Protection of wildlife and migration corridors along the arterial railway line: example of actions taken for the E20 line in Poland (Rzepin – state border section)

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Abstract. The work deals with the problem of wild animals living in the vicinity of the E20 railway line, in the area of the Rzepińska Forest (western Poland). The E20 railway line is part of the 2nd Pan-European transport corridor (relation: Moscow-Warsaw-Berlin-Paris) and is the most important railway connection between Eastern and Western Europe. An impact of modernization of 15 km section of this line on the local landscape and fauna has been evaluated. Moreover, the appropriate means mitigating its influence on the area resident and migrating animals, such as red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), fox (*Vulpes vulpes*), Raccoon dog (*Nyctereutes procyionoides*), badger (*Meles meles*), mink (*Mustela vision*), pine marten (*Martes martes*) and hare (*Lepus europeaus*), were offered. As a part of taken activities locations and technical parameters of 3 passages for large forest mammals and 7 for the medium and small ones were proposed as well as a construction of the protective wire fence for the whole forested section of the line.

Key words: arterial railway line, mammals, migration corridors, barrier efect, mitigation measures, fauna passages, protective fencings

1. Introduction

Modern communication infrastructure – fast train routes and arterial railway lines – have a multilateral effect on the environment of the adjacent areas. The intensity, scale, and ecological importance of such an effect result directly from the location of such an investment, structural solutions, and density of traffic. The negative impact of railway lines covers first of all fragmentation of migration (ecological) corridors, making the movement of wildlife across railway line impossible or difficult, and wildlife mortality as a result of collision with trains.

The most serious ecological effects of the development of railway infrastructure include making the unconstrained movement of animals impossible, that is, the barrier effect.

In the case of railway infrastructure, the barrier effect is conditioned first of all by:

- superficial modifications of land morphology (laying track-way on embankments and in excavations)
- introduction of protective fencing
- the presence of infrastructure objects of anthropogenic origin (track-way, power traction, control devices)
- removal of vegetation from the track-way zone and replacing the (sub)soil
- noise and light emission.

The currently applied methods of protection of wildlife within the impact of railway lines are similar as in the case of roads; they can be divided into three main types: (*i*) preventing conflicts between the course of a new line and the location of habitats and migration corridors by appropriately planning the course; (*ii*) minimisation of the effects of fragmentation of habitats and the effects of ecological barriers by building wildlife passages; (*iii*) reducing mortality on roads and railway lines by building protective fences, using active and passive dispersers.

2. Study area

The E20 railway line is part of the 2nd Pan-European transport corridor (relation: Moscow-Berlin-Paris) and is the most important railway connection between Eastern and Western Europe. The Polish section of the E20 line was for the most part modernised with the adjustment to the traffic of fast passenger trains. The subject of the analysis was a 15 km-long section of this line running almost entirely through the compact forest complex of the Rzepińska Forest, between the localities of Rzepin and Kunowice (a border crossing with Germany) (Fig. 1).

