

# Preface

(....)  
*Past cotton-grass and moorland boulder  
Shovelling white steam over her shoulder,  
Snorting noisily as she passes  
Silent miles of wind-bent grasses.  
Birds turn their heads as she approaches,  
Stare from bushes at her blank-faced coaches.*  
(....)

Night Mail, W.H. Audin (1907–1973)

## Rationale and Purpose

The transportation of people and goods is a critical part of the economy. However, a judicious choice of the means of transportation can ameliorate the impacts of economic activities on the environment. In this respect, railways can play a major role, as they provide far more cost-effective and energetically efficient ways of transporting passengers and freight than motor vehicles and airplanes. Hence, railways can contribute to the global efforts for curbing the emission of greenhouse gases and thus help achieve the goals set by the Convention on Climate Change, and the recent Paris Agreement to reduce the forecasted rise in global temperatures in the twenty-first century. Calls have thus been made to consider railways as the backbone of sustainable transportation and to increase their share in relation to more polluting modes of transport.<sup>1</sup> However, as with many other economic endeavors, railways have environmental impacts ranging from several forms of pollution to

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<sup>1</sup>Sadler, K., 2015. Rail to play key role in strategy for tackling climate change. <http://www.europeanrailwayreview.com/24816/rail-industry-news/rail-to-play-key-role-in-strategy-for-tackling-climate-change/>.

wildlife mortality. Therefore, a careful assessment of railways' impacts on nature and of mitigation measures is in order.

Trains are not cars, and railway tracks are not roads. These assertions are obvious, but they are often ignored when assessing the potential and actual biodiversity impacts of railways, which are normally equated to those of roads. This is regrettable because roads and railways differ in many respects, which can strongly influence their impacts. For instance, traffic on railways tends to be less intense than on roads, but trains often travel at higher speeds than cars. Roads and railways also have different physical structures, especially in the case of electrified railways, where overhead lines along the rail tracks can represent an additional source of impacts. All these differences are likely to affect wildlife responses to roads and railways, and hence their impacts on, for example, animals' behavior, mortality, and landscape connectivity.

A quick survey of the literature shows that studies on the biodiversity impacts of railways have greatly lagged behind those of roads. This is probably because the road network is much larger than the railway network, but probably also because the impacts of roads are more easily observed by ecologists and the general public. For instance, the safety and economic costs associated with the risk of collision with a wild or domesticated animal is more easily perceived in a road than in a railway, although the latter are also very significant: an accident with an animal is likely to go unnoticed by passengers in a train, with the remarkable exception of the train driver, but the same will not happen so easily in a car. Even the legal frameworks under which roads and railways operate can be different, conditioning the way the environment in the vicinity can be protected and which mitigation measures can be applied.

All these differences add to a number of specificities that clearly set railways apart from roads, and thus a paradigm shift is needed whereby the impacts of railways on biodiversity are considered on their own. This book aims at contributing to this shift, filling a gap in the literature about the impacts of transportation on biodiversity. We have brought together 44 researchers from 12 countries, from North and South America to Asia and Europe. We aimed at combining—in a single volume—the most relevant information that has been produced on the interactions between railways and wildlife, and to illustrate such interactions with a set of carefully chosen case studies from around the world. We have tried to produce a comprehensive volume that should be of interest to researchers and practitioners alike, including the staff of railway and consultancy companies that deal with the environmental challenges of railway planning, construction, and operation every day.

Although this book addresses several environmental problems raised by railways, we would like its main message to be one of hope. Indeed, while we expect societies to keep looking for more efficient means of transportation, we also expect that efficiency to become ever more synonymous with environmental efficiency, as societies seek to mitigate impacts or even improve biodiversity. We hope that our book can help achieve this goal, contributing to the mitigation of the negative impacts of railways on biodiversity, thereby improving the sustainability and environmental benefits of this mode of transportation.

