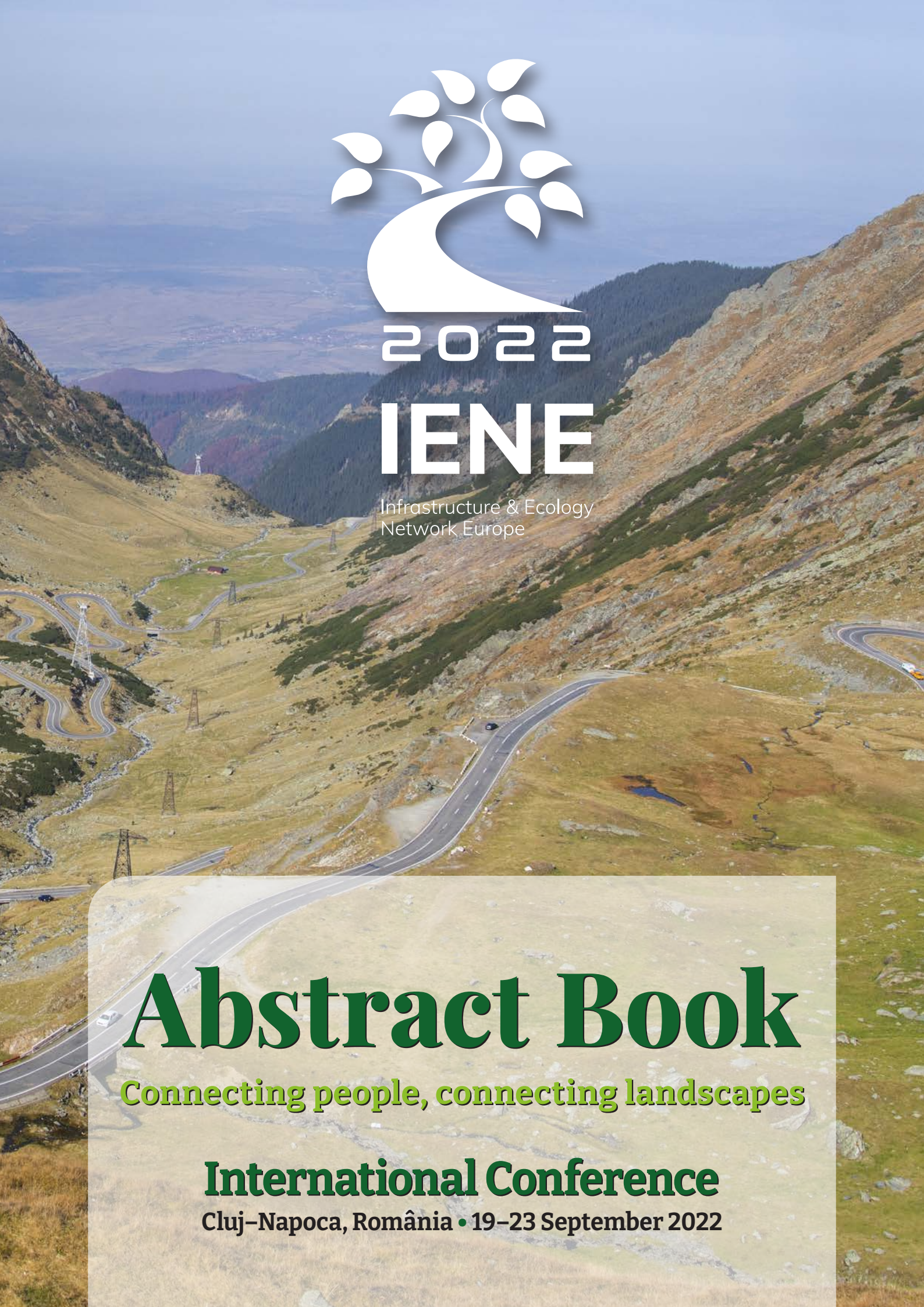

2022

IENE

Infrastructure & Ecology
Network Europe

Abstract Book

Connecting people, connecting landscapes

International Conference

Cluj–Napoca, România • 19–23 September 2022

IENE
Infrastructure & Ecology Network Europe

2022

Connecting people, connecting landscapes

Contents

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For more information about the IENE 2022 International Conference, please visit www.2022iene.info

For specific questions about the Conference, please contact us via e-mail:

- for programme matters: programme@2022iene.info
- for overall organisation matters: organisation@2022iene.info

For more information about IENE and the activities of the network, please visit www.iene.info

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The IENE 2022 International Conference "Connecting people, connecting landscapes" – Abstract Book, September 19–23, 2022, Cluj–Napoca, Romania

EDITORS: Gavril Marius Berchi, Darryl Jones, Radu Moț, Leon Muntean, Cristian-Remus Papp

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Welcome

The Organising and Programme Committees of the IENE 2022 International Conference have chosen the following motto for the Conference: ***"Connecting people, connecting landscapes"***, since connectivity is quintessential for both human society and natural systems.

Although in the past we mostly built transport infrastructure that became a barrier for wildlife movement, now we have the knowledge for developing sustainable, resilient and biodiversity-friendly transport networks. To put this into practice, we need to connect people and organisations across different sectors to collaborate in mainstreaming biodiversity into transport sector.

Transport sector (which includes infrastructure and energy networks) is a key sector for people and it is driven and influenced by a multitude of factors and has a tremendous and complex impact on natural environment. While important progress has been made to understand and to mitigate it, a lot more is needed for properly addressing this impact at landscape level and beyond.

Cooperation between stakeholders and specialists from different sectors as well as the support of the general public is crucial for developing functional and sustainable solutions.

We are inviting you to explore together during the 4 days of the Conference, and beyond, the current state of play, the gaps, needs and solutions, as well as to lookback for lessons learned and ahead for future challenges and opportunities:

- *from policies & financing to planning & environmental impact assessment;*
- *from design & implementation to operation, upgrading & decommissioning;*
- *from monitoring, research & learning to improving;*
- *from communication & awareness raising to efficient consultations & effective collaboration.*

We are looking forward to having you in-person in Cluj–Napoca, Romania, or on-line, and we are wishing you all an exciting and worthwhile experience!

The Organising and Programme Committees

The main theme of the IENE 2022 International Conference is:

AN INTEGRATED APPROACH FOR MAINSTREAMING BIODIVERSITY INTO TRANSPORT SECTOR (INCLUDING INFRASTRUCTURE AND ENERGY NETWORKS)

The themes and topics of the IENE 2022 International Conference are:

THEME #1: MAINSTREAMING BIODIVERSITY INTO TRANSPORT SECTOR (INCLUDING INFRASTRUCTURE AND ENERGY NETWORKS):

What is the state of play after 20+ years of transport ecology and what are the next strategic actions needed?

A general overview of the mainstreaming biodiversity into transport sector efforts *will provide the context for future strategic actions needed and will set the stage for the more in-depth discussions under themes no. 2 and 3.*

1.1. The state of play at European-level, including policies, strategies and funding mechanisms. (Similarities and differences between European countries; an overview of the existing support provided to biodiversity & transport harmonisation and what could be improved, etc.)

1.2. Regional needs specific to the South East Europe and Black Sea countries. (Challenges and solutions adapted to the rapid transport networks development, etc.)

1.3. Regional needs specific to the Western European countries. (Lessons learned: presentation of specific defragmentation programmes, etc.)

1.4. Strategic needs, challenges and opportunities for the future of biodiversity & transport harmonisation at European level.

THEME #2: PRACTICAL EXPERIENCES, CHALLENGES AND OPPORTUNITIES RELATED TO TRANSPORT ECOLOGY:

In practice, what works and what doesn't for harmonising transport and biodiversity?

We will discuss what we learned from transport ecology experience: *how we could identify good or bad practices, how to make best use of existing resources and how to adapt the available knowledge to the local context.*

Looking ahead, what are the key challenges and opportunities related to transport ecology?

2.1. What is a good practice? (Definition and criteria for good practices; what is missing or is still not sufficiently studied; needs for further applied research, etc.)

2.2. What has worked and not worked in the field of transport and biodiversity harmonisation? (The effectiveness of biodiversity & transport harmonisation solutions – from initial planning to learning and improving; evidences of lessons learned and how to use existing resources, including libraries and databases, etc.)

2.3. Harmonization of guidelines, standards and norms. (How to best use available guidelines, standards and norms, as well as scientific and grey literature, how to adapt them to different local contexts, etc.)

2.4. What are the key challenges and opportunities related to transport ecology? (From practical perspective, what are the most important challenges in implementing the principles of road ecology? What are the key opportunities, including in terms of development in road ecology? What are the future perspectives of this field?)

2.5. Applied research and studies in the field of transport ecology. (Presentation of findings, studies and research relevant for transport ecology, including different types of impacts, demonstration or innovative approaches, etc.)

2.6. Other topics.

THEME #3: INTEGRATED SOLUTIONS FOR ECOLOGICAL CONNECTIVITY:

As any complex problem, landscape connectivity requires multi-sectoral cooperation and therefore "breaking the silos".

We will address the goal of safeguarding *connectivity at landscape level* and the challenges and solutions for *cooperation between relevant sectors* (transports, nature protection, agriculture, forestry, water management, game management, tourism, spatial planning, etc.) for developing *integrated solutions*. We will discuss the need for transdisciplinary learning and the challenges of an *efficient communication*.

3.1. Multi-sectoral cooperation for integrated solutions. (Are there any relevant synergies? Examples of integrated planning and implementation; the role of formal and informal networks, etc.)

3.2. Communicating ecological connectivity. (How to improve awareness and knowledge exchange across a multitude of different target groups and stakeholders, etc.)

3.3. Improving stakeholder engagement and examples of concrete stakeholder actions towards maintaining landscape connectivity. (Challenges and solutions to advance from informing to collaborating and co-creating with stakeholders; joint strategies and partnerships for shared landscapes and visions, etc.)

3.4. Transdisciplinary approaches to landscape connectivity – the role of specific training and education. (Needs and possible solutions for creating future specialists; potential structure of an ideal tailor-made curricula, etc.)

3.5. Other topics.

The motto of the Conference: ***Connecting people, connecting landscapes.***

Connectivity is quintessential for both human society and natural systems. Although in the past we mostly built transport infrastructure that became a barrier for wildlife movement, now we have the knowledge how to develop sustainable, resilient and biodiversity-friendly transport networks. To put this into practice, we need to connect people and organisations across different sectors to collaborate in mainstreaming biodiversity into transport sector.

During the last 30 years, IENE has been developing as a powerful network of experts in transport ecology that became a formal organisation holding an impressive knowledgebase and a key entity to promote sustainable development of transport infrastructure in Europe.

Declaration of the IENE 2022 International Conference

Cluj–Napoca, Romania, 19–23 September 2022

We, the participants to the IENE 2022 International Conference in Cluj–Napoca, Romania, acknowledge that:

1. While the transport sector (including infrastructure and energy networks) is crucial to the development of human society, a diverse and functional natural environment is the prerequisite not only for our well-being but ultimately for our survival as a species.

2. The centuries of intensive transport development in Western Europe also taught us how detrimental for nature, and especially wildlife and the coherence of the ecosystems and landscapes, this infrastructure could become if it is designed, built or operated in an unsustainable way.

3. The transport sector is closely connected, directly or indirectly, to the five main direct drivers of biodiversity loss[1]:

   i. **Land- and sea-use change**, by irreversibly fragmenting habitats and populations and by increasing wildlife mortality risks and sealed soil, changing the structure and functionality of ecosystems and generating a cascade of changes at landscape levels;

   ii. **Direct exploitation of organisms**, by facilitating access to previously remote natural areas/roadless areas and overexploitation, of animals, plants and other organisms, mainly via gathering, logging, hunting and fishing;

   iii. **Climate change**, by increasing green-house gas emissions during the construction and use of the infrastructure;

   iv. **Pollution from all sources**, emitted during the construction and use of the infrastructure; and

   v. **Invasive alien species**, facilitating their introduction and spread.

As these drivers are reinforced by underlying causes such as the lack of consistency across sectoral policies, subsidies, and between regulations, there is a strong and urgent need for integrated sustainable approaches and an adequate and effective governance.

1 Brondizio, E.S., Settele, J., Díaz, S., Ngo, H.T. (eds) (2019) Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.3831673

4. Although during the past decades the concern about the impacts of the transport sector led to better approaches, adapted techniques and increased expertise on how to plan, build and operate sustainable transport networks, the past issues remained, making Western Europe one of the most fragmented landscapes worldwide, which has led to several countries responding by implementing vast and costly defragmentation programmes and plans.

5. In contrast with Western Europe, the Eastern part of the continent is rightfully demanding urgent extension and modernization of its transport infrastructure. At the same time, this area of Europe still holds unique natural and cultural values, productive landscapes and functional ecosystems as a result of predominantly extensive use of natural resources.

6. In the current political and socio-economic context, Eastern Europe and regions like the Balkans and the Black Sea are being presented with an unique possibility: to develop transport infrastructure that does not cause a devastating and costly fragmentation of nature, making the best use of existing knowledge accumulated over the last decades.

7. Moreover, Eastern Europe has the opportunity to become a reference region for overall sustainable development, especially in the critical context of climate change, water shortage, land degradation and biodiversity loss.

WE CALL FOR URGENT ACTIONS, FROM POLICY TO PRACTICE,

and invite the entities at all levels (local, national, European and international) governments, conventions, organisations, academia, institutions, businesses, transport planners, constructors and operators, networks, experts, funders, mass-media and civil society to foster cooperation, in order to:

1. Adopt sustainability in transportation development across the spectrum of human activities in the 21st century as essential under four basic pillars:

   i. The well-being of societies;

   ii. The resilience of healthy economies;

   iii. Environmental quality and safety and the link with effective biodiversity conservation;

   iv. Keeping the impacts of human activities on the environment reversible.

2. Recognize that safeguarding ecological connectivity is a key aim and a major challenge for the transport sector which needs to be addressed in spatial planning in collaboration with other sectors (i.e., other infrastructure, agriculture, forestry, tourism, hunting, water management, protected areas, etc.).

3. Include as a key objective for sustainability the avoidance of fragmentation of nature and landscapes in all developing activities, in accordance with relevant strategic policy documents and technical recommendations[2].

2
i. The Convention on Biological Diversity 2018 decision on mainstreaming biodiversity in developing sectors including transport.
ii. The Sustainable Development Goals include addressing biodiversity loss and securing ecological connectivity as essential drivers for sustainability.
iii. The United Nations plans for an active Restoration Decade through 2030.
iv. The EU Strategies for Biodiversity and Green Infrastructure.
v. The EU Green Deal and the implementation of Europe-wide Restoration Goals.
vi. The EC technical guidance on the application of "do no significant harm" under the Recovery and Resilience Facility Regulation, C(2021) 1054 final.
vii. The Carpathian Convention's initiatives on Sustainable Transportation, Biodiversity conservation and ecological connectivity.
viii. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) global assessment (2019) found that of the five pressures on biodiversity, the most important on terrestrial environments was land-use change, which may include deforestation, intensification in agricultural management, or habitat fragmentation.
ix. Experts from the Intergovernmental Panel on Climate Change (IPCC) and IPBES met in 2020 and concluded that none of the issues identified by these two platforms can be solved if they are not addressed together.

4. Adopt and implement the principles of the **IENE Global Strategy for Ecologically Sustainable Transport and other Linear Infrastructure**, namely:

   i. Create **a strong policy and legal framework** on safeguarding landscape connectivity as a primary concern for any project scale including regulatory requirements through standardization of tools, methods, etc.;

   ii. Begin with **strategic planning** with the implementation of "Avoidance – Mitigation – Compensation" mitigation hierarchy[3];

   iii. Follow an **ecosystem approach** based on the "Precautionary Principle"[4] respecting the value of natural capital and ecosystem functions and services;

   iv. Evaluate that **any case is an unique case.** Each project is site-and species-specific and therefore unique. Mitigation should be based on scientific and best available local knowledge without "copy paste" from other projects and cumulative impacts of other local projects should be taken in to account;

   v. Enhance **multi-disciplinary and cross-sectoral cooperation**;

   vi. Implement **the responsible polluter pays principle** not only from the pollution perspective, but also taking into consideration the impacts on biodiversity and ecological connectivity as well as ethical and transparency concerns;

   vii. Include **long life effective maintenance** and sufficient monitoring in all planning and budgeting of transport and other developing projects.

   viii. Create **climate change resilient infrastructure**;

   ix. Plan and manage **adaptable infrastructure habitats** to fulfill their potential as positive biodiversity refuges and ecological corridors;

   x. Establish **environmental supervision and monitoring** of the effectiveness of transport infrastructure features on wildlife permeability in all phases of programmes, plans and projects;

   xi. Promote a **culture of learning** to develop continuous evaluation and exchange of knowledge and experience.

5. Develop an urgent common framework of priority actions from policy to practical implementation of evidence-based solutions to mainstream biodiversity into a sustainable transport sector, such as:

   i. Support the appropriate political will for taking decisions based on criteria of the four pillars of sustainability and biodiversity conservation needs;

   ii. Think globally and implement policies locally while filling the gaps and overcoming barriers that have been highlighted by relevant transport & ecology projects (e.g., BISON, TRANSGREEN, ConnectGREEN, SaveGREEN, HARMON, among others);

   iii. Cooperate to enable the coexistence of ecological and transport corridors through the implementation of EU TEN-G, TEN-N and TEN-T Strategies while effectively sharing experience and know-how between countries and entities across Europe and globally;

3 See the Glossary of the Working Group on No Net Loss of Ecosystems and their Services: https://ec.europa.eu/environment/nature/biodiversity/nnl/index_en.htm

4 https://eur-lex.europa.eu/EN/legal-content/summary/the-precautionary-principle.html

iv. Develop cross-sectoral tools and management practices for effectively protecting the coherence of the ecological networks (e.g., NATURA 2000, Emerald) and the integrity of their component sites and of other protected areas (e.g., parks or reserves);

v. Proactively produce and use the scientific and practical knowledge to promote innovative and sound evidence-based sustainable solutions and make use of updated data bases, modern standards and innovative methodologies;

vi. Include in the necessary assessments (e.g., Strategic Environmental Assessments, Environmental Impact Assessments, Appropriate Assessments, Climate Change, or Water Framework Directive Assessments) independent scientific expertise and environmental supervision while involving the local society and the relevant stakeholders;

vii. Implement the appropriate measures to avoid, reduce and compensate the impacts on biodiversity, based on multidisciplinary cooperation between social scientists, environmentalists and engineers in order to achieve infrastructure sustainability, resilience and acceptability at landscape level.

Cluj–Napoca, Romania,
September 2022

Best Photo – Special award from the organisers

Life goes on

Carolin Berndt, Sweden

2022, July – Sweden, Grimsö (Lindesberg kommun)

A fox puppy was most likely killed by a collision with a car the night before this picture was taken. Two other fox puppies were checking their dead sibling and were playing close-by. Who knows if they realize that this was a dangerous place for a playground. Life goes on. Some survive, some die. But it is always more heartbreaking if it happens to the youngsters.

2022

IENE

Infrastructure & Ecology Network Europe

Plenary Keynote Speakers

PLENARY I: IENE, a key actor for the development and realisation of an ecologically sustainable linear infrastructure in Europe

Anders Sjölund

Anders Sjölund *has a Master of Science degree in zoological ecology and is an engineer. After 11 years in engineering at Ericsson, he has been involved for 31 years in biodiversity and nature conservation with regional and local authorities, mainly with the Swedish Road Administration and the Swedish Transport Administration.*

He also runs a small farm and forestry business where theory and practice meet in the field of biodiversity enhancement and renewable resource production.

Anders has been the chair of the Infrastructure and Ecology Network Europe (IENE) since 2009 and of the Transport4Nature initiative since 2021.

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Infrastructure and Ecology Network Europe (IENE) was established 1996 in connection with an EU financed project, COST 341, which aimed to compile the knowledge about the interaction between Roads and Ecology. The result was a Handbook Wildlife and Traffic that was launched 2003.

Since then, IENE has developed into a broad and comprehensive network of specialists, with an established general assembly (GA). The hub of the network consists of an executive secretariat and a Governance Board (GB), which execute tasks and missions according to decisions in the GA. Lately group of appointed scientists and experts (SEC) have been established to advise and support the GB in its work.

IENE provide an independent, international and interdisciplinary arena for the exchange and development of expert knowledge, and with the aim to promote a safe and ecologically sustainable pan-European transport infrastructure. IENE organises dedicated international conferences, workshops, training seminars and symposia, initiates collaboration projects and helps answering questions that require a joint international expertise.

The IENE vision is to be a key-actor in mainstreaming biodiversity in the sector of linear infrastructure, roads, railways, waterways, power lines, etc. Through the web based IENE handbook, any person working in this field can find the state-of-the-art, well-established and highest quality knowledge. Appointed experts responsible for different chapters will constantly update the handbook.

Through IENE any financer of researcher can get support to set up calls, to carry out research projects and programs, or to follow-up and check results and to implement and disseminate the findings.

Global, national and local conferences, workshops and seminars will be organised by IENE on its own initiative or on request of other clients. Events can be on site, on line or in a hybrid format.

IENE will be present in the society and be an obvious and natural partner to everyone involved in planning, designing, construction and maintenance of linear infrastructure.

PLENARY II: Biodiversity and infrastructure synergies and opportunities for European transport networks and beyond

Yannick Autret

*A geographer-urbanist by training, **Yannick Autret** holds a master's degree in planning, urbanism and spatial dynamics from the Sorbonne University, and works in the research and innovation department of the Ministry of Ecological Transition. He is a certified international expert in natural resource management, specialised in the environmental impacts of transport and energy, and manages the national research programme ITTECOP (Transport Infrastructure, Territories, Ecosystems and Landscapes – www.ittecop.fr).*

Yannick is the French representative to the OECD Joint Transport Research Centre and a member of the governance board of the European research network IENE (Infrastructure and Ecology Network Europe – http://www.iene.info). He is currently leading the H2020 BISON project (Biodiversity and Infrastructure, synergies and opportunities for European Transport Networks – https://bison-transport.eu), which brings together 16 countries and will set the future strategic research and innovation agenda on the subject at European level.

Yannick is a member of the sustainable infrastructure partnership – community of learners – UNEP (https://nicholasinstitute.duke.edu/sustainable-infrastructure-webinars).

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Carme Rosell

***Dr. Carme Rosell** is a senior research consultant who leads Minuartia and takes part in a research group at the University of Barcelona (UB). She has led many projects on mitigation of human-wildlife conflicts particularly focused on wild boar, animal-vehicle collisions, wildlife passages and practice to enhance biodiversity in transport infrastructure.*
Carme co-authored the European Handbook "Wildlife and Traffic", the "Handbook of Road Ecology", the "Technical prescriptions for wildlife crossing and fence design" and the "Guidelines for maintenance of ecological assets on transport linear infrastructure".

She participated in R&D projects such as the Action COST 341 Habitat Fragmentation due to Transportation Infrastructure, the CEDR project SAFEROAD Safe Roads for Wildlife and People, and currently, the HORIZON 2020 BISON on Biodiversity and Transport Infrastructure. She is also teaching for master's degree in Landscape Architecture at the Polytechnic University of Catalonia and Ecological Restoration at UB.

Carme is an elected member of the Infrastructure and Ecology Network Europe (IENE) Governance Board.

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PLENARY II: Biodiversity and infrastructure synergies and opportunities for European transport networks and beyond

Thierry Goger

Dr. Thierry Goger *is a senior executive in Transport Research and European Affairs. As the FEHRL Secretary-General – the association of the European National Road Research Centres –, Thierry is a strategist and an engaged facilitator of cooperative research and innovation, in the field of road and transport infrastructure.*

Thierry has also a solid experience in policy-briefing and research grant management, as well as in fostering the exploitation and implementation of research results. Prior to joining FEHRL, Thierry was the Science Officer for the Transport and Urban Development Domain at the COST Office – European Cooperation in Science and Technology. His expertise and advocacy skills are regularly demanded by the industry, policy-makers and transport authorities.

On the research front, Thierry has about 20 years of experience and is a Coordinator or Partner of several European projects.

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A “tsunami of infrastructure” were the words that Bill Lawrence used at the IENE 2016 in Lyon. In fact, nearly 60% of the infrastructure that will exist in 2060 has not yet been built. Most of it will be built in developing countries with huge investments that could cumulate to more than 94 trillion dollars by 2040.

The impact of infrastructure on biodiversity has been known for several decades and is a certainty. However, the initiatives and knowledge developed to mitigate its impact are scattered and are not, or only partially integrated into an insufficiently advanced strategic reflection. In fact, in order to achieve this objective, it is necessary to break out of the usual frameworks of reflection and to create new inter-disciplinary paradigms to respond to the issues at stake.

Being aware of these challenges, the UN, the G7, the G20, the OECD and the international investment banks are beginning to try to reconcile economic development with environmental protection or restoration. Europe plays an essential role in this objective. Its vast professional network, the expertise at its disposal and the willingness of its governments to try to reduce both climate change and the decline of biodiversity are essential ingredients. At the heart of this nexus, the BISON project, an intense cooperation initiative between administrations, research centres, companies and NGOs, aims to open the way to new synergies that will bring ambitions and hopes both for our continent and most certainly beyond.

PLENARY III: Harnessing the power of evidence to improve transport ecology

Silviu Petrovan

Since 2016, ***Dr. Silviu Petrovan*** *has been working at the University of Cambridge, focusing on evidence-based conservation, expert assessments and decision making in biodiversity conservation and biological risk.*

He is a Senior Research Associate and has published over 50 peer-reviewed papers and several book chapters, largely focusing on understanding the effects of anthropogenic changes on biodiversity and improving evidence-based solutions for counteracting negative effects at population or landscape scale.

Silviu has authored several papers on road ecology and road mitigation with a focus on small vertebrates and how to improve the quality of data monitoring, including with technological innovations and citizen science and how to assess the effectiveness of mitigation systems. The 2016 paper on the national-scale decline of common amphibian species in the UK and Switzerland used multi-decade citizen science data collection on roads to understand and document population trends and has since then become an important biodiversity monitoring tool in other countries.

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To maximise implementation success important management decisions should ideally be based on effectiveness as demonstrated by scientific testing or systematic review of evidence. However, experts commonly offer recommendations for management actions or mitigation which can be based entirely on individual experience or opinion and guidelines are often a mix of the two without clear separations.

Transport ecology and infrastructure mitigation are relatively new fields, but the scale of the problem is now enormous and with new data fast becoming available there is a clear need for evidence-based approaches. Such approaches have transformed fields including medicine and can visibly support improved decision making by providing unbiased information and directing data gathering that can in turn feedback on priority questions.

We argue that rapid progress could be made by adopting transparent evidence checking and embedding, including in guidance co-production with practitioners, as well as prioritisation of topics for testing. However, evidence is often messy and rarely provides a simple answer saying this is what you should do; translating it into something that informs decision making needs to consider a variety of other factors.

Silviu will discuss specific challenges – such as local relevance and adaptation to local conditions as well as ongoing issues with weak study designs and geographic biases. Collating and integrating evidence improves retention of institutional knowledge while embedding processes that capture the information used to guide decision making minimises the risk of knowledge erosion or loss and facilitates learning. Even when recommendations must be made in the absence of satisfactory information, making this process transparent can highlight the need for further evidence. It can also ensure that only efficient actions are put in place, maximising conservation benefits that can be achieved from a set budget.

The mature phase of transport ecology needs strategic generation and embedding of the evidence, improved expert elicitation, structured decision making that integrates local context and the robust embedding of experiments into practice, management plans, guidance and policies.

PLENARY IV: Developing practical solutions and tools for maintaining ecological connectivity

Irene Lucius

Irene Lucius *is the Regional Conservation Director of WWF Central and Eastern Europe. Holding a master's degree in biology, she managed projects in the field of environmental communication, integrated coastal zone management, policy advocacy and nature conservation in countries across the European continent and beyond before joining WWF in 2008.*

Today, Irene's responsibilities include coordinating WWF's conservation work in the Green Heart of Europe – countries in Central and Eastern Europe. The focus is on conserving and restoring the natural values of the region's forests, rivers and wetlands, protecting sturgeons and large carnivores, and promoting good governance and green economy approaches.

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Maintaining ecological connectivity is a complex task that requires the active participation of various stakeholders from all relevant fields of activity such as: nature conservation, hunting, agriculture, forestry, water management, etc.

To maximise and achieve long-term results, a genuine co-creation process has to be initiated with these stakeholders. This is the approach that WWF CEE started over a decade ago through some of its flagship projects concerning ecological connectivity, e.g.: Bioregio, TRANSGREEN, ConnectGREEN, SaveGREEN.

Various tools and solutions have been jointly developed with the stakeholders, thanks to all these projects, varying from practical guidelines on identifying corridors to interactive GIS maps and strategic documents endorsed by the parties to the Carpathian Convention. The SaveGREEN project is capitalising on these key results and fosters transdisciplinary and a joint venture to safeguard ecological connectivity and biodiversity in the Carpathians.

Best Photo – “Networking and cooperation” Category

Working on verges for pollinators

Lazaros Georgiadis, Greece

2022, June – Sweden, Malmö–Kivik road

Photo of a visit on a verges for pollinators monitoring project on the road from Malmo to Kivik while going for the physical meeting of the IENE Governance Board in Sweden, on June 2022.

2022

IENE

Infrastructure & Ecology
Network Europe

Full Presentations

IENE Infrastructure & Ecology Network Europe 2022

Emerging trends and future challenges for mainstreaming biodiversity in the transport sector

Andreas Seiler[1], Olivier Pichard[2], Sylvain Moulherat[3], Manon Teillagorry[4], Marine Pasturel[3], Fanny Benard[4], Chloé Desplechin[5], Sophie Menard[5], Miriam Herold[6], Pia Bartels[6], Jörgen Wissman[7]

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The future could be brighter! If business as usual is to prevail, we are likely facing a world with twice as much road and rail infrastructure in 2050 than in 2010, populated by over two billion personal vehicles, with significantly deteriorated living conditions, a lack of natural resources and failing ecosystem services, in an uncontrollably changing climate. But there is still a chance to avoid such a scenario and to create a more sustainable, equitable, cleaner and energy efficient transport system that helps protecting biodiversity and human values alike.

This presentation summarises report D3.4 within the European BISON project on biodiversity mainstreaming in the transport sector. The report discusses emerging trends, challenges and opportunities related to transportation, technology, climate, natural and human environment. These trends, each addressed in separate chapters and by different authors, refer to technological advancements, nature based solutions, invasive species, climate change adaptation, and cumulative effects, socio-psychological and economic-demographic factors and their influence on transport and biodiversity. The chapters are based on broad literature research involving scientific and non-scientific publications, websites, blogs and governmental communications.

The transport sector is currently undergoing fundamental changes that can have far reaching repercussions humans and nature. These changes are enabled by recent advances in vehicle, energy and communication technologies (chapter 1), but are primarily triggered by the apparent need to mitigate and adapt to climate change (chapter 2). Sustained biodiversity is neither a driving force behind these changes nor their goal, but rather a potential side effect. Nevertheless, these changes offer many opportunities to create and protect biodiversity and human values. Tools are available to deal with long-term cumulative effects on nature and society (chapter 5), to employ nature based solutions for integrating infrastructure in ecosystem services (chapter 4), and to control biological consequences of climate change such as the spread of invasive species (chapter 3). However, to accomplish this change, we may need a stronger governance and more ambitious, aligned policies, and cross-sector collaboration. It also needs new regulatory frameworks, economic incentives and support (chapter 7) and a swift implementation of mitigation measures. There is urgency in choosing the right path, but the decision requires both insight and acceptance at the very individual and personal level (chapter 6). The general public as well as stakeholders and political leaders must be willing to change attitude and behavior and it is probably here where the greatest obstacles still reside.

In essence, the key actions that can break the historic trend and lead toward a sustainable transport sector must hence be broad and comprehensive: i) reducing the demand for (unnecessary) mobility and instead aim for increased accessibility of resources, ii) including non-transport related and non-monetary values in a holistic long-term planning that favours both people and biodiversity, and iii) internalising external long-term and cumulative costs of transportation for society and environment (e.g., polluter-pays principle).

