

# Chapter 15

## Railway Ecology—Experiences and Examples in the Czech Republic

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**Abstract** The range of direct and indirect effects of railway transport on animals, plants, ecological processes and the actual ecosystems vary considerably. Railway transport operations and infrastructure building lead to environmental pollution, loss or conversion of habitats, landscape fragmentation and, last but not least, to animal mortality caused by collisions with passing trains. The impact of railways is determined by the nature of railway infrastructure, which is not as significant in the Czech Republic as road infrastructure, yet it is one of the densest in Europe. An important feature is relatively low electrification (about 33% of the lines) and the length of multi-track lines (about 20%). In the coming years, we can expect massive investments in revitalization, optimization and modernization of the railways in the Czech Republic, and eventually their electrification. To connect the crucial trans-European lines and all regions it will be necessary to complete the basic network of high-speed railways. Based on these facts we can say that the significance of railway ecology in the Czech Republic will grow with the amount of investment activities implemented in the railway network. In the past, similar development took place with road infrastructure, and therefore there is an opportunity to learn from it. To mitigate the direct effects of railways on wildlife, on the basis of previous experience in the Czech Republic we recommend working primarily with management measures. These are both in terms of wildlife management and the management of habitats in the area of transport infrastructure.

**Keywords** Habitat fragmentation · Train accident · Traffic mortality · Wildlife-train collision · Wildlife-vehicle collision

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## Introduction

Railway transport is more environmentally sustainable than road transport (Operational programme Transport 2014) and therefore more preferable for investment from EU structural funds (Partnership Agreement with the Czech Republic 2014). Therefore, we can expect that major construction activities, such as revitalization of train tracks, optimization, and the actual expansion of railway infrastructure, will continue on railway networks across the EU member states in future decades, also in connection with fulfilling objectives in combating climate change by developing low-carbon transport systems (European Commission 2011).

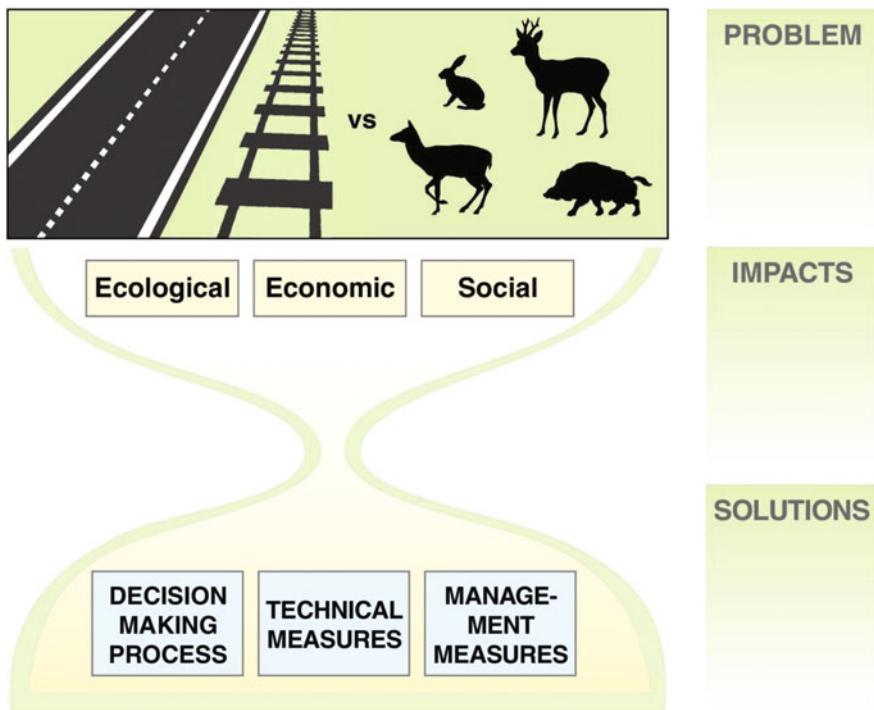
One of the major problems of nature and landscape protection at the turn of the 21st century is the fragmentation of natural habitats by settlements and transport infrastructure (Kušta et al. 2017). Railway transport is involved in this phenomenon as well (Anděl et al. 2010a). Railways can be a significant barrier to the migration of large mammals (Kušta et al. 2014b), especially high-speed railways, which in Europe are usually enclosed, thereby preventing large mammals from crossing them (Groot and Hazebroek 1996). Noise barriers along railway corridors also significantly contribute to the fragmentation of the landscape, creating an impenetrable barrier. Other factors negatively affecting migration near railway infrastructure include noise and light pollution, but also a higher level of human activities, for example maintenance (Dussault et al. 2006; Jaren et al. 1991) or development of residential and commercial activities.

