

## Biodiversity and Infrastructure: An Online Handbook for Promoting Cooperation and Action

**Carme Rosell**, Senior researcher, director, MINUARTIA, Spain

**Andreas Seiler**, Senior research, Swedish University of Agricultural Sciences, Sweden and

**Luis M. Fernández**, project manager, MINUARTIA, Spain

All three members of Infrastructure and Ecology Network Europe, IENE

Illustrations © Authors

The joint goals to enhance infrastructure resilience to extreme weather events, increase traffic safety and nature restoration can be achieved by mainstreaming biodiversity in planning, design and operation of transport infrastructure. Deployment of concrete actions which have been proven effective must be accelerated while new innovative solutions and technologies are being developed. The online handbook 'Biodiversity and infrastructure. A handbook for action' [1] promoted by IENE together with the Horizon 2020 BISON project, and other organisations, includes guidelines and standards to be applied by practitioners, which can also be upgraded to include newly available knowledge when required. It is a key tool in expanding the application of effective solutions. The website also includes the 'Transport ecology guidelines portal' allowing easy access to guidelines published in different countries and a 'Glossary', paramount for the use of a common vocabulary and for the mutual understanding between experts of ecology and infrastructure fields. This is the basis for cooperation of both disciplines to identify present and emerging conflicts, understand the driving forces and causes, and accelerate the application of appropriate solutions to reduce biodiversity loss and increase infrastructure resilience and safety.



Carme Rosell



Andreas Seiler



Luis M. Fernández

It is a key tool in expanding the application of effective solutions. The website also includes the 'Transport ecology guidelines portal' allowing easy access to guidelines published in different countries and a 'Glossary', paramount for the use of a common vocabulary and for the mutual understanding between experts of ecology and infrastructure fields. This is the basis for cooperation of both disciplines to identify present and emerging conflicts, understand the driving forces and causes, and accelerate the application of appropriate solutions to reduce biodiversity loss and increase infrastructure resilience and safety.

### GROUNDING ON OVER 20 YEARS OF PRACTICE

The new online handbook is based upon 'Wildlife and Traffic. A European Handbook for identifying conflicts and designing solutions' [2] developed in the framework of the Action COST 341 'Habitat fragmentation due to transportation infrastructure'. The same year in North America the book 'Road Ecology. Science and Solutions' [3] was published. Both publications marked a turning point in the topic of infrastructure and nature. Awareness about effects of linear transport infrastructure on species, habitats and ecosystems raised progressively due to evidence of the high number of animals dead on the causeways and accidents involving wildlife but also through the effect at population scale of the barriers that roads and other linear infrastructure pose to animal movement. The handbook 'Wildlife and Traffic', translated into many languages, provided a basis for revolutionary changes in the application of mitigation measures to increase ecological permeability and reduce animal vehicle collisions. It contributed to an explosion in the numbers of wildlife passages constructed all around Europe and the world. Hundreds of monitoring reports and scientific papers produced over the past 20 years clearly establish the effectiveness of such mitigation measures [4, 5, 6] but also point out possible problems and caveats in design flaws which negatively affect their use and require to be improved. This knowledge combined with emerging concerns about the interacting effects of climate change and

biodiversity loss, motivated IENE's decision to upgrade the handbook from 2003 into an online resource that can be complemented and updated easily. The upgrading was initiated through cooperation between IENE, the Swedish Transport Administration, the French Ministry for Ecological Transition and the Conference of European Directors of Roads (CEDR), and it was eventually financed within the Horizon 2020 BISON project by the European Commission. Over 50 coauthors, 30 reviewers and many more contributors from both transport and ecology organisations, including governmental agencies, research centres, consultants and companies merged their expert knowledge and best practice experiences into the recommendations provided by the handbook.

### GOALS AND TARGET USERS

The online handbook aims to provide a platform to access short, concise, and easy-to-update information on essential knowledge and experience to guide working at the interface of ecology and transportation. It provides recommendations and instructions for the design and maintenance of effective measures addressed to:

- mitigate impacts of infrastructure on nature,
- reduce conflicts between wildlife and traffic,
- find synergies addressing climate change

adaptation and ecological restoration, and

- provide benefits to ecosystems and landscapes in which the infrastructure is embedded. It clarifies basic concepts, provides a joint language and terminology, and offers help in designing planning and evaluation routines.