## Organization

We have divided the book into two parts. The first aims at reviewing the main ideas and methods related to the identification, monitoring, and mitigation of railway impacts on biodiversity, with emphasis on wildlife mortality, barrier effects, biological invasions, and the effects of other railway environmental impacts such as noise and chemical pollution. We begin by setting the scene (Chap. 1–Railway Ecology), framing railways in their economic context, and providing several examples of how railways can impact biodiversity. In Chap. 2 (Wildlife Mortality on Railways), Sara Santos and her colleagues provide a comprehensive review of mortality rates on railways, paying particular attention to the sources of bias when estimating mortality rates. In Chap. 3 (Methods for Monitoring and Mitigating Wildlife Mortality on Railways), Filipe Carvalho and his colleagues have further developed the theme of wildlife mortality, focusing on monitoring and mitigation. They discuss the application to railways of mitigation procedures routinely used in road ecology, and provide an overview of wildlife crossing structures and their role in reducing mortality and barrier effects. In Chap. 4 (Railways as Barriers for Wildlife: Current Knowledge and Future Steps), Rafael Barrientos and Luís Borda-de-Água examine the barrier effects of railways, reviewing the evidence and providing an overview on procedures used to quantify barrier effects, with emphasis on genetic methods and individual-based computer simulations. They then discuss mitigation measures and their effectiveness, providing guidelines for monitoring and mitigation. In Chap. 5 (Aliens on the Move: Transportation Networks and Non-native Species), Fernando Ascensão and César Capinha examine the role of railways in the spread of invasive species, showing that land transportation systems have greatly contributed to species introductions with high economic and environmental costs. They discuss measures to decrease the risk of alien species introductions, paying special attention to verges and associated vegetation corridors. In Chap. 6 (Railway Disturbances: Types, Effects on Wildlife and Mitigation Measures), Silva Lucas and her colleagues look at biodiversity impacts caused by railways due to noise, air, soil and water pollution, as well as soil erosion. They conclude that impacts are species-specific, depending largely on species traits, and that impacts can be minimized through improvements in the railway structure and the implementation of mitigation measures.

The second part of the book provides a set of case studies from around the world that illustrate the impacts of railways on wildlife and ways to reduce those impacts. Reflecting the strong interest in the topic of wildlife mortality, four chapters focus on the patterns of mortality resulting from collisions with trains and railway structures, each of which suggests several mitigation measures to reduce such mortality. In Chap. 7 (Bird Collisions in a Railway Crossing a Wetland of International Importance – Sado Estuary, Portugal), Carlos Godinho and colleagues examine the risk of aquatic bird mortality due to railway bridge crossing wetland habitats, by combining data from surveys on carcasses and the observation of bird movements. They have found that this bridge had a low risk for aquatic birds, as

only a few dead birds were found. In addition, less than 1% of 27,000 bird movements observed over 400 hours crossed the area of collision risk. In Chap. 8 (Cross-scale Changes in Bird Behavior around a High-speed Railway: from Landscape Occupation to Infrastructure Use and Collision Risk), Malo and colleagues examine bird mortality on a high-speed railway line crossing a rural landscape in central Spain. They found that the species commonly associated with rural and open spaces tended to avoid the railway, while those that are already associated with man-made structures were attracted by the railway. The latter species were those most exposed to train collisions; indeed, using video cameras in the trains' cockpits to analyze birds' responses to incoming trains, they observed that birds become habituated to the presence of trains, a behavior that leads to increased mortality.

Collision with large mammals is also a matter of concern in railway ecology, and this is dealt with in the two following chapters. In Chap. 9 (Relative Risk and Variables Associated with Bear and Ungulate Mortalities Along a Railroad in the Canadian Rocky Mountains), Dorsey and colleagues report the findings from a 21-year data set of train crashes with elk (*Cervus elaphus*), deer (*Odocoileus* spp.), American black bears (*Ursus americanus*) and grizzly bears (*U. arctos*) in Banff and Yoho National Parks, Canada. They found that mortality hotspots were affected by species abundances, train speed and the characteristics of the infrastructure. In Chap. 10 (Railways and Wildlife: a Case Study of Train-Elephant Collisions in Northern West Bengal, India), Roy and Sukumar report on the problems of elephant collision with trains in India, describing the spatial and temporal variations in mortality and relating these to elephant behavior. They found that mortality occur mainly at night and in well-defined hotspots, that males are the most susceptible to train collisions, and that mortality seems to be associated with the periods of elephants raiding of crops.

