	Minimum	NO/Blockage
1,5 - 2,0	13 x 4 : 30	Good	Medium	Minimum
2,0 - 4,0	20 x 5 : 30	Very good	Medium	Minimum
4,0 - 8,0	30 x 6 : 30	Very Good	Good	Medium
8,0 - 40,0	50 x 20 : 30	Very Good	Very Good	Good
Above 40,0	70 x 25 : 30	Very Good	Very Good	Very Good

OI - openness index: w x h / l (the wudth of the underpass multiplied by its height divided by its length)

Dimensions: width x height : length (in meters)

Table 8: Probability of bridge usage in relation to its dimensions.

Terrestrial invertebrates (especially insects): The same soil. light, precipitation conditions, and vegetation as on both sides of a given road/railway, minimum width of 40 m, vegetation at least 2-5 m wide.

Fishes and other aquatic animals: Maintain the watercourse under the bridge in a natural state, same water depth and the same speed of water flow. Also tube culverts has to be always excluded.

Amphibians: Watercourses including culverts should be made permeable for amphibians. To make the stream bed with a plate shape with slight bank slopes. The tube culverts of larger diameters are acceptable, unless water permanently flow through them.

Reptiles: Overpasses of the green bridge type, at least grassy vegetation and some hiding opportunities. **Underpasses** of watercourse including its banks remains in natural state.

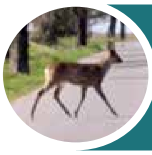
Birds: Attention should be paid to bridges over water. The minimum height of a bridge which birds are willing to fly through should be 2 m. Eliminate visual and noise disturbances by sutably proposed protection walls.

Terrestrial mammals up to the size of fox and badger: Overpasses - Field and forest paths leading over a motorway and widened by a green trip on both sides, green bridge. **Underpasses** - Rectangular culverts, bridges wider than 5 m, badgber tunnel.

Otter and other semiaquatic animals: Wide dry banks under all bridges. Where necessary - build special passage in the dam (otter tunnels) with guiding fencing.

Mammals living on the trees: The main principle is a system of ropes with a shelter to hide from predators. To build small bridge over motorways, with row of bushes on both sides. Such a bridge would be of more multifunctional use by other smaller mammals.

Bats: Both-sided rows of bushes on a bridge and watercourse with bankside vegetation. Buliding bridges offers the opportunity to create hiding places by installing special boxes.



Medium sized mammals: Overpasses - Field and forest paths leading over a motorway by a green strip on both sides. Green bridge represent an ideal passage. **Underpasses -** bridge wider than 5 m

Large mammals: Green bridges, viaducts are ofthen subjects of discurssion

Figure 6: Requirements of individual groups of Carpathian fauna on types and dimensions of passages.

Avoiding and reducing animal mortality

Mortality of animals on roads represents probably the most visible impact of traffic on wild fauna. Millions of individuals are killed on roads every year and even more are injured. Road mortality concerns practically all animal species including birds and insects. Collisions with large mammals, especially ungulates, are also very dangerous with respect to road safety.

It is therefore necessary to deal with measures to lower mortality and increase traffic safety.

FENCING | **BARRIER** | **ARTIFICIAL DETERRENTS** | **PROTECTION OF BIRDS**

Figure 7: Some practices to prevent animals from entering the road.

WARNING SIGNS	To influence the behaviour of drivers in order to reduce number and severity of collisions between large mammals and cars.
	Warning signs should be placed only in places where there is a high risk of collisions.
	Putting up signs only during critical seasons could make people more attentive to them.
	The combination of a wildlife warning sign with a speed limit is slightly more effective.
	The effectiveness is further enhanced if signs are marked with flashing lights or a flashing speed limit sign, which are lit only during periods of high animal activity.
WARNING AND DETECTION SYSTEM	Wildlife warning systems combined with sensors have shown to be able to reduce the number of collisions
	Heat sensors in the vicinity of roads detect approaching mammals up to a distance of 250 m.
	The sensors trigger the fibre optic wildlife warning signs which are combined with speed reduction signs.
	In case of railways, noise-warining systems that are activated by an incoming train are tested in areas with increased animal mortality.
INCREASING VISIBILITY	This includes first of all cutting down trees and bushes in immediate surroundings of the communication.
	Removing vegetation reduces attractiveness of the road surroundings for animals.
	Another measure is road lighing. It makes visibility better for drivers and animals can due to it avoid these areas.

Figure 9: Types of measures on the road.

9 Ecological compensation

Ecological compensation may be defined as creating, restoring or enhancing nature qualities in order to counterbalance ecological damage caused by infrastructure developments. Regarding transport infrastructure, ecological compensation is generally undertaken outside a given road, which in many cases leads to complications with regard to ownership of surrounding land.

Types of compensation measures

1) Habitat creation

Creation and management of new habitats is a key field that can significantly reduce negative impact of road/railway constructions on nature. Creation of spare/replacement habitats currently belongs to the most required measures in the road construction process. Primarily the following basic topics are under solution: A) placement of a spare/replacement habitat, B) dimensional and technical parameters, C) ensuring suitable eco¬logical conditions, D) means of implementation, including funding.