Keywords: Biodiversity, Infrastructure, Future transport, Electrification, Cumulative impacts, Invasive species, Climate change, Holistic.

Mainstreaming biodiversity in transport infrastructure management thanks to sensor-based data collection: future trends according to the BISON project

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Europe needs to adapt its existing infrastructure to new climatic conditions (floods, droughts, etc.), as well as finding innovative and sustainable solutions to reduce their impacts, such as ecosystem fragmentation. Simultaneously, the sharp rise in the development of new transport infrastructure must support economic development while paying attention to the local biodiversity. Faced with these needs, for the first time the European Union funds a 3M€ CSA on the topic of transport and biodiversity issues. As part of the last calls under H2020, the BISON project is timely to set the ground and upscale research on these topics in the next European research framework programme 2021–2027 (HORIZON EUROPE). In this context we explore common opportunities for both sectors offered by the development of digital technologies.

During the last decades, digitalisation of data and interactive processes underpinning current practices of infrastructure and biodiversity management and their respective representation have taken different tracks leading to the development of specific knowledge (data standardisation, representation mode, management processes, etc.). This knowledge now has to be mainstreamed in order to render transport infrastructure sustainable, reducing negative impact on biodiversity and enhancing synergies to achieve biodiversity net gain. In this work, we intent to point out the main digital technologies which use tends to emerge in order to manage transport infrastructures as well as biodiversity assets. In this respect, we tried to identify their main future trends in terms of new technologies or changes in their use. As much as possible, these discussions are turned, not only toward the benefits for the transport infrastructure sector or the biodiversity one, but rather are focused on the opportunities offered by the mainstreaming of biodiversity issues along the infrastructure life-cycle management.

In this presentation, we focus on the sensor-based data collection and associated artificial intelligence development and associated data management requirements. Sensors can be embedded in vehicles to record data along their trajectory (satellites, common vehicles, drones, etc.) permitting for large-scale recording or doing so in hardly accessible places. Sensors can also be static and monitor the infrastructure or the biodiversity asset they have been deployed for. These sensors are thus expected to be connected and part of the Internet of Things (IoT) to operate as a network. Such a functioning offers the opportunity for long-term continuous monitoring of the transport infrastructure and its environmental assets. We then show how artificial intelligence (AI) techniques implementation tends to exacerbate the benefits of sensor-based data collection. However, optimizing the expected benefits of sensor-based data associated with AI strongly depends on standardisation and normalisations. We then show that transferring knowledge and know-how from the BIM sector, especially concerning processes, constitute a large field of research, development and innovation to address the data interoperability issue.

We conclude that both biodiversity and transport sectors use these tools and data for specific purposes which can often be mutualised offering opportunities for cost-efficient improvement of transport infrastructure and biodiversity management.

Keywords: Data collection, Data management, Artificial Intelligence, Digitalisation, Emerging trends.

Mainstreaming biodiversity in transport infrastructure management in the digital model: the GIS, BIM, Digital Twin continuum for biodiversity data management and representation

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Europe needs to adapt its existing infrastructure to new climatic conditions (floods, droughts, etc.), as well as finding innovative and sustainable solutions to reduce their impacts such as ecosystem fragmentation. Simultaneously, the sharp rise in the development of new transport infrastructure, must support economic development while paying attention to the local biodiversity. Faced with these needs, for the first time the European Union funds a 3M€ CSA on the topic of transport and biodiversity issues. As part of the last calls under H2020, the BISON project is timely to set the ground and upscale research on these topics in the next European Research Framework Programme 2021–2027 (HORIZON EUROPE). In this context we tried to explore common opportunities for both sectors offered by the development of digital technologies.

Indeed, during the last decades, digitalisation of data and interactive processes underpinning current practices of infrastructure and biodiversity management and their respective representation have taken different tracks leading to the development of specific knowledge (data standardisation, representation mode, management processes, etc.). This knowledge now has to be mainstreamed in order to render transport infrastructure sustainable, reducing negative impact on biodiversity and enhancing synergies to achieve biodiversity net gain. In this work, we intend to point out the main digital technologies which use tends to emerge in order to manage transport infrastructures as well as biodiversity. In this respect, we tried to identify their main future trends in terms of new technologies or changes in their use. As much as possible, these discussions are not turned only toward the benefits for the transport infrastructure sector or the biodiversity one but rather are focused on the opportunities offered by the mainstreaming of biodiversity issues along the infrastructure life-cycle management.

This presentation focuses on the expected development of tools allowing for the biodiversity data management and representation along the GIS, BIM and Digital Twin continuum. We address the opportunities of developing a practitioner's community by the collaboration between the biodiversity management, the transport infrastructure management and the computer science communities. Finally emerging expected practices offered by the development of inclusive GIS/BIM/DT for biodiversity and transport infrastructure are explored. Some of these are the integration of biodiversity in the life-cycle assessment of transport infrastructure, the development of virtual and enhanced reality for infrastructure management and the relation with citizens or regulating administration, among others. Such an integrative continuum would otherwise require massive research, development, innovation and capacity building as it constitutes a new activity sector at the crossroad between civil engineering, ecology and computer science.

Keywords: BIM, Digital Twin, Data management, Collaborative work, Process innovation, Project management, Biodiversity.

Mitigating barrier impacts of transport infrastructure in Sweden – a permeability approach

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The rate of landscape change is ever increasing, and although sparsely populated, Sweden is facing severe fragmentation from roads and railroads. Sweden is also home to large ungulates such as moose and the semi-domesticated reindeer that have large home-ranges. The transport infrastructure causes some 60,000–80,000 accidents with larger wildlife every year. To mitigate road mortality, many roads have been provided with wildlife fencing. Increasing traffic volumes and added fencing continues to make the barrier impacts stronger and more widespread.

Many countries in Europe and around the world have analyzed their green infrastructure and created defragmentation programs. Most of those programs start with the identification of the remaining woodlands and other suitable habitat for migration and dispersal. Where roads and railroads cross the green infrastructure there is a need for mitigation measures. In Sweden, the STA (Swedish Transport Administration) started at the other end. With a new, GIS-based, barrier analysis the grey infrastructure and its impact on ungulates was quantified.

Several steps were used to analyze infrastructure barriers:

- Identification of infrastructure barriers – Factors included traffic volume, wildlife fencing, speed limit, presence of railings, etc.;
- Identification of existing bridges that may serve as crossing points for fauna – The theoretical level of function of existing passages for the target species were classified based on the main function, traffic volume, height, width and other factors;
- Quantification of remaining barriers – Sections of infrastructure where existing bridges do not resolve barrier impacts.

The result is useful on many levels, from national planning to local prioritizing of measures. At the Government level, STA presents the output to quantify the barrier impact on ungulates. The government then defines a target for defragmentation and allocates funding for defragmentation measures. At the national level, STA uses the barrier analysis to set regulatory goals and distribute funding for mitigation measures to the regional level. Through regular updates of the barrier analysis, STA also monitors the progress towards the set target. At the regional level specific sections of infrastructure are prioritized for measures using the theoretical degree of barrier impact together with wildlife accident maps and consideration of the green infrastructure. At the local scale, suitable mitigation measures are proposed at the prioritized sections. In this step the addition of new fauna passages and/or modification of existing conventional passages are considered and the best mix of these is chosen.

Considering both the permeability of infrastructure and the network of green infrastructure makes for a stronger and more robust prioritization of limited funding. Using the described method, STA monitors an effective goal-oriented target process and at the same time reports the progress made in limiting barrier impacts and wildlife-vehicle accidents.

Keywords: Geospatial analysis, Transport infrastructure, Roads, Railways, Barrier impacts, Permeability, Mitigation, Defragmentation.

IENE Infrastructure & Ecology Network Europe 2022

A Strategy and Actions for Biodiversity Conservation on European Railways

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Railways are the most sustainable form of transporting people and freight. The use of the rail network is predicted to increase significantly as the focus shifts toward achieving a net-zero carbon transport system. However, the operation and future growth of the rail infrastructure must not be at the expense of the environment and biodiversity. As part of the REVERSE project, the International Union of Railways (UIC) worked with its members and the UK Centre of Ecology & Hydrology to formulate a collective vision for protecting and enhancing biodiversity across the European (EU) rail network. Central to achieving this vision is a set of 13 key strategic goals and actions for biodiversity on railways. The report recommends that railway companies adopt these in order embed conservation and enhancement of biodiversity at every level of their business alongside safety, performance and sustainability. This will require putting in place specialist skills and competencies in ecology to fully understand and effectively manage these biodiversity assets. An audit of protected areas and rare species associated with the European rail network demonstrated the positive role railways can have in conserving biodiversity, and the importance of ensuring this is recognised by national and EU conservation policies. It is vitally important that companies limit the negative impacts of railway development by following the principles of avoiding, minimising, restoring and off-setting impacts on biodiversity. Similarly, rail companies should employ innovative approaches to managing biodiversity assets on the lineside. This best practice guidance should be published and shared with other rail companies to improve their effectiveness. It is important for rail companies to work collectively with neighbours and other stakeholders (e.g., WWF) to deliver landscape-scale benefits by connecting habitats together and creating wildlife corridors. The report recommends that companies set ambitious targets for conserving and enhancing lineside wildlife habitats, and biodiversity associated with the railway. Progress towards these targets should be monitored using consistent and repeatable approaches, where possible adopting the latest advances in digital surveillance technology, and ensuring the data can be readily integrated and shared. Rail companies should openly report the outcomes for biodiversity with internal and external stakeholders, including employees, passengers, neighbours and society. This article will outline how railways can transform and develop to play a leading and positive role in protecting and enhancing biodiversity across European landscapes as set out in the UIC 2030 vision.

Keywords: Landscape connectivity, Mitigation hierarchy, Habitat restoration, Integrated monitoring, Partnership working.

Development of a strategic research agenda for biodiversity-friendly transport infrastructures in Europe

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Through topic MG–2–10–2020, the call 2018–2020 Mobility for Growth was the first one issued by the European Commission on the topic of transport that directly integrates biodiversity issues. The Coordination and Support Action BISON (Biodiversity and Infrastructure Synergies and Opportunities for European Transport Networks, 2021–2023) was selected in response to this call. It counts 44 organisations from 16 countries, representing of all types of stakeholders.

One of the major objectives of the CSA BISON is to identify research and innovation needs for a better integration of biodiversity with transport infrastructure planning, design, construction, adapting, operating and decommissioning. In this view, the projects aims to develop a Strategic Research and Deployment Agenda (SRDA) which can be implemented at multiple scales, within the EU research framework programme or by other regional, national or local programmes.

The SRDA aims to define the vision, overall goals, main priorities, investment areas and a research and deployment roadmap for all types of European stakeholders. In the BISON work plan, a specific task is dedicated to elaborate the research side of the SRDA. The methodology used to elaborate the so-called strategic research agenda (SRA) for more biodiversity-friendly transport infrastructures in Europe follows a three step-approach: first, collection of expectations and proposals from the diverse types of stakeholders; second, analysis and classification of identified research issues; third, prioritisation of research actions according to their environmental importance and the gap with the current knowledge. In order to build a relevant and realistic SRA, it is most important to take into account points of view of all types of stakeholders (operators, authorities, agencies, associations, consultancy, research, etc.) as fundamental inputs, as well as for the agreement on the research agenda (endorsement of necessary actions and their prioritisation).

Inputs from stakeholders have been collected on one hand from an online consultation opened to volunteer individuals and institutions (47 contributions from 15 countries), and on the other hand from a survey of 80 documents published by stakeholder national, European and international representative organisations in the last decade. This resulted in 325 expectations and 314 proposals being expressed, more or less in line with the topic and addressing one to seven types of transport infrastructures (roads, railways, waterways, power lines, pipelines, airports, and harbours).

Each input of this census was then processed through a cross-sectoral analysis thanks to the diversity of expertise of 12 partners involved in this task (ecology, spatial planning, environmental sciences, engineering, social psychology, etc.). This process resulted in 718 potential issues for research (PIR) being identified, addressing under various angles the different infrastructure life stages from planning to decommissioning.

In the last step, the selection and merging of similar research PIR leads to the formulation of a coherent set of a hundred of complementary needed research actions. They are bound to 18 structuring themes highlighted by the process itself. Then, the recommended time horizon (5, 10, 20 years) for the completion of these research actions is set, before consolidation of the agenda through final consultation of stakeholders (fall 2022).

Keywords: Bottom-up, Cross-analysis, Expectation, Innovation, Knowledge, Methodology, Need, Proposal, Roadmap, Stakeholder.

Improving best-practice mitigation on road projects while meeting conditions of approval – a scientifically robust experiment to test the effectiveness of hollow-replacement strategies

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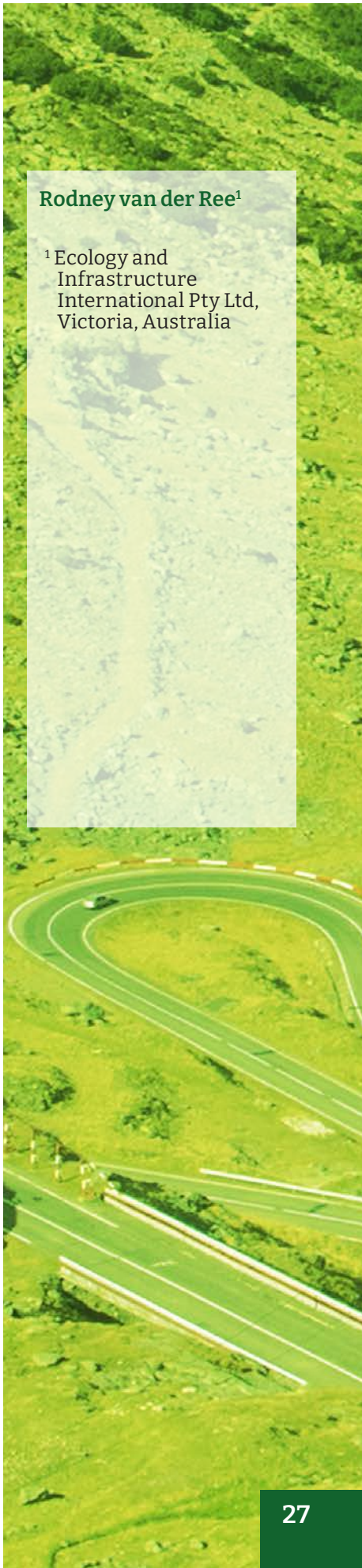

The loss of habitat remains one of the greatest threats to the conservation of biodiversity globally. Many transport projects around the world involve the clearing of vegetation that wildlife use for food, shelter or movement. Unfortunately, the most effective approach to restore or compensate for habitat loss is sometimes uncertain and we are at risk of recommending strategies and plans that do not deliver the outcomes required. In these situations, projects should test the effectiveness of current best-practice while at the same time developing new and innovative techniques that improve best-practice and set new standards.

The Echuca-Moama Bridge project in south-eastern Australia involved the clearing of thousands of trees, including 158 large trees with hollows. The project area supports several threatened species, including the Squirrel Glider *Petaurus norfolcensis* and woodland birds, as well as dozens of common species that all rely on tree hollows for shelter and raising of young. Once tree loss has been minimised as far as possible, the standard approach to mitigate the removal of tree hollows in the past has been to install ply-wood nest boxes in nearby trees. However, recent studies have shown wooden nest boxes are colder in winter and hotter in summer than natural tree hollows, placing significant thermal stress on animals using the boxes. In addition, nest boxes have high rates of decay and collapse, resulting in a net loss of tree hollows. In this project, we collaborated with Major Road Projects Victoria to test new approaches to replacing hollows while achieving the approval conditions of the project.

The project has a scientifically robust experimental study design with four types of hollows installed in clusters, allowing strong inference to be drawn on the cost and effectiveness of each approach. Each cluster is comprised of one installed ply-wood nest box, one installed salvaged log hollow and one hollow carved into a standing tree with a chainsaw, as well as an existing natural hollow, selected to provide an important baseline comparison. Each hollow is installed on a different tree, and all hollows within a cluster are ~25 m apart, and each cluster is ~100 m apart. There are a total of 158 clusters, comprising the total number of large trees removed on this road project. The use and condition of each hollow will be monitored for five years, as well as the health and condition of the host tree. The results of the first three years of monitoring will be presented, as well as insights into important aspects of study design and applying this approach to different impacts on transport projects.

Keywords: Experimentation, Applied research, Mitigation, Critical habitat, Shelter, Wildlife, Tree hollows, Condition of approval, Learning while doing.

Improving habitat connectivity: Developing best practice guidance and structural re-design of the Animex Wildlife Bridge for dormice in the UK

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The Hazel Dormouse (*Muscardinus avellanarius*) is an arboreal mammal in Europe with a declining population in the UK, partially due to habitat fragmentation caused by development of roads and infrastructure. In 2016 Animex helped design and test an arboreal bridge that was proven to be effective for dormice. However, the bridge had to meet technical standards of road agencies so that it could be approved and implemented on "real world" projects. This presentation explores the work we have done to improve the technical design and lifespan of the bridge to ensure it can be widely accepted and implemented by transport authorities.

The outcome of our work has resulted in two specific design types: a standalone bridge and a retrofit design. Several bridges have now been installed on projects across roads and motorways and we will be discussing the development and implementation process from two case studies:

- A 40 m retrofit bridge to a culvert on a farm road in Wales;
- Two 76 m+ bridges on an overbridge and underpass across an 8-lane highway.

During the presentation we will go into further detail on each project highlighting lessons learned and showcase what has influenced our most recent design and recently published Best Practice Guidance (BPG) that we hope will provide much needed technical and ecological advice to all stakeholders working on connectivity projects including ecologists, engineers and authorities.

Keywords: Bridge, Connectivity, Development, Research, Arboreal, Hazel Dormouse, Engineering, Improvement.

A multi-taxa approach to habitat connectivity modeling in the Terai Arc Landscape of Nepal: implications for road upgrading

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The Terai-Arc landscape (TAL) is one of the priority tiger conservation landscapes but also one of the most fragmented and threatened ecosystems in Asia. Road networks are expanding and upgrading in this region at an unprecedented rate. A road that connects Narayanghat – Hetauda – Patlaiya (NHP) in northern Chitwan National Park and cross part of the Parsa National Park in Nepal will be upgraded from 2 to 4-lanes to accommodate the traffic growth. Despite this road seems to limit the mammal individuals interchange between the two sides of the road, the upgrade may turn into a barrier to movement. The main goal of this study was to identify potential corridors for mammals to inform road mitigation measures. Our framework comprised two steps: 1) a large-scale analysis of the species habitat connectivity using a database of mammals occurrence in Chitwan and Parsa National Parks, and 2) validation of the models with data from roadkill data, underpasses use and species occurrence using camera trapping along the NHP. We selected 17 mammal species representing large mammals of conservation concern, ungulates, primate of conservation concern and small/medium size mammals and several environmental variables (elevation, land use, type of soil, building density, human population density and cattle density) to run habitat suitability and connectivity models using Maxent and Circuitscape, respectively. Potential corridors for movement varied among species. However, two main road segments seem to be crossed by potential movement of many species in particular large mammals of conservation concern: Barandabhar and Parsa National Park. Our results show large scale and local scale data can be complemented to find with more accuracy potential movement corridors and it can be a valuable approach to find locations for mitigation when roads are going to be upgraded.

Keywords: Mammals, Nepal, Wildlife corridors, Road impacts, Habitat suitability, Royal Bengal tiger.

Comparing the spatiotemporal variation of crossing and collision positions by roe deer, *Capreolus capreolus*

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Roads can have a negative impact on wildlife populations through increasing mortality through Wildlife Vehicle Collisions (WVC) and through loss of connectivity in the landscape due to habitat fragmentation. With expanding road network and the expected growth in traffic volume in the coming years, the challenges wildlife face due to roads are expected to become increasingly prominent. To mitigate WVCs, most studies use WVC locations to identify high-risk areas. However, identification of WVC hotspots through collision data alone does not incorporate information on where animals do not approach roads and where the road is a barrier to their movement. In this study, we address this gap by evaluating how animal crossings are related to WVC-risk probabilities across the road network. We used 56,076 WVC locations to predict the spatiotemporal risk zones for deer-vehicle collisions (DVC) in south-western Germany, using Species Distribution Modelling (SDM). We predicted collision locations in response to environmental (i.e., land cover type) and road-related (i.e., road density and category) predictors. We then compared the predictive risk maps to 20,744 road crossing locations from 46 roe deer individuals collared between 2010 and 2013. We found that collisions were more likely to occur, in areas with high surrounding broad-leafed forest, and where the road density was 2.5 km/km^2. Roe deer did not appear to actively choose against any road stretches and crossed all roads available in their home range. Furthermore, associated DVC risk positively influenced the frequency of road crossings. Finally, we found large behavioural differences between individuals, specifically that male roe deer crossed roads significantly more often than females, especially during the rut. Females crossed slightly less during the lactation phase when they are accompanied by their fawns, compared to the rest of the year. The results give novel insights into the spatial and temporal differences of roe deer crossings and locations of DVC. While spatial modelling of DVC occurrences performed very well in predicting collision hot spots, it completely ignores patterns in crossing activity that were due to behavioural differences rather than spatial locations. Hotpots of DVC did not necessarily occur where roe deer cross more frequently but were rather a combination of higher roe deer crossings and environmental/road characteristics which likely influenced driver behaviour. Further, we could not identify any specific locations where roe deer did not cross the road, only where they crossed less frequently. This demonstrates that the roads in our study area are not barriers, but rather filters for movement. This may have been a consequence of the fact that we analysed the crossing behaviour of individuals with roads within their home ranges. Furthermore, there were few roads of similar size, with no way of testing for the influences of for example, different speed limits and traffic volumes. Future analysis into the movement patterns within the habitat surrounding the road may help to identify if filtering and barrier effects occur further away from the road.

Keywords: Wildlife-vehicle-collisions, Roe deer, SDM, Spatiotemporal variation, Road crossings, Movement ecology.

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A large-scale analysis reveals unimodal and U-shaped effects of traffic volume on roadkill probability

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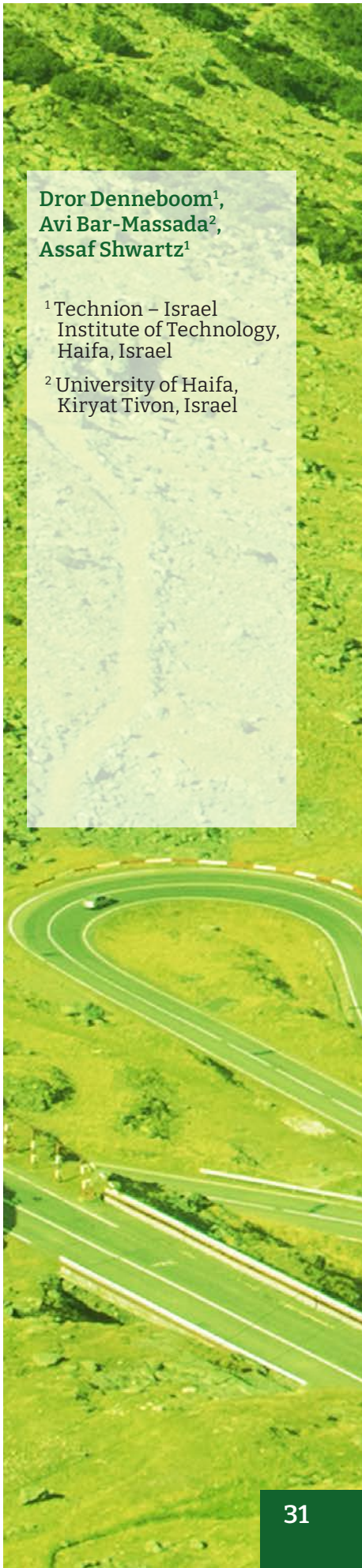

Wildlife-vehicle collisions are considered the predominant direct negative effect exerted by roads on many species, from insects to large mammals. Collisions with oncoming traffic cause millions of incidents of animal mortality annually, and the increased mortality rate plays a major role in the global biodiversity crisis. To effectively mitigate the effects of wildlife road mortality, it is important to understand the factors that affect the occurrence of roadkill for various taxa. The probability of roadkill is affected by species traits, road attributes, landscape features, and traffic characteristics, specifically traffic volume. It was theorized that the effect of traffic volume on roadkill probability should be unimodal with a maximum at intermediate traffic volumes, based on wildlife behavioral responses to traffic. However, empirical evidence of this theory is lacking, as few studies have quantified quadratic effects of traffic volume on the probability of roadkill at a large spatiotemporal scale. We tested for quadratic and linear effects of traffic volume on roadkill probability for twenty species with high road mortality rates in Israel. The effects of road attributes and landscape features were also quantified, while controlling for species abundances near the road, using habitat suitability as a proxy for abundance. The analysis incorporated a nation-wide database of roadkill occurrences, encompassing ten years of data on 2,864 road km, with a total of 16,653 roadkill records. Traffic volume ranged from low traffic roads (300 vehicles per day) to very high traffic highways (148,000 vehicles per day).

The theorized unimodal effect of traffic volume on roadkill probability was empirically supported for the striped hyena and gray wolf, with maximal roadkill probabilities at traffic volumes of 25,300 and 20,792 vehicles per day, respectively. For the first time, a quadratic U-shaped effect was identified for six species: golden jackal, red fox, Indian crested porcupine, southern white-breasted hedgehog, stone marten, and Palestine viper. These species are successful adapters to human dominated landscapes. A negative linear effect was identified for four other species: wild boar, European badger, rock hyrax and chukar partridge. We also found varying effects of road attributes and landscape features on roadkill probability. For example, road lighting decreased roadkill of three species, while concrete guardrails increased roadkill of three species. Woodland and orchard cover were positively correlated with roadkill of wild boars and striped hyenas. To conclude, our study highlights the variation and complexity in the effects of traffic volume on roadkill probability for different species. We have shown that the unimodal effect is supported for large, highly mobile carnivore species that can evade traffic and safely cross at low traffic roads, while avoiding high-traffic roads. We suggest that the novel U-shaped effect is caused by intra-species variability in avoidance behavior, driven by increased tolerance of anthropogenic disturbances associated with high traffic roads. Furthermore, low traffic roads can pose a major risk of wildlife mortality, and mitigation efforts should be directed accordingly. These insights, together with the gleaned effects of road attributes on roadkill probability, are valuable for implementing ecologically sound road planning and roadkill mitigation.

Keywords: Wildlife-vehicle collisions, Roadkill, Traffic volume, Unimodal effect, Roadkill mitigation.

Human footprint and mountain lion territory use in human-dominated landscapes

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Within the human footprint, there are a great number of pressures imposed on ecological systems by human development; including impacts from infrastructure, human activity, and nighttime light pollution, among other stressors. Whereas roads affect nearly all terrestrial species, large predators are particularly at risk due to their large territory requirements, low densities, and low reproductive rates. Despite being one of the largest ranging mammals in the Western Hemisphere, several authors have suggested that mountain lions (*Puma concolor*) avoid residential development and human infrastructure such as roads when selecting a territory. We studied the response of this top predator in Southern California – one of the most densely-populated urban regions – to the impacts of road distribution, landscape-level light pollution, and traffic-sourced light and noise. We proceeded with a two-fold approach: first, we hypothesize that both road density and landscape-level light are lower inside mountain lion territories compared with random points in the study area. Second, we explored if these carnivores approached stretches of roads with lower road light and road noise levels, as these may be perceived as less dangerous places to cross. We used the positions of 102 GPS-collared mountain lions to explore how their distributions and movements relate to the road network and lightscapes. We evaluated the distribution of main, secondary and dirt roads both inside and outside mountain lion territories. Also, we used Visible Infrared Imaging Radiometer Suite (VIIRS) Day-Night Band and World Atlas of Artificial Night Sky Brightness as estimates of surface light conditions to characterize mountain lion territories. The points used by mountain lions to cross roads were evaluated based on their potential traffic noise and light conditions. To understand potential traffic noise influence on mountain approach to highways, we used the US Federal Highway Administration's Traffic Noise Model to estimate traffic noise from regional highways. For light pollution, we used local windows on the VIIRS DNB data (amount of light escaping upward from a location with pixels about 150 m on a side) to assess the fine-scale exposure. In addition, we used other landscape variables useful in developing models for occupancy and movement such as individual sex and age, landscape attributes (slope, shrub cover, forest cover, open habitats, edge length) and potential deer occupancy based on SDM. Lightscapes and fine-scale light conditions are controllable elements in land-use (landscape) and linear infrastructure (roads) planning and mitigation. Understanding how anthropogenic light can influence lion individuals and populations will be important information in planning current and future infrastructure and land-use, and to mitigate these influences to benefit this and other carnivore species.

Keywords: Nighttime light pollution, *Puma concolor*, Roadkills, Roads, Traffic noise.

Creating power lines green corridors: An alternative vegetation management is possible

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When powerline networks are located in forest areas, vegetation management aims at continuously stopping the natural growth of surrounding plants in order to secure overhead lines against vegetation interference which can generate short-circuits and outages. The complete and regular cutting by gyro-grinding of trees, leads to recurrent costs and inappropriate management of habitats beneath the power lines in forests. Since 2011, two Transmission System Operator (TSO), RTE (France) and Elia (Belgium) have tested the implementation of new vegetation management methods and natural habitat restoration practices on a large scale, nearly 500 ha, via LIFE+ Biodiversity project (www.life-elia.eu). The feedback of this LIFE project has been used to define BELIVE, a RTE's project. BELIVE aimed at studying how at an industrial level, the alternative vegetation management can be generalized underneath overhead lines for the benefit of biodiversity, ecosystem services and local stakeholders. As a pilot study, a target were fixed for three regions: 100 ha in the regional natural park of Ardennes, 40 ha in west of France and 80 ha in Mediterranean region over the 2018–2021 period. Each region had an own organization and an associated governance. A national pilot steered the project with the support of the biodiversity politic pilot and vegetation management politic pilot.

The efficacy of the solution has been evaluated by (i) the number of hectares converted in an alternative vegetation management, which represent a reduction of the gyro grinding solution to cut young trees; (ii) a cost and benefit analysis, and (iii) the stakeholder satisfaction degree. BELIVE transformed 325 ha in sites managed in an alternative vegetation management corresponding to 149% more than the initial target of 220 ha. The cost and benefit analysis showed that investment in a habitat benefits both stakeholders that use it, and RTE in term of costs. The average break-even point without external services varies from 7 to 9 years. BELIVE is also distinguished by its high acceptance by local stakeholders. 92% of them agreed to work again with RTE.

In term of environmental success, RTE worked with environmental professionals, the regional natural park of Ardennes and with ecological engineers in each regions. In the regional natural park of Ardennes, some specific fauna surveys (lepidopterans, bats, reptiles, etc.) have been done before any management. This would allow in three to five years to do another counting of species in places.

In the other regions, alternative vegetation management have been done predominantly in protected places: wetlands, dry limestone cliff areas, special protection areas as Natura 2000, calcareous grassland.

The real added value of BELIVE lies in its replicability. It confirms the work engaged by Elia in Belgium and shows that it can be reproduced and carried out on an industrial scale. In the long term, this could have an important impact on the preservation of biodiversity on an European or even global scale by participating in the construction of an ecological corridor network.

Keywords: Biodiversity, Power lines, Ecosystem services, Vegetation management, Forest corridor.

Multiuse overpasses as crossing structures for wild animals – the role of human disturbance

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Wildlife crossing structures are widely used mitigation measures to reduce the adverse impacts of roads on animals. Wide overpasses and underpasses designed for wildlife are known to provide safe crossing opportunities for many species, but large structures are expensive. Therefore, it is tempting to build structures which could be used not only by wild animals but also by humans. The disadvantage of multiuse crossing structures is that human co-use could disturb animals and possibly lead to even reduced efficiency of passages.

To better understand how human disturbance affects the usage of passages, we studied animal and human crossings by using camera traps on nine overpasses located in southern Finland. All of these passages were multiuse overpasses i.e., they were meant for both animals and humans. There was a gravel or dirt road on each overpass, and the rest of the bridge was landscaped with vegetation. The overpasses were located on three different highways, with fencing guiding wildlife to crossing structures.

