This project has receiv
funding from the Eu
Union's Horizon 2020 resea
and innovation program und
grant agreement no. 10100666

BISON
BIODIVERSITY AND INFRASTRUCTURE SYNERGIES AND OPPORTUNITIES FOR EUROPEAN TRANSPORT NETWORKS

Deliverable D3.3

Online handbook 'Good practice for mainstreaming biodiversity on transport'

Due date of deliverable: 30/06/2023

Actual submission date: 23/11/2023

BISON
BIODIVERSITY AND INFRASTRUCTURE SYNERGIES AND OPPORTUNITIES FOR EUROPEAN TRANSPORT NETWORKS

Project details

Project acronym	BISON
Project full title	**B**iodiversity and **I**nfrastructure **S**ynergies and **O**pportunities for European Transport **N**etwork
Grant Agreement no.	101006661
Call ID and Topic	H2020-MG-2020 / MG-2-10-2020
Project Timeframe	01/01/2021 – 30/06/2023
Duration	30 Months
Coordinator	ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS (CERTH/HIT)

Document details

Title	Online handbook 'Good practice for mainstreaming biodiversity on transport'
Work Package	WP3
Date of the document	21/11/2023
Version of the document	V1
Responsible Partner	Minuartia
Contributing Partner	SLU, NCA, UPGE, CEREMA, AMPHI, BASt, MTES, UIC, OFB, EGIS, BfN, CAU, CDC Biodiversité, CERTH, ASTRA, BMK, FPP Enviro, Trafikverket, Zarand,
Reviewing Partner	Julien Pichenot (CEREMA) Dorothée Labarraque (EGIS)
Status of the document	Final
Dissemination level	Public

Document history

Revision	Date	Description
V1	15/11/2023	First draft
V2	21/11/2023	Final draft

BISON CONSORTIUM - LIST OF PARTNERS

Partner no.	Short name	Name	Country
1	FEHRL	FORUM OF EUROPEAN NATIONAL HIGHWAY RESEARCH LABORATORIES	Belgium
2	MTES	MINISTERE DE LA TRANSITION ECOLOGIQUE ET SOLIDAIRE	France
3	CERTH/HIT	CENTER FOR RESEARCH AND TECHNOLOGY HELLAS	Greece
4	CDV	CENTRUM DOPRAVNÍHO VÝZKUMU- TRANSPORT RESEARCH CENTER	Czech Republic
5	UGE	UNIVERSITÉ GUSTAVE EIFFEL	France
6	SPW	SERVICE PUBLIC DE WALLONIE – DIVISION MOBILITE – INFRASTRUCTURES	Belgium
7	UPGE	UNION PROFESSIONNELLE DU GENIE ECOLOGIQUE	France
8	UIC	INTERNATIONAL UNION OF RAILWAYS	France
9	CEREMA	CENTRE D'ETUDES ET D'EXPERTISE SUR LES RISQUES, L'ENVIRONNEMENT, LA MOBILITE ET L'AMENAGEMENT	France
10	Agristudio	AGRISTUDIO	Italy
11	WWF RO	WWF ROMANIA	Romania
12	UKF	FAKULTA PRÍRODNÝCH VIED - UNIVERZITA KONŠTANTÍNA FILOZOFA V NITRE	Slovak Republic
13	BMK	BUNDESMINISTERIUM FUER VERKEHR, INNOVATION UND TECHNOLOGIE	Austria
14	AMPHI	AMPHI INTERNATIONAL APS	Denmark
14a	FPP	FPP - WITH AMPHI INTERNATIONALS APS	Poland
15	FRB	FONDATION POUR LA RECHERCHE SUR LA BIODIVERSITE	France
16	UNILIM	CENTRE DE RECHERCHES INTERDISCIPLINAIRES EN DROIT DE L'ENVIRONNEMENT DE L'AMENAGEMENT ET DE L'URBANISME - EQUIPE THEMATIQUE DE L'OBSERVATOIRE DES MUTATIONS INSTITUTIONNELLES ET JURIDIQUES - UNIVERSITE DE LIMOGES	France
17	OFB	OFFICE FRANÇAIS DE LA BIODIVERSITE	France
18	BAST	BUNDESANSTALT FUER STRASSENWESEN	Germany

Partner no.	Short name	Name	Country
19	BMVI	BUNDESMINISTERIUM FUER VERKEHR UND DIGITALE INFRASTRUKTUR	Germany
20	ZARAND	ASSOCIATA ZARAND	Romania
21	UASVM-CN	UNIVERSITATEA DE STIINTE AGRICOLE SI MEDICINA VETERINARA CLUJ NAPOC	Romania
22	GDDKIA	GENERALNA DYREKCJA DROG KRJAOWYCH I AUTROSTRAD	Poland
23	STUBA	SLOVENSKA TECHNICKA UNIVERZITA V BRATISLAVE	Slovak Republic
24	MINUARTIA	MINUARTIA	Spain
25	SLU	SVERIGES LANTBRUKSUNIVERSITET	Sweden
26	AWV	BRUSSELS AREA, BELGIUM - AGENTSCHAP WEGEN EN VERKEER	Belgium
27	CAU	UNIVERSITY OF KIEL	Germany
28	UNI KASSEL	UNIVERSITY OF KASSEL	Germany
29	BfN	BUNDESAMT FÜR NATURSCHUTZ	Germany
30	ARMSA	ARMSA	Poland
31	IP	INFRAESTRUTURAS DE PORTUGAL SA	Portugal
32	MDPAT	MINISTERSTVO DOPRAVY A VÝSTAVBY SLOVENSKEJ REPUBLIKY	Slovak Republic
33	ASTRA	FEDERAL DEPARTMENT OF THE ENVIRONMENT, TRANSPORT, ENERGY AND COMMUNICATIONS - FEDERAL ROADS OFFICE	Switzerland
34	NTIC	NETIVEI ISRAEL - NATIONAL TRANSPORT INFRASTRUCTURE COMPANY LTD	Israel
35	NCA	NATURE CONSERVATION AGENCY OF THE CZECH REPUBLIC	Czech Republic
36	RWS	MINISTERIE VAN INFRASTRUCTUUR EN WATERSTAAT - MINISTRY OF INFRASTRUCTURE AND WATER MANAGEMENT	Netherlands
37	TII	TRANSPORT INFRASTRUCTURE IRELAND	Ireland
38	Egis SE	EGIS ENVIRONNEMENT	France
39	TRV	SWEDISH TRANSPORT ADMINISTRATION - TRAFIKVERKET	Sweden
40	DTES.GENCAT	DEPARTAMENT DE TERRITORI I SOSTENIBILITAT. GENERALITAT DE CATALUNYA	Spain

Partner no.	Short name	Name	Country
41	ANAS	ANAS	Italy

TABLE OF CONTRIBUTORS

Partner no.	Short name	Name
24	MINUARTIA	Carme Rosell, Luis M. Fernández, Roser Campeny, Ferran Navàs, Joana Colomer
25	SLU	Andreas Seiler
35	NCA	Václav Hlaváč
7	UPGE	Sylvain Moulherat, Jules Boileau, Chloé Desplechin, Christophe Girod, David Magnier, Fabien Claireau, Jean Guilmain, Sophie Mènard
9	CEREMA	Eric Guinard, Alain Morand, François Nowicki, Luc Chrétien, Gilles Chapelier, Olivier Pichard, Manon Teillagorry, Stephanie Favre, Thomas Schwab, Pierre-Yves Belan
2	MTES	Yannick Autret
3	CERTH/HIT	Ioannis Alertas, Lazaros Georgiadis
4	CDV	Michal Bil
8	UIC	Pinar Yilmazer
11	Egis SE	Allan Rauline, Dorothée Labarraque,
13	BMK	Elke Hahn
14	AMPHI	Alfred Figueras Anton, Alix Aliaga
14a	FPP	Joanna Gornia
17	OFB	Fabien Paquier, Nicolas Hette-Tronquart, Ondine Deyrieux
18	BAST	Pia Bartels, Miriam Herold

Partner no.	Short name	Name
20	ZARAND	Radu Mot
27	CAU	Heinrich Reck
29	BfN	Maritta Böettcher
33	ASTRA	Marguerite Trocmé, Antonio Righetti, Cécile Eicher
37	TII	Vincent O´Malley

TABLE OF FIGURES

BISON
BIODIVERSITY AND INFRASTRUCTURE SYNERGIES AND OPPORTUNITIES FOR EUROPEAN TRANSPORT NETWORKS

TABLE OF CONTENTS

INTRODUCTION

To achieve safe, sustainable and resilient infrastructure is fundamental for economic and social progress. Reaching this goal involves to find synergic solutions that face climate-related hazard while providing benefits for biodiversity throughout the complete life-cycle of transport infrastructure, from the strategic planning to the operational phase, including upgrading or decommissioning when applicable.

Building upon the knowledge generated over decades on transport ecology is essential to replicate and mainstream the best practices developed and applied over time. In a moment when the transport sector is experiencing a deep transformation in several aspects, like decarbonisation, adaptation to climate change or digitalization, new innovative solutions need to be considered to go beyond these goals and achieve a transformative change that brings benefits to biodiversity and human societies.

This transitional moment is also an opportunity that urges to act. On one hand, because transport infrastructure are already experiencing damaging climate-related hazard which, at the same time, are impacting people and biodiversity. On the other hand, transport infrastructure are an important driver of the biodiversity loss crisis, due to habitat loss and fragmentation. This urgency has also been manifested at the highest political levels, like the declaration of the United Nations Decade for Ecosystem Restoration (UN, 2020), the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) or the EU Biodiversity Strategy 2030 (EC, 2020).

The online handbook 'Biodiversity and infrastructure. A handbook for action'[1] , developed in collaboration with Infrastructure Ecology Network Europe (IENE), aims to encourage this transformative change enhancing knowledge transfer and capacity building, promoting an interdisciplinary approach to achieve sustainable transport infrastructure. Based on the first European handbook on the topic, 'Wildlife and Traffic. A European Handbook for Identifying Conflicts and Designing Solutions'[2] (Iuell et al., 2003), it provides clear technical prescriptions for the planning, implementation and maintenance of effective measures to protect biodiversity along transport infrastructure life cycle.

'Biodiversity and infrastructure. A handbook for action' goes beyond including new measures or approaches developed during the 20 years that have passed since the publication of the original handbook, and aims to be an innovative tool that provides evidence-based knowledge tailored to the needs of the different users, from decision-makers to practitioners. At the same time, is an open tool and living document that promotes further research on transport ecology, encouraging users to share information and results about the effectiveness of innovative measures; and an educational and training tool to be used in both engineering and ecology school, as well as for field staff working in transport infrastructure management.