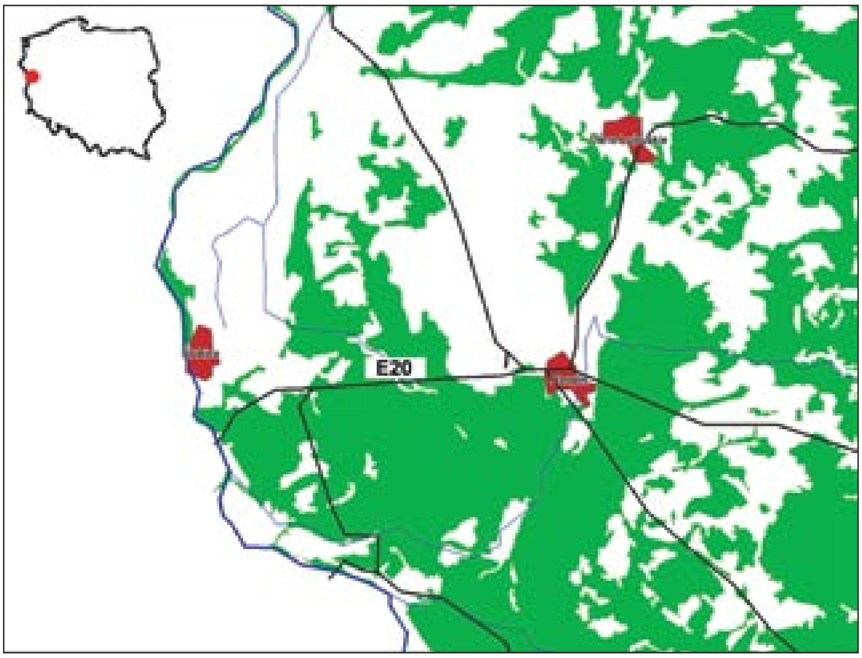

Fig. 1. Localisation of the study area

3. Investigative methods

Environmental analyses were conducted in two principal stages: (*i*) valorisation of the landscape in terms of usefulness for the needs of wildlife migration; (*ii*) localisation of conflict areas along the route of the railway line.

3.1. Valorisation of the landscape

Inventorying and valorisation of the area adjacent to the railway line was done in a strip 1 km wide in terms of the usefulness for the wildlife migration. The area was divided into 100x100 meter-plots, specifying the following features:

- presence of forest vegetation > 75%
- degree of density of tree cover > 60%
- multi-leyer forest stand
- multi-species forest stand

- no clearings > 100 m
- no urban developments
- no public roads
- no infrastructure related to railway line maintenance
- no above-standard light and noise emissions (sources beyond railway traffic)
- presence of natural water courses and water reservoirs
- presence of water courses of a length exceeding 500 meters
- presence of land depressions of a length > 500 m, not related directly to water courses
- hilly terrain of considerable elevation differences.

Using the 0-1 method, each plot was assigned a point for the presence of a given feature. The maximum number of points is 13 and theminimum is 0. Areas with the highest number of points were regarded as possessing landscape qualities superior for performing wildlife migration functions in the analysed area.

3.2. Localisation of conflict areas along the route of the railway line

The areas with the best landscape features were subject to further verification in order to precisely localise conflict areas. The following data was used in the verification:

- course of wildlife migration corridors of higher than local importance (regional, national, international)
- course of local wildlife migration routes
- the constitution of species and distribution of fauna in the analysed area
- topography of the area adjacent to the track-way (in particular embankments higher than 6 m and excavations deeper than 4 m)
- identified areas of collision with animals.

Verification and assessment were performed qualitatively, using multi-criteria analysis and expert appraisal, with the result of selecting areas with the most advantageous features.

4. Results

4.1. Fauna – species constitution and distribution of fauna

The following types of mammals are present in the studied area: red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), fox (*Vulpes vulpes*), Raccoon dog (*Nyctereutes procyionoides*), badger (*Meles meles*), mink (*Mustela vision*), pine marten (*Martes martes*), hare (*Lepus europeaus*).

The highest density of the ungulate population is in areas located north of the railway line and decreases considerably when approaching the infrastructure, reaching its minimum on the southern side of the track-way.

4.2. Migration corridors

Rzepińska Forest has been included in ECONET, the Polish ecological network concept, having the status of a junction area of national importance (Liro 1998).

The analysed fragment of the Repińska Forest has been included in the network of ecological corridors of the Natura 2000 network (Jędrzejewski *et al.* 2005). It has the status of a corridor of national importance and plays a key role in the regional connectivity of the network, in particular for the following areas, designed as refuge networks: the mouth of the Warta River, Łęgi Słubickie, the mouth of the Ilanka River, the Pliszka River Valley.

The ecological corridor, whose fragment is Rzepińska Forest, also plays an important role for the connectivity of the Natura 2000 network on an international scale – it complements the main corridor connecting the refuges of southern Poland with the forests of Brandenburg.

4.3. Effect of E20 railway line on populations of wild animals living in Rzepińska Forest

The negative effects of railway line include:
- breaking the continuity a the migration corridor of national importance in the section: the railway crossing in the locality of Gajec to the railway station in Kunowice; particularly threatened species: red deer, wild boar
- breaking the continuity of local migration routes for large and medium-sized forest mammals in three sections; particularly threatened species: wild boar, red deer, roe deer, badger, fox
- mortality rate amounting with some species to more than 10% of the total local population; particularly threatened species: wild boar, red deer, roe deer, badger, fox.