During our one-year-long study period (12/2019–11/2020), eleven species of wild mammals were photographed crossing the overpasses: mountain hare (*Lepus timidus*), European brown hare (*L. europaeus*), red fox (*Vulpes vulpes*), European badger (*Meles meles*), raccoon dog (*Nyctereutes procyonoides*), moose (*Alces alces*), roe deer (*Capreolus capreolus*), white-tailed deer (*Odocoileus virginianus*), wild boar (*Sus scrofa*), Eurasian lynx (*Lynx lynx*) and brown bear (*Ursus arctos*). In total, 2,028 wild animal and 7,146 human crossing events were detected. Almost 40% of animal crossings were made by white-tailed deer.

To study the effect of human disturbance on animal crossings, we used only winter and springtime data where the number of blank images caused by wind or sun was limited. As this reduced the number of pictures/species, we concentrated only on ungulates (moose, roe deer and white-tailed deer). During the winter months from December 2019 to May 2020, and November 2020, we detected 730 ungulate and 4,707 human crossings. While ungulates used the overpasses most active during the early evening, human activity peaked during the day. We also found that the time between non-motorized human disturbance and an ungulate crossing was longer than the time between motorized disturbance and an ungulate crossing. When looking at possible spatiotemporal avoidance, we calculated time differences (hours and minutes) between an ungulate crossing after an ungulate and an ungulate crossing after a human. The reaction to human disturbance differed between species, with only moose showing signs of spatiotemporal avoidance.

Our results indicate that multiuse overpasses could be to some extent successful, in working as a crossing structure for both wild animals and humans. However, our results indicate that the effects of human-caused disturbance need to be considered with severity. This is true especially in non-motorized human use i.e., hiking, dog walking and other outdoor activities. Therefore, we cannot cling to the thought that multiuse overpasses would be sufficient for all species in every situation, but we need to be prepared to provide crossing structures for only wildlife use or limit the human use of crossing structures if needed.

Keywords: Crossing structure, Passage, Mitigation, Co-use, Spatiotemporal avoidance.

Permeability of highways in Croatia for large carnivores

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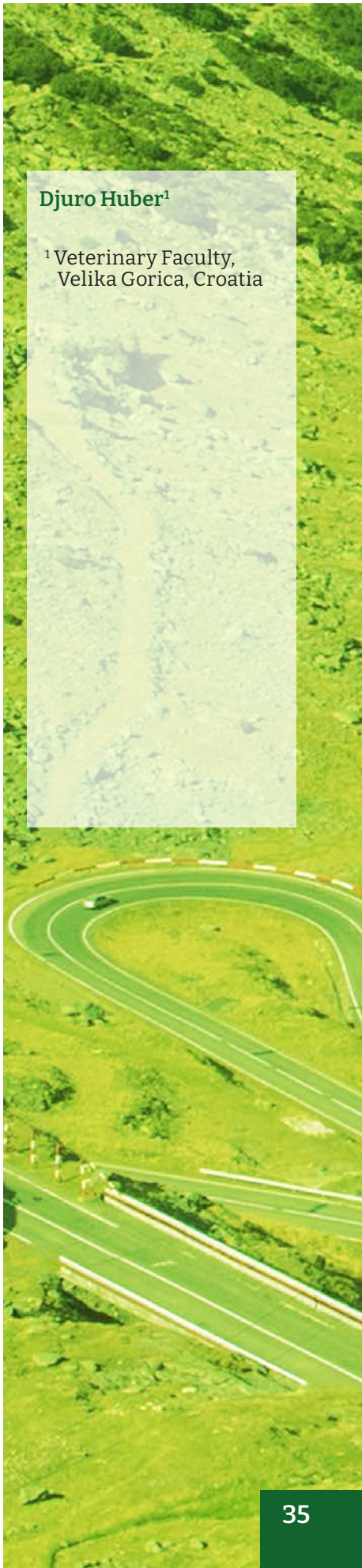

Of the total of 1,306 km of fenced highways in Croatia, 561 km are in the range of at least one of three species of large carnivores (LC): brown bear, grey wolf and Eurasian lynx. Most of these highways were constructed between 1999 and 2009. Environmental Impact Studies (EIS) did consider the needs of LCs, the species with large home ranges and sensitive to habitat fragmentation. A simple "rule of the thumb" was used to secure at least one safe crossing each 5 km of the highway length. Most of had been built due to the fact that the rugged mountainous landscape required numerous tunnels (N=50), bridges and viaducts (N=219), although even some of those were constructed specifically as wildlife passages. However, 14 green bridges were placed on sites were the EIS found the need for a crossing structure. These were artificial tunnels 100–250 m long (i.e., the width of the passage) with soil and local vegetation on the top. The large size was required to encourage shy animal species like LCs to cross (i.e., not to be selective to habituated individuals what may happen especially with some bears and wolves). Depending on the sections of highway, relatively high percentages of highway length is passable for animals, either above or under the road: Gorski kotar 25%, Lika 11% and Dalmatia 5%. The later is considered as the minimum acceptable. The use of green bridges by animals was initially monitored by infrared sensors and recently by automatic cameras. All bridges were proven to be used by LCs and a number of other local fauna species. Certain misuses were recorded as well, like some field vehicles or hunters on the bridges. All of these highways were fenced, and the fencing helps to guide animals to the crossing structures. Occasional appearances of individual animals (including LCs) on the motorway itself is typically an indication of inadequate fence maintenance. It can be concluded that overall mitigation measures do allow sufficient LC and other animal movements, but requires permanent monitoring and occasional improvements.

Keywords: Large carnivores, Croatia, Highways, Permeability, Green bridges.

Assessing and Mitigating the Impacts of Road Projects on Soil – The RoadSoil Project

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Road construction has considerable negative impacts on soils, both in the short and long term, through land-take, soil sealing, soil compaction, temporary soil storage, changes to local hydrology, and redistribution of potentially contaminated soils during maintenance. These operations have direct effects on soil processes and functions that provide the basis for biodiversity, ecosystems, and landscapes. Hence, soil protection measures and soil management plans are of great importance in road projects to reduce the environmental impact.

The CEDR funded ROADSOIL project aims to synthetise current knowledge and provide guidelines and best-practice examples for soil management and soil protection in road projects. Our project has a strong focus on soil quality indicators and soil management but will also bring together knowledge of high relevance for road impacts in a larger landscape. This includes: how to maintain soil quality and minimise landscape impacts in temporal soil storage, prioritising reuse of soil and mineral resources in the road project for road verges and landscaping, but also ecological compensation measures. As a consequence, the project will contribute to bridge the considerable gap between the engineering and ecological aspects of road projects.

The presentation will provide an update on the work in progress such as critical indicators of soil process and functions affected by road projects (primary productivity, water filtering and regulation, carbon sequestration and regulation, nutrient cycling, habitat and biodiversity provisioning) and how these can be monitored; how soil can be sourced, stored, and reused for targeted road verge solutions and landscaping providing habitats and connectivity for local ecological communities; and how soil resources can be reused in ecological compensation measures. These issues will be demonstrated with examples from practice in different regions of Europe and point out key strategies for temporal soil storage to reduce problems with invasive species and soil compaction; mass balance within road projects with reuse of most organic and mineral fractions and design of soil mixtures based on these; soil profile reconstruction both in land directly affected by the road project and in areas used for agricultural or ecological compensation; and strategies to source soil resources for specific vegetation along the road verges to support habitat functions, structural and functional connectivity.

Keywords: Sustainable land management, Soil functions, Guidelines, Mitigation.

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Net Loss or No Net Loss? Multiscalar analysis of a gas pipeline offset efficiency for a protected butterfly population

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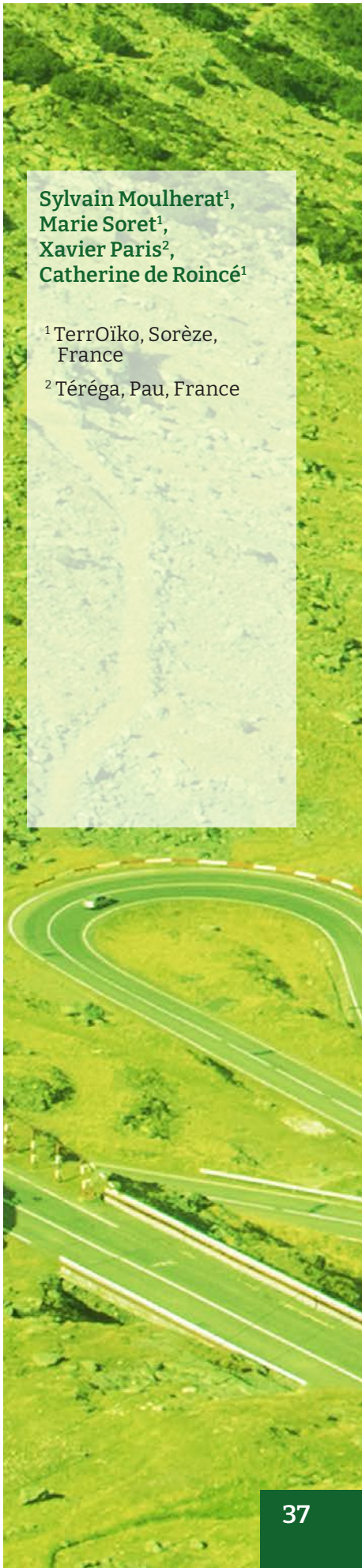

Linear Transport Infrastructures (LTI) are parts of our common life but contribute to the habitat fragmentation and reduction as well as to the land use changes underpinning the current sixth extinction phenomenon. However, as LTI covers several types of infrastructures such as roads, railways but also power lines or gas pipelines, the link between the existing of an LTI and the extinction risk is not always straight forward and depends on the nature of the LTI and its surrounding landscape. To limit the impact of LTI building and exploitation on biodiversity, the mitigation hierarchy deployment aims at balancing biodiversity losses and gains in order to achieve the No Net Loss (NNL) goals.

Based on a scenario comparison of expected losses and gains during the conception to exploitation sequence of a gas pipeline on the protected butterfly *P. alcon*, we showed that the spatial range evaluation of impacts and offsets is crucial to evaluate the ecological equivalency underpinning the mitigation hierarchy deployment. Indeed, using individual-based spatially-explicit model of *P. alcon* metapopulation functioning, we pointed out that if at the Environmental Impact Assessment (EIA) scope scale (about 500 m around the infrastructure), the equivalency (population size, global flow of individuals and connectivity) should be reached after the project development. This equivalence is supported by a limited impact on the suitable habitat patches for the species and the development of new functional corridors where the pipeline crosses forests improving the expected flow of individual at this EIA scale. Thus, the project fully respects the current French regulation being able to justify a no net loss for the targeted species at the EIA scope scale.

However, simulations results pointed out unexpected negative effects at the local scale (up to 3 km from the infrastructure). The changes in the population function induced at the EIA scope scale should influence the local population function leading to a net loss of population size, global individual flow and subsequently global connectivity.

Considering our results and in line with preexisting theoretical works, we illustrate the crucial role of spatial scales to adequately implement the mitigation hierarchy in EIA and Strategic Environmental Assessment (SEA) and therefore ensure that impacts and offsets range of expected effect overlap at any impacted spatial scales. In this respect, we argue that ecological modelling should be a relevant approach to test scenarios even at larger scales than those which can be monitored on the field in operative EIA.

Keywords: Metapopulation functioning, Linear infrastructure, Gas pipeline, Mitigation measure efficiency, Ecological corridor, Butterfly ecology, Landscape graphs, Environmental impact assessment, Ecological modelling, Scale.

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Including biodiversity on highway verges in road asset management

Every 5 years bridges, retaining walls and pavement are subject to an inspection cycle which is part of asset management. Highway verges have now been included in this cycle, with a new tool measuring how well biodiversity goals are being met.

The Swiss federal road guideline ASTRA 18007 on highway verge design and management set nine main objectives: enhance landscape integration, enhance buffer zone function, reinforce positive corridors effects and linkages, maintain and enhance biodiversity in defined areas, avoid and contain invasive plants and finally adapt design to ensure cost effective maintenance.

An assessment tool has been developed to measure how well these objectives are being met at 5 year intervals. The tool uses an approach comparable to other inspection guidelines.

Five potential conditions have been defined, going from good (scale 1) to alarming (scale 5). A good condition (1) means the maintenance standards and the state of the verges completely abide the guidelines. On the other end of the scale, an alarming condition (5) arises, for instance, in cases of problematic erosion or when invasive neophytes are overbearing. In the case of an alarming condition, immediate action is required. Corrective management measures are required as of insufficient conditions (scale 3 on 5). Not only is the physical state of the verges assessed but also its ecological function. The training of maintenance personnel is also undertaken. The physical state includes the mowing regime (respecting 10 cm minimal height), invasive plants, ecological structure diversity, hedges and biodiversity.

A standardized scaling method has been developed to assess biodiversity. A point system identifying number of species is used, combined with points for habitat structure. Birds, butterflies, grasshoppers, snails, reptiles, bees are among the fauna categories screened, without listing specific species. The diversity of the flora in mowing meadows is also examined using a very basic system. The diversity of species is identified with a color code. This allows a standardized approach permitting a rather easy evaluation of the whole network on a regular basis over the network. The state of the verges will become part of the global asset appraisal for highways and condition future maintenance efforts.

Keywords: Road verges, Biodiversity, Corridor function, Maintenance, Asset management.

IENE Infrastructure & Ecology Network Europe 2022

Presenting scientific evidence in guidelines for road mitigation

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National and international handbooks present "best practices" and guidelines for road mitigation that are usually based on a mix of monitoring studies, effect studies and best-professional judgement. However, the arguments for classifying a measure as "best practice" are lacking in many cases. This also applies to the substantiation of the guidelines presented. For example, it is often unclear whether a best practice or guideline is based solely on the experiences of experts or also on scientific research. In the new Dutch handbook for fauna measures at transportation infrastructure, published by the Dutch Road Agency in 2021 (in Dutch), extra attention has therefore been paid to this. Specifically, there were two goals: (1) to classify the fauna measures presented on the basis of the available scientific evidence for their effectiveness, and (2) to identify knowledge gaps regarding the effects of the fauna measures recommended in the handbook on the basis of which future effect studies can be prioritized. All fauna measures in the handbook are classified – per species group – on the basis of scientific evidence. For this classification, peer-reviewed scientific studies were used into the effectiveness of the measure in reducing fauna mortality and/or increasing habitat connectivity. Eight classes have been distinguished on the basis of a set of decision rules: (1) measure not intended for species group; (2) no research; (3) insufficient research; (4) research of insufficient quality; (5) fauna measure is unsuitable; (6) fauna measure is moderately suitable; (7) fauna measure is appropriate; (8) fauna measure is very suitable. For wildlife crossing structures, a classification was also presented that is based on studies in which the use of the structures has been investigated. On the basis of a set of decision rules, eight classes have again been distinguished: (1) measure not intended for species group; (2) no research; (3) insufficient research; (4) research of insufficient quality; (5) no or occasional use of structure; (6) regular use of structure; (7) frequent use of structure; and (8) very frequent use of structure. Both classifications provide insight into the scientific substantiation of the measures at a glance. The decision rules used in the classification take into account, inter alia, the number of impact studies, the quality of these studies and the size of the measured effect. The classification system has been drawn up in such a way that it is replicable. The classification can easily be updated on the basis of new research or extended to non-European species. In addition, the system allows to zoom in on the importance of various design features of fauna measures, such as the dimensions of wildlife fences or crossing structures. The insight gained into the effectiveness of a fauna measure and/or the extent to which it is used by the various species groups should help policymakers and road planners to make more informed choices when drawing up future mitigation plans. It also gives policymakers ammunition to draw up a research agenda to eliminate knowledge gaps, which seems substantial, regarding the functionality of fauna measures at transportation infrastructure.

Keywords: Road mitigation, Wildlife fence, Crossing structure, Effectiveness, Guidelines, Handbook.

The Wildlife Fencing Guide – Improving Wildlife Fencing for Herpetofauna to Aid Effective Implementation

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Wildlife fencing is used as a mitigation solution for herpetofauna species to prevent roadkill globally. However, the fence material, height, and implementation requirements vary between country to country, state to state and region to region.

Although many government organizations and researchers are working to create fencing guidelines for a variety of species, the materials and installation methods are often vague and, in many instances, are later discovered to be dangerous for the target species.

The lack of research and focus into this topic is resulting in many fences being installed and erected that are inadequate, environmentally damaging and ecologically ineffective. This can lead to frustration and resistance from stakeholders who want their investments on large projects to be sustainable yet often end up being fined, delayed or paying for repairs.

Through collaboration and private-public partnerships we have analyzed a comprehensive range of case studies from across the globe where innovative solutions have been rigorously tested to help solve problems that often hinder the implementation, management and success of wildlife mitigation schemes. Through this analysis we have created a standardized set of fencing specifications and installation recommendations that consider the ecological, practical and climatic challenges faced all over the world.

This resource will become a valuable asset and help agencies across the world ensure they can easily implement reliable, cost effective and ecologically sensitive mitigation measures to help reduce global wildlife mortality.

Keywords: Fencing, Handbook, Guidelines, Specifications, Reptiles, Amphibians, Mammals.

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Spatio-temporal patterns and successful mitigation of bird-caused electrical faults in transmission power lines in Portugal

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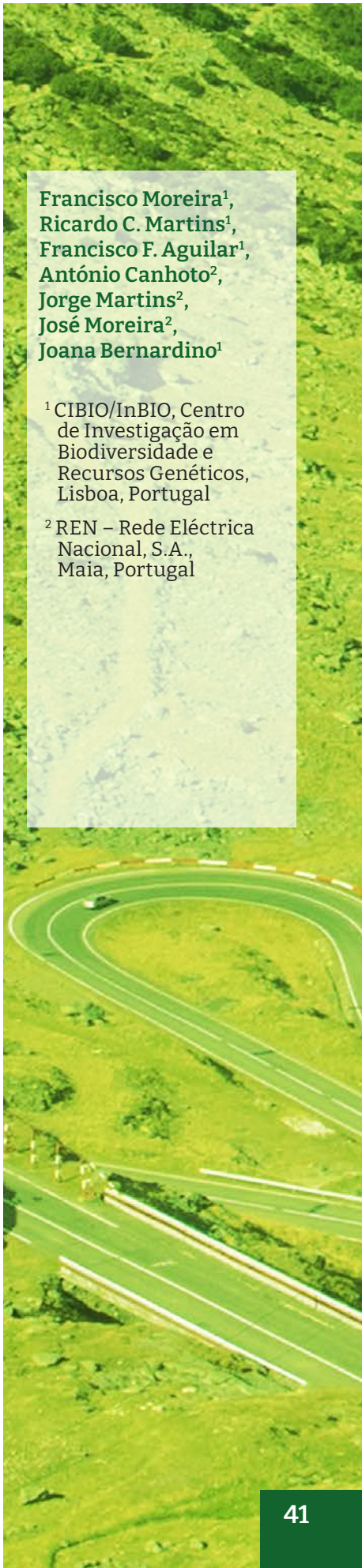

Birds can inadvertently cause a large number of faults in distribution and transmission electricity grids which reduces service reliability. Electrical faults may be caused by bird electrocutions which occur primarily in distribution lines (smaller power lines, with voltages <60 kV) but are uncommon in transmission lines (larger power lines, with voltages >60 kV), especially on those with voltages ≥150 kV. Nonetheless, in transmission lines have other bird-infrastructure interactions that can cause electrical faults, namely the use of pylons by birds for nesting. In Portugal, between 1984 and 2014, the proportion of white storks *Ciconia ciconia* nesting in electricity pylons increased from 1% to 25% of the whole national population. Thus, in the mid-1990s, the Portuguese Transmission System Operator (TSO) initiated a nest management program that entailed the translocation or removal (with a permit from the National Nature Conservation Authority) of nests in hazardous locations of the pylons (in the cross arm, above insulators and conductors), coupled with the installation of anti-perching devices in the same locations and the provision of alternative nesting platforms in safe locations of the pylon.

In this study, we evaluated the spatio-temporal patterns of bird-caused electrical faults in the Portuguese transmission grid (150–400 kV), over an 18-year period (between 2001 and 2018), as well as the success of the TSO management response to the use of pylons by white-storks for nesting. We found that birds account for an important portion of the overall electrical faults, with the vast majority being attributed to white storks. The seasonal pattern of bird-related faults was not obvious, but higher numbers were registered in April and in October-November. Faults were more likely to occur during the night, when storks spend more time on the pylons. The spatial distribution of bird-related faults was positively associated with the proportion of pylons with stork nests and the overall number of nests per 100 km of line. Over the years, there was a 3-fold increase in the number of stork nest on the transmission pylons but, concurrently, bird-related fault rates decreased significantly. This means that the long-term management actions carried out were effective, as a whole, in reducing the stork-TSO conflict. Future research should examine how white storks use the transmission pylons, even without nests, outside the breeding season (particularly in October-November), to better understand and address the remaining electrical fault rates.

Keywords: Power lines, Service reliability, Outages, Bird streamers, White stork, *Ciconia ciconia*, Nesting, Long-term management.

Planning for mitigation: Brown bear occurrence along a proposed highway route in the Eastern Carpathian Mountains of Romania

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The planned A8 (Târgu Mureș-Iași-Ungheni) highway, linking the Transylvanian city of Târgu Mureș in the West to the national border between Romania and the Republic of Moldova in the east, has been identified as a major threat to brown bear habitat connectivity. The future highway will traverse the Romanian Eastern Carpathians and their foothills on an East-West axis, intersecting prime bear habitats on a significant percentage of its length. Failing to preserve North-South connectivity across the Romanian Eastern Carpathians would entail far-reaching repercussions on bears and other wildlife. These mountains effectively link the Romanian bear population to those from Ukraine, Eastern Slovakia and Poland. Ensuring a high permeability of the future highway is important for the Romanian and Carpathian population by enlarge.

In 2014, 2017 and 2020 we monitored the occurrence of brown bears along 120 km of the planned A8 highway (Ditrău to Leghin segment). Our goal was to collect data prior to highway construction and thereby provide a baseline for proactive mitigation of highway impacts on bears in the region.

We used baited hair traps (68–71) that were active for a total of 3,519 days. We collected 45 bear hair samples: 12 (2014), 27 (2017) and 6 (2020). Using genetic analysis we confirmed the presence of 24 individual bears and a sex ratio (male:female) of 1:1.3. We were unable to produce direct evidence of bears crossing the planned highway route (e.g., same individual detected by hair traps on both sides of the future highway). Nevertheless, we provide evidence that the population uses both sides of the planned development, including the detection of animals that are closely related genetically on both sides of the highway route.

Bears occurred consistently in areas of high terrain ruggedness and western-most hair traps had the highest bear detections. Bear hair samples were almost exclusively collected from hair trap locations West of Lake Bicaz (43 of the 45 samples), a pattern most likely resulting from widespread poaching and extensive habitat fragmentation around and to the East of the lake. However, distance from the nearest human settlement and land cover did not influence the success rate of hair traps.

Based on our results, we provide recommendations on where to focus habitat fragmentation mitigation efforts for brown bears on the future A8 highway.

Keywords: A8, Fragmentation, Hair trapping, Highway mitigation, *Ursus arctos*.

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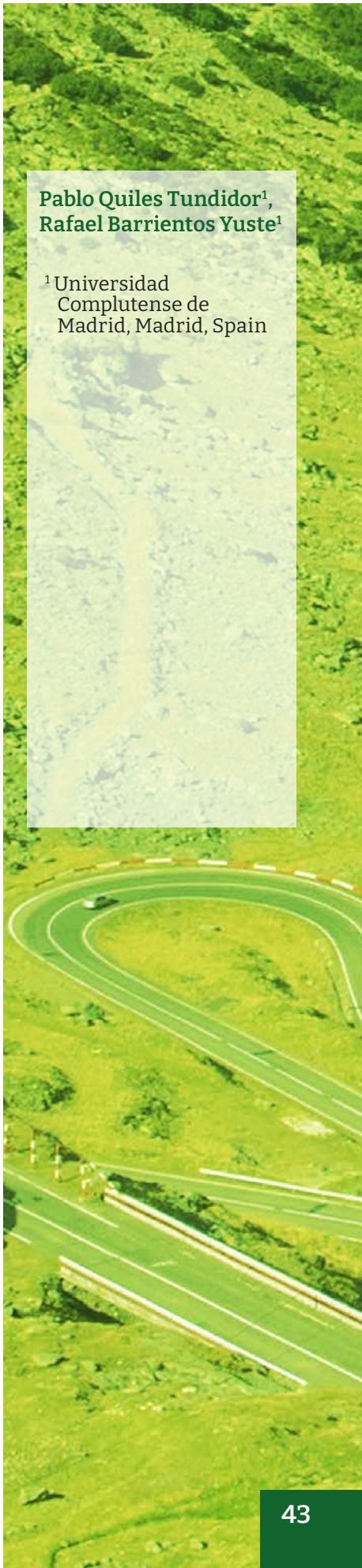
Road alteration of species interactions



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The road network is an ever-growing human infrastructure with serious impacts on nature, so it is important to understand how roads influence the natural flow of ecosystems and the relationships between its biological components. With this in mind, we conducted a systematic literature review (using the Web of Science) on how the main types of species interactions can be altered by roads. We used the terms "road" and each one of the six common species interaction types; "competition", "predation", "mutualism", "parasitism", "commensalism" and "amensalism", which are categories based on the outcomes for the species involved. The initial search returned 1,023 articles, that we filtered by title and abstract, finally retaining 92: 37 for predation, 29 for competition, 16 for mutualism, 10 for parasitism and none for commensalism and amensalism. Aside from evident lack of studies on this particular topic, the results of our search showed how some interactions have been given more attention than others. Worryingly, only a few of the articles revised were conducted in developing countries, where knowledge about this topic is crucial. We found some road impacts repeatedly represented in the selected articles, such as: the effect of road de-icing salts on individuals, populations and aquatic food chains, the effect of habitat alteration on parasitism rates in wildlife passages and nests close to the road, the alteration of ecosystem services such as seed dispersal and pollination, and finally the alteration of habitat usage of prey and predator species that in the end changes competition and predation dynamics. Moreover, we found a lack of research covering multiple taxa and their relationships, a lack of studies at a population scale and a lack of articles focused on the possible road-mediated cascade effects derived from these alterations of interspecific relationships. These gaps of knowledge may impede us to accurately mitigate the effects produced by roads.

Keywords: Road Ecology, Species interactions, Literature review, Road impacts.

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Operational integration of biodiversity in linear transport infrastructure projects

The national and European environmental regulations expose their expectations on projects that are partly related to biodiversity and more globally to environment. These expectations are translated into different procedures. Operational guides written by state actors are tools employed to set up projects. In addition to these purely regulatory aspects, giving advice regarding a project is one of the main roles of our study office. Critical understanding on regulations, on the client's expectations and on the possibilities of a project are keys to succeed integrating a project in its environment and including biodiversity concerns.

Three different aspects of biodiversity are raised in Environmental Impact Studies (EIS): population genetics, protected species and ecosystems via natural habitats. These are often used to integrate ecosystems and species into studies, but genetics is rarely treated as an issue. They are integrated by a range of measures (Avoid-Reduce-Compensate approach) such as the creation of new habitats for the fauna. The levels of each issue are defined in a rigorous way but that can change from one study to another.

Biodiversity and environment are considered in EIS as time and space aspects. This requires adaptation and flexibility for each project. Studies need to be adapted in a relevant way according to the project itself. Geographic data can be useful for this purpose if they allow us to see the evolution of a project through time with the measures proposed. At all steps of a project, different measures are proposed to avoid-reduce-compensate the impacts on environment and biodiversity and by different actors (building companies, operators, etc.). Study offices need in this context to set up environmental management and environmental requirements.

Projects are partly defined thanks to socioeconomic studies evaluating costs and benefits of different aspects (time gained, etc.). Environmental aspects and especially biodiversity are not monetized in these studies. Benefit transfer can partly be done for leisure and ecosystem services. Furthermore, the regulation does not give the method to introduce environment and biodiversity into this study.

As a result, environmental and socioeconomic studies are not using the same tools (level of impacts versus monetization). This gap is an obstacle to consider environment at the same level than socio economic topics even if benefit transfer allows to monetize ecosystem services. The more the services are monetized, the more the gains of biodiversity/environment are considered into socioeconomic studies. Nevertheless, ecosystem services and biodiversity are not the same notion, and monetization can lead to a reductive idea of biodiversity.

Setec is involved in the ITTECOP program and is aware of research results to try to apply the results into measures concerning biodiversity. Mainly the new tools from research are not used because of their costs, the lack of regulation, of transparency and feedbacks.

Nevertheless, some measures are effective and understanding why and how they were set up is an intellectual enrichment and a way to raise development paths for future research and future innovative measures.

Keywords: Integration, Biodiversity, Operational, Study office, Regulation, Approach, Gaps, Tools, Development, Feedbacks.

IENE Infrastructure & Ecology Network Europe 2022

Flor'Elec: a future indicator for power lines right of ways?

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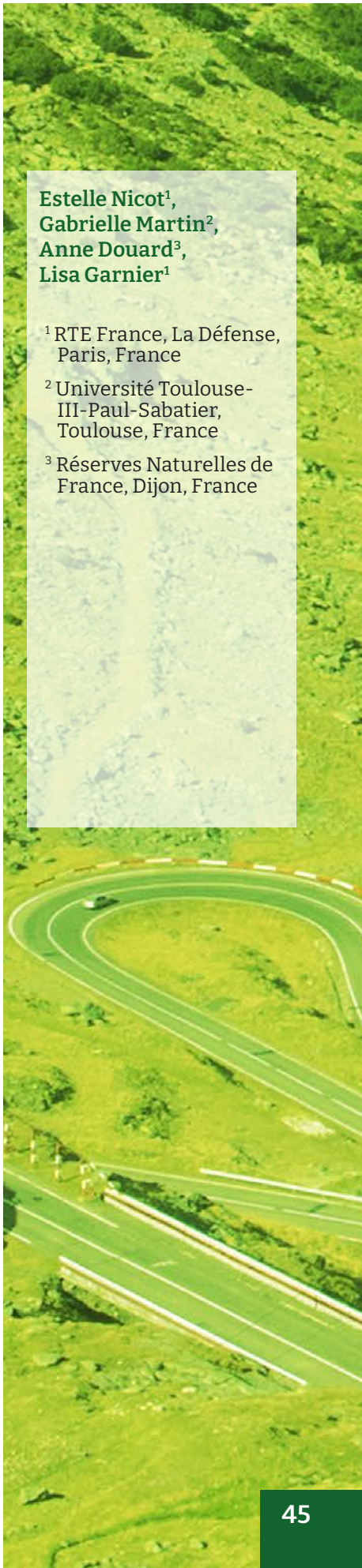

Power lines are associated with mechanical vegetation management for the safety of the electric grid and population in general, in particular in forest areas. Research has shown that they can be a source of fragmentation and loss of habitats for many species. The vegetation management by gyrogriding in rights of way modifies abiotic conditions as light, temperature and humidity compared to adjacent ecosystems. This can lead to a loss of species diversity. However, vegetation management can also have positive effects. With open lands in forest areas, some species, such as meadows one, could be promoted, helping pollinator and bird communities. Right of ways may then participate in an environmental heterogeneity.

Alternative vegetation management, which refers to change management practices and change of land use (transformation into pasture lands, for ex.), experimented by different European TSOs and especially RTE (France's transmission system operator) could participate in a diversification of habitats at a local scale.

Indicators measure relevant environmental phenomena. They describe or assess environmental conditions and changes. They can help to achieve environmental objectives. To investigate the contribution of right-of-way wildflower management practices to plant diversity, an indicator for non-botanical specialists, called Flor'Elec, has been developed by RTE with the help of the association Réserves naturelles de France, which federates nature professionals. The purpose of this study is to propose the Flor'Elec protocol, which is standardised and accessible to all, to collect data allowing the calculation of a wild flora indicator at the scale of the right-of-way, in relation to management practices. The standardisation of data collection along 25×2 m transects in each habitat type of the right-of-way allows comparisons in space and time of the indicator value. Additional comprehensive botanical surveys are conducted as part of this study to ensure the robustness of the Flor'Elec protocol and the resulting indicator.