To lay the foundation of a true interdisciplinary approach it is mandatory to achieve a common language that facilitates the understanding among sectors. In this sense, the handbook also includes a 'Glossary', considered as one of the cornerstones of the online handbook. This glossary has

[1] http://www.biodiversityinfrastructure.org/
[2] https://handbookwildlifetraffic.info/

fostered a collaboration with several organisations, such as the World Road Association (PIARC) or the International Standard Organisation (ISO), to achieve a harmonised vocabulary.

Similarly, to ensure that the recommended practices reach as far as possible is important to provide guidelines in the different European languages and better adapted to specific National conditions than a handbook targeted a European level. To achieve this, the website also includes the 'Transport Ecology Guidelines Portal' previously developed by IENE that has been updated and expanded.

Overall, the website developed to include the 'Biodiversity and infrastructure. A handbook for action' along with the Glossary and the Transport Ecology Guidelines Portal, becomes a central point for transport ecology knowledge in Europe and a key tool to achieve sustainable and resilient transport infrastructure.

Content production

The preparation of the online handbook started with a survey among partners, mainly from Work Package 3 but open to the whole consortium, regarding their vision of the handbook. Participants´ answers showed a preference for an interactive and customizable website, with a tag/filter search system allowing users to customize and easily find the information required. The contents were proposed to consist of short texts with support of illustrations and infographics (Figure 1). Providing external links to other available references to allow users to find additional information was also considered important. Regarding the main target user, participants identified practitioners as the most important, although the use for education purposes was also proposed. An important aspect of the contents is that information provided must be evidence-based and oriented to action. A list of remarks and recommendations about the contents and the online platform was also compiled.

Accordingly to the information collected, a document with 'Instruction to Authors' was distributed among co-authors to standardize the format and style of the contents, ensuring coherence among chapters.

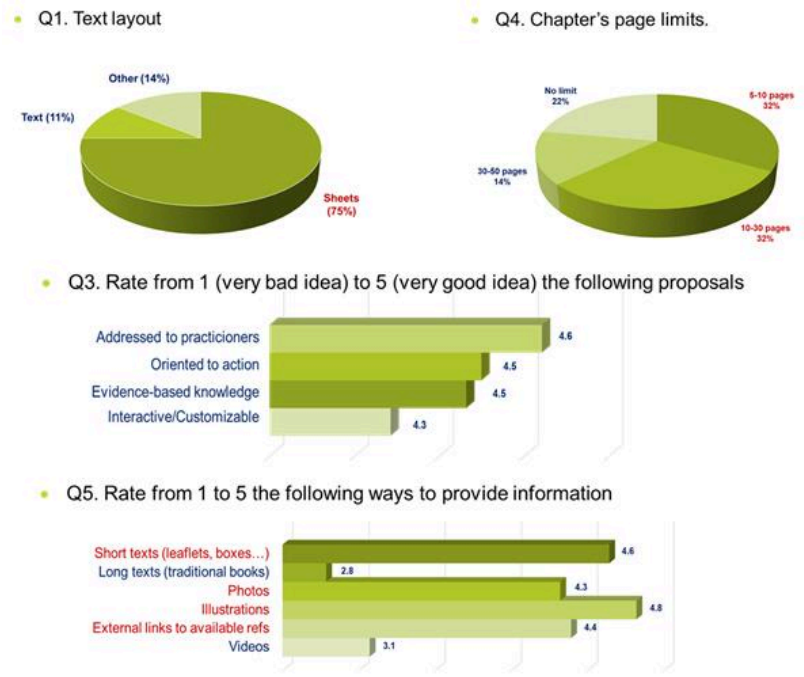

Figure 1. Most relevant results provided by partners regarding their vision of the Online Handbook.

Subtask leaders (from now on, main authors) and co-authors carried out periodical meetings to discuss the content to be included in each chapter, identify and fulfil potential gaps and avoid overlaps, as well as to identify literature and other information sources and develop a common vision of the guidelines to be produced. The first draft with the list of contents and an overview of each chapter was produced in October 2021 and the document was opened to BISON partners on 1st

November 2021. Feedback from contributors was collected and co-authors continued developing the contents of the Handbook. A second draft was produced by June 2022 and shared among BISON partners.

During the production of the drafts, co-authors suggested images to be included in the handbook. Production of technical drawings and infographics were developed by expert designers and a landscaper in close cooperation with main authors of each chapter. Regarding the pictures, communications with their authors were established to obtain high-quality files and get their authorisation to publish them in the handbook website.

Over 2023 the final drafts from the different chapters were produced and sent to the English reviewers to harmonise the language. A first edition was conducted before sending it to reviewers from Advisory Group and other target users. With the feedback from reviewers a final edition was produced.

Beside the contents to be included in each of the chapters of the online handbook, additional resources to be included on the website were produced, including a database of projects regarding different aspects of the impact of transport infrastructures on biodiversity (Subtask 3.2.8; Annex I).

Website development and integration of contents

In parallel to content production, the process to develop the website started by drafting the features and requirements needed. This 'Terms of reference' were developed in cooperation with WP2 (FBR) and delivered to different potential suppliers together with the evaluation criteria to be applied in the selection.

Once the web developer was selected meetings started in November 2022 to develop the structure and functionality of the Handbook website. Periodical meetings have been conducted to adjust the production of the website to the requirements defined by BISON partners.

The progress on the development of the website was presented in the BISON General Assembly held in Tel Aviv on 13th – 14th March 2023 and in the BISON Final Conference held in Strasbourg on 5th – 6th June 2023.

The handbook contents produced as text files need to be adjusted for integration on the website. For example, each section needed to be tagged to allow the search and filter functionality to work. To do so, four categories and several tags within each of them were agreed among co-authors. Once agreed, each section was tagged accordingly. Also, illustrations and pictures need to be tagged with a standardised name including key words facilitating their positioning on internet browsers.

These tasks and other modifications were conducted after a testing period to detect any issues affecting a successful user experience. Once all these issues were corrected, the website was opened to the public (Figure 2).

Figure 2. Online 'Biodiversity and Infrastructure' handbook home page.

Global features

The production of the 'Biodiversity and infrastructure. A handbook for action' has been a massive collaborative effort, involving 32 co-authors, 9 reviewers, 27 contributors, 4 graphic designers, 2 English editors, and 3 contents editors from 15 countries. The text files that have been uploaded to the website include nearly 500 pages, including 89 illustrations and 241 pictures, of evidence-based, up-to-date and ready to use information targeting practitioners, but also researchers and future professionals from ecology and engineering. In this section, the overview for each chapter is included as well as a representative illustration of the chapter. The complete content can be consulted at https://www.biodiversityinfrastructure.org/.

Additionally, the 'Glossary' includes a total of 264 terms and the 'Transport Ecology Guidelines Portal' includes 99 publications from all over Europe and 16 project websites in 10 different languages.

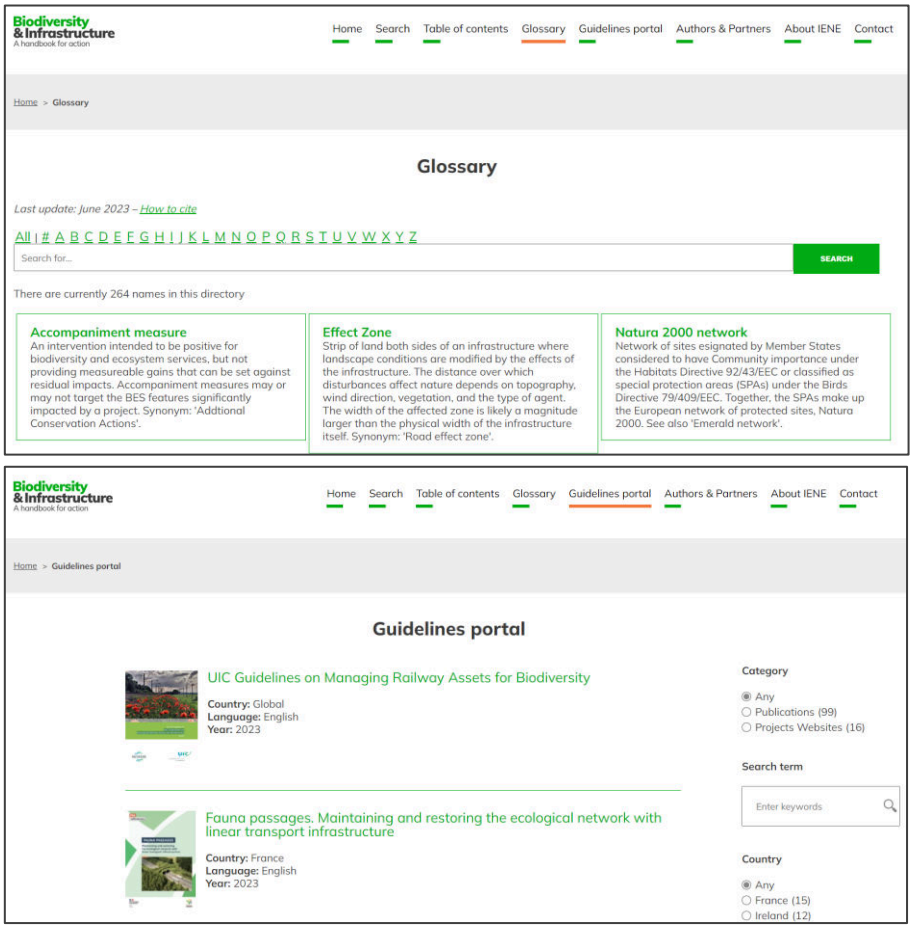

Figure 3. Screenshot from the 'Glossary' page (above) and the Transport Ecology Guidelines Portal (below).

Chapter 1 – Ecological effects of infrastructure

Overview

Transportation infrastructure and its traffic have widespread, complex, lasting, and mostly negative effects on the environment. Only few places on Earth remain that are not directly or indirectly affected. Infrastructure also paves the way for future land use change, urban development, and human settlements, which cumulatively threaten nature and are one of the most important drivers of biodiversity loss.

However, infrastructure is essential for the mobility of people, for trade and for social and economic development. To meet future transportation demands, infrastructure needs to be safe, accessible, reliable and efficient, but in order to be sustainable, affordable and resilient, it must also be adapted to preserve nature. Sustainable and resilient transport infrastructure can only be developed if nature is included as a fundamental aspect in new infrastructure planning and design, as well as in management and adaptation of that which are already under operation.