To show the degree of landscape fragmentation, the method of expressing Unfragmented Area by Traffic (UAT) is very often used (Illmann et al. 2000; Gawlak 2001; Binot-Hafke et al. 2002; Anděl et al. 2005; Anděl et al. 2010b). UAT is the part of the landscape which simultaneously fulfils two conditions: (1) it is bounded either by roads with an annual average daily traffic volume higher than 1000 vehicles/day, or by multi-track railways; and (2) it has an area greater than or equal to 100 km<sup>2</sup> (Anděl et al. 2010a). In the context of railway transport, the problem when expressing UAT is mainly seen with multi-track railways; however, research carried out in recent years suggests that even single-track railways with lower traffic intensity can be problematic in terms of railway ecology (Kušta et al. 2014b), and therefore more attention should be paid to them.

The key task is the integration of landscape fragmentation issues and their resulting effects into decision-making processes at all levels, from international and national concepts up to actual investment projects (Fig. 15.1).

### *Railway Network in the Czech Republic*

Railway transport in the Czech Republic has its origins in the first third of the 19th century. The Czechoslovak Republic took over the network at its inception in 1918, after the collapse of the Austro-Hungarian Empire. The dominant owner, builder



**Fig. 15.1** Road and railway and wildlife, overview of implication and general way of solution

and operator of railway lines in the Czech Republic throughout history has been the state. Currently, the state owns the majority of railway lines in the Czech Republic, represented by the state organization Railway Infrastructure Administration. Czech Railways are the largest national carrier.

The railway network in the Czech Republic is relatively inefficient by European standards, being characterized by its low technical level (insufficient ground speed and frequent drops in speed, low capacity, insufficient interoperability and insufficient standards for freight). The reasons for this include the fact that much of the infrastructure is obsolete, with previously neglected maintenance and high operational costs.

The total length of railway lines in the Czech Republic is 9566 km (CSO 2015). About 33% (3153 km) of the length of constructed lines are electrified, and 20% (1858 km) of lines are two tracks. Only 0.38% (36 km) of lines are three and multi-track. In terms of maximum speed, about 38% of tracks are in the category <60 km/h, 26% of tracks in the category 60–80 km/h, 22% of tracks in the category 80–120 km/h and 14% of tracks in the category 120–160 km/h (Fig. 15.2).

In 2014, 176.05 million passengers were transported by railway in the Czech Republic. The average transport distance was approximately 44.3 km. The average transport distance is increasing: in 1995 it was only 35.2 km. In terms of the