We propose to present (i) the results concerning the validation of the Flor'Elec protocol by botanical surveys, and (ii) the results concerning the calculation of indicators and the impact of management practices on the surrounding wild flora.

Keywords: Indicator, Alternative vegetation management, Biodiversity, Ecosystems, Right of ways, Power lines.

OCAPI – Biodiversity monitoring thanks to more intelligent cameras

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At a time of massive deployment of cameras on the territory and the development of connected infrastructures, the OCAPI project aims to extend the uses of cameras deployed on existing infrastructures to the management of biodiversity in the vicinity of these infrastructures within the framework of the management of risks associated with collisions and the monitoring of environmental measures effectiveness.

To this end, the OCAPI project contributed to the development of deep learning algorithms for the automatic identification of the large mammals most frequently encountered in accidents with vehicles (wild boar, roe deer and deer). This development was made possible by the deployment of an image annotation platform benefiting from the image contributions (photographs and videos) of major partners such as Vinci autoroute, the French Biodiversity Agency, or the Regional and Departmental Federations of Hunters. The recognition data produced by the automatic recognition systems are then processed using species distribution models (machine learning) to produce maps of the risks associated with the presence of these large mammals. The entire processing and analysis chain was designed and tested in a virtual environment based on a real case in the OCAPI project.

Although developed with the main objective of adaptive management of the risk of collisions between vehicles and large mammals, the monitoring and analysis scheme for wildlife in the vicinity of infrastructures can be applied to other operational frameworks such as the monitoring of environmental measures (measures resulting from the implementation of the mitigation hierarchy, voluntary management measures, etc.) on the scale of infrastructures, but also to other contexts such as hunting management or the monitoring of biodiversity conservation programmes. Thus, the deployment of the solution proposed in the OCAPI project on 1) existing infrastructures, then 2) on infrastructure networks, is likely to provide territories with large-scale biodiversity monitoring systems based on existing infrastructures.

Keywords: Artificial Intelligence, AVC, Risk map, Adaptive maintenance.

IENE Infrastructure & Ecology Network Europe 2022

Roads as drivers of population spreading: the case study of bee-eaters in Doñana

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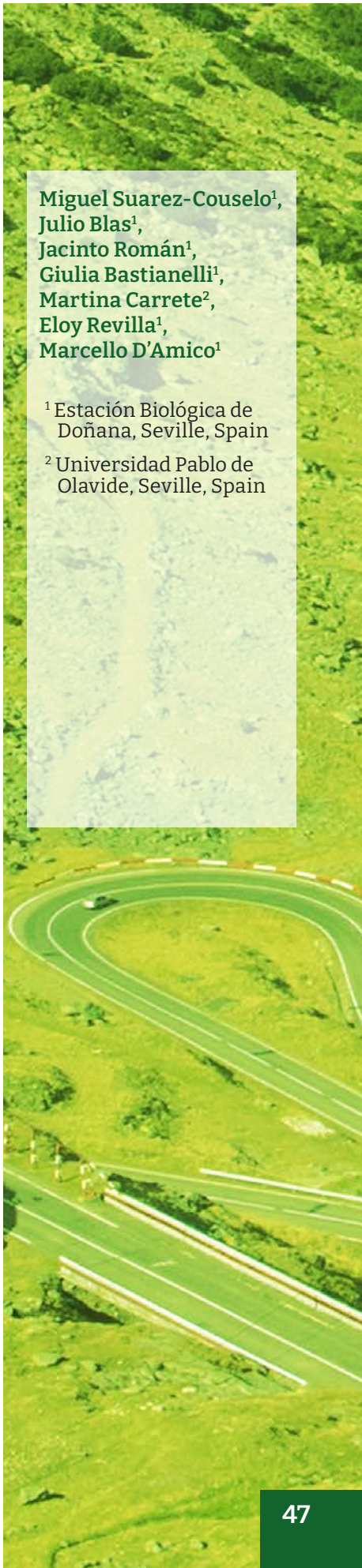
Roads have multiple impacts on wildlife, but several species have been described to benefit from these infrastructures for different purposes, from movement to foraging. In some cases, roads can provide a limiting resource, determining then a population spreading along road proximities. However, these processes have been rarely described, and the present study aims to investigate the mechanisms that determine them by focusing on a suitable study system for this purpose: the population of European bee-eater *Merops apiaster* in Doñana Natural Area (south-western Spain). Until the beginning of the 21st century, this species locally bred only on the margins of Doñana marshlands, the only suitable soils for digging underground nests in this sandy area. Thereupon, the breeding population of bee-eaters began to spread along the sloped roadsides of paved and dirt roads throughout the Natural Area, probably because these infrastructures also provide suitable soils. Nevertheless, not all the available roads were selected for breeding, so the present study investigates both road-related and environmental factors determining the selection of nesting habitat for this species in Doñana. With this aim, in the spring of 2011 we georeferenced and characterized all bee-eater nests in Doñana. As expected we found that, controlling for environmental variables, nesting bee-eaters actively select suitable soils (both natural and artificial), but the only selected roads had relatively low traffic volume. These types of studies are important because they help us understand why some species become increasingly dependent on anthropized areas and how this dependence may affect their conservation.

Keywords: European bee-eater *Merops apiaster*, Road Ecology, Doñana Biosphere Reserve, Habitat selection, Impact on wildlife.



Environmental audit of existing transport infrastructure

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The assessment of environmental impacts of transport infrastructure has long been defined by the EIA process according to the national law and relevant European directive, but it focuses mainly on new constructions or modernizations. However, a closer look reveals that the length ratio between old and new infrastructure is clearly dominated by old structures (in CZ 60% of motorways and 93.5% of national roads was built before the year 2000) that have never been subject to proper environmental assessment. In the case of older infrastructure, these are mainly issues that were not yet addressed at the time of the construction, or which are perceived differently today. It can be expected to have significantly more severe impacts on all components of the environment, which are interrelated in various ways. Specifically, the issues of migration permeability for wildlife, the fencing and barriers for animals, drainage of saline water from the road, soil erosion on the road embankment, etc. Also frequent cumulative and synergic effects occur regularly.

Main aim of the tool presented, the Environmental Audit of Transport Infrastructure (EADI), is to set up a systematic and comprehensive approach to the preventive identification of problematic locations on the existing road network to prepare proposals for practical and feasible optimization measures that can be addressed within the framework of routine repairs and small reconstructions.

The basic principles of the EADI methodology are:

- Prevention – to find the problem sites early, before serious consequences occur. It is therefore proposed to include this tool as a regular part of road management;
- Practical focus – the audit is based on the assessment of selected problem areas and its outputs are focused on realistic measures that can be implemented mostly within the framework of routine maintenance or road reconstruction. The environmental audit is in no way analogous to the EIA process; it does not seek a theoretical description of possible impacts, but rather practical proposals to mitigate them;
- Efficiency – to avoid the duplication of assessment it doesn't include procedures that are already regularly implemented today such as (i) the assessment of the impact on public health, (ii) road safety, (iii) the structural condition of road structures, (iv) the situation in the municipalities' intramural areas;
- Respect for local conditions – due to the considerable variability of both roads and surrounding natural conditions, the EADI is conceived as an open system whose basic methodological approaches must always be adapted to the specific local situation. At the beginning of each EADI, a screening and assessment of the local situation should be carried out and the scope and methodology of the assessment modified accordingly.

There are three components selected for EADI, each divided into several key problem areas: (i) biota; (ii) water and soil; (iii) landscape.

EADI was developed as a certified methodology of the Ministry of Transport. It should be a stimulus to address "old environmental burdens" on existing roads. Its application is currently on a voluntary basis and because the vast majority of the transport network is state owned, its application is in the hands of the state administration and infrastructure operators.

Keywords: Existing infrastructure, Auditing, Environmental impacts.

IENE Infrastructure & Ecology Network Europe 2022

Terrestrial transport infrastructure impact on longitudinal connectivity of rivers – a case study on Gilort River, Romania

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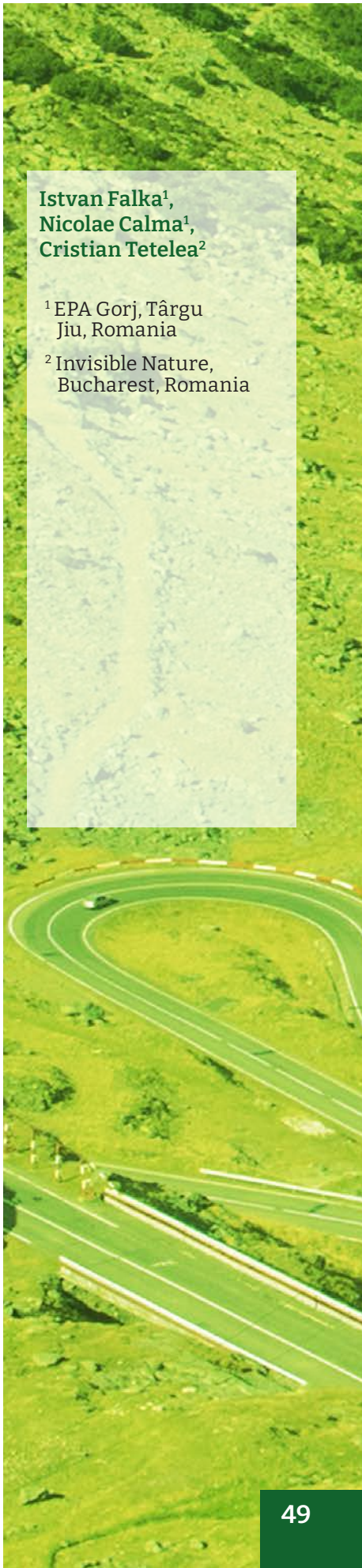

Fragmentation of river continuity is currently considered one of the most severe threats to rivers and freshwater biodiversity in European Union. Considering the interruption of the longitudinal connectivity Gilort River may be considered heavily impacted.

Currently, several structures are halting the migration of fish on Gilort River: weirs build for a small hydropower plant situated upstream of the Natura 2000 site in Novaci village; a threshold spillway located in Gilort River Natura 2000 site at the road bridge in Albeni village and a weir on the road bridge at Târgu Cărbunești downstream the Natura 2000 site.

In 2014 the Gilort River registered the largest historic flood which, beside a catastrophic impact on the local communities, swept downstream almost the whole fish fauna. Due to the barriers present on the river and consequence to the lack of connectivity between Gilort River and its tributaries, the colonization of the deserted stretch was impossible by means of upstream migration of fish. After the flood, we found only 8 species of fish and very low density of fish. We have continued the monitoring of the river in 2016 and we have found similar results as in 2014. Based on our findings we aimed to improve permeability and colonization of the impacted river with the support of a LIFE Nature project ("Fish for Life" LIFE16NAT/RO/000778).

Two fish passes were designed and constructed on Gilort River: an innovative step-pool fish ramp at Albeni road bridge and a technical fish ladder at the road bridge across the river at Târgu Cărbunești.

We performed ex-ante monitoring of fish fauna and evaluation of hydro-morphological conditions of the river segments at the road bridges. Fish monitoring was done by means of electrofishing during the migration period of the 2018 and 2019 seasons for 21 sites along Gilort River and tributaries. We have found an improvement regarding the diversity of the fish species: 13 species in 2018, 16 species in 2019. To confirm the functionality of the fish passes, electrofishing was continued during the construction phase and will be continued after the construction.

We present some of the preliminary results of our work carried out through the project Fish for Life which aim to restore longitudinal connectivity between two Natura 2000 sites in the Jiu River basin: ROSCI0362 Gilort River and ROSCI0045 Coridorul Jiului.

We also communicate our experience gained by mediating the project actions with the key stakeholders to be able to implement the proposed restoration activities.

Keywords: Longitudinal connectivity, Road bridge barriers, Fish passes, Weirs, Flood, Colonization, Biodiversity.

A spatiotemporal analysis of ungulate-vehicle collision hotspots in response to road construction and realignment

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The purpose of this study was to evaluate the spatiotemporal evolution of ungulate-vehicle collision (UVC) hotspots in response to major road construction. Our approach was novel in that we tested the paired use of a clustering method known as KDE+ and a spatiotemporal stepwise modification of this method, STKDE+, to monitor UVC hotspots. Two different locations and scales in the province of Alberta, Canada were examined: (1) Deerfoot Trail, a major artery into the City of Calgary which included wildlife mitigation (4.5 kms of fencing with underpasses); and (2) 54.5 km of Highway 63 in northern Alberta which was converted from a 2-lane undivided to a 4-land divided highway. Using government police collision and carcass data (2000–2021), a spatiotemporal analysis was applied using a 3-year moving window with a one-day step to assess hotspots. Before-after or control-impact analyses were used to assess changes to ungulate-vehicle collision frequency (UVC/km/year). On Deerfoot Trail STKDE+ detected emerging UVC hotspots, including a stable hotspot at the south end of the wildlife exclusion fence and ephemeral hotspots within the exclusion fence zone. Wildlife mitigation measures along Deerfoot Trail had a large effect on reducing ungulate-vehicle collisions. At a larger scale, however, net benefits were impacted by UVCs on a nearby unmitigated highway. As the average annual daily traffic (AADT) on Deerfoot increased, UVC shifted temporally to days with lower traffic volume (weekends in this case). Before-after analysis of the conversion of Highway 63 to a 4-land divided highway showed slight, but not significant increases in ungulate-vehicle collision frequency and severity. The majority of historical UVC hotspots re-emerged after construction was completed. Our analysis highlighted the need to incorporate wildlife considerations at a variety of scales into the transportation planning process. We demonstrated the complimentary nature of different UVC clustering approaches as part of retrospective UVC analyses or for dashboard-based real-time monitoring of UVC hotspots.

Keywords: Deer, Fence-end effect, KDE+, Mitigation monitoring, Moose, Mule deer, STKDE+, Underpass, White-tailed deer, Wildlife fencing.

IENE Infrastructure & Ecology Network Europe 2022

Key species and areas for research and conservation in Road Ecology. A widely applicable approach

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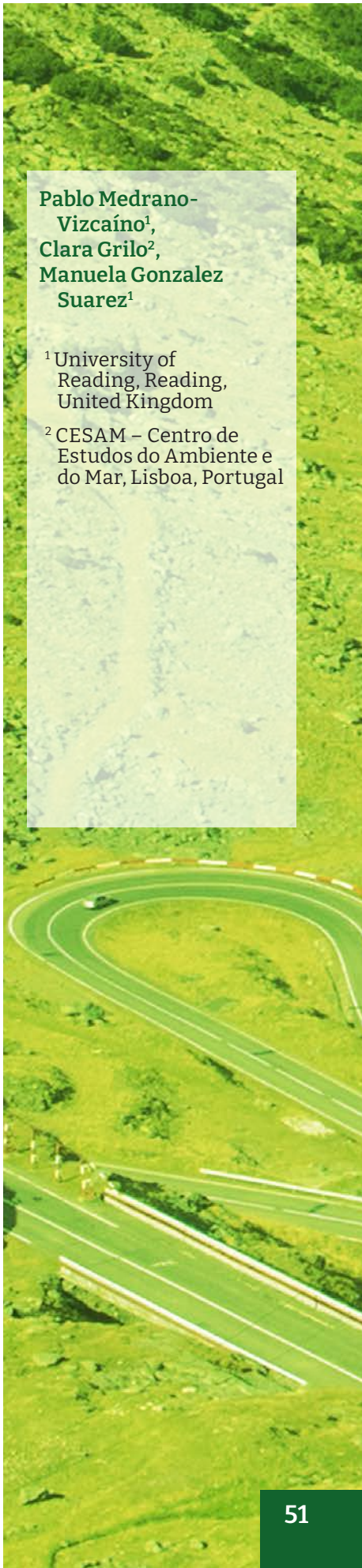
The existing and rapidly expanding global road network poses important threats to wildlife, including direct mortality. Studies of road mortality have revealed high rates for many populations; however, research is limited or completely lacking in some regions of the world. With limited resources, effectively addressing road impacts and filling knowledge gaps is critical to identify suitable targets for conservation and research. Latin America is an ideal case study where high biodiversity, an expanding road network, and emerging road ecology expertise coincide, leading to increasing risk to wildlife but also an opportunity for action. Here we propose and apply a method to identify priority areas and taxa for research and conservation in Latin America. We combined existing road mortality and infrastructure data with predictive trait-based models for birds and mammals, and identified priority areas for conservation (with many species susceptible to roadkill but few or inexistent roads) in northeastern Honduras, border of Panama with Colombia, a great part of the Amazon, and some areas in southern Argentina; priority areas for research (unstudied regions with many roads and many species susceptible to roadkill) were located in Central America, north-western South America, eastern Brazil, southern Uruguay, central Argentina, and southern Chile. Additionally, we identified as priority taxa for conservation (better studied and roadkill-susceptible groups of conservation concern) to Cathartiformes and Cariamiformes birds, and Lagomorpha, Pilosa and Cingulata mammals. Priority taxa for research (either poorly-studied roadkill-susceptible groups or unstudied groups of conservation concern) were: Cuculiformes, Caprimulgiformes, Pelecaniformes, and Anseriformes birds, and Lagomorpha, Paucituberculata and Eulipotyphla mammals. Using Latin America as an example, we present an approach that can be applied to other areas and taxa to contribute to more strategic allocation of resources in conservation and research in road ecology.

Keywords: Caribbean, Habitat, Knowledge gaps, Neotropics, Machine learning, Roadkill, Random forest, Traits, Birds, Mammals, Prioritization.



Protecting Railways from Wildlife-Vehicle-Accidents with a Virtual Fence

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In the area of rail transport, protection against wildlife accidents is becoming increasingly important. Therefore, based on our proven Wildlife-Vehicle Collision-Avoidance (WVC-A) DD430 Virtual Fence technology, the DD461 device was developed to meet the special requirements and challenges in the area of rail infrastructure.

Modern trains travel at ever higher speeds. This requires that the units must be activated before a train arrives, all at the same time within the section (electronic fence). Triggers also had to be developed to detect an approaching train from a distance so that the devices could be activated in time to allow the animals to leave the track early enough.

Therefore, a wireless connectivity is required for all devices in the system. Rail tracks are frequently crossing through rural and remote areas, so servicing of the WVC-A systems needs to be monitored by a remote service centre. This is established via internet connection from the sensors connected to a cellular gateway.

The noise of trains makes it necessary to increase the intensity of the alerts (warning sound and LED-flash) of the protective devices. The increase is about 10 times compared to the road.

Due to the high voltage of the overhead electric lines, there are high field strengths that have a strong impact on wireless connections in the area of the track. When developing the wireless connection of the devices, special consideration must be given to this in order to ensure a secure and reliable connection.

To maintain the security during rollout and service, crossing of the rails shall be avoided. Therefore, the system should work in 2 directions so a deployment on one side of the rail track is enabled even in case of a double track rail system.

Keywords: WiConNET, WVC, Wildlife vehicle accidents prevention, Railways, High speed trains, Electromagnetic compatibility.

The impact of COVID-19 related traffic reductions on the number of killed ungulates on Czech roads

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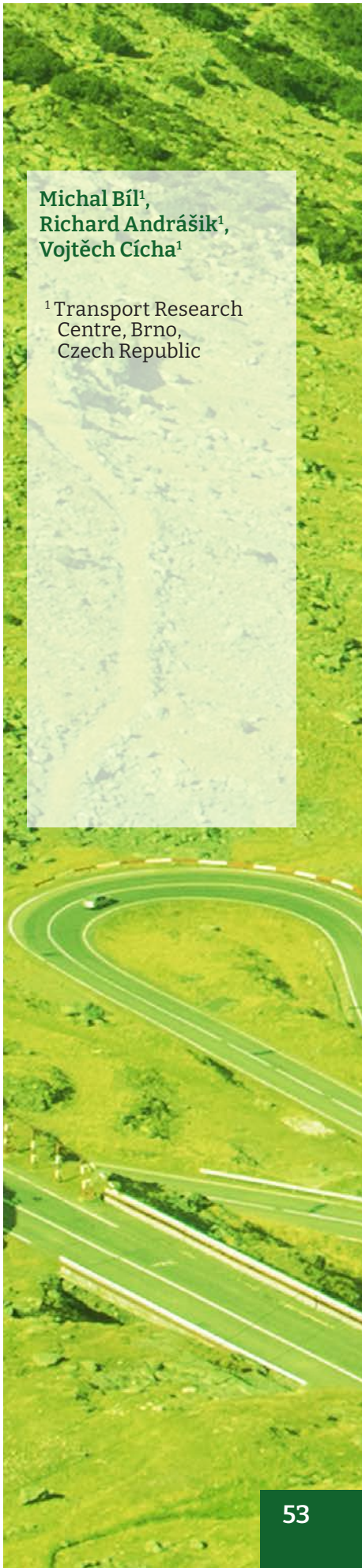

The impacts of traffic flow reductions, which occurred during the so-called first (March–June 2020) and second (September–November 2020) Covid-19 lockdowns, were studied in order to examine the change in the frequency of wildlife-vehicle collisions (WVC). WVC constantly rose between 2010 and 2019 in Czechia. There was a sudden drop in WVC of 9% in 2020 compared to 2019. Czech WVC data, which are provided by the Police and are related to car crashes only, consists of, according to our previous studies, approximately 80% of roe deer and 10% of wild boar.

According to the traffic flow data, we determined the beginnings and ends of the two covid waves in 2020. The beginning of 2020 was used as a test period for a model. Additionally, the period between the two covid waves was considered for comparison. We expected no or only a slight reduction of WVC in this period because the traffic flow was comparable with the traffic flow in previous years. In total, four periods were determined:

- the beginning of 2020 up to the 10th week;
- the first covid wave in the spring from the 11th week to the 24th week;
- a period in the summer of relatively standard traffic flow from the 25th week to the 37th week;
- the second covid wave in the autumn from the 38th week to the 49th week.

WVC data from 2015 to 2019 was used to build a seasonal model suitable for forecasting weekly sums of WVC in 2020, assuming that there were no lockdowns and thus no considerable reduction of the traffic flow. Several approaches were considered: Holt-Winters seasonal method, seasonal ARIMA models and INGARCH models with Poisson or Negative binomial conditional distribution. The best model was selected according to RMSE, MAE and its performance in the test period.

We compared the expected counts of WVC, forecast by the model, to the observed counts of WVC by means of the rate ratio test. Reductions of 16.4% and 25.3% were detected in the first and the second covid waves, respectively. During the summer period, a decrease of 13.3% was observed.

Keywords: Wildlife-vehicle collisions, Traffic flow, Covid, Lockdown, Time series analysis, Seasonal modelling.

Can linear transportation infrastructure verges constitute a habitat and/or a corridor for biodiversity and in which context?

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Transport infrastructure is one of the main sources of fragmentation of natural habitats. At the same time, their verges are often vegetated and represent a large surface area organized in networks. Hence they might play an important role for biodiversity as a habitat or corridor.

Here, we will present the results of the COHNECS-IT project, which has been dealing with this subject since 2015 through systematic reviews. At first, a systematic review protocol was published upstream (Jeusset et al. 2016), according to the guidelines for evidence syntheses proposed by the Collaboration for Environmental Evidence. Then, three systematic reviews have been conducted: first on insects (Villemey et al. 2018), second on vertebrates (Ouédraogo et al. 2020) and third on flora (Mell et al., in preparation). Five types of transportation infrastructures were considered in these reviews: roads (including highways), waterways, railways, power lines and pipelines. Importantly, studies had to report empirical data for sites in the temperate climatic zone to be retained.

In total, 81,893 references where gathered and sequentially screened on title, abstract and full-text, yielding respectively 104 studies (insects), 128 studies (vertebrates) and 459 studies (flora) for the evidence syntheses. The final corpus underlines biases recurrently found in experimental protocols, as well as knowledge gaps such as a comparatively small number of studies on railways, power lines and pipelines, or a lack of research material on the role of corridors.

An organized collection of case studies for all infrastructures and the three taxonomic groups was compiled to feed narrative syntheses on the impacts of various management practices as well as the influence of the surrounding habitats on the biodiversity found on verges. In addition, meta-analyses on the use of transport infrastructure verges as habitat highlighted for instance that pollinators and insect herbivores are more abundant in non-motorway roads verges than in similar habitats in the landscape matrix. Highway verges on the other hand represent refuge areas for small mammals but unfavorable habitats for passerines.

Overall, this presentation will thus detail cross-cutting lessons from the three reviews and highlight important methodological aspects regarding the research conducted on transport infrastructure verges. This should offer a rather comprehensive viewpoint on the issue of green verges as habitats or corridors for biodiversity, for the benefit of decision-makers, technicians, managers and researchers.

Keywords: Green infrastructures, Refuge, Corridor, Verges, Insects, Vertebrates, Vegetation.

IENE Infrastructure & Ecology Network Europe 2022

Evaluation of the effectiveness of trenches for reducing chelonian fatalities on railways

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Railways can act as traps for some terrestrial animals, such as amphibians and chelonians that get stuck between the tracks and end up dying from heatstroke and dehydration, even in places with little or no train traffic. Two Brazilian railway concessionaires identified this pattern of chelonian fatalities and developed three prototypes of trenches to be installed between ties, differing in their constructive complexity: 1) trench with a straight homogeneous base, resulting only from ballast removal between two ties, allowing turtles to exit under the rails; 2) wooden-structured trench, with a slightly convex base from the center to the sides of the rails with the purpose of passively eliminating the gravel that eventually falls into the trench due to the trepidation caused by the trains; and 3) trench with a convex base centered at the height of the ties, with a gradual slope towards the rails, stimulating the animal's descent, and a raised flap, preventing the animal proceeding forward. We aim to experimentally evaluate the use of these different prototypes of trenches by chelonians, applying behavioral experiments in arenas. Here, we present preliminary results from the first experiments and opportunistic observations. To be effective, the animals cannot cross the trenches and need to use them to escape from being trapped within tracks. We also expected a lower number of fatalities in sections with trenches. The experiments consisted of exposing 20 individuals, tested separately in 4-meter arenas delimited by the prototype being tested at one end and by a fragment of track at the other, implanted in non-operating railway sections. Each individual will be exposed in three battery tests of 15 minutes with a minimum interval of 30 minutes between each repetition. The experiments include two chelonian species, one terrestrial (*Chelonoidis carbonarius*) and one aquatic (*Trachemys* sp.). All repetitions will be video-recorded to evaluate the behavior of the animals in response to the trench's presence. So far, we have carried out the prototype 2 experiment, with *Chelonoidis carbonarius*, with almost all individuals avoiding the trench, apparently due to the height of the gap. Only one individual entered the trench once only (from 3 trials) but got stuck because it was larger than the trench. Although prototypes 1 and 3 have not been experimentally evaluated in the arenas yet, the chelonian exposures during prototype improvement tests in loco showed that *Trachemys dorbigni* uses the simplest trench (prototype 1) and *Chelonoidis carbonarius* uses prototype 3. In addition to carrying out experiments in the arenas with prototypes 1 and 3, the next step will be to evaluate the reduction of chelonian fatalities with the implementation of dozens of these trenches in the mortality hotspots identified on operating railways for these species. So far, our results show the trenches as a solution to allow these species to escape when trapped between the rails. However, the trenches need to be designed and tested considering multiple species of chelonians with different habits that are present in different railways.

Keywords: Mitigation measures, Wildlife crossing, Fauna trapping.

Results of the Austrian Research Project "WiConNET", Wildlife Protection at Infrastructure Facilities

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The WiConNET project was created by the Austrian Research Agency in cooperation with the Austrian Federal State Roads, the Austrian highway operator ASFINAG and the Austrian rail infrastructure provider OBB-INFRA.

Contractors are iPTE Traffic Solutions, Austrian Institute of Technology and WWN-Forstner.

This project aimed to record the status of European wildlife accident prevention on road and rail related to legislation and roll-out, as well as relevant applied research and test projects.

Identifying gaps in the current solutions and develop appropriate technical means to close them. Within the project, several new WVC prototype devices have been developed and reproduced in medium quantities. Focus was on wirelessly connected active protection systems. New developed solutions will be presented.

An essential task in the project is the practical evaluation of classical and the newly developed active and passive wildlife protection devices in a real environment. Therefore, within the project approx. 1,000 active and passive devices were deployed in 2 phases at 18 test sites (national roads, highways and railway lines).

Investigations of wildlife behavior, especially the response to active and passive protection measures (change of routes, day/night behaviour, etc.) will be undertaken. In order to obtain objective and comparable results, a test laboratory was established. The setup of the test arrangements for measurement of optical properties (colours, flash effects), sound properties (sound volume, frequency, cycle) as well as lifetime, maintenance requirements and cost factors will be presented.

Recommendations on creation or improvement of rules for the layout of measures for road and rail will be given to the RVS standardization committee.

Keywords: WiConNET, WVC, Wildlife vehicle accidents prevention, Roads, Highways, Railways, Test sites, Wildlife behaviour, Measures.

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Highway crossing structures in a tiger landscape: structural heterogeneity caters to the needs of multiple species

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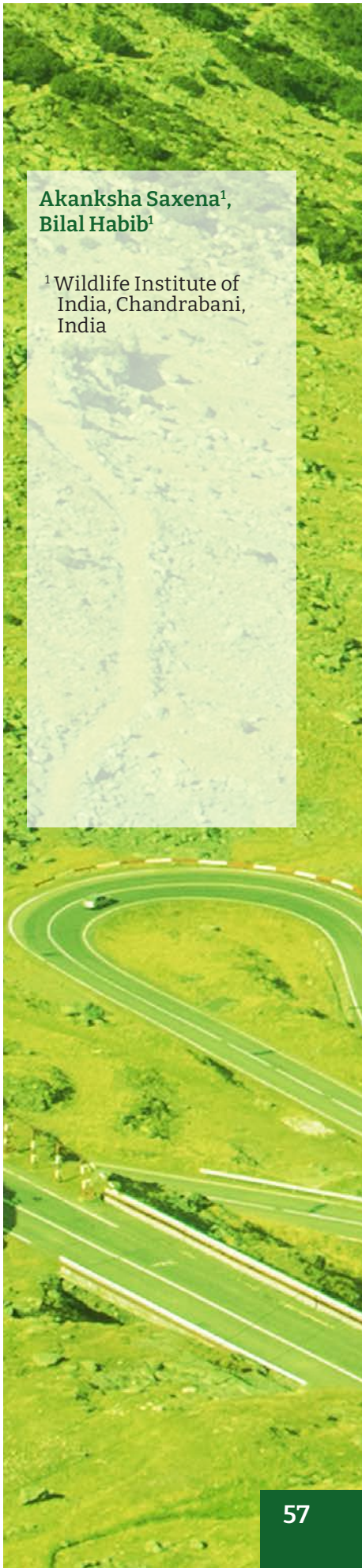

Road development at the core of a country's development and progress. Being the second-most populous country in the world, India is at the forefront of road development to fulfil the developmental aspirations its people. India is also one the most biodiverse countries in the world, and home to 70% of the world's wild tiger population residing within and outside its network of protected areas. Tiger meta-populations, spread out across a network of protected areas and tiger reserves in a landscape, are connected via corridors. These corridors are currently under great threat from road development, by causing mortality of dispersing individuals and creating barriers to movement and genetic exchange among populations. However with increasing recognition of the impacts of roads on long-term survival of tigers, associated species and forests, mitigation measures are increasingly being implemented with road development projects in the country.

The National Highway 44, a vital highway connecting the north and southern parts of the country, intersects several important tiger corridors in India. It passes through the Pench Tiger Reserve, an important tiger source for Central Indian tiger population, connected via a network of corridors to neighbouring tiger populations. Nine wildlife crossing structures, ranging between 50 and 750 m, were constructed when the highway was being up-graded from 2-lane to 4-lane configuration. The results presented here are part of a project to assess effectiveness of mitigation measures and impact of roads on wildlife. The study is important since the measures are among the first dedicated wildlife mitigation measures on highways in the country and have the potential to inform future measures in India and other tiger range countries.