Mainstreaming biodiversity with transport infrastructure means addressing the need for mobility and communication without compromising nature and the benefits humans derive from it. Choosing appropriate measures to mitigate the ecological impact of infrastructure and traffic and even to enhance potential positive ecological effects is challenging but can build on decades of experience and research. Cooperation and knowledge exchange between transport and ecology sectors, as well as a broad understanding of how biodiversity and infrastructure interact, are essential to achieve this goal.

Main messages

- The transport sector is one of the most important drivers of biodiversity loss as it causes habitat degradation, landscape fragmentation, pollution and wildlife mortality.
- The effects on biodiversity are non-linear, long-lasting, and mostly deleterious. They vary considerably among species, habitats, and regions, and require context-specific solutions, systematic monitoring as well as large scale strategies to avoid crossing tipping-points.
- The use and maintenance of transport infrastructure affects surrounding ecosystems through a variety of toxins, noise, light, changes in microclimate, and biotic pollutants. The combined disturbance, or ‘effect zone’, by far exceeds the physical footprint of infrastructure.
- New habitats that benefit some species in transformed landscapes can be created through transport infrastructure. However, these habitats can also facilitate the spread of invasive alien species by providing migration corridors or suitable habitats and may also create ecological traps attracting animals to areas with unsuitable conditions or a high mortality risk.
- The transport sector has a responsibility to mitigate its direct effects on nature, such as habitat loss and transformation, pollution, and corridor, barrier, and mortality effects. The negative effects interact and lead to habitat fragmentation and other cumulative effects such

as land exploitation and urban development. To address these secondary effects, the transport sector must take an integrated and holistic approach and collaborate with other stakeholders.

- Even with the best mitigation efforts, there is likely always a residual net loss of nature when new transport infrastructure is built. Improving existing infrastructures may offer opportunities to reduce the impact and achieve a net gain for nature.

Actions to take

- Rethink transportation itself and change policies, investments, behaviours, and mind-sets to reduce transport demand while, creating a resilient and efficient infrastructure.
- Upgrade existing infrastructure by implementing innovative, sustainable, nature-based solutions that integrate biodiversity, contain pollution, mitigate barrier and mortality effects, restore ecological connectivity, and enhance green and blue infrastructures in the landscape.
- Develop and benefit from necessary climate adaptations of infrastructure wherever they provide opportunities to improve conditions for biodiversity.
- Ensure effective and transparent cooperation amongst stakeholders throughout the entire life cycle of infrastructure projects, from plans and programmes to design phases and even further to maintenance and decommissioning.
- Engage all stakeholders in mainstreaming biodiversity in transport planning and design and implement the EU Green Infrastructure Strategy and the EU Biodiversity Strategy for 2030.

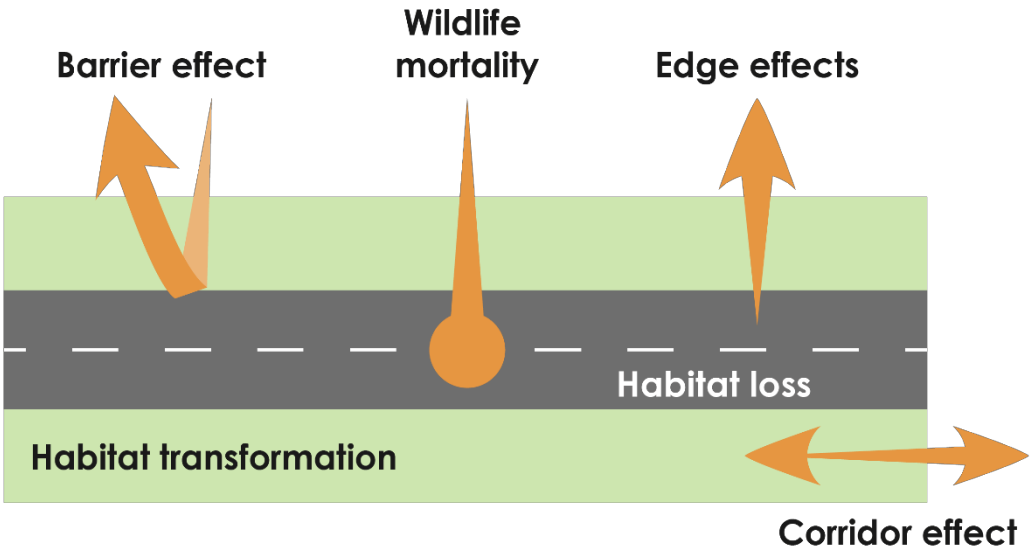

Figure 4. Primary ecological effects of transport infrastructure. (Source: Seiler et al., 2023. Adapted from Trocmé et al., 2003).

Chapter 2 – Policy, strategy and planning

Overview

Integrating biodiversity conservation considerations in all phases of the infrastructure development life cycle is key to achieving more sustainable transport systems. The project life cycle phases are strategic planning, design, construction, operation and maintenance, upgrading or adaptation, and finally decommissioning (where applicable).

To ensure that nature and the benefits it provides to people are mainstreamed into the transport infrastructure life cycle, countries and regions should align their transport policies and strategies with international environmental agreements, and all relevant sustainability standards and regulations. Potential benefits to ecosystems and the services they provide to people could also be preserved or restored if infrastructure is adequately planned, and during operation, particularly when upgrades or adaptations are undertaken.

Main messages

- The transport sector is one of the most important drivers of biodiversity loss as it causes habitat degradation, landscape fragmentation, pollution and wildlife mortality.
- The effects on biodiversity are non-linear, long-lasting, and mostly deleterious. They vary considerably among species, habitats, and regions, and require context-specific solutions, systematic monitoring as well as large scale strategies to avoid crossing tipping-points.
- The use and maintenance of transport infrastructure affects surrounding ecosystems through a variety of toxins, noise, light, changes in microclimate, and biotic pollutants. The combined disturbance, or ‘effect zone’, by far exceeds the physical footprint of infrastructure.
- New habitats that benefit some species in transformed landscapes can be created through transport infrastructure. However, these habitats can also facilitate the spread of invasive alien species by providing migration corridors or suitable habitats and may also create ecological traps attracting animals to areas with unsuitable conditions or a high mortality risk.
- The transport sector has a responsibility to mitigate its direct effects on nature, such as habitat loss and transformation, pollution, and corridor, barrier, and mortality effects. The negative effects interact and lead to habitat fragmentation and other cumulative effects such as land exploitation and urban development. To address these secondary effects, the transport sector must take an integrated and holistic approach and collaborate with other stakeholders.
- Even with the best mitigation efforts, there is likely always a residual net loss of nature when new transport infrastructure is built. Improving existing infrastructures may offer opportunities to reduce the impact and achieve a net gain for nature.

Actions to take

- Infrastructure planning is a multilateral process and should include meaningful consultation with local communities and other relevant stakeholders, especially during strategic planning and design where cumulative impacts come into play and are often poorly assessed. The consideration of specific issues related to biodiversity implies broadening the approaches to cumulative effects at the territorial level.

- When assessing and addressing the impacts of transport on nature, the mitigation hierarchy should be used: 'avoidance-reduction-compensation' (see Chapter 3 – The mitigation hierarchy). This applies to direct, indirect, and cumulative effects.

- Impact assessment should follow and comply with the European Union directives for Strategic Environmental Assessment (SEA Directive 2001/42/EC) and Environmental Impact Assessment (EIA Directive 2014/52/EC).

- Whether any Natura 2000 sites are potentially affected by the analysed infrastructure project, an Appropriate Assessment must follow the Habitat Directive's requirements (1992/42/EEC).

- Adaptive infrastructure maintenance plans are recommended as they allow to identify opportunities to benefit biodiversity, adapt to climate change and increase infrastructure resilience.

- Defragmentation of existing infrastructure must be considered in all upgrading projects as well as in maintenance practice. Providing safe wildlife passages contributes to reduce animal-vehicle collision risks, allow the movements of animals and restore ecological connectivity.

Gaps of knowledge and future research

- Climate change impacts are not well integrated into current transport planning. This includes impacts on species as they move across the landscape to adapt to climate change and impacts on infrastructure due to climate change-induced events (e.g. floods or erosion).

- The adoption of new technologies should be considered to allow better integration of data into plans and help make decisions more efficiently.

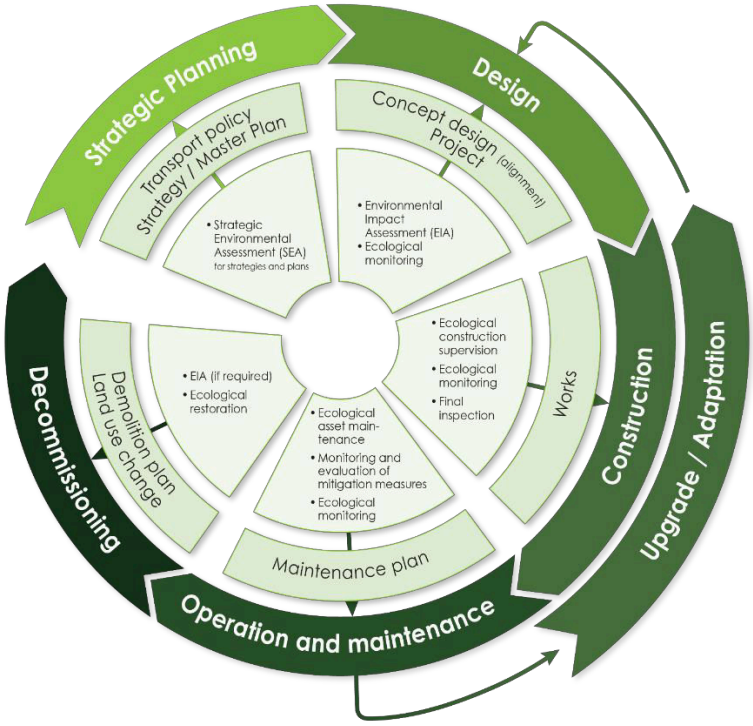

Figure 5. Phases in the life cycle of transport infrastructure including key processes and tools for mainstreaming biodiversity in each phase (Source: Hlaváč et al., 2023).