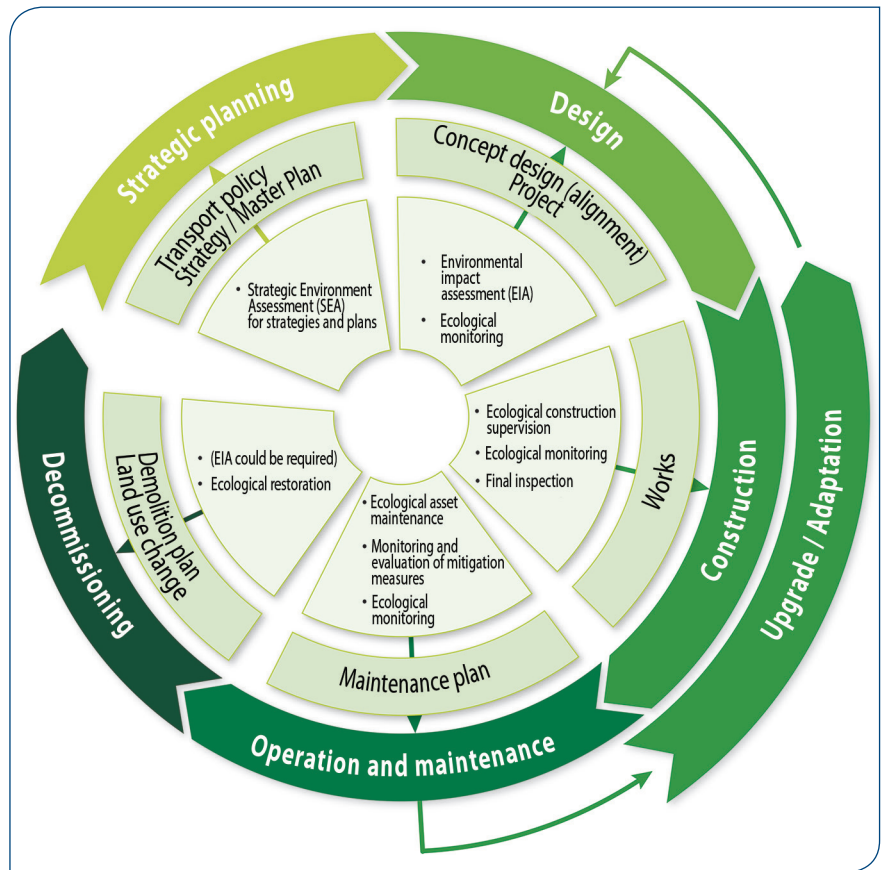
Main target users include technicians dealing with all phases of the life-cycle infrastructure development, particularly with design (including Environmental Impact Assessment) and operation (*illustration 1*). Upgrading and adaptation of existing infrastructures offer excellent opportunities to undertake defragmentation actions described in the guidelines and aiming to reduce effects of infrastructure on nature and to benefit biodiversity.

The online handbook may also be used in education and training in schools for engineering or ecology, as well as for training staff and field personnel working in infrastructure management. Short overviews on different topics provide cutting edge insights for decision makers and the public.

### MAIN FEATURES AND CONTENTS

Global warming alters climate and landscape conditions and entails important effects both in infrastructure and nature. At the same time, the transport sector undergoes significant changes to achieve decarbonisation goals, implement new technologies and digitalisation, and upgrade aging infrastructures to cope with new safety standards and climate change effects. Together with the urgent need to reduce the biodiversity loss, these changes produce opportunities to enhance ecosystems and the services they provide to people.

To draw up an online handbook instead of a standard book have been motivated by such scenario of rapid changes and development of new knowledge and technologies. The website provides a flexible tool which



*Illustration 1 - Biodiversity must be integrated through all life-cycle of the infrastructure. The handbook provides recommendations for actions to be undertaken particularly on Design, Operation and Upgrade phases [1]*

allows for the completion, upgrading or expansion of contents as well as including links to supplementary information, other websites on the topic and additional publications focused on specific topics or countries, which are included in the 'Transport Ecology Guidelines Portal'.

Co-authors were asked to guarantee that guidelines meet the following criteria:

- Evidence-based
- Oriented to action
- Feasible
- Effective
- Innovative (encouraging users to evaluate effectiveness or to improve design).

As the handbook also aims to be useful for training, images and technical drawings play an important role, particularly when illustrating recommended measures (*illustration 2*). Colour codes are used to provide information about common failures in design or installation, ineffective measures which should not be applied or techniques where knowledge is still limited and more research is needed to improve design or to evaluate their effectiveness.

The handbook includes seven Chapters:

1. **General concepts.** Providing basic knowledge about direct and indirect effects of infrastructure on nature that need to be understood both from an ecologist's and engineer's viewpoint.
2. **Policy, strategy and planning.** Highlighting the importance of including biodiversity conservation considerations in all phases of the infrastructure



*Illustration 2 - Examples of drawings providing instructions about (a) how to install fencing to guide animals to wildlife crossings, (b) how to reinforce existing fencing to avoid access of wild boar to the causeways. Red dots ('to avoid') highlight common incorrect installations, such as this example of (c) a cattle grid where the fence has been bad positioned leaving space which animals can use to bypass the grid, reducing its effectiveness. Green dots ('optimal') (d) show appropriate installation of the measure [1]*

development life-cycle as a key to achieving more sustainable transport systems.