The expected long-term ecological effects of the functioning of the E20 railway line in the analysed section (in conditions of maintaining or increasing the current level of train traffic) in the present form:
- genetic isolation of the ungulate population living on the northern and southern sides of railway track-way;
- seriously reducing long-range migration possibilities, in particular of rare and protected species – wolf, elk;
- gradual decrease in population of red deer and wild boar in a 500 m strip on the northern and southern sides of the track-way;
- gradual decrease in population of red deer in the entire fragment of the forest complex on the southern side of the track-way;
- dramatic increase of mortality of red deer and wild boar in late autumn and spring, and of red deer, wild boar, roe deer, fox in winters with deep snow cover.

4.4. Actions aiming at minimising the negative effect of E20 railway line on the populations of wild fauna

The optimum actions that minimise the negative impact of the E20 railway line in the Rzepin-Kunowice section are:
- construction of three passages meeting the requirements of large forest mammals: two overpasses in the form of green bridges and one underpass in the form of a viaduct in the embankment
- construction of seven passages meeting the requirements of medium-sized and small mammals, realised as modified protective fences in selected sections (passages on track-way)
- building protective fencing from metal mesh in the entire forested section of the railway line.

4.4.1. Location of structures

The location of structures was determined as the optimum resultant of two groups of factors:
- environmental valorisation of habitat areas fragmented by the railway line and the course of wildlife migration corridors of international, national, regional, and local importance
- degree of collision with the existing infrastructure – in particular with traction network and traffic control devices.

The simultaneous consideration of all the above-mentioned factors led to the determination of locations that optimally fulfilled the ecological needs and characterised by the lowest possible level of collision with the existing infrastructure. There is no way that collisions could be avoided entirely, because most of the collision-generating objects are linear and run along the entire length of the analysed railway line section.

Fauna passages should located as follows (Figs. 2, 3 and 4):

- overpass (green bridge I) – 466.778 km
- overpass (green bridge II) – 470.199 km
- underpass (viaduct in embankment) – 467.241 km.

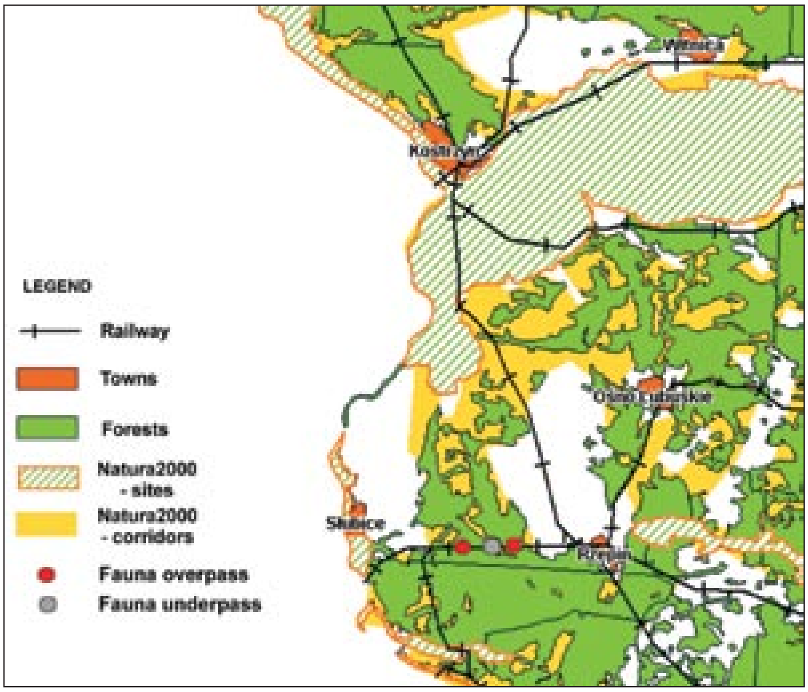

Fig. 2. Location of the planned fauna passages and distribution of Natura 2000 sites

Fig. 3. Location of the overpass on the 466.778 km. Photo R. Kurek

Fig. 4. Location of the overpass on the 470.199 km. Photo R. Kurek

4.4.2. Technical parameters and structural features of the structures

Overpasses (Fig. 5):