Chapter 3 – The mitigation hierarchy

Overview

The mitigation hierarchy is a conceptual framework designed to manage impacts on biodiversity. Applied to any impact assessment, here we describe it as a 3-step iterative sequence: Avoidance-Reduction-Compensation (ARC mitigation sequence). If applied to direct, indirect, and cumulative impacts, the mitigation hierarchy can greatly reduce impacts and is key to pursuing No Net Loss (NNL) or Net Gain (NG) of biodiversity in projects, programmes and plans. NNL or NG implies that no biodiversity has been lost or some biodiversity has been gained at the end of the project life cycle compared to a previously established baseline condition. The mitigation hierarchy is considered in Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) EU directives, although the way they are interpreted and implemented varies greatly between member states.

A wider territorial approach including a strong cumulative impact assessment to identify impacts on ecosystems and not only on protected species or areas is required within the SEIA and EIA processes. To achieve the goals of NNL or NG, interactions between mitigation measures must be considered through strategic landscape planning.

Main messages

- Avoidance: it includes measures designed to suppress the impacts on biodiversity of a project, a plan or a programme. This is the most effective action to limit impacts. Avoidance measures in impact assessment may be geographical, temporal or bring changes in the original design of a project. Most avoidance occurs in the first phase of the project life cycle.

- Reduction: these measures are undertaken to decrease the impact when no more avoidance is possible. Reduction measures, which include restoration, are intended to minimize impact, either by decreasing magnitude, partly suppressing the impact, via for example geographical, temporal measures or setting structures to reduce impacts such as wildlife crossings or underpasses combined with fencing. Reduction measures are designed early in the project cycle but implemented during the construction phase and monitored across the entire cycle.

- Compensation: impacts that cannot be avoided or reduced are known as residual impacts. Compensation aims to balance these residual impacts to achieve NNL or NG through offsets or accompaniment measures. Offsets involve the management of biodiversity to obtain measurable conservation outcomes and show an ecological gain has been achieved through restoration or creation of habitat. Compensation is the least effective measure of the mitigation hierarchy. Current practices focusing on the compensation step, result in mixed outcomes, which fail to reach the ambitions of NNL or NG. Moreover, its rules and implementation are highly variable across member states. Compensation measures should be designed early in the project cycle, implemented, and monitored for the whole project duration.

- Accompaniment measures aim to ensure better application of avoidance, reduction or compensation measures. They enable the progress of mitigation hierarchy implementation but do not compute in the NNL/NG assessment.

Actions to take

- Strong focus on avoidance, as the only measure that guarantees the absence of impact, is highly recommended.

- The mitigation hierarchy should be applied in full, not only at design but also at strategic phase. The aim is to strengthen biodiversity considerations in the execution of SEA assessments to influence subsequent assessments processes. A strategic approach also allows the consideration of cumulative impacts in the application of mitigation hierarchy.

- Consider the interaction between avoidance, reduction and compensation measures in strategic landscape planning to pursue NNL and NG net gain goals.

- For a successful compensation process, appropriate classification of mitigation measures should be established to determine the significance and extent of residual impacts.

- Equally important is defining the compensation approach, targets for compensation, equivalency principles, and identifying appropriate currencies and metrics to implement and monitor compensation.

Gaps of knowledge and future research

- More research is needed to determine to what extent and under which conditions the current ecological compensation practices are achieving NNL or NG for biodiversity.

- There are few examples of well-applied cumulative impact assessment in the EU. More practical examples and operational tools on how to predict and manage cumulative impacts of infrastructure development are key to halt biodiversity loss and, achieve EU Biodiversity Strategy for 2030 goals.

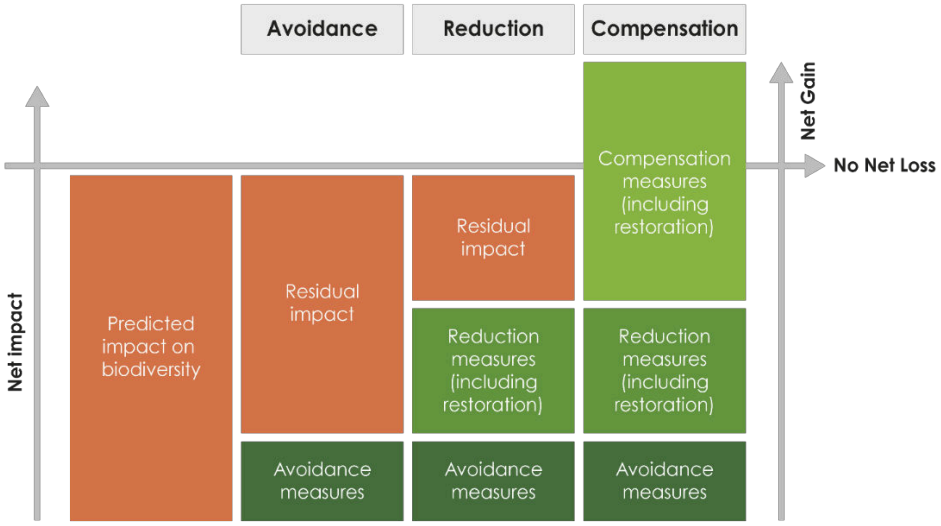

Figure 6. Balance between predicted impact of a project and net gains produced by implementing the mitigation hierarchy aiming to ensure a NNL or a NG of biodiversity (Source: Moulherat et al., 2023. Adapted from BBOP, 2012).

Chapter 4 – Integration of the infrastructure into the landscape

Overview

An appropriate integration of transport infrastructure into the landscape contributes to minimise its effects on biodiversity and even to achieve 'Net Gain' for biodiversity. To meet this goal, spatial planning, including other land uses and anthropic pressures affecting biodiversity, need to be considered, as well as the ecological networks affected. An interdisciplinary approach is key in this process to ensure all relevant effects are evaluated. Applying this approach at Strategic Planning and Design phases, could provide the most successful outcomes (see Chapter 2 – Policy, strategy and planning and Chapter 3 – The mitigation hierarchy).

The identification of ecological networks should be considered at relevant scales depending on the specific project and life cycle phase. In any case, this will allow to define the Green Infrastructure for a given territory, contributing to identify conflict points and the most appropriate solution for each of them (see Chapter 5 – Solutions to mitigate impacts and benefit nature).

Social and economic concerns should also be considered to fully integrate the transport infrastructure into the landscape. Promoting the implementation of Nature-based Solutions contributes to this holistic approach, since they simultaneously address societal and environmental challenges. They contribute to achieve sustainable transport infrastructure, contributing to meet the UN Sustainable Development Goals and the Aïchi´s targets.

Main messages

- The integration of transport infrastructure into the landscape must be undertaken applying an holistic approach, including environmental and land planning aspects, but also social and economic ones. Therefore, it is crucial to develop an interdisciplinary methodological approach.

- The ecological networks present in the landscape must be evaluated at the appropriate scale depending on the specific project and the phase of the life cycle it is on.

- Assessing ecosystems and ecological networks contributes to the identification of Green Infrastructure in the analysed landscape, which facilitates the implementation of appropriate solutions. Moreover it allows to identify the potential benefits ecosystems in the surrounding of the infrastructure as well as the services they provide to people.

- Favouring Nature-based Solutions contributes to achieve sustainable transport infrastructure.

- Infrastructure integration must be developed analysing different scales, at the landscape scale and also at local scale. At each scale different solutions and opportunities could be identified.

Actions to take

- Apply an interdisciplinary approach from the avoidance phase of the mitigation hierarchy. This should be applied from the Strategic Planning phase for new infrastructure, but also on upgrading and adaptation of existing infrastructure.

- Promote Nature-based Solutions over grey solution in order to achieve sustainable transport infrastructure that benefit nature (including biodiversity) as well as people.

Gaps of knowledge and future research

- Integrative solutions at landscape scale are still scarce and more information is needed to ensure a correct implementation and evaluation.

Chapter 5 – Solutions to mitigate impacts and benefit nature

Overview

Building on two decades applying good practice in all the steps of the transport infrastructure life cycle, a wide number of solutions or mitigation measures can be applied to reduce the negative effects of infrastructure (see Chapter 1 – Ecological effects of infrastructure) and benefit biodiversity and societies. Currently, innovative practices and new technologies are being developed to provide appropriate answers to emerging trends and new scenarios that arise from global change. More importantly, these solutions should provide appropriate response to the achievement of the objectives of the European Green Deal and particularly of the EU Biodiversity Strategy for 2030.

Main messages

- Solutions to be applied by the transport sector include measures to reduce the impact of traffic on wildlife populations and the negative effects associated to habitat fragmentation, particularly wildlife mortality and barrier effect. Moreover, preservation and restoration of ecosystems and ecological connectivity are crucial goals for mitigation measures.

- Mitigation measures must be developed following the mitigation hierarchy (Avoid – Reduce – Compensate) (see Chapter 3 – The mitigation hierarchy). It also must be implemented and accurately integrated along all the life cycle phases (see Chapter 2 – Policy, strategy and planning): Strategic Planning, Design, Construction, Operation/Maintenance and in the Upgrade/Adaptation processes. As a general rule, early stages of the infrastructure development provide more opportunities to avoid negative effects than latter stages.

- Location of the measures is a critical decision which determines success or failure. Accurate analyses to define in which places provide best benefits-cost balance are an essential step of the mitigation design.

- Mitigation measures can provide solutions to multiple conflicts and challenges if they are appropriately designed. For example, a measure to reduce wildlife mortality, such as a wildlife passage combined with fencing, could also contribute to restore ecological connectivity.

- Benefits for people can also be achieved in terms of reduction of traffic accidents but also by combining wildlife and human uses in the crossing structures. Conversely, negative consequences of the application of the mitigation measures should be carefully analysed and avoided.

- Habitats related to transport infrastructure (e.g. verges and drainages) can be adapted to provide refuges or food for wildlife. Nevertheless, attraction of fauna to areas where can cause conflicts or suffer a high risk of mortality must be avoided.

Actions to take

- Use mitigation measures to minimise the risk of wildlife mortality as well as to increase infrastructure safety and functionality. Examples include: reducing wildlife-risk events such as animal-vehicle collisions, animal droughts in waterways, bird strikes in airports, bird collisions or electrocution with railways catenaries, powerlines or wind miles, bird collisions with glasses and transparent screens, or animals being trapped in any parts of infrastructure.

- Maintain and/or restore ecological connectivity across infrastructure, allowing animal movement and providing safe crossing points areas of the infrastructure. This will reduce infrastructure barrier effect and help to restore ecosystems, particularly in ecological corridors connecting protected areas. Such actions will contribute to long-term persistence of wildlife populations and to climate change adaptation.

- Apply nature-based solutions to drainage systems, verges and other green areas maintenance helping to reduce the climate risk events, which cause negative impact for infrastructure but also to surrounding habitats and urbanised areas (e.g. floods, forest fires, or erosion).