We used camera traps to assess effectiveness of the crossing structures, and to assess spatio-temporal use of wildlife adjacent to the highway (before and after construction of structures). Between 2019 and 2020, 21 species of wild mammals were using the crossing structures with varying frequencies. Highest species richness was recorded under the largest structures. Tigers, wild dogs, most small mammals and ungulates used crossing structures near Pench more, while ungulates and small mammals preferred structures with proximal vegetation cover. Similar capture rates for large carnivores between crossing structures and adjacent habitat were observed. We found varied responses by structure generalists and specialists, a consequence of animal behaviour and tolerance to human disturbance. Construction of wildlife crossing structures increased spatial use of habitat near roads of some large mammals as compared to that before construction. Temporal activity at different sites (underpasses, adjacent and control habitat) varied among wildlife species, possibly because of factors such as avoidance of traffic-related and anthropogenic disturbance, conspecifics and predators.

Currently, a large body of literature exists pertaining to wildlife crossing structure design and use in the West. However such information from tiger landscapes and the Indian subcontinent is lacking. Through long-term monitoring of these mitigation measures, we aim to fill this lacuna and to increase the acceptability of crossing structures as important strategies for mitigating the impact of linear infrastructure on wildlife in tiger landscapes.

Keywords: Mitigation, Linear infrastructure, Mammals, Central India, Animal community, Wildlife underpass.

Biodiversity loss in Dutch road verges explained by climate and mowing regime

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Road verges may provide valuable habitat for grassland species if they are managed appropriately, because of their large spatial extent, the connected structure and the significant fraction of biodiversity that is already present. During the last decades, plant diversity in Dutch road verges has, however, declined. Our aim was to describe changes in botanical diversity and to assess which environmental factors may cause these changes. We analyzed data of 850 permanent quadrats in Dutch main road verges, surveyed every four years between 2004 and 2020. Changes in vegetation composition were correlated with three potential drivers of change: nitrogen deposition, change in management and climate change.

We found that the presence of competitive and tall species increased, while smaller and less competitive (including very common) species declined, resulting in a lower botanical diversity in all regions of the Netherlands. Both management and climate change were found to contribute to this decline. Lowering mowing frequency from twice to once a year resulted in strong decline in biodiversity and a change in vegetation composition. Winter warming was also found to negatively affect biodiversity.

To prevent further loss of biodiversity and to account for future, warmer climates, intermediately productive to productive road verges should be mown twice a year with hay removed. In addition, a delayed mowing period of a few weeks is advised. This will be particularly important in high productive road verges.

Keywords: Winter warming, Climate change, Management, Nitrogen deposition, Permanent Quadrats, Plant diversity decline, Road verges.

Species or group of species to predict roadkill likelihood?

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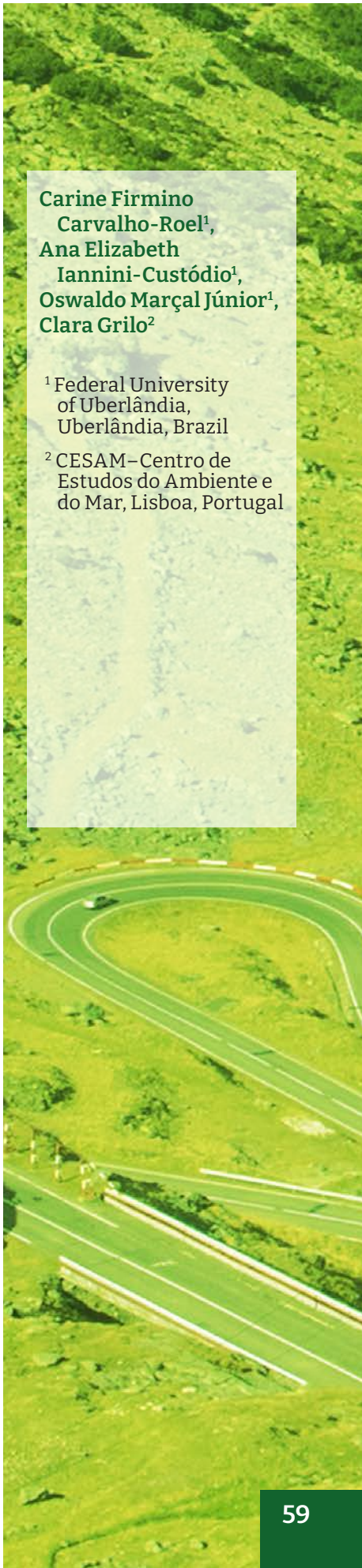
Research that evaluates the drivers of roadkill likelihood have been analyzed by species or by group of species according to some species-specific characteristics. However, little is known about which approach can be more effective to prioritize road segments for mitigation measures. A comprehensive analysis comparing the results of analysis of species and group of species is needed to understand if the findings are consistent within and between taxa and which approach provides more confident results. This study aimed to assess the role of the taxonomic level in determining the spatial, climate, and temporal drivers using roadkill data for 26 species and group of species of reptiles, birds, and mammals. The study used data from a road survey performed on 96 km of the 4-lane paved highway BR-050, a Cerrado biome area in Brazil from April 2012 to March 2014. We evaluated the performance of spatial, climatic, and temporal variables to estimate roadkill likelihood for three classes of vertebrates (reptiles, birds, mammals), 10 orders (with two or more species: Accipitriformes, Falconiformes, Cuculiformes, Strigiformes, Passeriformes, Didelphimorphia, Pilosa, Cingulata, Carnivora, Rodentia) and 13 species (*Boa constrictor*, *Crotalus durissus*, *Coragyps atratus*, *Caracara plancus*, *Cariama cristata*, *Tamandua tetradactyla*, *Dasypus novemcinctus*, *Euphractus sexcinctus*, *Cerdocyon thous*, *Chrysocyon brachyurus*, *Conepatus semistriatus*, *Procyon cancrivorus*, and *Hydrochoerus hydrochaeris*). We ran Generalized Linear Models (GLM) to evaluate how land cover and climate affect roadkill likelihood. We used circular statistics to analyze temporal patterns. Our study showed that spatial, climatic, and temporal factors differ among and within group of species. Climate seems to be more important to explain reptiles and birds roadkill while land cover seems to be more important to explain mammals roadkill. All the results were consistent within the class reptilia for climate, spatial and temporal patterns. We recommend that climate and temporal analyses should be taken at bird species and order level, respectively. For mammals, climate analyses should also be assessed at species level while landscape variables should be evaluated at species level or if not possible at least at order level. Order level seems also the best approach for temporal patterns for mammals. Our study highlights that estimating roadkill likelihood should be in majority at species level except for reptiles that could be assessed at class level and for temporal patterns that should be evaluated at order level.

Keywords: Cerrado, Human-wildlife conflict, Land cover, Road mortality, Savanna, Seasonality, Spatial patterns, Climate patterns, Temporal patterns, Wildlife-vehicle collision.



Experimental Studies for Measuring the Effectiveness of Roadkill Mitigation Measures: A Bayesian Approach

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Wildlife-vehicle collisions (WVC) have increased rapidly in frequency over the last decade in the Czech Republic. While they made up less than 5% of all registered traffic crashes in 2011, it is almost 15% at present. WVC have become a serious issue causing the deaths of animals, property damage and injuries to car occupants. One possible WVC mitigation measure is the installation of odour repellents. This device consists of foam containing an unpleasant scent attached to a wooden pole. However, there are contradictory results regarding their effectiveness as these measures are not primarily designed to block animals from entering roads. Therefore, we focused on clarifying this issue.

In our pilot study conducted in 2014–2016, we tested the effectiveness of odour repellents on 18 road sections across the Czech road network. Only one repellent scent intended for ungulates was used. There were 30 weeks of once-per-week monitoring in total combined with WVC data from the Police crash database. We employed the Before-After-Control-Impact study design to control for any confounding factors. Since the counts of WVC in our pilot study were relatively low, classic statistical approaches primarily provided only statistically insignificant results. Therefore, we applied a Bayesian inference approach to obtain at least some answer to the question as to whether the repellents decreased WVC numbers or not. We concluded that the frequency of WVC was reduced between 26% and 43%. The results were based on a limited sample size. Thus, we launched a follow-up study in 2021, benefiting from our previous experience.

The follow-up study has been planned for 2021–2022. Due to low counts of WVC in the previous study, a prior precaution was taken. We estimated the minimum sample size in order to find an effect of at least 50% reduction of WVC, if such an effect exists, with a statistical power of at least 0.8. The minimum sample size was estimated using a simulation study. There turned out to be a need to monitor at least 133 km of the road network.

In total, 135 road sections and the same number of control sections were selected. Their overall length amounts to 150 km. The study consists of two phases. In the first phase, conducted in 2021, selected road sections were monitored by 56 field workers once per week for 14 weeks during spring or autumn. No odour repellent was applied in this phase. In the second phase, which began in April 2022, odour repellents were applied along the selected road sections while keeping the control sections without mitigation measures. The last phase is planned for September 2022.

This contribution aims to discuss methodological issues experienced during the planning phase and when carrying out this experimental study, as well as to present preliminary results. We will further mention difficulties which emerged in relation to performing such a state-wide study with tens of collaborators.

Keywords: Mitigation measures, Before-After-Control-Impact study, Odds ratio, Bayesian inference, Wildlife-vehicle collisions.

IENE Infrastructure & Ecology Network Europe 2022

Wildlife warning for safer railways – testing technical solutions to prevent animal-train collisions

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Animal-train collisions are steadily increasing in Scandinavia, imposing a growing problem to wildlife management, rein deer husbandry and train operators. Costs of material damage and train repairs and delays are significant and call for effective mitigation. Earlier studies from e.g., Poland and Japan suggest that animal-train collisions may be avoided if animals are warned in time using natural sounds such as predator or alarm calls. We present results from an ongoing Swedish-Norwegian collaboration aiming at developing cost-efficient deterrent systems that reduce accidents while maintaining functional connectivity for wildlife and that can complement traditional exclusion fences and wildlife passages.

In particular, we study whether and how ungulates can be alerted, warned or temporarily deterred from railways to prevent collisions with approaching trains. The study involves two different approaches: A) a stationary, railway-based approach where animals trigger a motion activated system (MASS) that displays potentially fear inducing sounds while recording animal responses on video, and B) a train-based device similar to a dash cam that is manually activated by train drivers (DASS) to record video while displaying warning sounds.

We compared the effect of sounds such as human voice, dog barking, train horn, railway bell, and control sounds (bird and silence). Our preliminary results from the MASS studies (N=143) corroborate earlier findings that the human voice is a more efficient means to displace wildlife than other natural or artificial sounds (88% vs. 64%). DASS studies (N=191 videos) could so far only include the warning from the train horn but again supported earlier findings that the horn may indeed help to alert wildlife and lead to a flight response (72% vs. 56%) when compared to no warning sound. Still, sounds displayed from the train may need to be of a different character than those that can be used in the stationary MASS approach. We discuss options and challenges for future implementation of stationary and mobile approaches for train operators and railway administrations.

Keywords: Railroad, Wildlife-vehicle collision, Mitigation, Deterrent, Warning, Accident avoidance, Fear.

Global spatial-temporal trends in habitat fragmentation by road traffic

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Globally, roads and traffic are leading to habitat fragmentation and decreasing habitat connectivity. With a rapidly growing and urbanising human population, the past decades have seen especially high levels of habitat fragmentation due to roads and traffic. In most assessments of such fragmentation, only the roads are considered. Yet, for many animal species, the traffic on these roads causes the largest fragmentation effect. Due to regional differences in road network configurations, socio-economic conditions and population growth, fragmentation due to traffic may show strong spatial and temporal variations. However, due to a lack of continental or global traffic volume datasets, few studies have assessed traffic-induced habitat fragmentation at large spatial scales. In this comprehensive study, we have generated a global, multi-temporal traffic volume dataset to study spatial and temporal trends in traffic-induced habitat fragmentation. Based on a global road dataset, we built a network of all primary and secondary roads and highways outside of settlements (i.e., cities, towns and villages). The nodes in this network were either settlements or road intersections. As edge attributes, we calculated several network metrics, the surrounding human population density, the human development index as well as the gross domestic product. As the road network and edge attributes were all derived from multi-temporal datasets, we were able to create road networks for four time-steps: 1975, 1990, 2000 and 2015. We subsequently linked the 2015 road network to Annual Average Daily Traffic (AADT) counts or estimates from the year 2015. We obtained AADT data from regions or countries across all continents (except Antarctica). We used a random forest model to link the AADT values to the edge attributes in the road network, and subsequently predict AADT for every edge in the four road networks. To assess the level of habitat fragmentation, we calculated the effective mesh size for various traffic volume thresholds. We finally compared the 40-year development of the level of traffic-induced habitat fragmentation between countries and regions. With our random forest model, we obtained a high validation accuracy (74.4% explained variance). We found strong spatial and temporal differences in the development of the effective mesh size due to different traffic volume thresholds. We found that large regions of the terrestrial land-surface are still unfragmented when high traffic volumes are considered. Whereas some countries with high levels of population growth and a high road network density showed relatively moderate levels of traffic-induced fragmentation, others displayed strong and abrupt decreases in fragmentation. Further analysis should point out what factors generate these differences. Results of this first global assessment of traffic-induced habitat fragmentation not only increases our understanding of drivers of species and biodiversity decline, but can also lead to more sustainable urban and transport planning strategies.

Keywords: Road network, Effective mesh size, AADT, Traffic volume, Habitat connectivity.

IENE Infrastructure & Ecology Network Europe 2022

Mitigating traffic disturbance can improve functionality of wildlife underpasses

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Wildlife passages are crucial to mitigate landscape fragmentation caused by infrastructure but details in the design of passages may affect their functionality. From 2020 to 2022, we studied the use of a wildlife passage built for large mammals under a busy highway (10,000 vehicles per day) in southern Sweden, before and after the construction of solid screens along the road bridge on top of the underpass. These screens mitigate human disturbance by reducing noise and visual impacts generated by passing vehicles. Wildlife movements were derived from motion-triggered cameras and movements through the passage in relation to visitation rates were compared before and after the screens were in place. We recorded whether vehicles were passing by or not during each ungulate visit.

We observed that the screens boosted the probability for approaching wild boar, fallow deer and roe deer to pass through the underpass. After screens were constructed, wild boar was 1.6 times (95% CI: 1.0–2.5) more likely to pass through, fallow deer was 2.1 times (95% CI: 1.0–4.7) more likely to pass through and roe deer was 2.9 times (95% CI: 1.7–5.0) more likely to pass through. Screening off traffic disturbance thus improved the function of the wildlife passage.

Likelihood of ungulates passing through the underpass was the same when vehicles were driving by compared to when vehicles were not present. Thus, we found no impact from passing vehicles intermittently disturbing approaching wild boar, fallow deer or roe deer.

Increased group size in wild boar resulted in 1.5 times (95% CI: 1.3–1.7) higher likelihood that the group of wild boars would pass through the wildlife passage. But we found no corresponding impact from group size in likelihood of passing through among other ungulates, such as fallow deer.

Number of daily visits by ungulates differed before and after the construction of screens, but there are many external factors that can contribute to these changes, such as different individuals living in the areas, changes in crops on nearby fields, interspecific competition and hunting activities. Visits from fallow deer were 2.9 times (95% CI: 2.0–4.2) more frequent after screen construction. In contrast, visits by roe deer were 1.3 times (95% CI: 1.1–1.6) less frequent after screen construction. Visits by wild boar were equally common before and after screen construction. Red deer was seldom approaching the wildlife passage, and no trends could be detected before and after screen construction.

Temporal activity patterns differed among ungulates. There was no difference during daylight compared to nighttime in probability of approaching wild boar and fallow deer passing through the wildlife underpass. In contrast, roe deer was 2.6 times (95% CI: 1.4–4.9) less likely to pass through during nighttime compared to during daytime. This propensity in roe deer to more often passing through during daytime than nighttime was the same between period before and after the screen construction. Thus, roe deer seem to be more reluctant to use the underpass during darker hours and the screen construction did not impact this behavior.

Keywords: Mitigation efforts, Traffic disturbance, Fauna passage, Wildlife screen, Wildlife tunnel, *Sus scrofa*, *Damadama*, *Capreolus capreolus*, *Cervus elaphus*.

Assessing the impact of roadkill on the persistence of the giant anteater

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Human activity is depleting biodiversity, and road networks are directly contributing to this trend due to roadkill. Nevertheless, few studies empirically estimated the impact of roadkill on wildlife populations. We integrated information on roadkill rates, population abundance, and animal movement to estimate the survival rates and the proportion of the population likely to be extirpated due to roadkill, using giant anteater (*Myrmecophaga tridactyla*) as model species. We then assessed the consequent implications of roadkill on population persistence using population viability analysis (PVA). The yearly survival rate of resident anteaters inhabiting road vicinity areas (0.78; CI: 0.62–0.97) was considerably lower than for those living far from roads (0.95; CI: 0.86–1.00). The real number of anteaters being road-killed is considerably higher than the one recorded in previous studies (by a factor of 2.4), with cca. 20% of the population inhabiting road vicinity areas being road-killed every year. According to PVA results, roadkill can greatly affect the persistence of the giant anteater populations by reducing the growth rate down to null or negative values. This study confirms that roads have significant impacts on local population persistence. Such impacts are likely to be common to other large mammals, calling for effective mitigation to reduce roadkill rates.

Keywords: Population Viability Analysis, Population persistence, Road Ecology, Transportation 39 infrastructures, *Myrmecophaga tridactyla*.

Development of the ecological network of bird's habitats near the M6 motorway in Tolna county, Hungary

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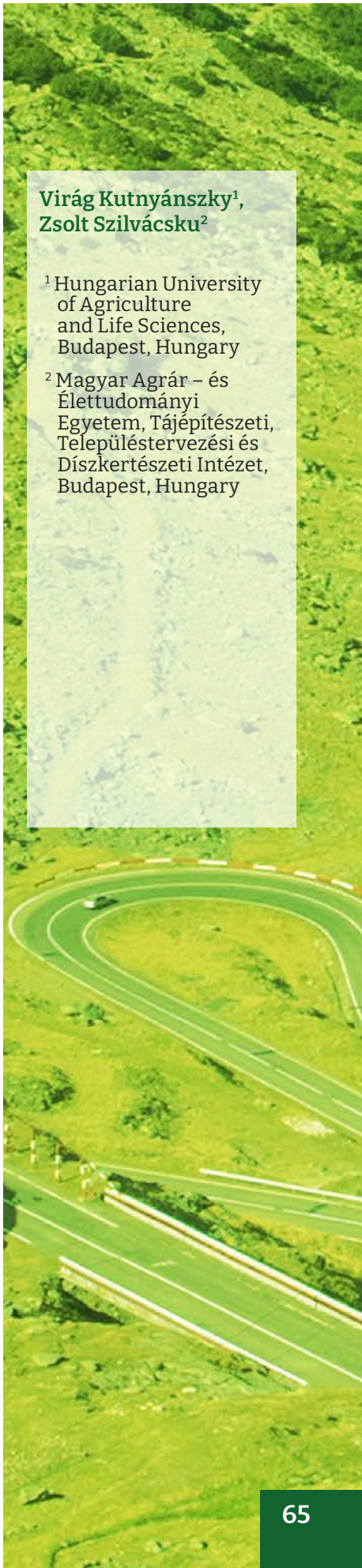

The aim of our research was to define the deficiencies the gaps and conflicts in the ecological network. Our aim was to identify key patches and linkages in the network, while also identifying where there is a need to complement the network. Specifically, we aimed to determine the spatial impact of the M6 and the M9 motorways on the ecological networks system. The main motivation was to help combat the drastic decrease of bird species (especially farmland birds) in Hungary, for which the development of a landscape level ecological network could be a solution.

Our research took place in Tolna County, around Szekszárd, where the M6 and the M9 motorways intersect. When defining the area, we chose to consider the natural characteristics of the landscape, so we examined two regions: the Hills of Szekszárd and the Tolnai-Sárköz (840 km^2) which are separated from each other by the M6.

To supervise the ecological network, we used four bird species as indicators, while also taking the natural characteristics of the research area into account. We chose an indicator species from all four bird groups commonly found in the area (farmland birds, forest birds, waterbirds and birds of prey) and used GIS methods to determine the species ecological network taking the ecological needs of the species into consideration. After calculating the networks, we defined conflict areas and elements that could act as a barrier for the birds. We also used two other indicators that describe the characteristics of the landscape and should have some kind of ecological protection: buffer zones of the waters and erosion.

Our results showed that the ecological network in the area is insufficient, the buffer zones of the core areas are almost completely missing and some key links could be also identified. The M6 has a strong fragmenting effect between the Kapszeg Lake Nature Reserve and the Backwater of Tolna. The M9 crosses through the most ecologically valuable area, the Gemenc, resulting in the decrease of the biodiversity of the well-protected habitat.

To dissolve the conflicts, we suggested a landscape level ecological network that helps to complete the national network and identified the missing corridors and buffer zones.

Keywords: Ecological network, Motorway, Connectivity, Barrier-effect, Fragmentation, Bird species, Bird ecology.

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Can traffic mortality of wild forest reindeer *Rangifer tarandus fennicus* impact population persistence?

Ungulate-vehicle collisions (UVCs) are an increasing traffic safety issue and animal welfare concern in boreal regions. However, although the annual number of UVCs can be high, road mortality is not likely to negatively affect the population persistence of abundant ungulate species. This is not without exceptions: traffic mortality of some endangered species or isolated populations can reach such high rates that it negatively affects population levels.

One ungulate species which is potentially negatively affected by traffic mortality is the European wild forest reindeer (WFR) *Rangifer tarandus fennicus*. This forest dwelling subspecies of the reindeer *Rangifer tarandus* is now only found in Finland and Russian Karelia; the total population is cca. 5,000 animals. As a female produces only one calf per year, WFR's possibilities to compensate any mortality factor is limited. As traffic mortality is practically the only direct mortality factor in WFR which can be mitigated, it is important to understand the magnitude of the problem.

There are currently two distinct subpopulations of WFR in Finland (Kainuu and Suomenselkä). In 2017–2020, we collected data on annual WFR traffic mortality in both regions and estimated its proportion in overall mortality of the wintering subpopulations. The study was conducted in the EU-funded conservation project WildForestReindeerLIFE.

In Finland, drivers are required to report all UVCs to an emergency number. This information is then forwarded to the police, who assign the task of removing a carcass or tracking down the injured animal to predetermined local volunteer hunters. Since the beginning of 2017, volunteers are required to report every task carried out, and information about the species in question is collected along with other details. We combined this dataset (2017–2020) with the results of aerial WFR wintering population censuses conducted by the Natural Resource Institute Finland and calculated collision rates (collisions per 100 individuals) and road mortality rates (road-killed WFR per 100 individuals) for both subpopulations.

In relation to population size, the Suomenselkä subpopulation had a higher collision rate (3.4 collisions/100 individuals) than the Kainuu subpopulation (1.6). Accordingly, the road mortality rate was higher in the Suomenselkä subpopulation (2.2) than in the Kainuu subpopulation (1.1). As it is highly likely that most animals hit by a vehicle are injured and will die later, and some collisions are never reported, road mortality rates were probably underestimated.

We found that among road-killed individuals classified according to age (adult vs. juvenile), the percentage of road-killed calves was 4.8%. Our dataset was too small to draw any firm conclusions, but the results suggest that WFR road mortality might be adult-biased. If true, the possible negative effect of road mortality on population persistence might be larger than collision numbers indicate.

Even though our study was based on only four years of data, the high proportion of adult road-killed WFR implies that traffic mortality should be seriously considered. This calls for species-specific mitigation measures for WFR, which differs from other wild ungulates as a strongly migratory, herding species.

Keywords: Ungulate-vehicle collision, The LIFE programme, Road-kill.

The direct effects of roads on leopards' spatial behavior

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Transportation infrastructure has several impacts on wildlife, including felids. A few studies highlight the effects of roads on species' spatial behaviour, but to our knowledge none has aimed to find an unified pattern across the species' range. In this context, the main goal of this study was to analyse how roads affect leopards' spatial behaviour in different regions of its distribution.

We compiled information on leopard movement from GPS-based information from five countries (South Africa, Kenya, Iran, Turkmenistan, and India), where two of which have high road densities (South Africa and India). In total we analysed 11,562 locations from 36 radio collared leopards (24 males and 12 females).

We found that leopards tend to avoid paved roads but seem to actively use unpaved roads. We also found that the average distance from paved roads beyond which leopards' locations stopped to increase was at 240 m. In general, females seemed to avoid more the paved roads than the males. Also, males seemed to use unpaved roads more than females. We detected that there were almost 200 male locations and only 60 female locations up to 20 m from unpaved roads.

We also found that both sexes tend to avoid more the paved roads during the day, while males preferred unpaved roads during night than day. Male locations were more than 3 times higher during the night (150) in comparison with day locations (40) up to 20 m from paved roads.

Overall, our findings might be explained by the fact that paved roads have a higher traffic volume, acting as a barrier to leopard movement. On the other hand, unpaved roads have higher usage by these felids due to less human activity and represent lower energetic costs than crossing understorey forests. Males have larger home ranges and seem less secretive than females, which can force them to get closer to paved roads while presenting a higher usage of unpaved ones. In addition, male leopards are known to more frequently scent-mark on roads.

In conclusion, this study stressed that the negative effects of paved roads are aggravated at daytime and greater on females, which may have implications on population structure. In contrast, unpaved roads appear to have a positive effect, as they are more frequently used by leopards for navigation.

Keywords: *Panthera pardus*, Road impacts, Paved roads, Unpaved roads, GPS-locations, Africa, Asia, Daily activity.

Modelling wildlife movement and connectivity for the Nairobi to Mau Summit Highway Project in Kenya – improving standards for highway ESIA

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The Nairobi-Nakuru-Mau Summit Highway Project in Kenya involves the dualling of 175 km of the A8 Highway and strengthening of 58 km of the A8 South Highway. This infrastructure forms part of the busiest and most important transport corridors in East and Central Africa. This Public Private Partnership (PPP) Project is being led by the Rift Valley Highways Limited Consortium (RVHL) composed of Vinci Highways, Vinci Concessions and Meridiam. WSP Canada is the consultant responsible for the environmental and social impact assessment (ESIA) for the project.

The project is set in a complex biodiversity context and extensive flora and fauna surveys were undertaken to inform the ESIA. In addition, an extensive fauna connectivity study was undertaken to identify locations where wildlife occur and are likely to cross the highway. This work relied on many innovations, which will set a standard for future ESIAs: the formal engagement of transport-ecologists from Africa as a "brains trust" for the project; the deployment of internet-enabled remote camera-traps; the use of artificial intelligence (AI) to identify target fauna; the use of systematic surveys, existing data and expert opinion to develop habitat suitability models to predict the occurrence of wildlife and movement pathways; and the use of rigorous statistical methods to identify wildlife crossing locations.

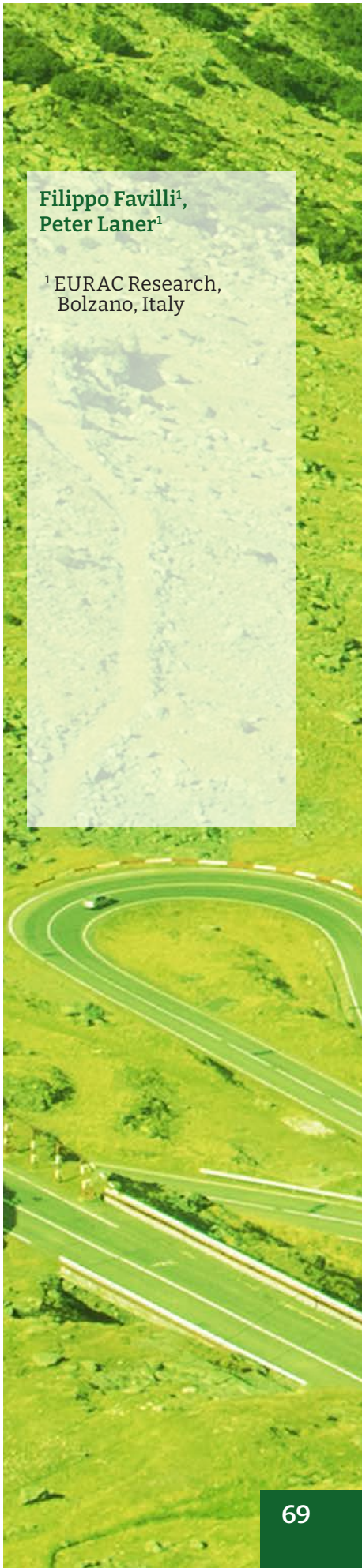
Fifty cameras were deployed between February and June 2021 which collected over 80,000 detections of wildlife. AI solutions were developed and refined to ensure efficiency and accuracy of species identification, quantified to ~>75%. The lack of systematically collected wildlife occurrence points was overcome through the use of Maptionnaire (www.maptionnaire.com), an online participatory mapping tool that enables local experts and stakeholders to input their knowledge directly onto maps. Connectivity models were built using the General Approach to Planning Connectivity from Local Scales to Regional (GAP CLoSR).

The presentation will focus on the innovative solutions applied to collect data and develop habitat suitability and ecological connectivity modelling. The final results of the connectivity study, as well as lessons learnt for future projects will be discussed. A significant outcome of this project is the ability to use statistical methods to quantify connectivity, even in landscapes where little formal data exists. This project has set a benchmark that impact assessments for linear infrastructure projects in the developing world must emulate if they are to be considered best-practice.

Keywords: Best practice ESIA, Connectivity, ESIA, Kenya, Africa, Habitat suitability modelling, Impact assessment.

IENE Infrastructure & Ecology Network Europe 2022

Combining GIS and SWOT analysis for enhancing ecological connectivity in the Alpine-Adriatic Area



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The Interreg ADRION DinAlpCONNECT project builds on previous experiences of ecological connectivity projects in the Alps to safeguard the ecological network between the Alps and the Dinaric Mountains and in the whole Adriatic area. The project aims at developing specific regional, transboundary strategies to protect the most relevant core areas and corridors, and overcoming existing and future barriers, for the connection of these two mountain ranges.

Spatial models for ecological connectivity have provided the basis for the development of macro-regional strategies for the enhancement of ecological connectivity on a trans-boundary level. However, such an analysis has never been conducted so far to analyze the ecological continuum between the Alps and the Dinaric mountains, including the natural elements, the socioeconomic dimension, and the human management of the territories.

With this contribution we show the adaptation and use of a spatial model, developed in former Interreg Alpine Space projects, simulating the landscape permeability and defining the most important connections between the Alps and the Dinarides, involving eight different countries. The model follows a structural approach based on the Continuum Suitability Index (CSI), a specific multi-criteria evaluation, which takes into account the experts' opinion done in each of the countries involved. An ecological connectivity assessment was elaborated combining the GIS model results with the SWOT analyses done in each of the four trans-boundary pilot regions, which highlighted the main issues regarding the interactions between the socioeconomic matrix of each area and the ecological needs of wildlife species.

At macro-regional level, the results shows that, while 82% of the ecological conservation areas are overlapping with protected areas, non-EU countries have still wide gaps of protected landscapes, compared to the member states. It was also revealed that 36% of protected land is strongly fragmented, in altitudes not suitable for most species, or is facing a high land use pressure in combination with a low protection status. 416 regional ecological corridors were identified and categorized. The main barriers identified are mostly represented by cities, main roads and productive land uses. In the whole project area, 108 ecological corridors were intersected by highways, of which 60 represent a real physical barrier, proving that the area is highly fragmented and in need of specific actions for local enhancement of ecological connectivity.

The results from the combined analysis GIS-SWOT in one of the four transboundary pilot sites will be presented. The integration of stakeholders on both sides of the border has highlighted the need for habitat conservation and maintenance of the conditions appropriate for target species, mainly through an increase in cross-border cooperation, encouraging people to recognize that nature knows no political or administrative boundaries and to promote sustainable agriculture, forestry, tourism, and organic production. This innovative approach will represent the basis for the development of a macro-regional strategy, which will focus on the most important corridors for protection or restoration measures in agriculture, forestry, and spatial planning.

Keywords: Ecological connectivity, Spatial models, SWOT, Alps, Dinaric.