**Fig. 15.2** Categorization of railways in the Czech Republic (location in Europe in *inset*) by maximal speed

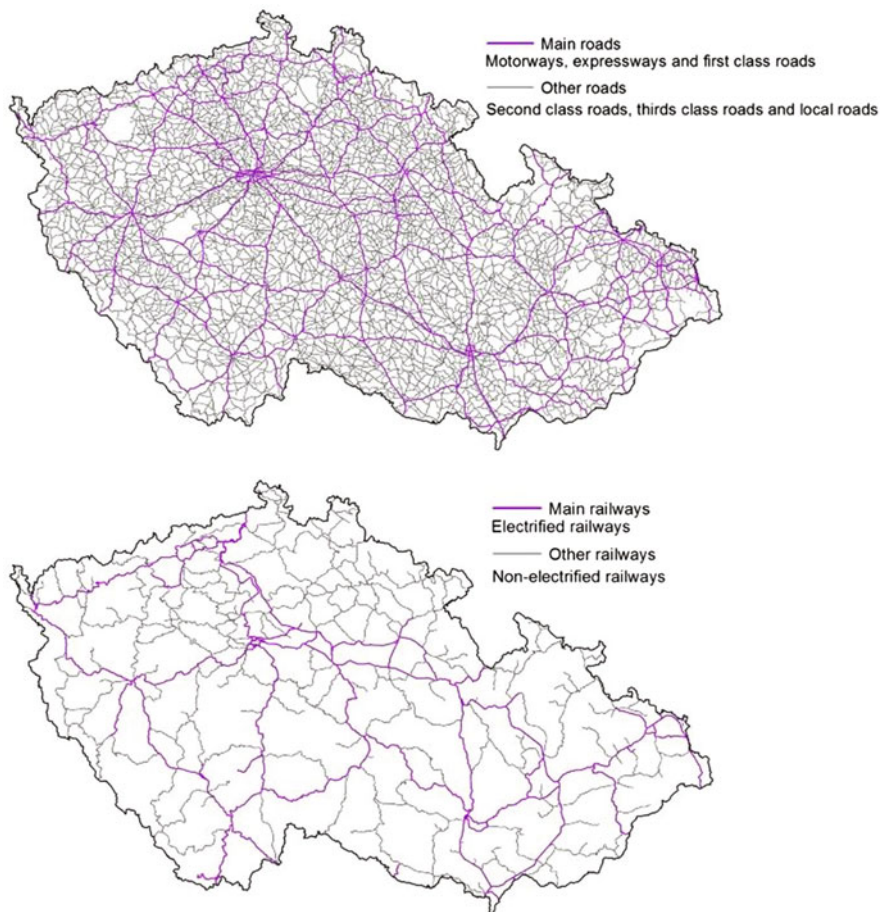
amount of transported goods, 91.6 million tons of goods were transported by railway with an average transport distance of 159.2 km in 2014 (CSO 2015).

In 2014, 104 serious accidents happened on the railway in the Czech Republic, resulting in 29 fatalities and 60 people seriously injured. Property damage was 151.7 million CZK (CSO 2015).

### ***Railway Versus Road Infrastructure in the Czech Republic***

The problem of animal mortality, often discussed in relation to road transport, is only marginally known in the case of railways. There are only a few studies that quantify the impact of railways on the mortality of wildlife (e.g. Andersen et al. 1991; Child 1983; Kušta et al. 2011; Kušta et al. 2014a, b; Paquet and Callaghan 1996; Wells et al. 1999).

Although railway infrastructure in the Czech Republic is significantly less extensive compared to road infrastructure (Fig. 15.3), it is one of the densest in Europe. The overall density of railways is  $0.12 \text{ km/km}^2$ , while road density is approximately six times higher ( $0.7 \text{ km/km}^2$ ) (for comparison, the density of railways in Poland is  $0.071 \text{ km/km}^2$ , in Italy  $0.065 \text{ km/km}^2$ , in Sweden  $0.025 \text{ km/km}^2$ , and the average in the EU is  $0.053 \text{ km/km}^2$ ). In the Czech Republic in many cases, the main railway corridors are parallel with the main roads.



**Fig. 15.3** Road versus railway infrastructure in the Czech Republic

### ***Future Perspectives for Railway Infrastructure Development***

To define good practice within Railway Ecology, as well as Road Ecology, it is necessary to put the acquired knowledge and experience into context with the planned strategic development of transport infrastructure. This is because a summary measure of impact affecting both the environment and public health will be generated from the nature of future development directions and extension as well.

Based on White Paper on transport (2011), The European Commission adopted a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport

by 60% by 2050. According to the general requirements of this roadmap, planned railway development in the EU member states can be described as follows:

- Implement structural changes that would enable railways to compete effectively and take a significantly higher proportion of freight and passengers over medium and long distances.
- By 2030, 30% of road freight transport over 300 km should be transferred to other means such as railway or ship transportation, and by 2050 it should be more than 50%.
- Finish the European high-speed railway network by 2050. Triple the length of the existing high-speed railway networks by 2030 and maintain a dense railway network in all EU member states. By 2050, most passengers over medium distance should travel by railway.
- By 2050, link all core network airports (T-ENT) with the railway network, preferably high-speed; ensure that all major seaports are connected to the railway freight transport and, where appropriate, to inland waterways.