- Implement early-awareness and control measures to prevent the spread of Invasive Alien Species (IAS), which may threaten native habitats and species, pose problems to infrastructure maintenance, and even increase health risks to people.

- Benefit species which provide essential ecosystem services and particularly, contribute to the recovery of pollinators by applying appropriate maintenance to green and blue areas associated to transport infrastructure.

- Reduce the use of pesticides and fertilizers and minimise noise and light pollution allowing to improve both, quality of habitats for wildlife and human health.

Gaps of knowledge and future research

- Effectiveness of some mitigation measures remains uncertain, limiting the replication of best practice. In some cases, this is due to lack of appropriate monitoring while in other occasions there is a need to disseminate the results obtained.

- Digitalisation of transport infrastructure offers an opportunity to improve the consideration of biodiversity along their life cycle. Innovative and effective ways to take advantage of this transformation to benefit biodiversity are needed.

- Increasing transport infrastructure resilience to climate-related hazards is a priority to the transport sector. Finding synergic solutions to achieve infrastructure resilience while enhancing biodiversity could improve the cost-effectiveness ratio of such measures.

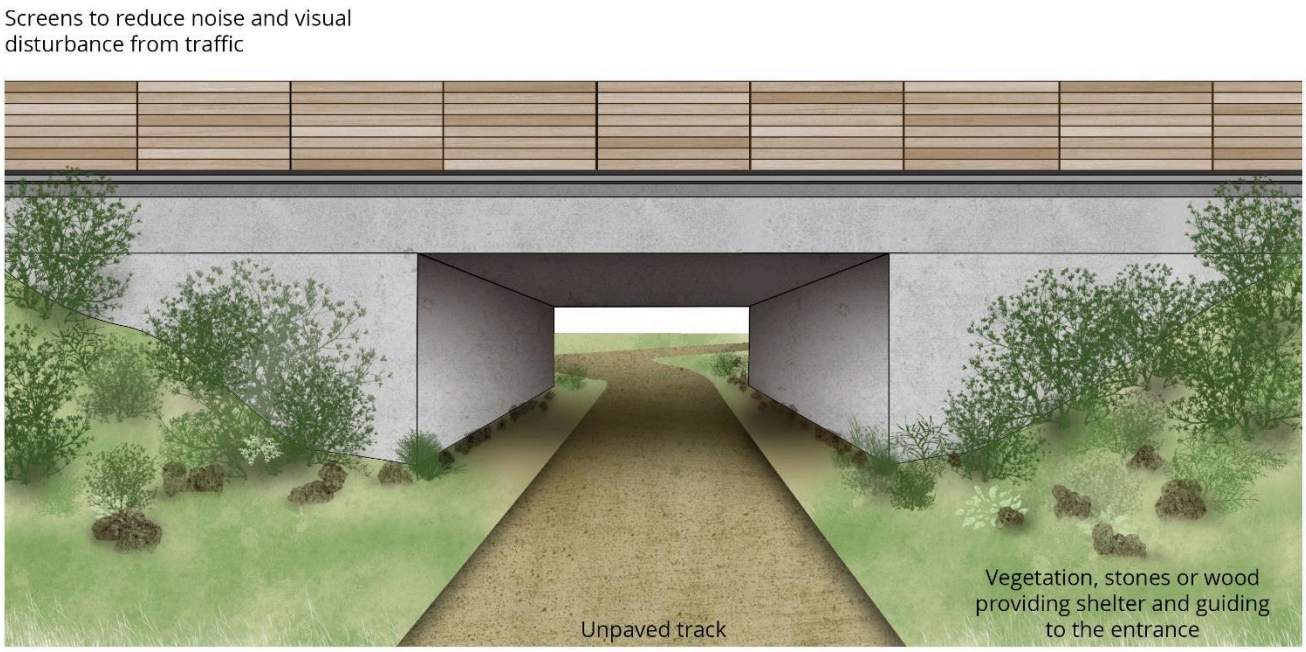

Figure 7. Image of a multiuse wildlife underpass showing how to adapt vegetation, substrate and screening to reduce disturbance from traffic and enhance the use of the structure by wildlife (Source: Rosell et al., 2023).

Chapter 6 – Evaluation and monitoring

Overview

Transport infrastructure projects generate diverse impacts on habitats and species (see Chapter 1 – Ecological effects of infrastructure). European legislation and country specific regulations, require an assessment of these impacts on local biodiversity, and the design and application of mitigation measures to manage those impacts. These measures include actions to avoid, reduce or compensate for the impacts of any new infrastructure, and for enlargement and adaptation of existing infrastructure (see Chapter 3 – The mitigation hierarchy). Monitoring and evaluation comprises the activities needed to understand whether these measures have been effective in reducing impacts on biodiversity, and if not, apply corrective measures and verify whether these are working or not.

Main messages

- Monitoring combines repeated observations and measurements taken over time, usually to assess the temporal change in a parameter either in response to a disturbance or intervention or to quantify the performance of a plan or project, measure, or action.

- Evaluation aims to critically assess, test, and measure the design, implementation and results of a plan or project, in relation to its objectives.

- Monitoring and evaluation have two main goals: i) assess the effectiveness of mitigation measures in reaching the goals for which they have been designed, and ii) measure the effects of the project on biodiversity conservation targets.

- Research studies are a type of monitoring and evaluation that go beyond usual practice by conducting more advanced studies to assess the correlations or causality of an intervention or exposure on a population. These can provide invaluable insights into not only on what works and does not but also on why which is fundamental to apply corrective actions efficiently.

- The monitoring plan should be designed, discussed, and approved within the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) process and will be different depending on the aim of monitoring. All monitoring plans should: establish a biodiversity baseline, define the monitoring parameters, delineate the monitoring area, identify habitats and species to be monitored, define a time frame as well as methods, schemes, and techniques to be used, and agree on the form and scope of the monitoring outputs.

- Planning and preparing an appropriate monitoring plan takes place at the end of the initial Strategic Planning phase and throughout the successive phases of the project, from design, construction, and operation phases to decommissioning.

- Establishing appropriate schemes, methods and techniques is fundamental to ensure comparability and replicability of monitoring activities.

Actions to take

- Define clear objectives for monitoring and evaluation identifying which biodiversity elements and mitigation measures are the focus of monitoring.
- Elaborate indicators, metrics, and tools to monitor the achievement of objectives.
- Design clear and robust methods and techniques to ensure results are replicable and reliable.
- Propose a sampling design and evaluate its feasibility within the available budget. If not feasible propose a new sampling design and/or method and re-evaluate feasibility.
- Collect a robust baseline on natural habitats and species in the study area before project construction.
- Follow clearly defined schemes, methods, and techniques to collect information in the study area about impacts on the biodiversity elements identified in the monitoring plan.
- Apply adaptive management principles by changing mitigation measures when monitoring shows that mitigation objectives are not being met.

Gaps of knowledge and future research

- There is little well documented available knowledge on the impacts of transport infrastructure on biodiversity over long term periods (more than 10 years after construction), especially on long-lived species demography and the genetic pool.
- More research is needed on eco-ethology, or behavioural ecology. This is the study of what behaviour an animal adopts to maximise its chances of survival and reproduction in a given environment. This discipline can link the pressures created by infrastructure with the chances of survival of an animal population which can be important for mitigation design and ecological restoration.
- Much progress has been made in recent years in modelling how the presence and distribution of species evolves over time. This modelling is most often based on machine learning with software capable of learning from sample data. However, further computer coding research is necessary to create efficient and robust algorithms.
- The use of new technologies such as DNA surveys, image processing, bioacoustics or automatization of data collection, among others, have a huge potential to improve the efficiency and reduce the costs of biodiversity monitoring and evaluation.
- The digital era brings a range of new techniques and approaches such as, for example, Building Information Modelling (BIM) or the use of sensors to manage risks of accidents, that can greatly improve the design of infrastructure and its subsequent monitoring and evaluation.

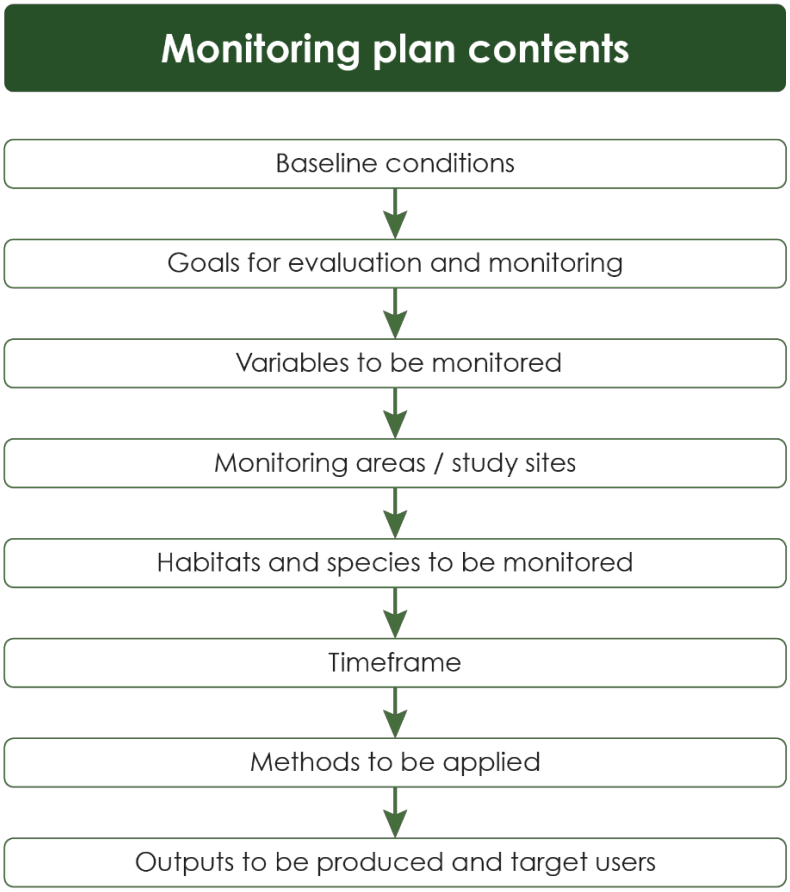

Figure 8. Contents to be included in the preparation of a monitoring plan. (Source: Guinard et al., 2023).