The next four chapters deal with problems related to habitat loss due to the railway infrastructure and its impacts, and the loss of connectivity due to barrier effects. In Chap. 11 (Assessing Bird Exclusion Effects in a Wetland Crossed by a Railway), Carlos Godinho and colleagues examined the extent to which aquatic birds were excluded from wetland habitats close to a railway bridge. They found that bird densities were similar in areas both close to and far from the bridge, and thus there were no noticeable exclusion effects on the wetland bird community. In Chap. 12 (Evaluating the Impacts of a New Railway on Shorebirds: a Case Study in Central Portugal), Tiago Múrias and colleagues addressed a similar problem, using comprehensive monitoring of data on bird numbers, behavior and breeding during the pre-construction, construction, and post-construction phases of a new railway line. Using a Before-After-Control-Impact (BACI) design, they found that the abundance of breeding and wintering shorebirds was reduced in saltpans close to the railway in the post-construction phase. In Chap. 14 (Fragmentation of Ungulate Habitat and Great Migrations by Railways in Mongolia), Ito and colleagues evaluate the impact of the Ulaanbaatar-Beijing Railway on the great migrations of ungulates in the largest grassland in the world – Mongolia's Gobi-steppe ecosystem. They found that fencing along the railway represents a source of mortality and

a barrier to ungulate movement that prevent the long-distance movements required to find food during the harsh winters of Mongolia.

The final four chapters describe novel approaches to reduce and mitigate the biodiversity impacts of railways and also some positive impacts of railways on biodiversity. In Chap. 15 (Railway Ecology – Experiences and Examples in the Czech Republic), Keken and Kušta provide an overview of the impacts and management policies of railways in the Czech Republic. They describe the current Czech railway network and the plans for future expansion, discussing several management options for preventing accidents with animals and mitigating other environmental impacts. In Chap. 16 (Ecological Roles of Railway Verges in Anthropogenic Landscapes: a Synthesis of Five Case Studies in Northern France), Vandavelde and Penone focus on railway verges and their potential positive impacts on the environment. They show that verges may provide habitats for grass plants, bats, and orthopteran, as well as functional connectivity to plants, thereby counteracting some of the negative effects of large-scale urbanization. In Chap. 17 (Wildlife Deterrent Methods for Railways – an Experimental Study), Seiler and Olsson discuss management options for reducing ungulate collisions with trains in Sweden. They review trends in ungulate collisions with trains since 1970 and their economic costs, and then introduce and discuss a new crosswalk design with a deterrent system, where animals are encouraged to leave the railway shortly before trains arrive. Finally, in Chap. 18 (Commerce and Conservation in the Crown of the Continent), Waller describes how a partnership between a railway company, the government and public stakeholders allowed the recovery of the grizzly bear (*Ursus arctos*) in Glacier National Park in the U.S. They describe the mortality problem that resulted from grizzly bears feeding on grain spilled from derailed cars and becoming habituated to the presence of trains, and how this was dealt with through the partnership of a range of stakeholders.

In the final Chap. 19, we wrap up the key messages of the book. We briefly consider the future of railway ecology and give several recommendations on how to mitigate their impacts on the environment.

We hope this book inspires scientists and practitioners to develop approaches to make railways increasingly biodiversity-friendly. But we would also like to dedicate this book to those working for railway companies that have done their best to ameliorate the impacts of railways on the environment and made railways one of the most sustainable modes of transportation.

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