Meeting these goals will require massive development of the railway infrastructure across EU member states, both in towns and their immediate surroundings, as well as in the open countryside. In the case of the Czech Republic, various kinds of investments will be needed, from revitalization, optimization and modernization of railways to retrofitting the existing railways with modern security systems, and eventually their electrification. Next, we need to take into account the completion of a basic network of railway lines that will provide connection to the crucial trans-European lines, linking all regions, connection of Prague international airport to the long-distance railway network, and solutions for major urban and suburban linkages (Operational programme Transport 2014).

## **Railway Ecology Experience in the Czech Republic**

Obtaining data on train accidents with wild animals is very difficult. One reason is probably that these accidents very rarely involve human injuries or property damage (Steiner et al. 2014). It is common knowledge that many animals are killed due to railway transport (Kušta et al. 2014b).

In the Czech Republic there is no database where accidents between trains and animals are recorded. This contrasts with road accidents, where the reported accidents are registered by the Police of the Czech Republic. In case of railways some data is obtained from employees of Czech Railways, and it is often the only way to get more detailed information (in particular the exact time and location of the accident). A site visit will only give data on the location of the accident, not time or other information. Also, it is not easy to find the carcasses near the track because they can be thrown into the surrounding vegetation. Most of the studies addressing this topic struggled with the issue of obtaining input on wildlife-train collision

(WTC) (e.g. Becker and Grauvogel 1991; Jaren et al. 1991; Muzzi and Bisset 1990).

The first known study in the Czech Republic dealing with the influence of railways on animals was the study by Havlín (1987), which focused on animal mortality caused by railways in the agrarian landscape. A 314-km long railway line in the South Moravia Region was studied between 1981 and 1986. In that period, 91 birds (19 species) and 149 mammals (11 species) were killed. The most common species were European hare (*Lepus europaeus*) and common pheasant (*Phasianus colchicus*).

Another well-known study in the Czech Republic was carried out on the track between Trhový Štěpánov and Benešov u Prahy (Jankovský and Čech 2001). The track is 33 km long and it crosses many very different habitats and therefore enables a more comprehensive view of the impacts of railways. The first research on this track was carried out in the winter of 1999–2000. The research was based on field trips and analysis of skeletal findings of animals killed by train. The results show that Leporidae were hit in 32% of cases, Even-toed ungulates in 22% [in the vast majority of cases, roe deer (*Capreolus capreolus*)], Carnivora in 18%, Birds in 10%, Insectivora in 4% and Reptiles in 2%. The findings of physical remnants were tied to those sections where the track does not form a significant barrier height, whether by an embankment or a cutting. At areas significantly banked and often vegetated by shrubs, many pheasant carcasses were found. In May 2006, repeated research was carried out on the track between Trhový Štěpánov and Benešov u Prahy which, among other findings, found an increase in the mortality of roe deer (Jankovský and Čech 2008).

Kušta et al. (2014b) published the results of the monitoring of roe deer deaths in 2009 on four train tracks (regional as well as local): (1) Plzeň–Horažďovice; (2) Bělčice–Závišín; (3) Obrataň–Jindřichův Hradec; (4) Dobrá Voda u Pelhřimova–Hřibčecí. The research showed that collisions of trains with roe deer occur most frequently in winter. The results of this study show that when evaluating animal mortality the specific context should be taken into account (location, climatic conditions, animal abundance in the location, its biology and ethology, railway transport intensity, etc.). For example, on the monitored track Dobrá Voda u Pelhřimova–Hřibčecí, collisions with roe deer occurred most often in summer months, while on the track Jedlová–Chřibská in winter months. Both tracks lie at approximately the same altitude (650 m a.s.l.) and about the same number of trains use them weekly (132 and 197).