Chapter 7 – Maintenance

Overview

Developing appropriate maintenance of ecological assets to guarantee the long-term performance of wildlife mitigation measures and provide appropriate management of habitats related to transport infrastructure is critical achieving positive biodiversity outcomes. Maintenance activities should be designed to be adopted and implemented by linear infrastructure operators and managers with the objective of optimizing traffic safety while at the same time enhancing benefits for biodiversity and its advantages to society.

Main messages

- Ecological assets in transportation infrastructure comprise of all the elements aimed at reducing wildlife hazards including traffic safety, the mitigation of negative impacts on nature, and the enhancement of biodiversity in areas associated with transportation networks.

- Ecological assets can be divided into: i) Wildlife mitigation measures: aimed to reduce Animal-Vehicle Collisions (AVC) risk, preserve ecological connectivity, and reduce disturbances caused by traffic to adjacent ecosystems. Main elements included are wildlife fences and screens, wildlife crossings and wildlife warning signs; ii) Habitats related to transportation infrastructure (HTI) hosting wild flora and fauna. Main elements included are verges and other green areas, ponds, and other drainage elements (aquatic habitats).

- By undertaking appropriate maintenance of ecological assets, infrastructure operators optimize investment in traffic safety, which in turn contributes to enhanced benefits for biodiversity and human welfare.

- Neglecting maintenance aspects in infrastructure design and construction may compromise the functionality of ecological mitigation during the operation phase and increase hazards to traffic safety. It may also lead to damage to protected species and sites.

- Operation and maintenance contracts are key tools to guarantee good practice. A detailed description of ecological asset maintenance SMART objectives (Specific, Measurable, Achievable, Relevant and Time-bound), standards and Key Performance Indicators (KPI) along with inclusion of suitable ecological capability within the maintenance team are requirements that should significantly improve practice.

Actions to take

- Follow a PDCA (Plan-Do-Check-Act) approach to develop, implement, and improve maintenance strategies for ecological assets. Taking an adaptive approach in ecological asset maintenance is particularly important due to temporal variation in species and ecosystems and increasing extreme events related to climate change.

- Develop an ecological assets maintenance plan following these seven key phases: 1) Define elements to be maintained; 2) Compile and organize information; 3) Draft maintenance plan; 4) Apply a cooperative approach; 5) Train technical staff and field crews; 6) Monitor, evaluate and report performance; 7) Adapt maintenance according to monitoring and evaluation results.

- Maintenance practice for each ecological asset should be developed following the guidelines included in maintenance plans. This includes creating a detailed inventory of elements to be maintained, clearly scheduling inspection and maintenance tasks, setting standards to be met, establishing and applying procedures to manage conflicts or deviation from standards, carrying out training of maintenance staff, monitoring and evaluating results, and modifying the maintenance plan to apply corrective measures.

- Use maintenance tasks sheet to manage every ecological asset identified in the plan to make sure the right inspection tasks are undertaken, specific maintenance tasks are completed, and a the agreed schedule is being followed.

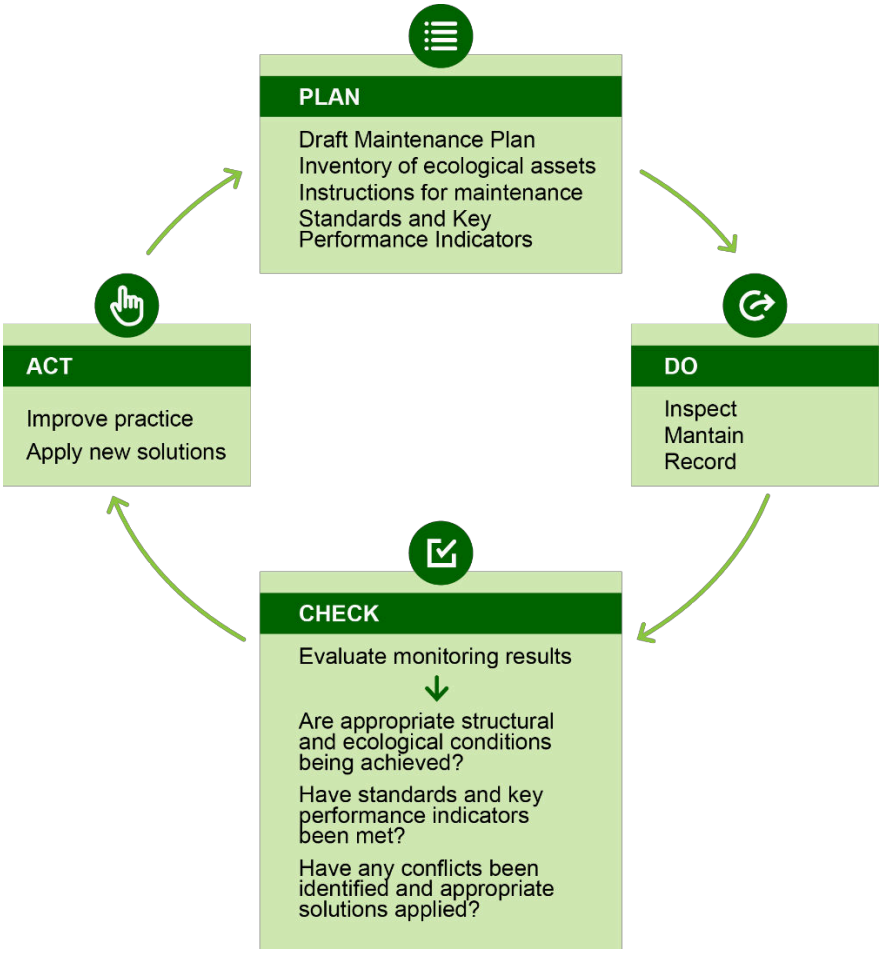

Figure 9. PDCA (Plan-Do-Check-Act) to be followed for the development of ecological asset maintenance during the operation phase. (Source: Rosell et al., 2023).

CONCLUSIONS

The publication 'Biodiversity and infrastructure. A handbook for action' compiles knowledge about how to mainstream nature and transportation updating and expanding the information included in the 'Wildlife and Traffic' handbook, published 20 years ago.

A website has been developed to allow an easy access and update of the guidelines and technical prescriptions provided in the handbook. It also provides a platform to include new innovative digital tools, upgrade contents and provide links to other knowledge platforms. The handbook provides a basis for promoting mutual understanding and cooperation of engineers and wildlife experts becoming a milestone in the field of infrastructure ecology in Europe. Like the BISON project itself, the online handbook is a step to break silos between professionals from infrastructure and ecology sectors, but also between the different profiles within each sector (e.g. decision-makers, researchers, practitioners).

The content included in the online handbook is based on decades of experience on transport ecology, but it also encourages the application of innovative technologies to go further in mainstreaming biodiversity and transport infrastructure, not only to mitigate impacts but also to achieve 'Net Gain' of biodiversity. Both traditional and innovative solutions need to be properly evaluated to ensure that the most effective measures, the best practices, are widespread and ineffective measures are avoided. The handbook is a living document which will allow to update the recommended technical prescriptions according to the most up to date technologies and information.

Furthermore, the development of a common 'Glossary' (including term from biodiversity and infrastructure) along with the compilation of national and regional guidelines from different countries, all in a single website platform, makes it an important knowledge hub for transport infrastructure ecology in Europe. Future upgrade and expand to include other types of infrastructure -particularly energy production- is planned to ensure that most appropriate solutions to mainstream biodiversity and infrastructure are applied all over Europe.

REFERENCES

Convention on Biological Diversity. (2022). Decision adopted by the Conference of the Parties to the Convention on Biological Diversity. 15/4. Kunming-Montreal Global biodiversity framework. (CBD/COP/DEC/15/4). 14 pp. https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf

European Commission. (2020). Communication 'EU Biodiversity Strategy for 2030' (COM/2020/380 final). https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52020DC0380

Guinard, E., Hlaváč, V., Moulherat, S., Pichard, O., & Teillagorry, M. (2023). Evaluation and monitoring. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Hlaváč, V., Georgiadis, L., & Moulherat, S. (2023). Policy, Strategy and Planning. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Iuell, B., Bekker, G.J., Cuperus, R., Dufek, J., Fry, G., Hick, C., Hlaváč, 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.

Moulherat, S., Boileau, J., Chapelier, G., & Favre, S. (2023). The Mitigation Hierarchy. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Rosell, C., Chrétien, L., Guinard, E., Nowicki, F., Righetti, A., Seiler, A., Trocmé, M., Fernández, L.M., Aliaga, A., Bartels, P., Böttcher, M., Deyrieux, O., Eicher, C., Elstrom, M., Figueras, A., Herold, M., Morand, A., Navàs, F., Paquier, F., Petrovan, S., Schwab, T., Suter, S., & Zumbach, S. (2023). Solutions to mitigate impacts and benefit nature. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Rosell, C., Seiler, A., Chrétien, L., Guinard, E., Hlaváč, 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. (Eds.). (2023). *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Rosell, C., Torrellas, M., Colomer, J., Reck, H., Navàs, F., & Bil, M. (2023). Maintenance. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

Seiler, A., Guinard, E., & Mot, R. (2023). Ecological effects of Infrastructure. In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and infrastructure. A handbook for action*. http://www.biodiversityinfrastructure.org/

United Nations Environment Programme (2020). *The United Nations Decade on Ecosystem Restoration: Strategy*. https://wedocs.unep.org/20.500.11822/31813.

ANNEX I

The following table includes the information collected of all projects identified with similar scope to the BISON Project.