Coupling connectivity modeling, roadkill hotspots and expert-opinion to reduce barrier effects of transport infrastructures

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Wildlife crossings (underpasses and overpasses) have become standard practices to reduce the barrier effect of major transport infrastructures. Many studies aim to identify relevant locations for the creation of new wildlife crossings, based on connectivity modeling tools or animal movement records. But results are rarely confronted with the opinions and knowledge of experts. However, integrating a field expertise is necessary to meet operational requirements. That allows to confirm and/or adjust the large-scale recommendations based on ecological connectivity considering the local context, and to make technical recommendations. We proposed to address this issue by the following question: how can modeling and field approaches be combined to reduce the barrier effects of major transport infrastructures?

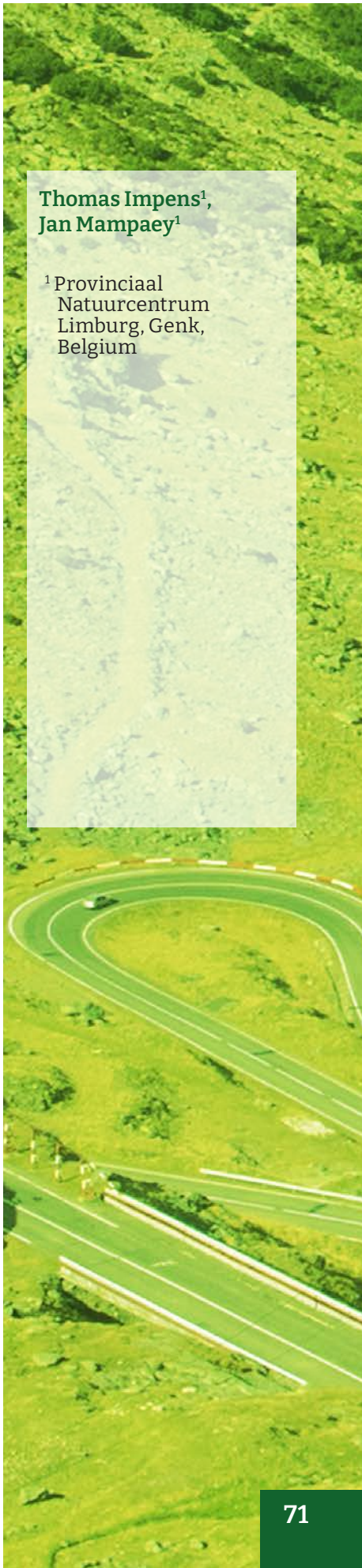
Applied to the 1,800 km highway network of Northern France, we defined a methodological framework using graph theory and field expertise i) to prioritize existing road structures to be improved, ii) to find the best locations for new wildlife crossings, iii) to make precise, costed technical recommendations on what needs to be done and iv) to compare the resulting locations with roadkill data. In the first step of the connectivity analysis, we defined and grouped 9 species according to their habitat preferences, modeled their ecological networks, and calculated several connectivity metrics combined in a multispecies approach. Next, we prioritized specific existing road structures for improvement through an ecological functionality index, and as a final step, we found the best locations for new wildlife crossings based on the connectivity gains provided on a global connectivity index. The identification of the most favorable road sections led to a more detailed evaluation to define, in the form of program sheets, the minimum technical characteristics of the structures to be created and the facilities to be provided to guarantee high level of ecological functionality, an estimate of the cost of the work and the studies and regulatory procedures to be carried out subsequently.

Comparison of the potential mitigation measures with roadkill data showed that most collisions corresponded spatially to the proposed mitigation measures. These areas were characterized by a medium level of connectivity, and a high level of connectivity gain provided by the potential mitigation measures. However, some collisions occurred in areas not identified as attractive for wildlife crossings by connectivity modeling. In these areas, the initial connectivity was very high, and the potential gains were not large enough to detect a mitigation problem. Mitigation measures must therefore consider both the initial connectivity and the potential gains. This study provided a better understanding of the barrier effect of transportation infrastructure and highlighted the complexity of the relationships between connectivity, roadkills and mitigation.

Keywords: Mitigation measures, Wildlife crossing, Impact assessment, Landscape connectivity, Graph theory, Conservation planning.

IENE Infrastructure & Ecology Network Europe 2022

Ecological corridors: the right (policy) instruments to encourage cooperation



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As an educational nature centre that is part of the provincial government, we are the main support in biodiversity policy making in Limburg for this government. In Flanders the provinces have a responsibility for the organisation and realisation of a network of ecological corridors.

This is a complex task because of the strong fragmentation of the landscape, the many civil functions that coexist in the open space, the fragmentation of ownership, the difference in vision. As a government on an intermediary level between local and regional authorities we are well suited for this.

In preparation of the task ahead we updated our vision on an ecological network by adding functional, ecological data to an earlier vision that was primarily based on spatial planning. By doing so we made a clear distinction between an ecological corridor, which has a specific ecological function, and the broader green-blue grid which can in principle provide a wider array of ecosystem services.

In our ecological based vision we distinguished 16 groups of animal species for which we identified potential ecological corridors in Limburg. For each of these corridors we are able to specify for which species they would be useful and what their habitat requirements are.

To make the step towards realisation we are taking various actions. We are for example, based on our data, making reports on ecological corridors tailored to each of the 42 municipalities of Limburg.

In this presentation we focus on 2 specific cases where we are experimenting with tools and policy instruments which can inspire our partners.

In testing different policy instruments and tools for realising ecological corridors we want to learn the advantages and disadvantages of these instruments so that we can advise and support partners. Furthermore, we want to build the confidence of our partners to take action themselves.

These examples are real life projects in which the provincial government is involved and which will lead to the actual realisation of ecological corridors. They are similar in size and objectives to those that are managed by our partners. A distinction is made between the elimination of barriers and the realisation of a corridor (creating habitat).

In case 1 we examine the role of the province within a broad collaboration of partners. In a central region of Limburg called "The Wijer"s we are working on a corridor for various amphibians. Within the knowledge and resources gathered by the entire group we are looking what the specific contribution of our organisation could be.

In case 2 we are setting up a framework of agreements with partners on the management of a corridor that will be realised in the near future. This corridor is for the smooth snake (*Coronella austriaca*) and is part of the mitigation of a new bike path in the east of Limburg.

In our presentation we reveal our experiences and lessons learned in these two cases and how they contributed to the stakeholder engagement of our potential partners.

Keywords: Cooperation, Stakeholder engagement, Realisation, Ecological corridor, Policy instruments.

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A substantial theoretical and practical post-graduate professional diploma course in transport ecology

One way of guiding infrastructure development in a more sustainable way is to ensure there is enough capacity and expertise to incorporate environmental and climate considerations into the planning and design. The current formal civil engineering curriculum and teaching approaches do not include courses, lectures and content on sustainability, ecology and natural capital accounting. Hence, even though the government acknowledges the important links between infrastructure and the environment, its officials lack capacity to understand and implement safeguards for linear infrastructure.

As Myanmar is home to a wide array of species and ecosystems that provide many benefits to the people of Myanmar, it is important to develop transport infrastructure that will ensure that biodiversity can continue to thrive. To support Myanmar's ambitious infrastructure plans, we developed a Diploma Course curriculum which is the blueprint of training and capacity building through carefully designed teaching and learning methods. This Diploma is a substantial theoretical and practical post-graduate course in transport ecology that will improve sustainable development in Myanmar and further the career and professional development of participants. This course is officially recognised by the Ministry of Construction (MOC) and Ministry of Natural Resources and Environmental Conservation (MONREC) in Myanmar and is affiliated with TransportEcology.info and Yangon Technological University (YTU). The course offers a comprehensive overview on transport ecology and aims to attract a batch of 15–20 participants from the Ministry of Construction, Ministry of Transport and Communications and MONREC and select professors from the YTU. The course has been designed around five modules, with each module being approximately the equivalent of a two-day/weekend course of contact hours, including an additional equivalent amount of time for readings and assignments. Each module has been designed to be delivered during a two-day intensive session, however can easily be modified and adapted as needed, with a total duration of approximately nine months.

To initiate the knowledge of transport ecology, WWF Myanmar brought the environment authorities and infrastructure planners to the IENE conferences, and to the ICOET in 2019 as well. As part of the results, the former head of the Department of Highways of MOC presented the mitigation plan for the Dawei Road in the 2021 Evora IENE virtual conference. The IENE experts were invited to Dawei road project and delivered the first basic Transport Ecology training in Myanmar for inter-ministerial and Yangon Technological University professors participants, in 2015 and 2019 respectively.

Keywords: Transport ecology, Diploma, Stakeholders engagement, Collaboration.

IENE Infrastructure & Ecology Network Europe 2022

Development of an evaluation methodology for ecological corridors on the planed section of the M2 highway

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It is well known that with the spread of human kind, a growing number of linear facilities (e.g., roads, railways, sewers, overhead cables, etc.) lead to the fragmentation of habitats. Today's science has reached the level of recognizing the ecological problems caused by fragmentation, but solving them is "in its infancy" in the science arena. In my presentation, I represent a new system for evaluating ecological corridors that can be used to determine their value and importance, and, where appropriate, the type and location of the wildlife mitigation measures. I illustrate the applicability of the evaluation system with the help of a case study on the planned section of the M2 motorway. During the preparation of the study, I examined and evaluated the ecological corridors exposed to the development of the expressway network in Nógrád County, and I determined the location and type of ecological passages on the planned route of the M2 highway.

At the beginning of my study, I describe the major conflicts between ecological corridors and linear infrastructures and their resolution. After the description of the sample area, the evaluation system of the ecological corridors will be described and developed on the basis of the collected knowledge. In the first part, I identified the "target" animal groups and species occurring in the area, which is a total of 13 animal species. Then I defined their needs according to the given six criteria, such as their demand for vegetation or how well they tolerate the disturbance. Following that, I examined the properties of ecological corridors. 6 aspects were identified: corridor length, width, vegetation, water presence, continuity, and surrounding land use or confusion. I compared these values with the needs of the animals and examined how suitable a particular property of a corridor is for different animal species. Here I defined 4 values: S1, S2 S3, S4, where S1 is the most suitable and S4 is the most unsuitable. I averaged the values by animal species and illustrated the results in a summary table that shows which animal species are best suited to use the corridor. I aggregated the data using a GIS system so that I could able to locate the ecological gateways along the route of the M2 highway. Finally, I identified suggestions for the type of gateway that I would make by comparing the characteristics of the ecological corridors and the needs of the animal species that define the area. The suggested creation of the wildlife mitigation measures should help the safe passage of the occurring animals in different areas such as large ungulates (wild boar, red and roe deer), small and medium-sized mammals (red fox, eastern hedgehog, otter), amphibians (brown toad, Danubian crested newt), reptiles (green lizard, forest glider) and fish (chub, pined loach, gudgeon) while it also reduces the damage caused by fragmentation.

This study was financially and technically supported by projects Interreg-DTP SAVEGreen.

Keywords: Ecological corridors, Wildlife paths, M2 highway, Evaluation, Animal crossing.

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International perspectives on fundings and research needs in infrastructure and biodiversity

According to the G20, the forthcoming investment of over $94 trillion worldwide in the transport and energy sectors represents a major opportunity for stimulus measures such as the EU Green Deal. However, the 50% increase in networks by 2040 is also a major challenge for biodiversity and the environment, as highlighted by the World Economic Forum. Moreover, as ¾ of the increase in infrastructure will be concentrated in developing countries, international collaboration is needed.

The crisis that the world has been experiencing since 2020 shows the immense vulnerability of transport and energy systems to increasing alterations in the natural environment, and the impacts that these events have on human and animal health. Land-use change induced by the creation of transport or energy infrastructure will increase potential friction points and reinforce the need to take into account the limits of ecosystems. Although we are aware of the impacts of these networks on biodiversity and can also propose appropriate mitigation measures, these issues are not yet sufficiently addressed in view of the massive and rapidly increasing challenges. The knowledge developed on these topics has so far remained compartmentalised between the different types of infrastructure.

In this presentation, based on our experience as a ministerial official in charge of research and innovation in infrastructure and environment, pilot of the European BISON project and member of the UN Sustainable Infrastructure Partnership, I will analyse how sustainability research and policy in the transport and energy sector should now take into account both biodiversity and climate issues.

To this end, I will present a synthetic mapping of the issues at stake in terms of sustainable financing of infrastructure research and innovation. Based on an analysis of the latest publications from the G20, OECD, World Bank and UN resolutions, I will also present the trends and potential future tensions in terms of research needs on the interactions between infrastructures and biodiversity in view of the massive investments underway or to come. In particular, we will address the closely related political, legal, economic and societal issues and the way in which international organisations but also private companies are integrating these issues and how, at the European level, we can improve the coordination of research investments and the exploitation of the results. To this end, based on my experience of strategic research management, I will discuss the way in which research organisations are mobilised to meet these needs, the challenges they face and the responses they provide, particularly in terms of transferring research results to operational action.

Keywords: Research, Prospective, Policy, Norms and standards, OECD, UNEP, G20-G7, EU – Horizon Europe, GEF 8.

IENE Infrastructure & Ecology Network Europe 2022

An imaginative and prospective approach to linear infrastructures: a landscape architecture educational experience at the service of the ecological and energy transition

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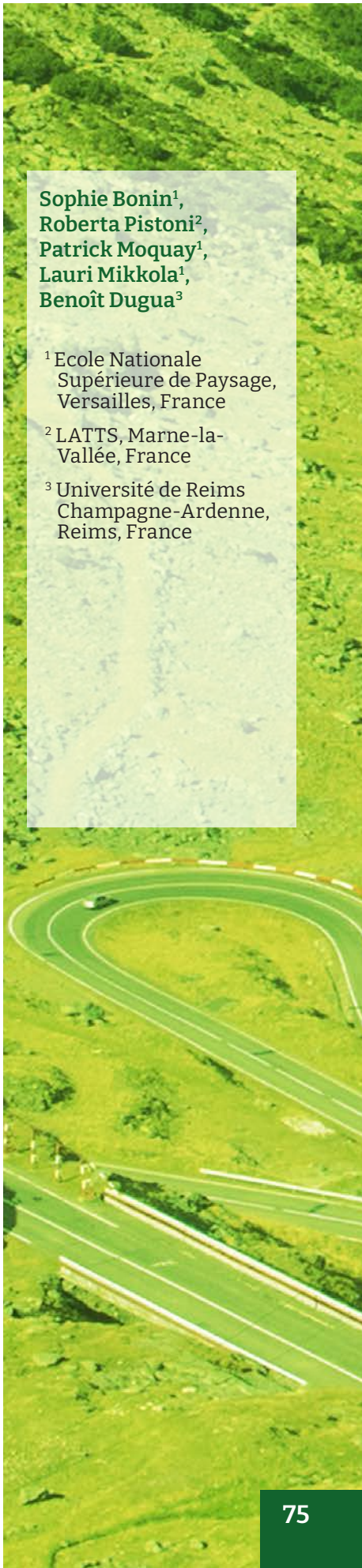
A major challenge for infrastructure is to succeed in recreating a dynamic ecosystem trajectory which would include these objects that by their nature and their functions are very human. This requires a strong prospective effort, to imagine new spaces associated with linear infrastructure, preserving but also implementing new functions or opportunities for the living beings: this means to enter into the logic of biodiversity's "continuous creation". This is even more important in an ecological and energy transition process that needs to rethink and reshape the territories we live in and the infrastructure we use daily. This paper aims to reflect on this need for imagination, its framework and its limits in order to answer to the ecological challenges highlighted scientifically, but also to propose a locally engaging social project. In order to point out the advantages and limits of imaginative approaches, we will rely on an educational exercise conducted with students in landscape architecture: the students were asked to project themselves 30 years into the future, inspired by different energy transitions scenarios, in order to develop a design for areas marked by a complex network of roads, rail and electricity transmission infrastructures. In what way can linear infrastructure become traces, favoring wayfaring more than transport, and be thought/designed as surfaces more than threads, referring to Tim Ingold's anthropological proposal?

The design sites were chosen in two different geographical context, one in France in the Ardennes in the region of Charleville-Mézières, and the other in the Netherlands in the province of Zuid-Holland. This allows to offer a diversity of the initial conditions able to point out different solutions but also to support the analysis, for the heuristic interest of the comparison.

We established a system of criteria to analyse the different projects imagined and designed by the students, which integrates: the place of multifunctionality, in the social sense (public space) and in the ecological sense (biodiversity and actions against climate change); the conceptual choices and design of infrastructure (twinning, reversibility, derelict areas); the identification of action levers and actors; the articulation between technology and ecological processes.

After a quick presentation of the eight projects designed by the teams of 4–5 landscape architecture students, the paper will focus on discussing the results of this experiment based on the hypothesis of landscape design as a relational political instrument. We identify and discuss five levers: infrastructure create unseen spaces, non-accessible, de facto protected; energy goals for the near future generate new expectations; connections and network points could be opportunities for more integrated design; the improvement of ecological functionalities and biodiversity restoration is articulated with social practices of space management; designers need to be trained to deal with these infrastructures. These levers constitute a basis to be mobilised for future linear infrastructures project.

Keywords: Landscape architecture, Global approach, Linear infrastructure, Territory, Landscape didactics, Imagination.



Alignment Optimization: A preliminary assessment of construction, economic, and environmental costs

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The Alaungdaw Kathapa National Park (AKNP) is Myanmar's oldest and one of its largest national parks. Located in the northwest part of the country, the 1,426.45 km^2 park is near Myanmar's border with India and falls within one of the largest intact expanses of forest in the country. The park was also designated as an ASEAN Heritage Park and an Important Bird Area due to its unique biodiversity value. Myanmar has recently been planning to upgrade an unimproved dirt road through the AKNP to increase the flow of people, goods, and services as part of the India-Myanmar-Thailand Trilateral Highway Investment. Myanmar law and numerous international investment standards dictate that the environmental impacts of linear infrastructure development projects should be properly assessed and alternative routing options considered during the planning process to avoid unnecessary impacts on environmentally sensitive areas.

The upgraded road through the AKNP is expected to result in increased traffic volume, wildlife collision risk, and habitat fragmentation that would negatively affect the park's biodiversity. To explore options for avoiding or mitigating these impacts, we engaged with authorities and several conservation organizations to explore alternative road alignments for a proposed 25.6 km stretch of road that currently bisects the northeast corner of the national park. Given that this proposed highway project is being planned as an upgrade of an existing road, we focused on this relatively small stretch of road as we assumed a large realignment would likely be cost-prohibitive. We implemented a genetic algorithm in Google Earth Engine, a web-based spatial analysis platform, to find optimal alignment alternatives under each of four scenarios that differed in their environmental and economic objectives:

- Scenario 1 ("Go Anywhere"): Route selected based only on road construction costs and technical design criteria (e.g., slope);
- Scenario 2 ("Avoid Park"): Route must avoid the park while minimizing cost and meeting design criteria;
- Scenario 3 ("Connect People"): Route seeks to connect areas of higher predicted economic activity while minimizing cost and meeting design criteria;
- Scenario 4 ("Connect People/Avoid Park"): Route must avoid the park and prioritize economic activity while minimizing cost and meeting design criteria.

Alternative routes identified for this road section ranged from 26.8 km (Scenario 1) to 59.6 km in length (Scenario 2) while construction costs (paving + earth moving + land acquisition/clearing) were projected to vary from being roughly equal to the original route (+1% for Scenario 1) to being double or more in Scenarios 2, 3, and 4 (+163%, +100%, +142% respectively). However, the lengths of these potential realignments are relatively small compared to the entire ~350 km section of road planned for upgrading between the cities of Kale and Monywa, and would therefore entail a modest "green premium" for avoiding the AKNP. For example, avoiding the park would add only 8.5%–9.5% to the overall paving cost of this larger section of road.

Keywords: Environmental impact, Alternative routes, Google Earth Engine.

IENE Infrastructure & Ecology Network Europe 2022

Targeted tree and habitat establishment alongside the operational railway in Great Britain to benefit safety, people and nature

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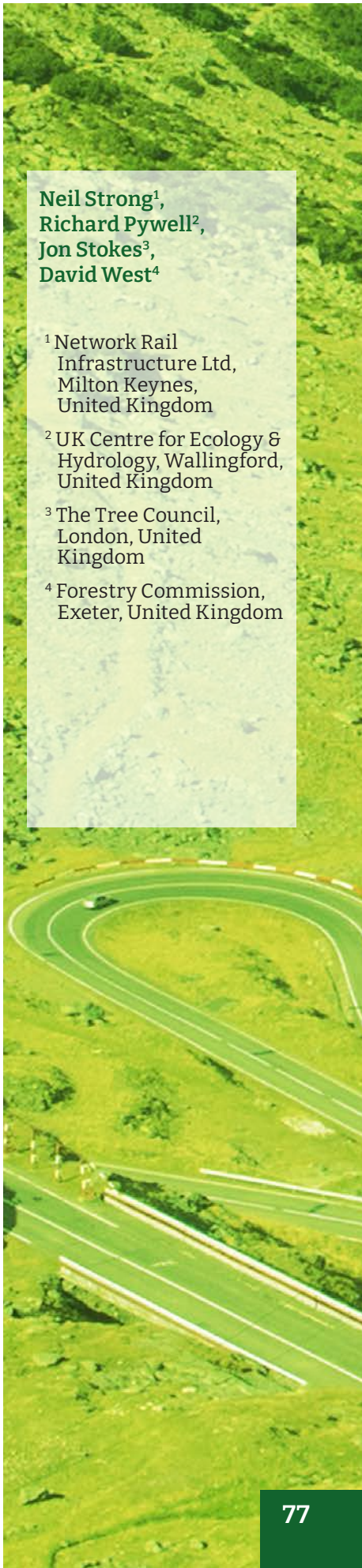

The rail network across Britain extends to over 50,000 hectares within 32,000 km of boundary. There are approximately six million trees on the railway estate creating a woodland coverage of approximately 20%, almost double the average for Britain. The management of this vegetation has been subject to scrutiny over the last ten years. An independent report in 2018 resulted in the UK Department for Transport imposing targets of no net loss and net gain of biodiversity by 2024 and 2035 respectively. To achieve these targets we needed a baseline of the habitats on our estate. We used satellite data to quantify the existing habitats along with those in the landscape through which we pass. Collecting data within 1 km of the railway fence has categorised approximately 3.2 million ha of Britain's habitats. As well as baselining the biodiversity of the habitats on our estate, this extensive dataset highlighted an opportunity to work with adjacent landowners to increase tree planting across England.

Working and surveying in the vicinity of a live rail network is expensive and puts field workers in situations requiring many safety precautions. The use of satellite data to initially identify habitats and locations of interest reduces the need to survey everywhere. This in turn reduces the need to put staff in hazardous locations. Field investigation of prospective trial sites can be undertaken once the sites have been chosen. Ongoing monitoring can be a combination of remote and field studies. This work has seen 3.2 million ha of habitat surveyed with no surveyor injury, kept costs to a minimum and undertaken that survey work in one season. Other initiatives the partners of this work are investigating include improving the resolution of remote sensed data and comparing this with field investigation data. This paper will present the outputs of a feasibility study with the Forestry Commission in England.

Working with the UK Centre for Ecology and Hydrology we have created a simple and practical tool to identify locations that will deliver the greatest public benefits for tree and habitat establishment. Constraints within the model take railway safety, species connectivity and habitat suitability into account. The Tree Council worked with us to develop a structure of woodland habitat that would provide biodiversity and carbon sequestration benefits, whilst also enabling the operational railway to be managed safely.

The outputs provide an opportunity to develop a targeted landscape scale scheme working with adjoining landowners and managers that provides major benefits for people and nature.

Keywords: Railway, Biodiversity, Satellite remote sensing, Adjacent landowner, Carbon sequestration, Safety.

Modelling structural connectivity to identify areas of conflicts between ecological and transportation networks in Hungary

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The possible development of the connectivity of the ecological network clashes with the development of the motorway network in many places around the world, including Hungary. The networks intersect in numerous places, which is a primary ecological problem (habitat fragmentation). The basic philosophy of the network analysis was the hub-corridor landscape ecological model, based originally on Forman's patch-corridor-matrix model. In the patch-corridor-matrix model, patches, core areas, nodes are connected by ecological corridors. To model the ecological network, we used the modeling tool of Circuitscape Linkage Mapper, an ArcGIS add-on. The software is the most widely used ecocorridor analysis software in the world. The modeler was created to describe population genetic relationships. Linkage Mapper was originally developed to exploit the links between circuit theory and gene flow, but has since been applied to many other network analyses (McRae 2006).

The first step in the connectivity analysis is to identify hubs. Nodes are defined as existing core areas of the ecological network. For the identification of the corridors the geospatial modelling method of the Least Cost Path (LCP) was used in Linkage Mapper. The LCP is based on the construction of a "cost" or resistance map. The first step in the modeling process is to produce a suitability map (resistance or impedance map) from existing land use maps. In the process of producing the resistance map, the categories of the landuse map were reclassified from 1 to 100 in terms of "cost". In terms of cost, urban areas have the highest value and forest, wetland and grassland areas have the lowest. The intermediate map of the analysis is the cost map. The idea of the LCP method is to use this cost map to find a route to connect core areas where these combined costs are lowest. Here "cost" means energy, so it costs the least energy to get a species from point A to point B. The resulting ecological corridor proposals have been simplified, with common spatially tractable errors filtered out. The links were used to form an ecological corridor at least 500 m wide, as recommended in the literature. As a last step, we analysed where these corridors cross existing natural areas, where they may cross transportation network and where touch agricultural land.

Keywords: Structural and functional ecological connectivity, Ecological network, Biodiversity, Transportation network, Spatial and regional planning.

Maintaining ecological connectivity in the Carpathian region through an integrated and participatory approach

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Conserving ecological connectivity, especially at large scale and for species like large mammals, is a complex challenge that requires the consideration of various issues. First, functional ecological corridors need to be identified in a matrix of different land-uses and generally in a human shaped landscape, often fragmented by linear barriers, including transport infrastructures. Second, ecological connectivity, including networks in general and corridors in particular, are highly dynamic, as well as vulnerable to global changes, being influenced by both anthropogenic and natural factors. Third, ecological connectivity provides valuable benefits to the societies, e.g., in the form of allowing ecosystem processes and functions, but also enables human-wildlife conflicts. Forth, stakeholders, depending on their interests and background, may have different or even conflicting views and opinions on the needs and ways to manage ecological networks. Lastly, connectivity conservation requires a multi-disciplinary, ideally a transdisciplinary approach to foster genuine stakeholder interactions and eventually the co-creation of knowledge and long-lasting agreed management measures.

Many of these issues can be tackled by co-designing and co-implementing a wide range of specific tools, of which results can be integrated into relevant policy documents and frameworks. We are presenting the outcomes of an unique collaborative effort and approach that we facilitated between nature conservationists including protected area representatives, spatial planners, research and academia, decision makers, NGOs, etc., to mainstream ecological connectivity in the Carpathian region, within the ConnectGREEN project. These include: the development of a harmonised methodology to identify ecological corridors across the Carpathian region, using large carnivores as umbrella species; modelling, projection and validation of an ecological network for large carnivores in the Carpathians, through specific GIS tools, field data collection and various stakeholder consultations from local to national and international levels; development of relevant guidelines, e.g., on how to use spatial planning tools in integrative management of ecological corridors; development of a decision support tool for assessing the impact of various economic projects on nature; the development of an international action plan on conservation of large carnivores and ensuring ecological connectivity in the Carpathians, which was adopted by the parties to the Carpathian Convention; the development of on-line training courses and organisation of different capacity building, information and awareness raising events; development of a road map for integrating ecological connectivity into spatial planning.

Our methods included a wide stakeholder engagement and participation facilitated through meetings at various levels, identification of linear transport infrastructure and other types of barriers in the landscapes, use of tools such as MaxEnt, CircuitScape, Fragmentation Geometry, etc., collection of occurrence data of large carnivores, stakeholder validation. The target species are represented by the three large carnivore species present in the Carpathian region, namely the brown bear (*Ursus arctos*), grey wolf (*Canis lupus*) and Eurasian lynx (*Lynx lynx*). The project was implemented between June 2018–October 2021 and included 23 project partners and associated strategic partners from nine countries.

Keywords: Connectivity conservation, Ecological network, Large carnivores, Stakeholder engagement.

Best Photo – “Open for creative photos” Category

Climbing the railroad bank

Mattias Olsson, Sweden

2021, August – Sweden, Dals-Ed

Autocamera photo of a moose that is slowly moving up a steep railroad bank in order to cross the railroad. The railroad infrastructure often crosses the landscape direct through valuable habitat without any mitigations for limiting the number of wildlife-train accidents or to reduce the barrier effects. The Swedish Transport Administration are financing the project Viltsäker Järnväg in order to find new measures to protect wildlife at railroads.

2022

IENE

Infrastructure & Ecology
Network Europe

Lightning Talks

CAPTURE – New platform for image management and recognition

Andreas Seiler[1], Peter Jäderkvist[2], Jan Dalheimer[2], Caroline Jansson[2]

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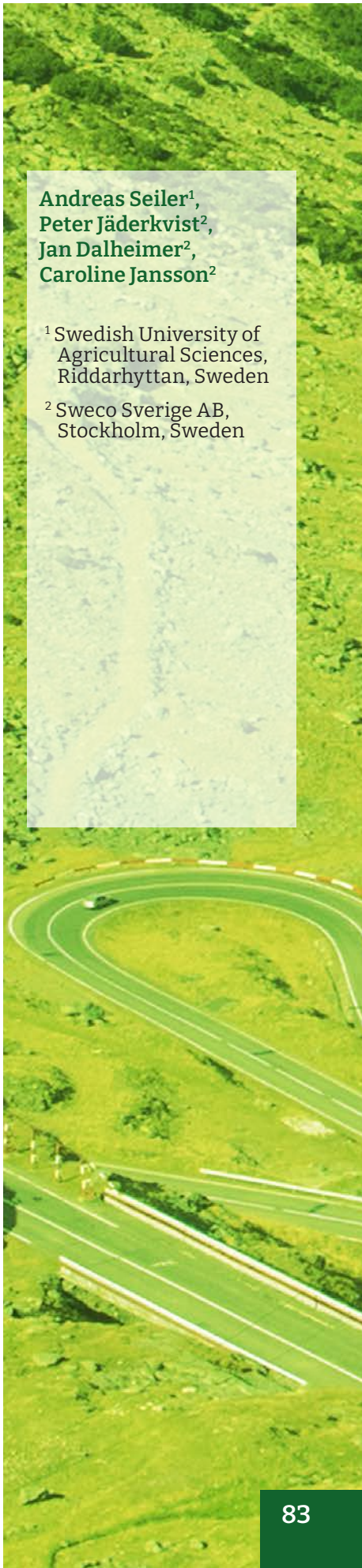
[2] Sweco Sverige AB, Stockholm, Sweden



Automated camera traps are increasingly used in infrastructure projects, providing a relatively inexpensive and non-invasive method to monitor wildlife. Many thousand images and videos can be produced in a single project, requiring substantial human resources to manage and sort image data. Camera traps alongside infrastructure also inadvertently or by design capture people and thus do impose a risk for infringing on protected personal data. Thus, practitioners and administrations need a tool to handle images in an efficient, safe and a legally complying way. Available image management platforms and desktop applications, however, did not satisfy the requirements of governmental agencies such as the Swedish Transport Administration (STA) has for data safety, archiving and privacy protection.

Together with the STA and the Norwegian Institute for Nature research (NINA), we developed a tailored, non-commercial, open-source, image platform that combines a half-automated management of metadata with automatic image analysis through artificial intelligence and automated depersonalization of potentially privacy-infringing images. The platform's modular structure enables new algorithms for image recognition and machine learning to be connected and thereby expand the area of use. Capture offers a centralized and secure way of managing and archiving monitoring data and research results. Capture is currently used to manage images and videos from monitoring studies on wildlife passages and experiments on animal deterrents, but it can be used in a much broader context.

We present Capture through a promotion video and invite IENE participants to test the platform.

Keywords: Camera traps, Monitoring, AI, Application, Data management, Data integrity.

ControlInRoad: Controlling invasive alien plant species along roads

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Invasive alien species (IAS, including plants, animals, microorganisms; IAP, invasive alien plant) are a threat to the biodiversity in Europe. The total cost of IAS in Europe between 1960 and 2020 was calculated with 116.61 billion euros. For example, ragweed, one of the common roadside IAPs, caused costs of $11.61 billion in 29 countries in 2017 (Habrock et al. 2021).