2) Habitat enhancement

Enhancement of habitats implies that the com¬pensated habitat is present, but not one of the right quality. The enhancement needs to be focused on:

a) Wildlife corridors

(improving their function by planting trees, e.g. as a guiding structure for a fauna passage).

b) Linkage areas in a wider range, especially related to the need for support of large target species connectivity in the wider area.

c) Replacement habitats for slowly-moving species (amphibians etc.).

3) In-kind/out-of-kind compensation

Compensation aims at a 'no net loss' situation for the protected species and habitats. Thus, compen¬sation measures should preferably aim at creating similar ecological qualities to the area impacted ('in-kind' compensation). However, it may be legitimate to compensate in terms of comparable qualities ('out-of-kind' com¬pensation). This is the case when in-kind compen¬sation is not feasible and out-of-kind compensation favours the persistence of important species that are impacted by the infrastructure developments.

4) Measures linked to fauna passages

Securing the continuity of fauna passages to the surrounding landscape is an absolutely essential step. The situation is problematic especially in intensively used agricultural landscape, where guiding vegetation elements are needed, but their implementation means changes in land use. In such cases, purchase of the land within necessary extent is usually the only solution.

5) Translocation

Rescue transfers belong to ex situ measures where the conservation of individuals takes place out of the original locality. Their basis lies in capturing individuals at an endangered locality and their transfer to a different place.

HABITAT ENGANCEMENT	IN-KIND COMPENSATION	OUT-OF-KIND COMPENSATION	TRANSLOCATION
▪ Wildlife corridors ▪ Linkage areas in a wider range ▪ Replacement habitats for slowly-moving species	▪ Involves replacement with the same habitats, species or functions	▪ Creation of habitat patches of the same size and ▪ Upgrading habitats ▪ Combination of enlarging and upgrading habitats or increas-ing the connectivity of isolated habitat patches.	▪ Target locality of the transfer ▪ Regime of the transfer

Figure 10: Different type of compensation

10 Monitoring the impact of transport on nature

Objective information about populations of individual species in the surroundings of a transport infrastructure and information about their changes caused by transportation are necessary in order to be able to successfully limit negative effects of transportation on wildlife. Such information can be gained solely by correctly designed monitoring.

The following can only be found out by means of monitoring:

- How many animals really die on roads and what is the effect of this mortality on populations of respective species
- How does the barrier effect of a linear transport infrastructure become evident in populations
- How is the disturbing effect of traffic manifested in populations

Monitoring of effectiveness provides an important feedback and allows to:

- Avoid repeating mistakes.
- Provide new information for improving the design of mitigation measures.
- Identify the measures with an optimal relationship between cost and benefit.
- Save money for future projects.

An activity can only be called monitoring if the following requirements are met:

- Measurements are standardised.
- The variables selected indicate ecological processes of interest or properties that need to be detected.
- The scale (both in time and space) of measurement is appropriate for the detection of change.

Monitoring programme should be part of the EIA process and should always include:

- Monitoring the state of biota in the defined territory, performed as three phases
- Monitoring negative effects
- Monitoring effectiveness of implemented measures

Monitoring the state of biota:

The goal of monitoring is to gain basic expert data set about the development of biota before construction, during construction and in the first phases of operation. Monitoring follows up on biological surveys carried out in the phase of road planning (EIA, documentation for planning permit and building permit and becomes the resource material for further evaluation after a longer period of operation (5, 10 years).

Used methods are given by evaluated groups of animals; they can also differ based on the factor, whose effect is being monitored. The most commonly used methods are described in the following table:

	Key topics	Processes
1	Terrestrial invertebrates	Special monitoring methods are used for individual groups of invertebrates: their describtion is beyond the scope of these guidelines. If animal category is the subject of monitoring, monitoring methods must be proposed by an appropriate expert on the given species (group of species)
2	Fishes and other aquatic animals	Monitoring species composition and the age structure of populatons by electrofishing. Other methods are used to monitor the use of fish crossings (fish telemetry, camera and detection systems).
3	Amphibians	Using special life-traps - inventorying of newts in aquatic environmnet. Capture-recapture method - allows to estimate abundance. Inventorying of amphibians migrating along barriers. Monitoring mortality on critical road sections. *
4	Reptiles	Visual control of suitable habitats in suitable weather conditions. Checking potential hiding spots including artificial ones. Monitoring mortality on roads and bicycle paths. *