3. **Mitigation hierarchy.** Defining the importance to follow-up the ARC mitigation sequence (Avoid-Reduce-Compensate) but additionally, the opportunity to contribute to the restoration of nature and provide 'Net Biodiversity Gain' when planning, designing or operating infrastructure.
4. **Integration into landscape.** Introducing key concepts to embed infrastructure into the landscape and proposing approaches allowing for the multidisciplinary and trans-sectorial cooperation between stakeholders from transport, spatial planning and landscape.
5. **Solutions.** Providing instructions for actions to be applied which reduce impacts on wildlife, habitats and ecosystems - particularly the effects associated with habitat fragmentation, such as animal-vehicle collisions and the barrier effect - and to preserve and restore ecological connectivity and ecosystems.
6. **Evaluation and monitoring.** Comprising a description of activities required to establish whether mitigation measures have been effective, understand the causes for failures and successes and ensure this crucial knowledge is transferred to improving future designs.
7. **Maintenance.** Describing how to design and apply adaptive maintenance plans to guarantee the long-term performance of mitigation measures and provide

appropriate management of habitats related to transport infrastructure.

## ADDRESSING IMPACT MITIGATION AND SYNERGIES TO BENEFIT BIODIVERSITY AND INFRASTRUCTURE

The most extensive part of the handbook is included in the section 'Solutions' which encourages transport stakeholders to undertake best practice and effective transformative actions. It provides knowledge about mitigation measures to reduce recognised conflicts but also invites practitioners to go beyond 'business as usual' and to undertake actions that not only reduce impacts on wildlife but contribute to restore nature. It provides recommendations to replicate practices which have been proven to be effective in achieving the following goals:

- to reduce the risk of wildlife mortality and animal-vehicles collision - which numbers are raising sharply in last decades -, reduce disturbances from noise, light or pollution and reconnect ecological corridors.
- to enhance the ecological value of habitats associated with infrastructure, while minimizing the propagation of invasive alien species.
- to employ nature-based solutions and benefit from opportunities provided by

infrastructure improvements due to climate change adaptations, technical upgrades and renewal of aging structures.

Some examples of the contents in this chapter are usually included in handbooks on the topic but have been expanded and updated with the best practice available. For example, this is the case in the descriptions of wildlife passages (*illustration 3*) and fencing which have been proven to be the most effective measures to prevent road mortality and the reduce barrier effect in large roads with high traffic intensity [7]. Types of wildlife passages and fencing techniques for different target species are described, providing detailed instructions for design, construction and maintenance. Other innovative measures i.e. level crossings, may be applied on roads with lower traffic intensity, that use electronic animal detection systems to activate deterrent methods to animals and warnings to drivers.

Moreover, several sections deal with emerging topics brought about by global warming, which has important effects for both infrastructure and nature. Alien invasive species control deserves a large section as well as management of verges, drainage systems or other green and blue areas.



*Illustration 3 - Overpasses and underpasses may be adapted (a) to facilitate wildlife use providing vegetated strips and screens to reduce noise and visual disturbance from traffic circulating under the structure.*

*Joint work of engineers, ecologists and landscaper are crucial to guarantee effectiveness*

© F. Nowicki [1]; Viaducts may also contribute to wildlife passage and nature restoration