Road and traffic areas are increasingly seen as a major threat to biodiversity because they are associated with a growing number of invasive plants of concern that need to be eradicated or at least controlled. Road maintenance activities can easily spread seeds of invasive plants to other sites. Many countries are aware of the problem posed by IAPs, but generally appropriate management plans are not in place.

Roadside vegetation managers rely largely on mechanical and chemical methods to control weeds and invasive plants on roadsides. The use of chemicals has been debated for several years and is also becoming less accepted by the public. In addition, the approval of herbicides is being discussed at the political level, and some active ingredients are likely to be withdrawn from the market in the next few years.

The ControlInRoad project (http://www.controlinroad.org) investigated the occurrence of IAPs on roadsides, reviewed current control methods and regulations across Europe, and tested different control methods. A list of relevant IAPs on roadsides in Austria, Germany, Ireland, the Netherlands, Norway, Slovenia, and Sweden was compiled and a brochure describing and control methods for the most common IAPs was prepared. Furthermore, field trials with common ragweed (*Ambrosia artemisiifolia*) and knotweed (*Fallopia* spp.) were conducted in 2018 and 2019 testing different control methods. For ragweed control, several of the tested methods like hot foam were successful. For knotweed, plants treated by the Zasso method were smaller than untreated plants, but the number of plants did not differ. To make valid conclusions, it will be needed to validate the obtained results in additional environments.

To evaluate the available methods for the control of IAPs in terms of cost, a cost-benefit analysis was conducted to determine the benefits of a particular intervention compared to normal daily vegetation management in different scenarios of IAP invasion with three different plant species, ragweed, knotweed, and giant hogweed. For all evaluated IAPs, chemical treatment has the best cost-benefit ratio. Besides chemical control, the type of treatment with the best cost-benefit depended on the plant species.

To successfully control IAPs, a management plan should be established. The action plan should include the following items: Documentation of IAP invasion, schedule of treatment according to plant species and waste disposal and monitoring of treatment success. Achieving this will require clear IAP management responsibilities and accountability, adequate budgeting for control, and a management plan specific to the plant species and type of invasion. The findings and recommendations are summarized in the deliverables and can be found on the project website at http://www.controlinroad.org.

Keywords: Invasive alien plants, Road margins, Weed control methods, Cost benefit analysis.

IENE Infrastructure & Ecology Network Europe 2022

A Global Assessment of the Impact of Scavengers in Roadkill Persistence

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The network of roads is continuing to expand across the globe, and, as a result, is causing millions of wildlife fatalities. Wildlife-vehicle collisions can have an enormous impact on biodiversity. Therefore, providing an accurate assessment of the number of fatalities is essential for understanding the population impact of roads. Producing accurate estimates, however, can be highly challenging, being biased by a number of factors, including the impact scavenger species can have on carcass persistence time. Both obligate and facultative scavengers can be attracted to roads to forage, and in doing so can provide essential ecosystem services (including nutrient cycling, disease control and, in some cases, road safety). However, the removal of carrion by scavengers can result in the inaccurate quantification of wildlife-vehicle collisions, and can lead to the wrongful prioritisation of areas for conservation and mitigation. Despite its importance, there is a significant lack of research into carcass persistence and the role of scavenger species. Here, we provide a global assessment of scavenger species that feed on roadkill, and suggest prime areas where scavengers may have a higher impact on carcass persistence time, as well as suggesting areas where scavengers themselves (especially threatened species) may be at risk of road induced mortality. A list of scavenger species that feed on road carrion was complied, by conducting a literature search and through an international survey sent out to road ecology experts. We conducted two literature searchers, using different search terms, the first bringing up 142 articles and the second bringing up 384. While the final list of species is still being complied, at present, the literature search has provided 32 articles that directly described scavenger species feeding on roadkill, and there has been 56 responses to the survey. These species were described feeding on roadkill in 24 different countries. From this, we produced a bivariate map that reflects the co-occurrence of scavenger species richness and road density. We were able to identify areas of high co-occurrence primarily in Central Europe and areas of North America, but others regions, at a lesser scale, can be highlighted all around the globe. This suggests that studies in these areas should pay more attention to the potential impact of scavenger species on carcass removal. Scavenger species feeding on the roads have a greater risk of being involved in a collision themselves. Therefore, this map also identifies areas in which the ecosystem services provided by species scavenging on roadkill may be at risk. A second map, only focusing on scavengers listed as threatened by the IUCN, highlights priority areas for mitigation of scavenger-vehicle collisions, in order to preserve their endangered populations. Our findings indicate that the impact of scavengers on roadkill persistence varies across the world, so overlooking this factor can affect the proper estimate of the impact of wildlife-vehicle collisions on wildlife populations. We therefore suggest that trials of persistence time become more common place in monitoring studies.

Keywords: Scavenger, Carcass persistence, Road ecology, Wildlife-vehicle collisions, Roadkill, Vultures, Carnivores.

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Invasive plant management on railway infrastructure: study of different biological mechanisms of plant competition on the development of invasive alien species

Developed at the initiative of SNCF Réseau from 2019 on two French regions, the R.E.E.V.E.S program ("Recherche sur les Espèces Exotiques Végétales EnvahissanteS" which can be translated as "Research on Invasive Alien Plant Species") has the vocation to define a management solution for several invasive species thanks to the natural mechanism of plant competition. These particular species cause numerous disturbances for train traffic, the safety of the agents and the maintenance of the infrastructure (economic cost).

Based on the principle of ecological restoration of a polluted environment, the objective is to reduce the access of the invasive plant to biotic resources (micro-organisms and biological interactions) and abiotic resources (e.g., water, nutrients and light) in order to reduce its growth and, consequently, to reduce the nuisance on the infrastructure. To achieve this restoration, a new plant layer (shrub and herbaceous), composed of several plant palettes, is implanted on the invaded surfaces according to several experimental modalities to analyze the influence of three biological phenomena: allelopathic interactions, microbial interactions and the effect of mycorrhizal fungi. The experimentation focuses on 5 invasive alien species: *Reynoutria japonica*, *Ailanthus altissima*, *Robinia pseudoacacia*, *Arundo donax*, *Mimosa dealbata*.

In order to address the many scientific components of the project, it brings together two methodologies to marry theory and practice: 27 experimental stations on railway embankments (technical application research) and laboratory trials (fundamental research). The latter is an important part of the project, bringing together a consortium of fifteen researchers from four laboratories specializing in plant ecology and pedology to study and investigate topics such as allelopathy, the influence of soils, mycorrhizal symbioses and the various biological mechanisms at work in plant competition. The technical solutions proposed will be based on the results obtained on the experimental stations, coupled with laboratory tests.

With a budget of 2 million euros, the project is of interest to infrastructure managers for its ability to be deployed in different geographical regions and other abiotic conditions, but is also of interest to natural environment managers to preserve sites from invasion by these species. During the conference, we will present the protocols put in place as well as the results of the first analyses conducted in 2021 and 2022. These analyses show a good growth of the restoration plant layer and a heterogeneous response of the invasive plants. We will also present the perspectives envisaged until the end of the project, planned for 2023.

Keywords: Invasive Alien Plant Species, Railway infrastructure, Ecological restoration, Plant competition, Allelopathy, Mycorrhiza, Microbial activity.

IENE Infrastructure & Ecology Network Europe 2022

A480 Motorway – Maintenance and reinforcement of longitudinal ecological continuity through innovative ecological solutions on acoustic and retaining walls

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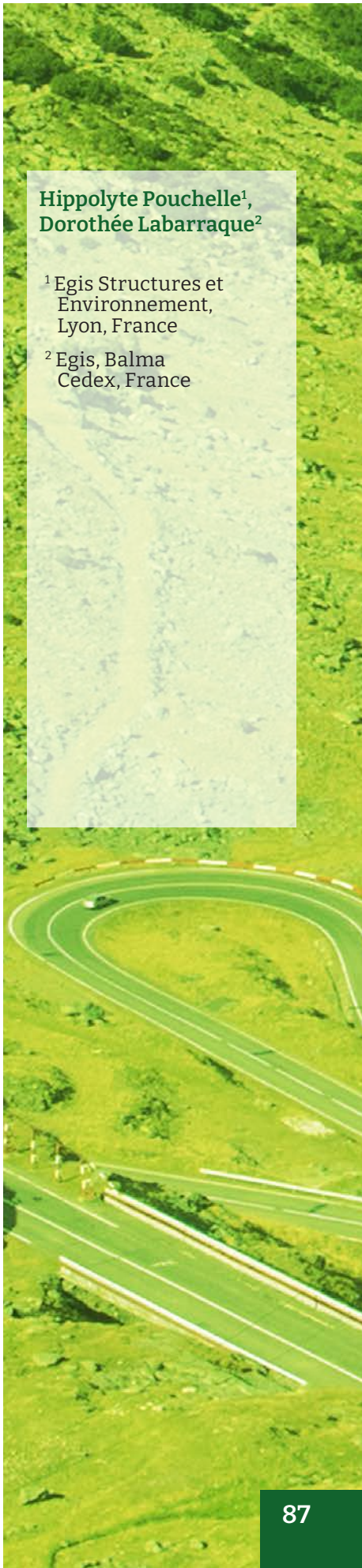

The upgrading of the A480 to a 2×3 lane motorway required concessionaire AREA/APRR (Autoroutes Paris-Rhin-Rhône) and Egis as its project manager to bring an innovative management of the ecological functions. As the project is the widening of a road infrastructure, located between the Grenoble urban area and the Drac river, which is a major ecological corridor, the main challenge was to maintain or even strengthen this longitudinal ecological continuity.
The main actions in favour of biodiversity consisted of:

- maintaining the existing corridor, in particular the riverbank woodlands on its right bank, by restricting right of way;
- reinforcing this corridor with the specific treatment of every retaining and acoustic walls, this was an essential support measure in obtaining the environmental authorization.

It should be noted that the acoustic walls also reduced significantly the fauna mortality risk by collision.
The walls' ecological treatment was designed according to the Landboost® Ecodesign approach, developed by Egis to accommodate biodiversity in engineering structures, in two stages:

- 1st stage: ecological diagnosis and identification of target species;
- 2nd stage: design of hosting structures combined with landscaping.

Regarding the A480 project, the development consisted in setting up:
A) Eco-integrated structures within the gabion (acoustic or retaining) walls to accommodate:

- nesting boxes for birds;
- summer shelters for bats;
- winter shelters (or "hotels") for insects;
- a compartmentalised integrated hibernaculum-insolarium at the foot of each wall, that allows: a shelter for small mammals (such as the European Hedgehog); surface areas for resting and/or sunbathing for reptiles and small mammals and underground hibernation spaces (for reptiles, small mammals, amphibians, etc.).

B) Vegetation on the acoustic and retaining walls on the Drac side to encourage biodiversity and further strengthen the ecological continuity along the river. The plant species used were chosen to consider local climatic conditions. Their development also allows them to compete with invasive exotic species and offer food and shelter to birds and insects through the production of nectar or fruit. Vegetated walls were laid out on the Drac side to provide resting, nesting or hibernation areas for different groups of species and to encourage the return of a more diversified fauna in a context of close proximity to urban areas.
The motorway, in its initial design, had no hosting wildlife potential before the work was carried out, as the separation was classically only made by a low concrete barrier.
Ecological monitoring during the construction phase of the project revealed an unexpected effect on the presence of the gabions with the nesting of the Black Redstart and Common Wagtail. In the Spring of 2022, several nesting species such as the Great Tit, Blue Tit, Grey Wagtail and Black Cricket were observed. The taxa monitored so far are mammals (notably the beaver), chiroptera, avifauna, insects, amphibians, and reptiles. The ecological monitoring will continue for 5 years after commissioning. Nevertheless, we can already consider the creation of artificial habitats along the longitudinal ecological continuity as an effective measure.

Keywords: Motorway, Biodiversity, Continuity, River, Alpes, Integration, Fauna, Biodiversity artificial structure.

Uncovering barriers to implement WVC mitigation measures through a literature review

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The implementation of wildlife-vehicle collision (WVC) mitigation measures is key to decreasing roadkill rates. Understanding the bottle necks in the process of their implementation is critical to understanding how these problems can be overcome. This includes the steps from the identification of measures to be selected, up until the actual implementation. The barriers to implementing of mitigation measures is still one of the most neglected topics in road ecology literature. The process of identifying these barriers can help to improve their resolution. Although WVC literature do not mention barriers directly, other fields such as construction, have addressed this topic extensively including categorizing e barriers in their specific field, what can be used as a reference.

In this study, we aimed to analyze literature to identify barriers to implement WVC mitigation measures based on authors opinion. We used the search platforms google academics and web of science using the mitigation measures terms that include: speed bump, wildlife roadkill, wildlife passage roadkill, speed radar wildlife roadkill, fencing roadkill wildlife, wildlife overpass roadkill, wildlife warning signs, and wildlife road signs. We obtained a total of 103 peer reviewed articles related to mitigation measures (google scholar: 45; web of science: 58). From the selected articles, 73 (70.87%) mentioned problems for implementing mitigation measures, although authors did not classify the problems as barriers.

We named all problems mentioned per article, obtaining a total of 120 mentions. We then, grouped these mentions in six main categories: (1) barriers related to cost or economics (no. of mentions: 40); (2) barriers related to ecological or biological aspects of biodiversity (no. of mentions: 32); (3) barriers related to lack of knowledge of different parts of the mitigation process including measure efficiency (no. of mentions: 21); (4) barriers related to technical aspects (no. of mentions: 11); (5) barriers related to political and institutional aspects (no. of mentions: 9); and (6) barriers related to road user behavior (no. of mentions: 7). We believe that our effort to understand barriers from the literature point of view may contribute to understand the difficulty that involves implementing mitigation in practice. Although the literature may reveal mainly the categories, specialists should also be heard as part of the process for categorizing barriers for mitigating WVC. Another use of our results is to identify who are the key stakeholders that have power to act in each of the barriers described. We believe that by understanding in which extent the same stakeholders collaborate with each other (stakeholders' network) we could also act more effectively in improving their relationship network improving mitigation measures implementation.

Keywords: Barriers, Roadkill mitigation, Wildlife conservation, Mitigation setbacks, Literature review, Specialists' opinion, Decision making, Communication.

IENE Infrastructure & Ecology Network Europe 2022

Seasonal variation in vertebrate roadkills in Gabes Region, southern Tunisia

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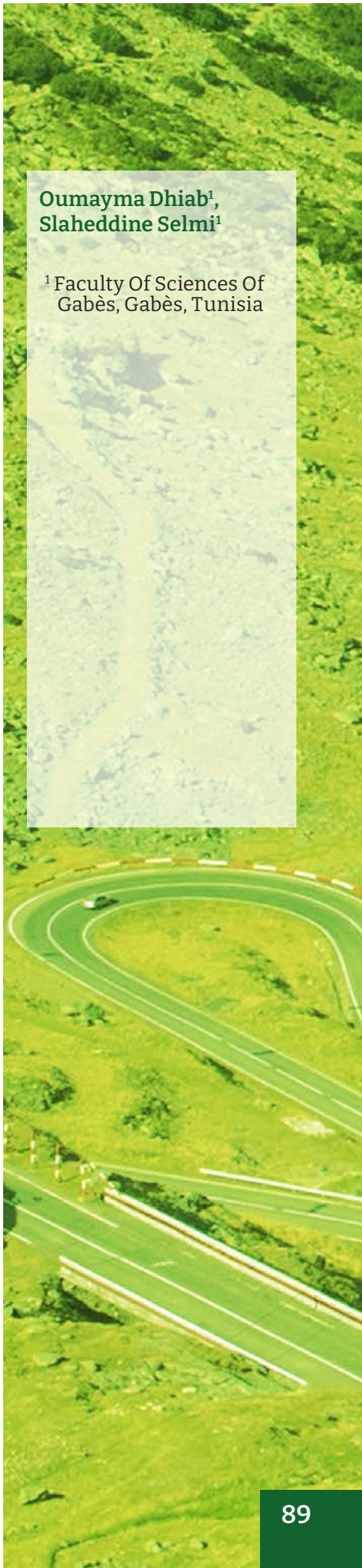
Although wildlife–vehicle collisions are increasingly recognized as a major biodiversity threat worldwide, detailed data on animal road-kills are still lacking from a large number of areas, such as North Africa. In this work, we assessed the temporal trends of vertebrate-vehicle collisions on a 15.5 km road section in south-eastern Tunisia. The flow of motorized vehicle traffic can exceed 12,000 vehicles per day, while the speed limit is 50 km/h in towns and villages and 90 km/h in non-urban areas. From early February 2019 to the end of January 2020, this road section was monitored 104 times for the survey of road-killed vertebrates, at the rate of two surveys per week (Thursday and Sunday). During each survey, animal carcasses were searched for, identified and counted by two observers in a car moving at less than 40 km/h. In total, 480 road-killed vertebrates were recorded: 322 birds (67%), 133 mammals (28%), 23 reptiles (5%) and 2 amphibians (less than 1%). This gave an overall daily road-killing rate of 0.085 road-kills/km/day. Birds and mammals showed opposite seasonal road-kill patterns. Birds were mostly affected in spring and summer, with a maximum of 0.19 road-kills/km/day in April, while mammal mortality was highest in fall and winter, reaching a maximum of 0.10 road-kills/km/day in January. Overall, our results highlight the need for serious measures aiming to reduce road mortality for sustainable wildlife conservation in southern Tunisia. These measures should take into account the differences between affected taxa in their critical periods of road mortality.

Keywords: Roads, Season, Tunisia, Vertebrates, Wildlife–vehicle collisions.



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Capacity building regarding EIA and AA assessments for transport infrastructure (SaveGREEN project component)

The main reasoning for the capacity building will be to allow participants (interested parties, stakeholders) to improve their understanding of environmental impact assessments in the context of new transport infrastructure. It will help consolidate new requirements of the European Commission on this issue and help participants in understanding the specific problems and necessities of EIA done for projects in the transport sector.

The main objective of the training will be to allow for a better and more complete understanding of the EIA challenges related to transport infrastructure. It aims at explaining both what is new and what is different in terms of EIA in the context of the transport sector.

The training will begin with an interactive data collection from the participants, in the form of a live questionnaire that the participants can answer in the training event itself. A short analysis of the responses will follow, concluding on the participants level of knowledge regarding EIA in the context of transport infrastructure.

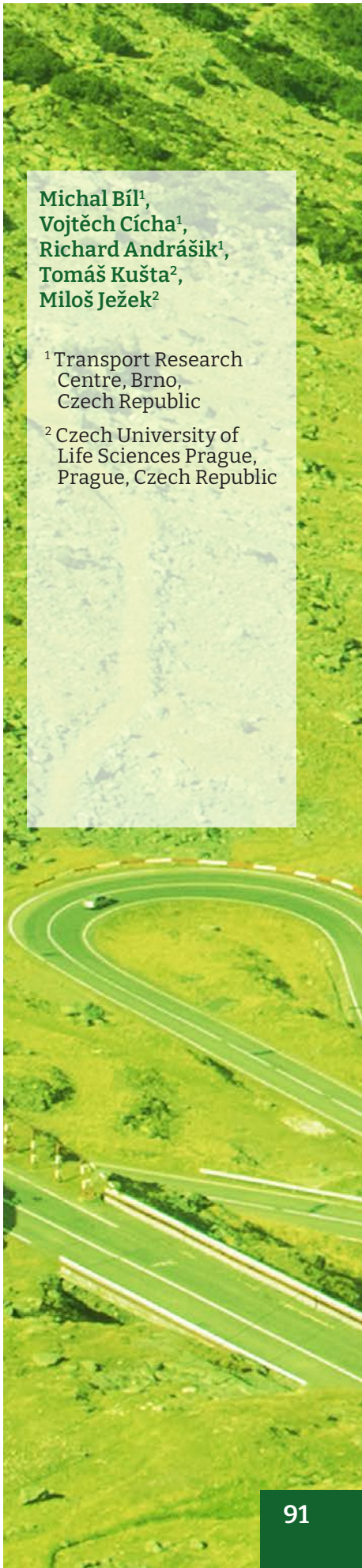
A short presentation on the EIA process and the challenges related to infrastructure will be done after the questionnaire. The presentation will include many short quizzes inside, which the participants will have to answer. This will create an opportunity for further discussions during the session, thus ensuring that all participants have their questions answered and fully understand the content of the presentation.

At the end of the session there will be an additional short quiz, similar to the first one, which will indicate how much the participants took in from the presentation and the previous discussions.

Keywords: Natura 2000 impact assessment, Road ecology, Ecological connectivity, Long distance impacts, Cumulative impact.

IENE Infrastructure & Ecology Network Europe 2022

When do roe deer cross roads? A case study on precise road crossing data



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Roads are widespread artificial linear constructions which fragment the landscape. Wildlife is therefore often forced to cross roads, for many reasons such as migration, searching for food or shelter. Some of these attempts are not successful, however, and animals are struck by motor vehicles. Data on wildlife-vehicle collisions thus only represents these unsuccessful events. Successful crossings are conducted without any negative interactions with traffic. The problem is that we usually have no idea how large a proportion of all crossings the WVC data represent. In addition, only limited information exists about the actual crossings, concerning the time or the width of gaps between the individual cars.

In this study, which took place between 2018 and 2020 in northern Czechia, we observed the behaviour of several roe deer equipped with GPS collars. The collars are capable of precise monitoring of animal movement as they provide a GPS position every 5 minutes, allowing thus for determination of accurate time and place of road crossings. We also installed a statistical radar at the primary road (AADT 12,000 cars) which was frequently crossed by roe deer. It measured traffic for 11 weeks from the middle of July to the beginning of October 2020.

88% of all recorded crossings (267 out of 302) occurred during the night time. 56 road crossing were detected when the radar was installed. For this data we determined time gaps, i.e., temporal distances between two consecutive or opposite cars. More than 75% of crossings took place when the traffic intensity was below 200 vehicles/hour. In this contribution, we will further discuss issues related to the GPS collar data such as reliable determination of road crossings and the spatial and temporal accuracy of this data.

Keywords: GPS collars, Tracking, Traffic intensity, Behaviour, Ungulates.

Factors determining roadkills in a mammal carnivore are road type specific

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Transportation infrastructure are one of the main threats for the conservation of many vertebrate species. Although many animals die every day on roads, mammal carnivores are one of the most susceptible groups due to their low reproductive rates, large home ranges, and high mobility. In addition, many of them are threatened. A better understanding of how road features influence carnivore roadkill will help scientists and stakeholders to implement more effective preventive measures, at times that build safer infrastructure both for passengers and wildlife.

This work aimed to study the influence of the characteristics of two different types of roads on carnivore roadkill. This makes the project novel as previous work has only been carried out on conventional roads, never in motorways; here we work with both. We carried out a study to identify habitat and road features that determine roadkill rates in an agricultural-dominated landscape, using the European polecat (*Mustela putorius*) as a model species. We recorded 85 polecat roadkills in motorways and 73 in conventional roads in the whole road network of Valladolid province (Spain), from February 2019 to January 2021. The roadkill locations were obtained both from citizen scientists and own records. We included one random point for each roadkill location where no collisions were detected (i.e., control point) inside an area of a 1.5 km radius regarding his roadkill. Our response variable was "roadkill" (i.e., roadkill versus control point with no roadkill). Three types of explanatory variables were used: road type, 7 habitat-related variables and 9 road-related variables. We hypothesized that differential road traits could influence in carnivore roadkills.

Number of rabbit burrows and road width was significantly higher at roadkill points, and crop cover was significantly lower. However, the most influential variable was type of road. For that reason, we analysed motorway and conventional road subsets separately in the following analyses. In motorways, roadkills were in wider sections and in those sections where the number of rabbit burrows was higher. In conventional roads crop cover was significantly lower in roadkill points. Also, we found a marginally significant effect of number of rabbit burrows that was higher in roadkill points.

Our study shows that ecological and road-intrinsic factors influencing roadkills of a mammal carnivore varied among road types. The motorway verges provide an optimal environment for the settlement of prey species, such as rabbits, which is reflected in carnivore roadkill rates. Predators like polecats, which may locally specialize on prey who proliferate in these rights-of-way are highly susceptible to roadkill there. Where roads are surrounded by natural habitat represents a risk for predators than could be foraging in these habitat remnants. This work helps to understand the ecological processes and identify the most sensitive areas for carnivores in each road type, which can be very useful when implementing mitigation measures to reduce roadkill. The installation of underpasses especially where preys are abundant or the reinforcement of physical barriers where road width is wider, especially at road merges and exits could be useful measures to mitigate road impact on wildlife.

Keywords: Road ecology, Linear infrastructure, Road verges, *Oryctolagus cuniculus*, *Mustela putorius*, European polecat.

IENE Infrastructure & Ecology Network Europe 2022

An inventory of amphibian roadkill in the western Soutpansberg, Limpopo Province, South Africa

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The interactions of transport corridors and terrestrial landscapes can compromise the integrity of wildlife by posing risk to animals and their ecosystems. Roads, in particular, have numerous threats to wildlife with the most noticeable direct impact being roadkill, and this requires urgent conservation interventions. To assess amphibian roadkill, driven surveys were conducted on three regional roads around the western Soutpansberg in the Vhembe Biosphere Reserve, an important area for biodiversity conservation in northern South Africa. Six road verge habitat types were identified along the monitored road stretches and their influence on the occurrence of amphibian roadkill was determined. The results comprised an inventory of 248 roadkill specimens, belonging to eight species and six families, and one unidentified specimen. Roadkill proportions were strongly influenced by season, with the greatest roadkill rate recorded in the hot/dry season (0.051 roadkill-1 km-1 day-1) compared to the hot/wet season (0.019 roadkill-1 km-1 day-1). Amphibian roadkill patterns were related to roadside habitat. Of the roadside habitat types identified, road sections that were adjacent to waterbodies had the highest amphibian roadkill frequency, followed by road sections closer to open savanna bushland. Roadkill frequency was low in areas that were partly located in human modified habitats (residential and agricultural areas) but highest in natural landscapes (near waterbodies and savanna bushland). The study provides baseline data that confirms the potential threat of roads and their users on the persistence of amphibians in Vhembe Biosphere Reserve and presents the first systematic inventory of amphibian roadkill in the area.

Keywords: Amphibians, Road ecology, Roadkill, Western Soutpansberg, South Africa.

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Controlling vegetation in a railway environment: "Chosen seeding" of service tracks and runways as an alternative to pesticides use

In 2017, the SNCF committed to stop using glyphosate starting on January 1st, 2022. To meet this objective, SNCF RESEAU had to anticipate and find alternative solutions to prevent the proliferation of adventices on the tracks and their surroundings.

The implementation of a National Research Program for alternatives has become a lever for management change and meeting this challenge. The issue of maintaining old service tracks and runways was quickly raised and has become one of the main stages of research with a dedicated team working on a thesis, partnerships with companies and several experimental sites starting in 2019.

The difficulty to maintain a "no vegetation" standard on tracks and runways imposed by our internal technical guidelines was called into question on this occasion. It seemed necessary to improve it in favor of a practice that takes into account both the regulatory and technical constraints inherent in the railway sector, leading to controlled and chosen species of vegetation on these parts of our network. Rather than finding a way to eradicate all vegetation, a tailored mix of plant species was proposed to be planted in order to compete with the plants already present on our lightly trafficked service tracks and runways.

This new vegetation cover should, in the long term, make it possible to:

- prevent the growth of undesirable species;
- maintain the continuity of all activities on our railway sites. It must guarantee technical safety, by means of an even cover in height and density, allowing easy access and carrying out track surveillance operations with a good visibility of the installations.

To achieve this objective of an "acceptable plant cover", several constraints had to be considered by the company. The solution we proposed had to meet numerous requirements from our railway network.

At the same time, "chosen seeding" must fit into its national and regional geographical context, relying on a selection of species that do not jeopardize their direct environment and that can be used nationwide. This is an opportunity to position ourselves on the right balance between industrialized techniques and local adaptation.

For this presentation, we would like to share the first feedback from the past 5 years of the project. Different seed mixtures have been tested on different experimental sites. We will present the selection criteria for the mixtures and the sites, the monitoring protocols set up and the first results we obtained. We will focus on the seed spraying method (hydromulching). Finally, we will present the follow-up questions that these first results have raised as well as the possible openings to improve this project.

Keywords: Seeding, Plant competition, Service road, Tracks, Railway, Alternative, Vegetation, Nature-based solution, Ecological engineering.

IENE Infrastructure & Ecology Network Europe 2022

Spatially prioritizing mitigation actions for amphibian roadkills based on fatality estimation and landscape cover change

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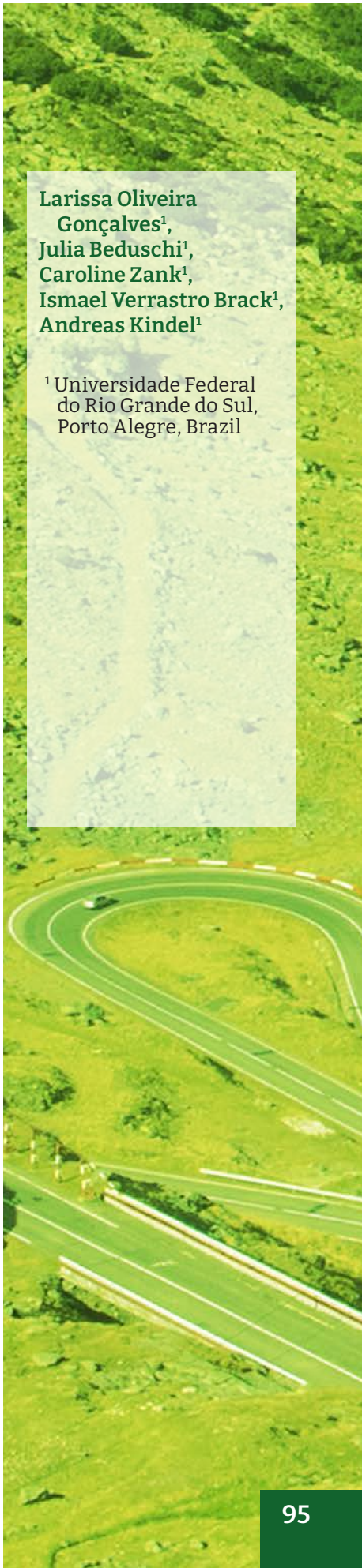

Roads cause biodiversity loss and the effects of wildlife-vehicle collisions may ripple from individuals and populations to ecosystem functioning. To plan mitigation measures that can work for the long-term, one approach is to identify where roadkills most occur, while also accounting for landscape stability. Valuable information on the concentration of roadkills can be obtained by estimating fatalities based on observed carcasses. Amphibians are threatened worldwide and as they do not avoid traffic, collisions may impact them, however, they are often neglected in impact assessments of these infrastructures. We developed a framework for spatially prioritizing mitigation actions for anuran amphibian roadkills based on fatality estimation and landscape change on two roads in Southernmost Brazil. Our framework is composed of the four following steps:

1) We selected 50 road segments with 100 m length using the wetland coverage in the surroundings based on remote sensing and field observations;
2) We conducted spatiotemporally replicated counts with a dependent double-observer protocol, that is, each of the 50 selected 100 m segments was sampled multiple times by two pairs of people on foot. Surveys occurred twice a day – one survey at dawn and one at dusk – during three consecutive days in January of 2021, resulting in six sampling occasions per site;
3) We used a hierarchical open-population N-mixture model to estimate population dynamics parameters, which accounts for imperfect detection and spatiotemporal heterogeneity in the removal, detection, and carcass fatalities, and explicitly estimates carcass entries per time interval. We used as covariates the wetland coverage and urban areas in the 200 m site surroundings obtained from remote sensing; the traffic volume categorized from the distance to the most populous human settlement, and the presence/absence of rain before sampling occasions based on the nearest weather station for each site. We used a Bayesian approach in JAGS using R;
4) We prioritized segments with higher fatality rates and lower landscape conversion rates. Landscape change was measured using the land cover classification series of Mapbiomas 5.0 and the software Dinamica EGO, measuring the percentage of native vegetation converted into intensive human use between 2009 and 2019.