Project name	Year/s	URL	Geographical level	Country or Region	Main goal and short description of the project
TADIL and DEITEL	2016	https://cordis.europa.eu/project/id/729775	National	Spain	TADIL is an ARTIFICIAL INTELLIGENCE software applied to the automatic development of tracings of linear infrastructures.
TRANSGREEN - Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature	2017-2019	http://www.interreg-danube.eu/approved-projects/transgreen/partners	European	Carpathians	Develop Guidelines on integrated transport infrastructure planning, construction, management and monitoring, taking into account aspects of road safety and biodiversity conservation.
CONNECTGREEN - Restoring and managing ecological corridors in mountains as the green infrastructure in the Danube basin	2018-2021	http://www.interreg-danube.eu/approved-projects/connectgreen	European	Carpathians	Increase the capacity of ecological corridors identification and management and to overcome the conflict between infrastructure development and wildlife conservation.
SAVEGREEN - Safeguarding the functionality of transnationally important ecological corridors in the Danube basin	2020-2022	http://www.interreg-danube.eu/approved-projects/savegreen	European	Carpathians	The project SaveGREEN aims to demonstrate ways of designing appropriate mitigation measures and maintaining or improving the functionality of ecological corridors through integrated planning.
HARMON – Harmonization of Green and Grey Infrastructure in Danube Region		http://green-web.eu/projects/harmon/	European	Central and Eastern Europe	The aim of the HARMON project was to produce a quick (due to constrains in time and budget) assessment of the state of play / status quo in harmonization of green and grey infrastructure in the Danube Region (with a focus on four countries – Austria, Bulgaria, Czech Republic and Romania) and, based on this, to propose a strategic action plan aiming to support development of future projects in this field of interest.
LIFE GREENCHANGE- Green infrastructures for increasing biodiversity in Agro Pontino and Maltese rural areas	2018-2022	http://lifegreenchange.eu/en	European	Italy, Malta	Implementing green infrastructures in pilot agricultural areas, by creating new core and buffer areas and ecological corridors between them

LIFE IGIC- Improvement of green infrastructure in agroecosystem: reconnecting natural areas by countering habitat fragmentation	2017-2024	http://lifeigic.eu/en	National	Greece	Develop a green infrastructure network in agro-ecosystems and to demonstrate its potential at regional, national, and EU level.
Using functional water & wetland ecosystems and their services as a model for improving green infrastructure and implementing PAF in Sweeden	2017-2025	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4817	National	Sweden	The long-term aim of the GRIP on LIFE IP project is to help fully implement the Prioritised Action Framework (PAF) for Natura 2000 in Sweden
LIFE ARCTOS/KASTORIA-Improving conditions of bear-human coexistence in Kastoria Prefecture, Greece - Transfer of best practice	2010-2015	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3235	National	Greece	Improve conservation status of brown bear
TRANSPORT & ENVIRONMENT	2017	http://www.transportenvironment.org	European	Europe	Campaigns to promote environmentally responsible approach to transport of all kinds
LIFE SOLAR HIGHWAYS-Solar panels as integrated constructive elements in highway noise barriers	2014-2020	http://www.rijkswaterstaat.nl	National	Netherlands	Construction of highway noise barriers with integrated bi-facial PV modules
ELIA Development of the beddings of the electricity transportation network as means of enhancing biodiversity	2011-2026	http://www.life-elia.eu/	National	Belgium	Demonstrate how powerline beddings can be used to enhance biodiversity
APOMARINA_SK: Conservation of *Aquila pomarina* in Slovakia	2011-2015	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3265 (project website does not work)	National	Slovakia	Conservation of *Aquila pomarina*. Installation of insulators on powerlines

AYBOTCON Conservation of *Botarus stellaris* and *Aythya nyroca* in SPA Medzibodrozie in Slovakia	2011-2018	http://medzibodrozie.vtaky.sk/	National	Slovakia	Conservation of *Botarus stellaris* and *Aythya nyroca*. Installation of markers on powerlines
Life Chiro Med Conservation and integrated management of two bat species in the French Mediterranean region.	2010-2014	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3087 (project website does not work)	National	France	Conservation of two bat species Experimentation of noisy layers on roads to prevent collisions
Marais de Rochefort - Preservation and restoration of the Rochefort marshes biological functions	2006-2010	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2715 (project website does not work)	National	France	Implement high-priority conservation measures for species and habitats of European importance. To reduce road mortality rates of the otter and the European mink, a survey of the road collision points was carried out. A network is now in place for road collision data to be centralised. A partnership was developed with road infrastructure services, which committed to neutralising the main collision points in the near future. However, no concrete action was foreseen during the LIFE project. Based on these works concrete actions to neutralise those main collision points with national funding will start in 2012.
HARMONICA - HARMOnised Noise Information for Citizens and Authorities	2011-2014	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3357	National	France	Development of a noise pollution measurement index
Reintroducción Lince Andalucia - Conservation and reintroduction of the Iberian lynx in Andalucia	2006-2012	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2736	National	Spain	Conservation of Iberian lynx Prevention of road kills: - fencing - creation of fauna passages - road side cleaning

S.HI.D.R.A. - Sustainable highway development in rural areas	2004-2007	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2440	National	Italy	Creation of vegetation barriers to prevent pollution of surroundings of roads
LIFE Marais - Conservation of the most remarkables habitats and species of the Poitevin Marshes	2004-2008	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2330	National	France	The objective of this LIFE Nature project was to improve the conservation status of the Marais de Poitevin Natura 2000 site, and of its species and habitats Creation of paths for otters to cross roads
AQUALUTRA - Conservation of otter population (*Lutra lutra*) in Goricko - phase 1	2004-2008	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2291 https://aquaviva.si/life-aqualutra	National	Slovenia	Otter conservation Creation of underpasses
LiRiLi - Living River Liesing - Demonstrative Ecological Reconstruction of a Heavily Modified Waterbody in an Urban Environment	2002-2006	https://webgate.ec.europa.eu/life/publicWebsite/project/details/1978	National	Austria	Living River Liesing - Demonstrative Ecological Reconstruction of a Heavily Modified Waterbody in an Urban Environment
Rohrschollen island - Restoration of the dynamics of Rhine alluvial habitats on Rohrschollen island	2010-2015	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3048	European	France, Germany	Restore alluvial dynamics of Rhine River
LIFE CONTRA *Alianthus*-Establishing control of invasive alien species *Ailanthus altissima* (tree of heaven) in Croatia	2020-2025	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5364	National	Croatia	Eradication of *Alianthus* in targeted Natura 2000 sites (30 Km of roads inspected and cleaned)
LIFE SAFE for VULTURES- First step to the restoration of the vulture in Sardinia	2021-2026	http://www.uniss.it	National	Italy	Conservation of griffon vulture (*Gyps fulvus*) over the entire island of Sardinia. Reduce the risk of collision with energy infrastrucuire and electrocution

LIFE RIPARIAS-Reaching Integrated and Prompt Action in Respons to Invasive Alien Species	2021-2026	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5334	National	Belgium	Develop an innovative evidence-based workflow for decision-making on IAS management
LIFE LYNXCONNECT-Creating a genetically and demographically functional Iberian Lynx (*Lynx pardinus*) metapopulation	2020-2025	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5324	National	Spain	Iberian Lynx conservation
LIFE AMPHICON-AMPHIbian CONservation and habitat restoration	2019-2026	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5156	European	Slovenia, Danmark, Germany	Conservation of different amphibian species. Construction of at least 60 amphibian tunnels and 10200 meters of permanent fences on four road sections
BG4US LIFE 2015-Bio Guardrail 4 your Safety LIFE 2015	2016-2022	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4506	National	Netherlands	Production of a price-competitive bio-based guardrail
LIFE LINES-Linear Infrastructure Networks with Ecological Solutions	2015-2021	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4283	National	Portugal	Evaluate and disseminate best practices to mitigate the effects of transport and energy infrastructures on wildlife
Vultures back to LIFE-Bright Future for Black Vulture in Bulgaria	2015-2022	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4254	European	Bulgaria, Germany, Netherlands, Spain	Promote the return of the Eurasian Black Vulture to Bulgaria. Isolation of around 170 of the most dangerous electricity pylons for the Eurasian black vultures
LIFE-SOUNDLESSS-New generation of eco-friendly asphalts with recycled materials and high durability and acoustic performance	2015-2019	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4185	National	Spain	Innovative noise-reducing asphalt

CLEAN-ROADS- CLEAN-ROADS: Addressing the environmental impact of salt use on the roads	2012-2016	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3673	National	Italy	Reduce the environmental problems related to the widespread use of de-icing/anti ice chemicals (mainly salt) for the winter road maintenance
LIFE OZON-Restoration of natural habitats for critically endangered species by defragmentation of the Sonian Forest	2013-2018	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3785	National	Belgium	Ecological connectivity of the Sonian Forest by constructing wildlife crossings and erect fences to impede the access of wild animals to roads and rail lines
Life/Amphibia/2012/PL-Amphibians protection on the Natura 2000 areas in north-eastern Poland	2013-2016	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3762	National	Poland	Conservation of key amphibian populations in Natura 2000 sites in north-eastern Poland. Technical solution (tunnels, fencing and protective grills)
LIFE STRADE-Demonstration of a system for the management and reduction of collisions between vehicles and wildlife	2013-2017	https://webgate.ec.europa.eu/life/publicWebsite/project/details/3666	National	Italy	Demonstration of a new system to prevent animal vehicle collisions
LIFE SAFE-CROSSING-Demonstration of Best Practices targeting priority species in SE Europe	2018-2023	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4979	European	Italy Greece Romania, Spain	Reduction of AVC; improve habitat connectivity, raising awareness of drivers. Implementation of the electronic system developed in the frame of LIFE STRADE; adaptation of already existing crossing structures.
LIFE IMPACTO CERO Development and demonstration of an anti-bird strike tubular screen for High Speed Rail lines	2013-2019	https://www.lifeimpacto0.com/index.php/ES/	European	Spain	Experimentation of installation of tubular screens along high speed train lines to prevent bird collisions

Building a waiting dock for Inland Navigation at Noordlandbridge	2021-2023	https://wayback.archive-it.org/12090/20221217005550/https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2019-be-tm-0087-w	National	Netherlands	Build a waiting dock for inland navigation to improve traffic organization. Also aims at the reduction of the impact on biodiversity. The main action concerns the building of a new waiting dock for inland navigation on the Scheldt-Rhine canal connection (east bank) in the neighbourhood of Noordlandbridge. This dock specifically provides waiting space for vessels carrying dangerous goods towards the Port of Antwerp, where there is a shortage for waiting space for inland navigation. Will also by build a spawning area which is connected to the Scheldt-Rhine Canal, a sand martin breeding place, and a sound retaining wall.
NEREIDAS	2013-2015	https://wayback.archive-it.org/12090/20221208122351/https://ec.europa.eu/inea/en/ten-t/ten-t-projects/projects-by-country/spain/2012-es-92177-s	National	Spain	The aim of NEREIDAS is to provide a standardization tool for preventive and compensatory measures for environmental damage caused by transport and port activities. The Action will aim to propose adequate solutions for the minimisation of CO2 emissions and the reduction of biodiversity in Mediterranean ports, as well as the minimisation of environmental impact of new infrastructure through the use of biological technologies, sensors and numerical methods. First, the constraints, difficulties and bottlenecks encountered by port authorities will be analysed and then, in the pilot phase it will be attempted to improve their situation through the use of biological technologies, sensors and numerical methods. The results of the pilot will then be evaluated and appropriate tools for standardisation will be suggested. If successful, the results of the project would, on the one hand, lead to a more environmentally sustainable port and on the other hand, pave the way for new investments in port infrastructure as the standardisation of environmental activities in port areas will facilitate the approval of port development plans.