5	Birds	Common methods of qualitative and quantitative surveys. Acoustic monitoring with the use of electronic records of bird voices. Monitoring nesting density in selected area (for example owls, waterfowl) Monitoring bird mortaility caused by traffic (on-foot checking). * Monitoring bird mortaility on transparent screens (of-foot checking). *
6	Terrestrial mammals up to the size of fox and badger	Using special traps for capture of small mammals (mice, voles, insectivores). Analysis of owl pellets from the selected area. Hair traps (wildcat). Cameras and phototraps. Snow tracking (mustelids, fox, har, rabbits, etc.). Direct observation (ground squirrel, hare, etc.). Monitoring mortality on roads. *
7	Otter and other semiaquatic animals	Checking for signs of residence (spraints - excrements) under bridges over watercourses. Monitoring tracks on snow - allows not only to prove the presence, but also todetermine the abundance of the given species in the selected area (for determination of abundance only fres "one-day-old" snow needs to bude used) Cameras and phototraps. Monitoring mortality on roads. *
8	Mammals living on trees	Track on snow (squirrel, martens). Direct observation (squirrels). Analysis of owl pellets (the hazel dormouse, dormice). Hair traps (the hazel dormouse, dormice). Cameras and phototraps. Special life-traps (dormice, the hazel dormouse). Acoustic monitoring in the summer (the edible dormouse). Monitoring forage residues (spruce cones, hazelnuts) - it is possible to determine the originator (dormice, the hazel dormouse, squirrels). Installation and checking of bird nesting boxes or special tubes (dormice, the hazel dormouse).
9	Bates	Using bat detectors (devices able to record ultrasound displays of bats and to determine species based on that). Trapping to nets. Checking wintering sites and known summer colonies of bats. Direct obesrvation (often impossible to reliably determine the species). Monitoring road mortality. *
10	Medium-sized mammals	Direct observation. Tracking on snow and mud. Cameras and phototraps. Monitoring road mortality. *
11	Large mammals	Tracking on snow and mud. Phototraps and cameras. Direct observation (bear - long-term network of observation places in the autumn). Telemetry. Genetic analyses - it is possible to determine individuals and their relations or population abundance from found extcrements/hairs. Monitoring mortality on roads. *

* Monitoring mortality is a standard method for road upgrading and for monitoring the effects of measures to reduce mortality rates. It can however be added as a supplement to "three phase monitoring" of the effects of new constructions on biota.

Table 10: Monitoring fauna before construction, during construction and during operation of a road/railway (so-called three-phase monitoring) – recommended methods for individual animal categories.

Monitoring individual negative effects of transportation

While monitoring, it is necessary to quantify physical or chemical influence of each factor, so that a base for comparison to changes in abundance and species composition of biota is created. Evaluation of negative factors must be integrated as part of monitoring the state of biota in the preparation phase, construction phase and implementation phase (three-phase monitoring). It can also be in specific cases further incorporated into individual separate studies focused only on a partial current issue.

Influencing factor:	Characteristics of monitoring:
Elimination and transformation of habitats	Development of landscape cover in wider surroundings of the infrastructure is monitored
Fragmentation of population and habitats	Genetic variability of populations on both sides of an infrastructure
Mortality	Methods of evaluation: direct monitoring of mortality on roads, police statistics of accidents, questionnaires for drivers, online databases, etc.
Noise disturbance	Initial input is noise measurement. Connection with hunting activity of bats, nesting occurrence of owls, waterfowl, etc.
Soil pollution	Initial input consists of dispersion studies; basic monitored component is soil contamination
Water pollution	Effect lies in contamination of water by petroleum substances, road salts and other contaminants from traffic (heavy metals, polycyclic aromatic hydrocarbons, etc.).

Table 11: Potential negative effects of transportation and possibilities to monitor them.

Standards and responsibility for monitoring

At the same time, standards for minimum extent of monitoring to always be ensured have to be set. It should be emphasized that standards relate only to monitoring that has been assigned as a condition for construction authorization or as a measure – it is so called "mandatory monitoring". Based on specific needs and financial possibilities, the environmental and transportation authorities can assign other studies and monitoring activities as well, which do not directly follow up on decision-making about new constructions – this is so called "above-standard monitoring". It is represented for example by:

- Scientifically demanding monitoring that exceeds the standard monitoring frame
- Effects of disturbance by traffic on wildlife during operation on existing roads
- Identification of places with increased fauna traffic mortality on existing roads

The following minimal extent (standard) of monitoring is set for new constructions and reconstructions (upgrading) of transport infrastructure and for implementation of measures that are subject to an authorization process following in the Table 12:

Type of construction	Minimal extent of monitoring	Minimum monitoring period
New constructions	Monitoring fauna before, during and after starting operation of the construction – "three-phase monitoring Monitoring impacts of construction (noise, soil pollution, water pollution)	2 years before and after construction 2 years after construction is finished
Upragrading	Three-phase monitoring reduced according to real needs Registering the proportion of animals that succeed in crossing the transport infrastructure Fauna traffic mortality	2 – x – 2 2 – x – 2 2 – x – 2
Fauna passages	Effectivness of fauna passages	3 years after operation starts and then every fifth year
Fences and other barriers	Registering the proportion of animals that succeed in crossing the transport infrastructure Fauna traffic mortality	2 – x – 2 2 – x – 2

Table 12: Potential negative effects of transportation and possibilities to monitor them.

Table 12: Overview of recommended minimum extent of monitoring for different types of constructions.