Interestingly, railway accidents most often occur in winter, while accidents on roads occur less frequently in winter (Hothorn et al. 2012; Kušta et al. 2014a; Kušta et al. 2017; Pokorný 2006). Therefore railway transport can influence animal behaviour in a different way than road transport. It is necessary to look for the reasons why accidents happen so often in this season. In the Czech Republic it may be due to the attractive food availability, which is in the immediate vicinity of the tracks in the winter (wild raspberry bushes, etc.). This explanation is also supported in other studies (Bowman et al. 2010; Rea et al. 2010; Marchand 1996). In the

winter months the cleared track can also act as a migration corridor. On sunny days, it can serve as a resting place for animals (Seiler 2005).

Kušta et al. (2014b) found a connection between the number of accidents and the frequency of passing trains, a pattern also reported in other studies (Danks and Porter 2010; Hussain et al. 2007; Seiler 2004). On the other hand, there was no correlation between accidents and the abundance of wildlife around the monitored tracks. The study also found that there were more accidents on tracks with more meadows and fields around them than on tracks with prevailing forest. However, significant differences in accidents in different types of habitats (meadows, forests and scrubland) were not statistically confirmed. According to the information from employees of Czech Railways, the most frequent collisions with animals occur in open flat sections of the track, especially at dawn, dusk or at night. This is probably caused by grazing ungulates in these locations and their greater physical activity at dusk and dawn (Kušta et al. 2017), which can correlate with temporal patterns of wildlife-vehicle collision (WVC) on roads (Kušta et al. 2017).

## **Good Practice and Recommendation for Future Action**

### ***Decision Making Process***

For individual investment plans, the permissible level of environmental impact is already pre-defined within a strategic level by SEA procedure (Strategic Environmental Assessment) and at a project level by EIA procedure (Environmental Impact Assessment). In the future, the results of the evaluation need to be considered, especially through the implementation of EIA Follow-up (Environmental Impact Assessment post-project analysis). To ensure more accurate predictions and more effective mitigation measures, the existing railways need to compare the predicted impacts with the ones that occurred in reality and define recommendations for future authorization procedures based on these comparisons.

### ***Technical Measures***

Technical measures against accidents with animals on railway tracks are not very frequent. For example, measures for reducing drive-through speed of trains or warning devices are placed (Becker and Grauvogel 1991; Muzzi and Bisset 1990), noise warning devices are installed (Boscagli 1985; Child 1983), the ground speed of trains is reduced (Becker and Grauvogel 1991; Child 1983), snow along the railway is cleaned up, enabling animals to escape from the corridor when snow is deep (Child 1983; Child et al. 1991), carcasses are removed from around the tracks (Gibeau and Heuer 1996), spilled cereal grains and other food sources are cleaned



from around the tracks and occurrence of this spillage is prevented (Gibeau and Heuer 1996; Wells et al. 1999), or fences are built along the tracks (Boscagli 1985).

In the Czech Republic, the above mentioned technical measures are used quite rarely. The most common technical solution is the application of odour repellents near railway tracks. However, their effectiveness is questionable. Their effectiveness depends on many factors. Among them is, for example, seasonal food availability and its nutritional value (Van Beest et al. 2010), weather, frequency of product application and its concentration (Diaz-Varela et al. 2011; Knapp et al. 2004; Wagner and Nolte 2001). The reason for the ineffectiveness of repellents can often be the excessive disturbance of animals (e.g. by hunting), which then changes their behaviour (Benhaiem et al. 2008) making them less responsive to the repellents. The most probable reason for their frequent ineffectiveness is the fact that the environment around tracks is highly food-attractive for the animals and the applied odours are not able to discourage the animals from being near the railway. Other studies (Elmeros et al. 2011; Schlageter and Haag-Wackernagel 2012a, b) came to similar conclusions, i.e. ineffectiveness of odour repellents in places with attractive food for animals. In contrast, in the vicinity of roads, odour repellents appear to be an efficient tool to reduce the number of animals killed in collisions with cars (e.g. Kušta et al. 2015).