*(b). Field training is crucial for dissemination of best practice*

© Carme Rosell

### REFERENCES

- [1] Rosell, C., Seiler, A., Chrétien, L., Guinard, E., Hlavac, V., Moulherat, S., Fernández, L.M., Georgiadis, L., Mot, R., Reck, H., Sangwine, T., Sjolund, A., Trocmé, M., Hahn, E., Bekker, H., Bíl, M., Böttcher, M., O'Malley, V., Autret, Y., van der Grift, E. (editors). (2023). Biodiversity and infrastructure. A Handbook for Action. IENE. <https://biodiversityandinfrastructure.org/>
- [2] Iuell, B.; Bekker, G.J.; Cuperus, R., Dufek, J.; Fry, G.; Hick, C.; Hlavác, H.; Keller, V.; Rosell, C.; Sangwine, T.; Torslov, N.; Wandall, B. (2003). Wildlife and Traffic. A European Handbook for Identifying Conflicts and Designing Solutions. KNNV Publishers. <https://handbookwildlifetraffic.info/>
- [3] Forman, R.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V., Fahrig, L., France, R., Goldman, C.R., Heanue, K., Jones, J.A., Swanson, F.J., Turrentine, T., Winter, T.C. (2003). Road Ecology. Science and Solutions. Island Press, 481 pp.
- [4] Beckmann, J. P., Clevenger, A. P., Huijser, M. P., & Hilty, J. A. e. (2010). Safe Passages: Highways, Wildlife, and Habitat Connectivity (J. P. Beckmann, A. P. Clevenger, M. P. Huijser, & J. A. Hilty, Eds.). Island Press. <https://doi.org/10.1017/S0030605311000573>
- [5] van der Ree, R., Smith, D. J., & Grilo, C. eds. (2015). Handbook of Road Ecology. John Wiley & Sons, Ltd. <https://doi.org/10.1002/9781118568170>
- [6] Sijtsma, F. J., van der Veen, E., van Hinsberg, A., Pouwels, R., Bekker, R., van Dijk, R. E., Grutters, M., Klaassen, R., Krijn, M., Mouissie, M., & Wymenga, E. (2020). Ecological impact and cost-effectiveness of wildlife crossings in a highly fragmented landscape: a multi-method approach. *Landscape Ecology*, 35(7), 1701-1720. <https://doi.org/10.1007/s10980-020-01047-z>
- [7] Rytwinski, T., Soanes, K., Jaeger, J.A.G., Fahrig, L., Findlay, C.S., Houlahan, J., van der Ree, R., van der Grift, E. (2016) How Effective Is Road Mitigation at Reducing Road-Kill? A Meta-Analysis. *Plos One*. <https://doi.org/10.1371/journal.pone.0166941>
- [8] European Commission. (2013). Green Infrastructure (GI) — Enhancing Europe's Natural Capital. Communication from the Commission to the European Parliament, the council, the European economic and social committee and the committee of the regions. 12 pp.
- [9] United Nations (2020). The United Nations Decade on Ecosystem Restoration. Strategy. P51.

## GLOSSARY: SHARING VOCABULARY TO EMPOWER PROFESSIONALS FOR WORKING TOGETHER

Working on the edge between two fields poses additional difficulties for cooperation. In this case civil engineers and ecologists must work together, joined by other landscape stakeholders (e.g. geographers or land planner architects) involved in the development of mitigation measures and other actions to mainstream biodiversity and transport infrastructure.

Using a common vocabulary is the first step for breaking silos. While it would seem obvious to start in this way, it is often overlooked and poses a major obstacle for effective cooperation. For example, the word 'corridor' is often used by both ecologists and civil engineers, with the ecologist referring to 'ecological corridors', and the civil engineer or land planner referring to 'transport corridors' or 'development corridors'. A second example is the term 'Green infrastructure' (in singular) defined by the European Commission as 'A strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services, while also enhancing biodiversity' [8]. However, 'green infrastructures' (in plural) is rather used as a catch-all term to describe 'sustainable' transport infrastructure. Another example may be the variety of names for different types of wildlife passages -including structure specific for wildlife but also multiuse structures which have been adapted to be used by fauna- that easily cause confusion and misunderstanding.

Both IENE and PIARC are aware of the value of a harmonised vocabulary and just recently signed a Memorandum of Understanding in developing a common Glossary as well as other cooperative tasks. This glossary is considered as one of the cornerstones of the online handbook and may further be expanded and merged with other organisations such as the international railway association UIC.

## AN INVITATION FOR COOPERATIVE ACTION

The United Nations called on all sectors of societies in 2019 to mobilise for a decade of action to deliver global Sustainable Development Goals, including 'Climate Action', 'Life on land' and 'Life below Water'. It also published the Strategy for a 'Decade on Ecosystem Restoration' [8]. The European Green Deal aiming to transform the EU, which is 'Striving to be first climate-neutral continent', also commits to the protection and restoration of nature. Cooperation between the sectors of transport and ecology plays a crucial role to contribute to such goals in providing benefits for biodiversity and people while contributing to safe, resilient and sustainable infrastructure.

The handbook website shall facilitate such cooperation. Moreover, users can actively contribute to updating the handbook when new evidence-based information and new

innovative knowledge becomes available. In addition, the handbook may be used to develop joint training seminars and dissemination activities in both sectors and speed up the dissemination, transmission and application of best practices. Time is short for the halting of the accelerating loss of biodiversity loss.#

## ACKNOWLEDGMENTS

We acknowledge colleagues leading or coordinating the handbook edition, or undertaking previous tasks: Eric Guinard, Vaclav Hlavac, Sylvain Moulherat, Diego Juffe Bignoli, Luc Chrétien, François Nowicki, Marguerite Trocmé and Antonio Righetti. We also acknowledge IENE Governance Board members and former chairs, particularly Hans Bekker, Anders Sjölund and Yannick Autret who were main promoters of the production of the handbook and website but also Elke Hahn, Lazaros Georgiadis, Marita Boettcher and Radu Mot. Special thanks to Charlotte Navarro, IENE secretariat, for her help in coordinating reviews. We also acknowledge Vincent O'Malley and other colleagues from the Conference European Directors of Roads cooperated in the contents about maintenance and Giovanni Magaró from PIARC who cooperates in the Glossary update.