- passage in the form of a viaduct over the railway line, located between traction poles, over the main power supply line
- the effective width of the passage at the narrowest point – 40 m
- the passage surface widening smoothly towards the passage approach area
- maximum inclination of the passage surface and the inclination of the surface in approach area – 10%
- restoration of the natural vegetation of the passage surface and on approaches to the passage – minimum 80 cm layer of soil, of which 50 cm of humus
- formation of grassy vegetation cover on the surface of the passage with clusters of bushes and higher-growing perennial vegetation, allowing the natural expansion of species
- using protection fences on the outer edges of the passage – fences connected to the whole fencing system
- using acoustic and anti-glare screens in the form of a light wooden structure.

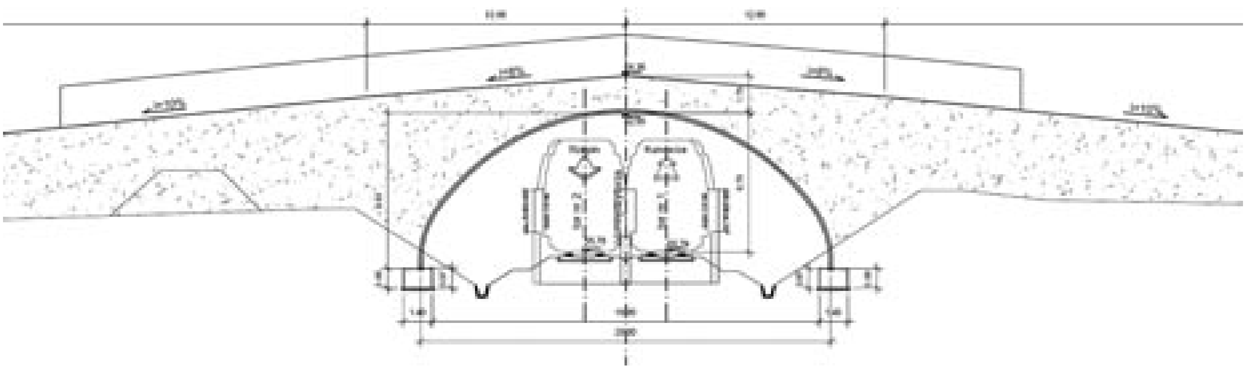

Fig. 5. Cross-section (along the structure's axis) of the planned overpasses

Underpasses:

- a passage in the form of a viaduct under the track-way within the embankment
- effective height of the passage: 5 meters
- effective width of the passage: 20 m
- single-span structure
- keeping a water course (stream) in an unchanged course and the unchanged physiognomy of the bed under the surface and near the passage
- maintenance or restoration of the natural vegetation of the land under the passage – minimum 80 cm layer of soil, of which 50 cm of humus
- formation of grassy vegetation cover under the surface of the passage with single bushes and higher-growing perennial vegetation, allowing the natural expansion of species
- connecting the entrances with a system of protective fencings.

4.4.3. Protective fencings

The designed protective fencings have the following features and parameters (Fig. 6):

- nominal height – 240 cm
- the mesh must have various sizes of holes – getting smaller toward the bottom
- the mesh needs to be dug underground to the depth of 30 cm
- a solid foundation of the piles, enabling strong tension of the mesh and ensuring vertical stability of the structure; it is recommended that the allowed deflection from the pi-meson does not exceed 1 cm

- the distance between piles should not exceed 300 cm
- the fencing should be built in straight lines or with slight curves with a radius not exceeding 15^{o}.

Due to the migration needs of medium-sized and small mammals (mainly rodents and hare-like), amphibians, reptiles, and invertebrates, which will not be fully satisfied by the construction of viaducts for large mammals, modification of the principal (above-described) type protective fencings in the selected sections of the line is proposed (Fig. 6). These modifications will perform the function of passages under the track-way surface.

These modifications ensure that the above-mentioned groups of animals can cross fences in a fairly unconstrained manner. Due to their small body size, these animals are no threat to the safety of railway traffic in the event of collision. Mortality of these animals in the conditions of the expected train traffic density should be very low.

The major differences in parameters of fences modified in relation to the principal type:

- bottom edge of the mesh laying on the ground level – without burying it underground
- larger loops of the mesh in the lower part of the fence.