EPIC ROADS - Ecology in Practice: improving infrastructure habitats along roads	2018-2021	https://www.nibio.no/en/projects/epic-roads-ecology-in-practice-improving-infrastructure-habitats-along-roads	National	Norway	The goal of the CEDR funded EpicRoads project is to provide a knowledge base and practical guidelines for the construction and maintenance of roadside habitats. The project wants to deliver a set of practical guidelines that will outline principles for defining objectives and targets for planning, construction and management of HTI (Habitats related to Transport Infrastructures). These guidelines will address processes from the landscape to the habitat and ecotone and will contain recommendations of how to increase connectivity, prioritise habitats and design ecotones to prevent ecological traps. A framework for classification of HTI that can be used for assigning proper packages of management activities to different groups of habitats will also be developed. In addition, we will generate scientific review papers, and a paper based on a modelling study on the impact of roadside characteristics on landscape connectivity for different organism groups. We also attempt a meta-analysis on the influence of HTIs on populations and species diversity.
Latest technology used to improve thousands of miles of lineside biodiversity	Up to 2021	https://www.networkrail.co.uk/news/latest-technology-used-to-improve-thousands-of-miles-of-lineside-biodiversity/	National	UK	A detailed national map of all the habitats found alongside the rail network, combined with millions of records of species, UKCEH has predicted what animals and plants are likely to be present in these lineside habitats including grasslands, heathlands and woodland. The UK Centre for Ecology & Hydrology (UKCEH) has used high-resolution imagery from satellites and aircraft to produce a detailed national map of all the habitats found alongside the rail network, which dates back almost 200 years. By combining this information with millions of records of species, UKCEH has predicted what animals and plants are likely to be present in these lineside habitats including grasslands, heathlands and woodland. This information will ensure Network Rail workers and contractors are aware of the possible presence of rare species when carrying out vegetation management, plus inform the company's conservation measures to increase biodiversity. It also provides a baseline for monitoring future trends in biodiversity.

BLUE GREEN CITY	2019-2022	https://www.interregeurope.eu/bluegreencity/	European	Ireland, Romania, Croatia, Germany, Sweden, Italy, France, UK	BLUE GREEN CITY seeks to improve policies that promote Green and Blue Infrastructure (GBI) as an integral part of a local or regional natural heritage preservation strategy. BLUE GREEN CITY will increase individual, organisational, stakeholder and external knowledge of the concept of ecosystem services and the value of GBI through project events, workshops and training. This will be done through interregional Policy learning process and collaboration in finding common solutions to common challenges posed by climate change adaptation and by sharing experience and exchanging good practices.
Securing the Conservation of biodiversity across Administrative Levels and spatial, temporal, and Ecological Scales - SCALES		http://www.scales-project.net/	European	Germany, Greece, UK, Czech Republic, France, Poland, Sweeden, Finland, Spain, Bulgaria, Estonia, Switzerland, Portugal, Australia, Slovenia, Lithuania, Norway, Hungary, Cyprus and Taiwan	The SCALES project will seek ways to build the issue of scale into policy and decision making and biodiversity management. The general objective of SCALES is to provide the most appropriate assessment tools and policy instruments to foster our capacity for biodiversity conservation across spatial and temporal scales and to disseminate them to a wide range of users. Assess and model the socio-economic driving forces and resulting environmental pressures (habitat loss and fragmentation, changing climate, disturbance) affecting European across scales. Develop and evaluate new methods for upscaling and downscaling to facilitate the provision of environmental, ecological, and socio-economic information at relevant and matching scales. Assess the effectiveness and efficiency of policy instruments and identify innovative policy instruments to address scale-related conservation problems; improve multilevel biodiversity governance; Evaluate the practical suitability and matching of methods and policy instruments to deliver effective European biodiversity conservation across scales, using networks of protected areas, regional connectivity, and monitoring of status and trend of biodiversity as a common testing ground; Disseminate the results to policy makers, biodiversity managers, scientists, and the general public.

Sustainable transportation in the Carpathians for the Benefit of People and Nature	2017-2019	https://www.interregeurope.eu/good-practices/sustainable-transportation-in-the-carpathians-for-the-benefit-of-people-and-nature	National	Romania	The main objective was to contribute to an environmentally-friendly and safer road and rail network in the Carpathians as part of the wider Danube river basin by integrating Green Infrastructure (GI) elements into TEN-T related transport infrastructure development at the local, national and transnational levels. Cooperation among stakeholders from transport, nature conservation and spatial planning sectors has been significantly improved. Conflicts between transport planning and GI were minimized by building trust between representatives of relevant sectors and involving them in the elaboration of different project outputs. The tools developed supported capacity building for future transport infrastructure planning. A scientific knowledge base for sound decision-making was created and consisted of a Planning Toolkit based on scientific research and experience handed over to policy makers, planners, and managers. It included among others the Guidelines on Wildlife and Traffic in the Carpathians, an EIA Training Package, and the Road-kill app.
Forest-Sax-Project	1999-2002	https://webgate.ec.europa.eu/life/publicWebsite/project/details/708	National	Finland	The scope of the project was to reduce the environmental effects of high voltage power lines. The environmental benefits of the CC (covered conductors) technique for power lines was to be demonstrated. Installation of covered conductors on 9,1 km powerlines, in order to narrow the line corridor from 46 to 11 meters, therefore enhancing connectivity and habitat suitability.
LIFE Living Streets	2016-2018	https://energy-cities.eu/project/life-living-streets/	European	Belgium, France, Croatia, Italy, Netherlands, UK	The Living Streets project aims to implement a system that enables inhabitants to temporarily transform their street into a sustainable place. One of the main strategic questions of this experiment is how we can organise citizens daily lives without using cars as much as we do today. By removing cars and finding other places for parking, new spaces become available and can be turned into places for community, interaction and support for example, playgrounds for children, picnic benches, pop-up bars, urban agriculture and business opportunities such as new ways of grocery shopping and electric car sharing.

SIMPYC - Environmental integration for ports and cities	2004-2008	https://webgate.ec.europa.eu/life/publicWebsite/project/details/2383	European	Spain, France, Italy	The SIMPYC project fostered good relations in areas of Port-City interaction thereby contributing to a more harmonious coexistence in socio-environmental terms. This was achieved by joint initiatives like the monitoring and tracking of noise and air pollution, and the environmental visual impact, as well as by raising awareness about the need to facilitate relations between citizens, municipal government and the port authority with regard to environmental matters.
LIFE-GREEN4GREY - Innovative design & development of multifunctional green & blue infrastructure in Flanders grey peri-urban landscapes	2014-2019	https://green4grey.be/en	National	Netherlands	This project aims to convert the scarce remaining open space fragments in a greying peri-urban context into ecological stepping stones with a multifunctional character. By upgrading and connecting natural and semi-natural landscape elements, such as pools, orchards, natural grassland and watercourses, the so-called green/blue infrastructure, an ecological framework will be developed throughout built-up areas.
Nature4Cities - Nature Based Solutions for re-naturing cities: knowledge diffusion and decision support platform through new collaborative models	2016-2021	https://cordis.europa.eu/project/id/730468	International	Spain, Luxembourg, France, Hungary, Turkey, Italy, Austria, UK, Netherlands,	Based on a detailed mapping of urban challenges and relevant nature-based solutions (NBS), Nature4Cities aims at developing complementary and interactive modules to engage urban stakeholders in a collective-learning process about re-naturing cities, develop and circulate new business, financial and governance models for NBS projects, as well as provide tools for the impacts assessment, valorisation and follow-up of NBS projects.
LIFE DINALP BEAR - Population level management and conservation of brown bears in northern Dinaric Mountains and the Alps	2014-2019	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4031	European	Croatia, Slovenia, Italy and Austria	Establish a more strategic population level approach to the conservation management and monitoring of brown bear populations in Slovenia, Croatia, Italy and Austria. Other key aims included decreasing human-bear conflicts and promoting better coexistence between bears and humans
LIFE WILDislands- Danube Wild Island Habitat Corridor	2021-2027	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5641	European	Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania	Improving the conservation of the priority EU Habitats Directive habitat type 91E0* along the entire course of the Danube

LIFE AMYBEAR- Improving Human-Bear Coexistence Conditions in Municipality of Amyntaio	2016-2020	https://webgate.ec.europa.eu/life/publicWebsite/project/details/4543	National	Greece (Region of Western Macedonia)	Improving conservation status of the local brown bear population
LIFE_UrbanGreeningPlans - Designing innovative mechanisms to plan, implement, strengthen and manage green infrastructures in (peri)urban areas	2021-2023	https://webgate.ec.europa.eu/life/publicWebsite/project/details/5447	European	Belgium, Italy, Portugal	The objectives of this LIFE Preparatory project focus on designing mechanisms to increase the presence of biodiversity in urban and peri-urban areas. The main goal is to enable local policy makers and greenspace managers to design and demonstrate innovative mechanisms to increase the overall presence of biodiversity in their territories.
LIFE-SEADETECT - Marine automated DETECTion and anti-collision system with cetaceans	2022-2026	https://webgate.ec.europa.eu/life/publicWebsite/project/details/101070722	National	France	LIFE-SEADETECT aims to halt the biodiversity loss due to shipstrikes with cetaceans - being the first non-natural threat to large cetaceans' lives - by implementing and developing new technologies. To considerably reduce this risk of collision, the SEADETECT project aims to develop two innovative systems that can ensure the detection of the cetaceans with a radius range of 1km in most of the weather conditions, day and night in real-time.
SAFELINES4BIRDS - Reducing bird mortality caused by power lines	2023-2028	https://webgate.ec.europa.eu/life/publicWebsite/project/details/101073826	European	France, Belgium and Portugal	SAFELINES4BIRDS' goal is to reduce non-natural mortality of 13 representative bird species by reducing the negative impact of their interactions with power lines. The aim is to ensure that high-risk power lines and dangerous poles and transmission towers are retrofitted using state-of-the-art and innovative technical standards for bird safety.
Concrete port infrastructure: the new climate adaptation and marine biodiversity solution	2021-2024	https://cordis.europa.eu/project/id/970972	International	Israel, Denmark, Spain	A solution for carbon-storing, ecologically-friendly, structurally superior concrete is needed and at scale to meet the standards of marine construction. The EU-funded Living Ports project will showcase the adoption of such a technology in maritime construction best practices. This infrastructure uses biomimicry to bring concrete to life, delivering unique benefits and cost savings.