### ***Management Measures***

On the other hand, we recommend paying close attention to management measures, whose implementation is often the cheapest and can be most effective option of solving collisions.

We should study in detail the ecological and behavioural needs of animals that are threatened by railway transport. It is very important to identify critical areas where collisions occur most frequently and establish databases on animal mortality on railways with the information on location, time and external collision factors.

Fencing is an option for sites with high collision rates, and also in the case of main corridors with significantly high capacity, but it requires maintenance and has a major impact on the fragmentation of habitats and populations. For the wider countryside, the most important management measures include the management of wildlife in such numbers that match the capacity of the environment (applies to the species that can be managed by hunting). Animals must not be overpopulated in a given area in any case. Their high numbers do not only cause frequent damage to agricultural land, crops and forests, but also cause significantly frequent WTC as well as WVC.

Furthermore, hunting must not interfere with the appropriate social structure (i.e. age and sex) of the population and a correct sex ratio must be retained. In this context, the heads of the herd and their young need to be protected. This prevents excessive migration of animals due to excessive stress and the need to find new locations.

In the Czech countryside it is common practice to give supplementary feed to game in the winter season. Knowledge of this feeding can be used to reduce migration and therefore even collisions (Kušta et al. 2017). It is important to place feeding devices near animal resting areas so that they do not have to migrate in search of food in winter, or even have to search for it intensively. Feeding devices should never be placed near railways, which would enable animals to concentrate near them.

Also, around railway tracks where the animals occur in higher numbers, very intense hunting should be practiced within the hunting plan in the given territory. On the contrary, hunting should be reduced in areas where there is no danger of WTC or wildlife-vehicle collision (WVC). In game management this corresponds to establishing so-called quiet zones: there is no hunting, peace and quiet is ensured and food is supplied intensively. Suitable conditions for animals should also be created in these locations (e.g. planting appropriate woody plants, planting feeding field, etc.). Animals are then focused into them and protected. They can thus be detained in a certain place, which will prevent their migration in search of food across railway tracks. The results of the study Kušta et al. (2017) show that when animals have suitable resting, cover and feeding conditions, they limit their physical activity to a minimum.

In the vicinity of transport infrastructure (road and railway) there are often hiking trails, country lanes, or the area is used for recreation (walking, dog walking, etc.). Thus, resting animals are often disturbed and forced to cross a road or railway in their escape, which may result in a collision with a passing vehicle or train. Peace and quiet must be guaranteed, especially in winter, which is extremely energy-intensive for animals. For this reason, it is undesirable to let dogs move freely when walking in the countryside in this period, especially around roads and railways; in the Czech Republic there are very often successional areas with sparse vegetation or woody plants growing outside the forest, and the animals rest there (Keken et al. 2016).

A practical tool for reducing collisions with animals also appears to be removing vegetation from the immediate vicinity of the tracks (deciduous trees, herbs, brambles) and trimming browsing trees that are very attractive to animals from the food point of view (Jaren et al. 1991) and also growing unattractive plant species along railway tracks (Jaren et al. 1991; Gundersen and Andreassen 1998; Lavsund and Sandegren 1991). Some studies demonstrated a reduction of animal mortality due to a decrease in food supply along the tracks, for example a 56% reduction in collisions on a railway studied in Norway (Jaren et al. 1991). The measure consisted of the removal of vegetation 20–30 m along the train track. However, Sielecki (2000) states that this method is very costly.

## Conclusion

Taking into account the worldwide research on this subject, it is obvious that this issue is very topical and requires further thorough investigation. The planned future growth of railway transport associated with an increase in the probability of collisions with animals must be treated as a nationwide issue with the involvement of the largest possible number of affected organizations, including government administration, businesses farming on adjacent land, hunters, conservationists and others.

Although it is very difficult and expensive to prevent animal mortality due to collisions with road and railway transport, it is important to find solutions which will at least minimize these accidents. Above all, we propose: evaluating the risks associated with the environment more efficiently and accurately in the planned projects within the decision-making process; providing feedback to individual licensing procedures; paying close attention to management measures; and focussing on technical measures in the riskiest sections.

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