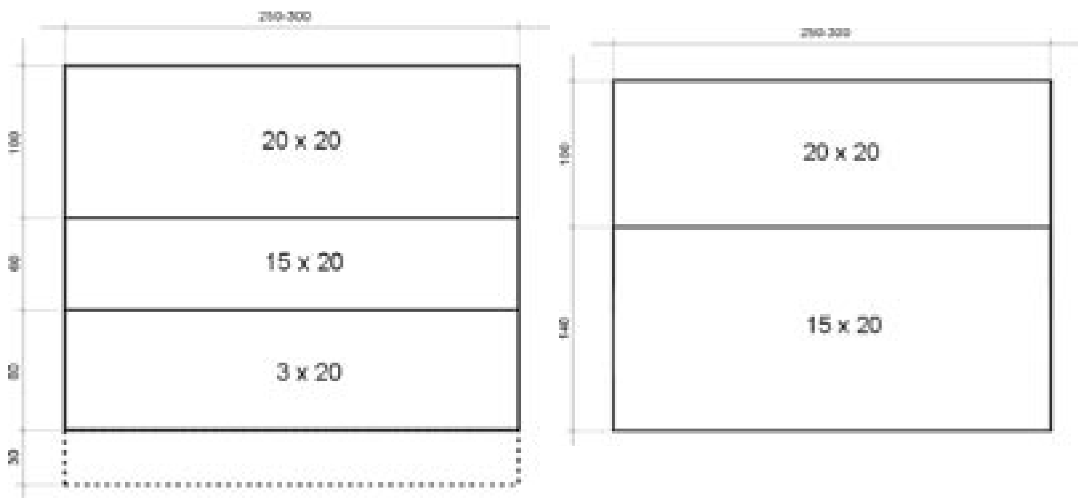

Fig. 6. Fencing modules diagram: principal and modified for the needs of migration of small mammals

4.5. Collisions with the existing infrastructure

The construction of fauna passages near railway lines in the form of overpasses is tied to a number of collisions with the existing infrastructure related to railway traffic maintenance. These collisions considerably impact the selection of materials and structural features of the planned passages. These collisions pertain in particular to:

- traction network – the distance between the traction piles necessitates a limited maximum width of overpasses; the height of suspending the power lines and bearing lines necessitates adjusting the terminals of overpasses, which is related to the considerable height of overpasses and high elevation over the surrounding terrain;
- train traffic – building the passages usually takes place without stopping the planned train traffic, which necessitates appropriate non-colliding performance of assembly works and the choice of such a design solution which will be possible to install from the terrain neighbouring the track-way;
- linear drainage of track-way – the span of the designed overpasses has to be increased so as to provide for passage over the drainage ditches.

An additional problem in designing the fauna passages is the necessity to keep a safe distance from the individual constituents of railway infrastructure, which is regulated by detailed provisions of law on the conditions for terminals by railway lines.

When fauna passages along the discussed section of E20 line were designed, environmental and building analyses were conducted for various types of passage structures, taking into account ecological, technical, and financial conditions. Analyses showed that the optimum solution will be building overpasses ('green bridges') of the minimum width 40 m, with a steel structure, made of high-profile steel sheets. The assembly of the structure will take place in conditions of continued train traffic (switching off power and introducing motor traction) by sliding subsequent layers of steel sheath from the area located outside the track-way.

Building fauna underpasses in railway embankments is free of the above-described collisions and therefore is the best constructional solution for lines which are newly-built or subject to overhaul. It is important to start the realisation of such passages at an early enough stage, when embankments and track-way zone are reconstructed, before the stage of assembly of railway traffic infrastructure. When planning underpasses by existing railway lines which are not redeveloped and on which train traffic will be continued, considerable difficulties should be expected, which will require additional technological activities and a considerable increase in the costs of realisation of objects. The construction of the underpass by the E20 railway line would require the complete demolition of the embankment where the structure is located, disassembly of traction network and other traffic control installations, complete stoppage of train traffic on both tracks for a period of more than ten weeks, or directing train traffic to one track using proper, complicated protections. The estimated total cost of the construction of such a passage, together with the costs of removal of collisions resulted in this type of structure being regarded as currently unfeasible.

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