We estimated a mean of 114 (95% CI: 109–119) anurans per km per day in the 50 sample sites. The initial number of carcasses had a positive relationship with the percentage of wetlands and a negative association with the percentage of urban areas. The number of carcass entries per interval was higher in rainy moments and had a positive association with the wetlands cover. Carcass persistence probability was higher at night and lower in sites with high traffic volume. Ten segments were prioritized with our threshold for fatality estimates and landscape change. It is urgent to appropriately evaluate the roadkill impact on amphibians aiming to plan and implement mitigation measures specifically designed for these small animals, like fencing and passages, to reduce this massive impact. Our framework provides an approach that accounts for reliability (focused on sites with potentially greater relevance), robustness (considering imperfect detection), and steadiness (less prone to loss of effectiveness due to landscape dynamics).

Keywords: Anurans, Imperfect detection, Persistence probability, Hierarchical models, Mitigation.

Environmental and traffic-related factors determining wildlife road-kills threatening human safety in Mediterranean landscapes

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Roads are a direct threat to biodiversity and contribute to both fragmentation and degradation of landscapes. One of main consequences on biodiversity is wildlife mortality by roadkill. This mortality depends on the interaction between the presence/abundance of the affected species and both road-related and environmental characteristics. Road accidents involving large vertebrates also generate a direct risk to human life, with major health and economic consequences. Wildlife-vehicle collisions involving large vertebrates are little explored in Mediterranean environments, where climate can affect several aspects of animal biology, such as activity and movement patterns that can be different than in northern Europe and North America. In this case study, wild boar roadkills within a Mediterranean protected area (Regional Nature Reserve Lago di Vico, central Italy) are analyzed to investigate both environmental and landscape factors potentially affecting collision risk. We used the dataset of wild boar roadkills recorded by local officers during fourteen year (2004–2017) on a provincial road (16 km of surveyed road, allowed speed of 50 km/h), and we analyzed them by implementing two different scales: 1) the finest possible resolution scale, i.e., 500 m (depending on the scale recorded by local officers), and 2) a landscape scale of 3,000 m, which corresponds to an average home range of wild boars in Mediterranean environments. By means of field surveys and GIS analyses, several variables were identified at both scales: number of troughs (as a proxy of wild boar abundance), dominant land use (including or not water surface), percentage of forest, natural environments, crops and urban areas, distance to water, traffic volume, road bio-permeability and difference in elevation between the starting and finishing point of the road section considered. Two new variables, sinuosity and roughness of the road section, are presented in this study and used as proxies for vehicle speed. The variables have been analyzed by means of an AICc model, and the best supported models at both scales included distance to water (as expected for Mediterranean environments), whereas other factors showed relative importance only at one scale or the other.

Keywords: Roadkill, Wildlife-vehicle collisions, Road Ecology, Wildboar, *Sus scrofa*, Road safety, Landscape Ecology, Habitat selection, Remote sensing, Road sinuosity, Road roughness.

IENE Infrastructure & Ecology Network Europe 2022

Use of wildlife crossing structures does not mean low roadkill records

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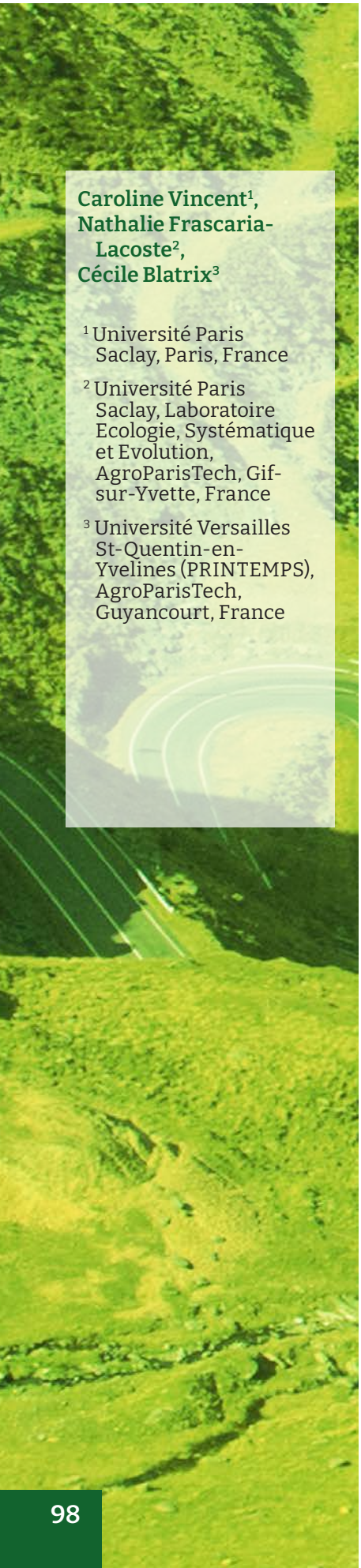
Although wildlife crossings structures on roads are designed to restore the connection between roadsides and do not block animal access to the roads, they are still seen in some professional niches as a synonym of mitigation to reduce roadkills. Here we present a case study conducted on a Brazilian toll road (ES-060) with both data from wildlife roadkills and underpass crossings collected over 13 years (2004 to 2017). We aimed to evaluate if the crossing structures are preventing roadkill of ground using species >1 kg. The roadkill surveys were conducted by one road inspector in a car at 60 to 80 km/h, eight times per day. The use of seven underpasses was monitored with sand track beds installed on both entrances and reviewed daily. The underpasses are clustered in three locations on the road, so we considered each of these clusters as a sample unit for the analysis. For each species recorded in the underpasses, we counted the total number of complete crossings in each cluster, and we considered a complete crossing when the species entered and exited at opposite entrances of the structure. To test for scale effects, we counted the roadkills in three scales of proximity to each underpass cluster: strictly on the cluster extension, 500 m and 1,000 m beyond the end of the last underpass of the cluster. For the most roadkilled species and those with the highest crossing numbers, we ran a hotspot analysis to identify roadkill aggregations. We recorded 1,421 roadkills from 16 species of mammals and reptiles and 8,924 complete crossings from 13 species also from mammals and reptiles. From that pool, we were able to run the hotspot analysis for 11 species. We identified five concerning species for mitigation since they were both among the most recorded as roadkills and the least recorded using the underpasses in all clusters and scales evaluated: the crab-eating fox (*Cerdocyon thous*), the boid snakes (*Boa constrictor*, *Corallus hortulanus* and *Epicrates cenchria*) and the Bahia-hairy-dwarf porcupine (*Coendou insidiosus*). From the hotspot analysis, only the capybara (*Hydrochoerus hydrochaeris*) and the tayra (*Eira barbara*) roadkill aggregations did not overlap a mitigation cluster. The presence of hotspots where wildlife crossing clusters are installed, including species frequently recorded using them such as de Brazilian common opossum (*Didelphis aurita*), reinforces that only connecting roadsides is not enough to mitigate roadkills, is essential to block animal access to the road. Although the underpasses monitored here have associated fences, they are lacking maintenance or adaptations to effectively stop animal movement on the road and minimize roadkill impact on the target species.

Keywords: Underpass, Roadkill mitigation, Long-term road monitoring, Mitigation fences, Road crossings, Wildlife-vehicle-collisions.



Is ecology science used at its full potential? The perspective of 44 years of practice in linear infrastructure projects

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Over the last 20 years, the length of the French national road network has increased by 12.6%. Despite ongoing research on transport ecology and the improvement of follow-up methods and mitigation of ecological impacts of linear infrastructures (LI), the erosion of biodiversity hasn't stopped. And even though land use change and fragmentation aren't the only factors preventing biodiversity from thriving, they remain the biggest consequences of LI's construction, along with the increase of greenhouse gases emissions they might cause. So what does it say about the efficiency of transport ecology and ecology science itself to help prevent and/or mitigate these harmful consequences? Is it enough?

In order to determine if and how ecology has been used as a decision driver in LI's project, hence helped reduce ecological impacts and biodiversity loss, we studied French environmental impact statements (EIS) of 15 projects (10 LI), for a period of 44 years (1976–2020). To analyze these EIS, we have built an evaluation grid based on international literature on environmental impact assessment's (EIA's) quality, conservation biology and ecology. We applied this grid to other projects in order to have a better understanding of the contemporian planning framework and practices. This grid focuses on six main criteria: accessibility, definition of the project and its linkage with the environment; ecology in data collection; ecology to define interactions between environmental components and the project; environmental ethics and overall consequences of the project on the environment.

The main findings of our study were that biodiversity impacted by all LI projects has been reduced to taxonomic diversity. Therefore, functional diversity has not been taken into account when impacts of projects were assessed, even though it is common knowledge that functional traits influence ecosystem functioning and are under a bigger threat than taxonomic diversity.

Nonetheless, great improvements have been made on mitigating and offsetting measures over time. Yet, these measures are based on the assessment of the initial state of environment that will be affected. Hence, as our work shows, these assessments are based on a reduced conception of biodiversity and on a disputable justification of impacts significance. Therefore, it can only be incomplete. Moreover, no LI project has been conceived as part of a socio-ecosystem. They tend to be built to fit esthetically into the landscape and to accommodate with the project's impact, not to make it a part of it.

These findings led us to think that ecology and transport ecology have always been used in an accommodating way in LI projects. Indeed, instead of questioning the origins of these impacts, ecology has been used to mitigate and offset them. Our findings call for a deeper ecological perspectives of LI projects, to conceptualize them as part of a global socio-ecosystem they will transform and adapt for as long as they stand.

Keywords: Environmental impact assessment, Environmental impact statement, Ecological quality, Effectiveness, Ecology.

IENE Infrastructure & Ecology Network Europe 2022

Estimating the linear and surface potential of linear transport infrastructure rights-of-way as ecological shelter on a national scale – Case of metropolitan France

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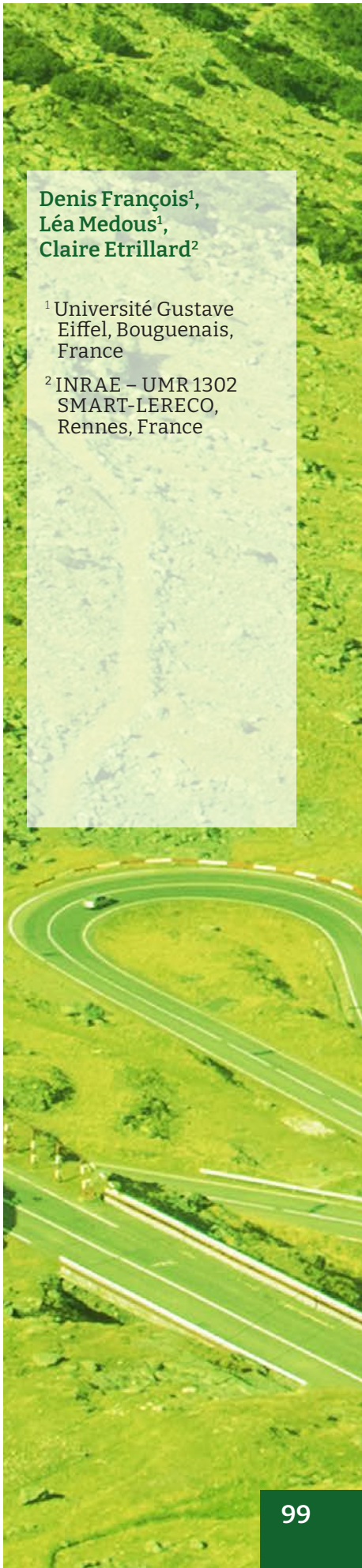

In recent years, research has shown that rights-of-way (ROW) of linear transport infrastructures (LTI) can have ecological value. In places where natural habitat is fragmented because of land planning (including LTI), some ROW sections, through their functions as habitat and ecological conduits, are able to provide shelter to local flora and entomofauna. They constitute a resource that can be rapidly mobilised to safeguard declining species and can contribute to the re-weaving of the surrounding green and blue networks.

Metropolitan France is heavily affected by the loss and fragmentation of natural areas and the decline of wild species. It is also heavily criss-crossed by LTI (roads, railways, waterways and power lines). In order to develop coordinated and relevant actions in favour of biodiversity, it is essential to know the nature and the linear and surface extent of the rights-of-way likely to provide ecological shelter potential (ESP).

Thanks to databases on transport networks and land use, the processing of data by geographic information systems combined with knowledge of the geometric and maintenance characteristics of the different types of LTI, can provide a rational mean of locating and measuring the sections with ESP. Following this approach, the objective of this work has been to approximate the linear extent of ESP and to estimate the minimum value (floor value) of the surface area of ESP available in metropolitan France.

The total length of ESP is 88,094 km (85,226 km along in-service LTI, plus 2,868 km of non-operated railways). The largest shares are those of power lines and railways (39% and 34%, respectively). Road and waterway networks are just 18% and 9% respectively. Railway and road networks and their ESP are more evenly distributed across the country than the two other infrastructures (north-eastern quarter of France and large forest areas). The total minimum surface area associated with this network is 2,091 km^2 (including 43 km^2 for non-operated railways). It is made up of 68.5% power line ROW, 16% railway ROW, 11.5% road ROW and 4% waterway easements.

Maintaining certain sections of ROW as ecological shelter is a new perspective for public and private LTI operators, as well as for the owners of rights-of-way. This implies new commitments and opens up new opportunities. The State, as owner of ROW, appears to be the primary depositary of this asset, in the railway (exclusive; 32.0% of the total), road and waterway domains. This means too that the other actors (local authorities, concession companies, private individuals) are in charge for more than half of the ESPs' asset (53.8%). They are in majority in the road sector (concession companies and local authorities) and almost exclusive in the power transmission sector (municipal and private forests; 39.1% of the total). In order to make the most of ROW for biodiversity, operators have the possibility of associating with local actors within the framework of partnerships through which they can entrust them with the specific management to be developed in the ESP areas.

Keywords: Action, Asset, Connectivity, Coordination, Habitat, Network, Operator, Owner, Private, Public.

Re-developing a road-kill reporting app to improve the user experience and quality of data collected

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People have been recording roadkill data to help gain a better understanding of how transport networks impact wildlife across the world for many years.

Following a review of many existing mobile applications used to record roadkill we have developed a new app to improve user experience and data collection that is suitable for use globally and has the ability to plugin to existing data sets and methods of collecting.

This presentation explores the process in which the team have taken to implement unique features and enhance functionality for citizen scientists and professional users and ensure better quality data capture.

Unique features include an intuitive and aesthetically pleasing user interface, survey and ad hoc recording capabilities and complete offline functionality.

A case study in Georgia, USA was conducted during the 1st BETA testing in 2021. This case study enabled us to test the apps functions in a real world scenario, offering no prior training or experience of the software to the users. The users were able to use the app to collect valuable roadkill data whilst simultaneously providing feedback for development purposes.

TRAX is due to be available to download publicly and we are actively looking for partners to conduct further pilot studies and BETA testing across the world prior to release. Please visit the website to find out more.

Find out more: www.traxapp.info

Keywords: Technology, Collaboration, Software, Citizen Science, Roadkill, App.

IENE Infrastructure & Ecology Network Europe 2022

Making Roads Safer for All: Influencing public policy in Mato Grosso do Sul through engagement and a multi-stakeholder approach

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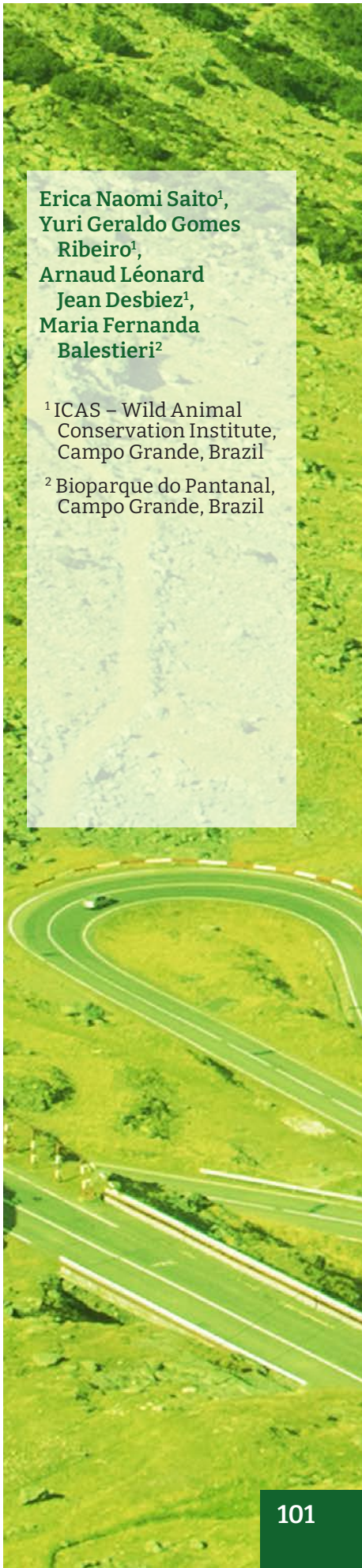

Mitigating wildlife-vehicle collisions (WVC) is important not only for wildlife conservation but also for the safety of people. Accidents can cause material, psychological and physical damage to people, and can even be fatal. In Brazil, annually about 1,062 people are victims of collisions involving animals on highways. In the Mato Grosso do Sul State, according to Federal Highway Police database, between 2007 and 2019 there were 614 collisions with animals involving fatal or injured human victims. Between 2017 and 2020, we monitored 4 highways every 2 weeks for 3 years, totalizing in almost 85,000 km and registered more than 12,000 wild animals as victims of vehicle collisions. 40% of these records belonged to medium and large animals capable of causing serious accidents, such as giant anteaters, capybaras and tapirs. In Brazil, the lack of information on the distribution, numbers and impacts of WVC, lack of political will, limited access to information on mitigation structures or other relevant aspects on effectiveness, have often impeded implementation and monitoring of WVC mitigation measures. However, we hope this is changing.

We conducted a series of participatory workshops with state authorities to understand their perception and what information they require to build an effective state policy regarding WVC prevention. One of the results of this work was the creation of a "Manual of Technical Guidelines for Mitigating Wildlife Vehicular Collisions on State Highways in Mato Grosso do Sul". The document is the result of both numerous exchanges of expertise by technicians of an Interinstitutional Working Group formed by professionals from government institutions, the scientific community and several NGOs, as well as the participation of state authorities themselves. This carefully facilitated participatory document is a living document that will be updated as new information, knowledge and experience is gathered.

On December 17, 2021, in a formal session, the manual was endorsed as a public policy of the state and signed by several authorities, among them the current Governor, the Secretary of Infrastructure and the Secretary of Environment, Economic Development, Production and Family farming. The Handbook is available at: https://www.estradaviva.ms.gov.br/manual-de-orientacoes-tecnicas

These guidelines are designed to provide relevant information to guide planning and decision-making for the implementation of WVC mitigation structures on state highways. The manual answers sequentially the following questions: Why mitigate? What to mitigate? And, of course, how to mitigate. Each step is carefully illustrated to help guide decision-making to seek safer roads for animals and people.

The participatory approach taken before and during the elaboration of this manual highlights the importance of collaboration between different institutions to first understand what is needed and then to compile the practical information required. The participatory approach helped to create the political that will be needed to implement the manual. It also helped to create a strong Interinstitutional Working Group network to support the next steps. We believe that this document is a major milestone in mitigating the impacts of WVC on the highways of Brazil.

Keywords: Mitigation measures, Road safety, Biodiversity conservation, Wildlife Vehicle Collision, Roadkill, Road Ecology, Public Policy, Cerrado, Pantanal, Brazil.

Acoustic deterrent for large terrestrial mammals: Development of a tool applicable to rail networks

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Wildlife-vehicle collisions are an important issue for transport companies around the world because they induce frequent damages and represent considerable financial and ecological costs. Collisions affect the metropolitan French rail network throughout the year, and significant incidents occur mostly with large ungulates such as wild boars (*Sus scrofa*), red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*).

The aim of our project is to develop a tool that would keep animals away from tracks when a train is approaching, whilst limiting their habituation to the deterrent signal and considering potential disturbance to humans and other animals. While visual solutions such as reflectors are largely ineffective, acoustic devices are more encouraging. Here we investigate on-board or fixed sound solutions adapted to the specific needs of railways.

We first investigated ultrasound, which are already used by commercial devices because humans cannot hear them, despite being technically difficult to use given their poor propagation properties and sensitivity to environmental conditions. Specifically, we tested the efficiency of ultrasonic acoustic signals on a range of species with different hearing abilities in a zoological reserve.

While we did not observe flight responses in reaction to playbacks of ultrasonic signals in red deer hinds or wild boars, peccaries (*Tayassu pecari*) showed a surprisingly strong flight response to our stimuli, indicating that while ultrasound could in principle serve as deterrents, they are inefficient for our target species and thus ineffective for reducing ungulate-vehicle collisions on metropolitan French railways.

Keywords: Collisions, Railways, Mammals, Ultrasounds, Bioacoustics.

Sustainability and road mobility, PIARC's commitments

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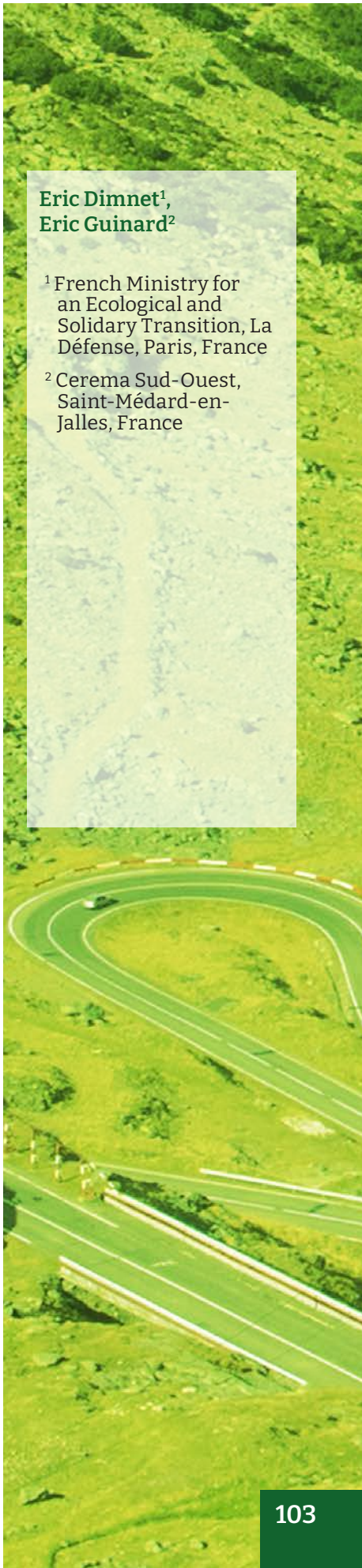

The World Road Association (PIARC) is a network that has existed since 1909 at the dawn of the Motor Age. More than 110 years later, PIARC continues to foster and facilitate global discussion and knowledge sharing on roads and road transport. As a non-political and non-profit association, PIARC is open to everyone. It currently has nearly 3,000 members in 142 countries throughout the world and now boasts 122 government members worldwide and retains consultative status to the Economic and Social Council of the United Nations.

Mission:

PIARC exists to serve all its members by:

- being a leading international forum for analysis and discussion of the full spectrum of transport issues, related to roads and road transport;
- identifying, developing and disseminating best practice and giving better access to international information;
- fully considering within its activities the needs of developing countries and countries in transition;
- developing and promoting efficient tools for decision making on matters related to roads and road transport.

PIARC's mission is fulfilled through operations guided by a 4-year Strategic Plan. The Plan of Activities for the cycle 2020–2023, covers 4 Strategic Themes developed through 17 Technical Committees (TC) and 6 Task Forces, with related Regional Working Groups and is completed with Cross-cutting Committees, Response Teams and Special Projects.

TC 3.4 Environmental Sustainability in Road Infrastructure and Transport:

Technical committee 3.4 is divided into 3 Working Groups (WG) [Chair: Eric Dimnet (France)]

- 3.4.1 Real-time evaluation of pollution and mitigation measures
- 3.4.2 Noise mitigation
- 3.4.3 Road and road transport impact in wildlife habitats and their interconnections

WG 3.4.3's work aims at (1) understanding the road and road transport impact on wildlife habitats and their interconnections, (2) develop a road corridor landscape design and its role in ecological habitat connectivity, (3) identify barrier effect mitigation for wildlife. WG 3.4.3 products are a full report, a case studies collection, a glossary in collaboration with BISON Team and several oral presentations.

Keywords: World Road Association, Environment, Biodiversity.

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Stakeholder perceptions on environmental issues, causes and mitigation measures related to linear infrastructure development in Sri Lanka

A lack of exchange between science and practice in conservation has been identified as a key issue that hampers the effectiveness of measures taken to conserve and restore biodiversity. This lack of exchange between science and practice is largely driven by the lack of communication between actors in the two sectors and could easily intensify due to knowledge deficits on either side. Moreover, these knowledge deficits leave most conservation decisions made by practitioners to be guided by personal intuition and guesswork while being affected by external factors associated with the development process. Developing countries in particular are known to be struggling with managing such conservation and development efforts.

Sri Lanka is an island nation in Asia that has had several large-scale linear infrastructure (LI) development projects, funded by several international donor agencies, and also is now experiencing the greatest economic challenge in its history. In this light, we wanted to understand factors that are affecting perceptions of key stakeholders associated with the LI development process in Sri Lanka on the following: 1) the impacts of LI development on wildlife, 2) the need to avoid/mitigate these impacts, and 3) about the hindrances they are facing when it comes to implementation of mitigatory measures. The investigation was performed through one-on-one semi-structured interviews conducted with selected stakeholder groups. The questions were structured within three main areas, namely, identifying impacts on wildlife, considering alternatives, and applying sound mitigation. Participants (16) from five stakeholder groups were recruited based on their level of experience in the field in which they are working. The five stakeholder groups that were selected are, 1) ecologists involved with the Environmental Impact Assessment (EIA) process, 2) ecologists that only conduct conservation research and education activities, 3) decision-makers at government agencies for environmental regulations, 4) decision-makers at government agencies dedicated for LI planning and development, and 5) decision-makers at key international funding agencies that have funded LI projects in Sri Lanka.

Grounded theory and thematic analysis methods were used to identify the main thematic findings from the interviews. Preliminary analysis suggests that there are six broad themes that seem to be affecting environmentally friendly decision-making in the LI development process. These include personal thoughts and solutions, the influence of the community and NGOs, ethics and responsibilities, financial restrictions/limitations, history and evolution of the EIA process, and unique national concerns. These themes could be used to identify how the relevant stakeholders could be influenced at the beginning, middle, and end of the decision-making process in similar development projects. Overall this study would enable targeted stakeholder framing of conservation issues, based on a clear understanding of their respective perceptions and values, enabling the process of environmental conservation to get its due attention and recognition.

Keywords: Stakeholder perceptions, Limitations, Unique national concerns.

IENE Infrastructure & Ecology Network Europe 2022

Thermal water polluted infrastructures as invasion corridors

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Most biological studies on linear infrastructures focus on fragmentation, road-kills, invasion by exotic species, the effect of air, noise, and chemical pollution on animal behavior, or the effect of preventing measures in different terrestrial and semi-aquatic systems. Relatively little attention is given to the habitat and biological function of different types of rainwater ditches, channels, and ponds on the surface and subsurface, which in many cases are subject to several pollutions. Hungary is very rich in different natural and artificial thermal springs and spas which are used. The surplus thermal water has driven outflow systems in the direction of different aquatic habitats. An intensive research program was started in 2015, in order to measure the species composition in the natural and different man-made thermal water habitats in the whole territory of Hungary. Our research team detected the first occurrence and active spread of several warm water preferred invasive animal species (mollusk, crayfishes, fishes, amphibians, reptiles) into different thermal water polluted channel and ponds systems in the Carpathian Basin. We were able to prove that the red swamp and marbled crayfish (*Procambarus clarkii*, *P. virginalis*) colonise the main arm of the River Danube in different surface and subsurface channel systems not only in the center but also in the agglomeration area of Budapest too. We have detected, that several exotic Cichlid species, such as the *Amphilopus* sp, *Hemichromis* sp., *Parachromis* sp, *Vieja melanura* and the marbled crayfish use as invasions corridor the thermal water outflows of Lake Hévíz and colonized the natural wetlands and channel systems successfully. Based on our monitoring processes we determined, that the juvenile crayfish individuals have almost the same spread dynamic in two different Danube tributaries, which are polluted by thermal water. Our research has shown that the warm-water preferred exotic crayfish, fish, and turtle species can be active in the thermal water polluted habitats during the cold winter periods too, which means an intensive predation pressure on whole ecosystems throughout the year.

This study was financially and technically supported by projects GINOP - 2.3.2 - 15 - 2016 - 00004, TKP2020 - NKA - 16, EFOP - 3.6.3 - VEKOP - 16 - 2017 - 00008, Interreg - DTP SAVEGreen (DTP3 - 314 - 2.3), NEA - 20 - EG, NEA - 19 - EG, PTKF/569/2018; PTKF/345/2020; PTKF/412/3/2021.

Keywords: Aquatic invasion, Escape, Rainwater, Urbanized habitats, Water management, Maintenance.

Conservation hot-spots or barriers: the effect of stream sections under bridges for the populations of native and non-native crayfish in Hungary

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Most of the biological studies on linear infrastructures focus on fragmentation, road kills, invasion by exotic species, effect of air, noise and chemical pollution on animal behaviour or the effect of preventing measures. Relatively little attention is given to the habitat function of different types of streams and channels under the road, motorway and railway bridges. In the last decades the results of monitoring indicated that not only the ecological status of waterbodies are changed negatively by human activities, but also the population of several native aquatic species, for example all native crayfishes, the narrow-clawed crayfish (*Pontastacus leptodactylus*), the noble crayfish (*Astacus astacus*) and the stone crayfish (*Austropotamobius torrentium*) are substantially reduced in whole territory of Hungary. Recently the researches have few information about the role of aquatic habitats in streams beneath and around bridges. In 2013 a research program was started, which focus the crayfish assemblages were surveyed by different methods twice a year around 138 bridges of whole territory of Hungary. Each sampling area is a section consisting the neighbouring upstream and downstream from the bridge as well, and the sampling sites were characterised by 11 environmental variables. Apart from different intensive anthropogenic effects on the catchment area of lowland and hilly running waters the non-native crayfishes (*Faxonius limosus*, *Pacifastacus leniusculus*, *Procambarus clarkii*, *P. virginalis*) were high density in the ripraps of bridges and upper section. We were able to confirm, that the noble crayfish could only be caught under the bridges, where the current velocity and sediment composition were optimal for them in the polluted and well regulated running waters. The stone crayfish occured in those bridge crossed sections in higher density in Börzsöny and Visegrád-mountain, where the forest harvesting were intensive in the drainage area, because the current velocity and the sediment composition were optimal at different water levels. The results presented that aquatic habitats under bridges had key role in conservation of native crayfishes in modified and natural streams and in the successful spread of non-native crayfish species in colonised running waters.

This study was financially and technically supported by projects GINOP - 2.3.2 - 15 - 2016 - 00004, TKP2020 - NKA - 16, EFOP - 3.6.3 - VEKOP - 16 - 2017 - 00008, Interreg - DTP SAVEGreen (DTP3 - 314 - 2.3), NEA - 20 - EG, NEA - 19 - EG, PTKF/569/2018; PTKF/345/2020; PTKF/412/3/2021.

Keywords: Underpasses, Watercourses, Aquatic habitats, Aquatic invasion, Water management, Maintenance.

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Best Photo – “Mitigation measures and other best practice” Category

Leopard investigates scent marks at a railway underpass

Hannah de Villiers, South Africa

2021, July – South Africa, Balule Nature Reserve, Greater Kruger National Park

Male leopard investigates scent marks on a small railway underpass (culvert) that is regularly used by leopard in Balule Nature Reserve. Balule is a big five reserve that is part of the Greater Kruger National Park of South Africa. This is a freight railway line that bisects the reserve and links the mine in Phalaborwa with the town of Hoedspruit.

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Poster Communications

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Appropriate Assessment on regional road improvements in Northwestern Greece. Local needs and proposals for securing wildlife permeability

Lazaros Georgiadis[1]

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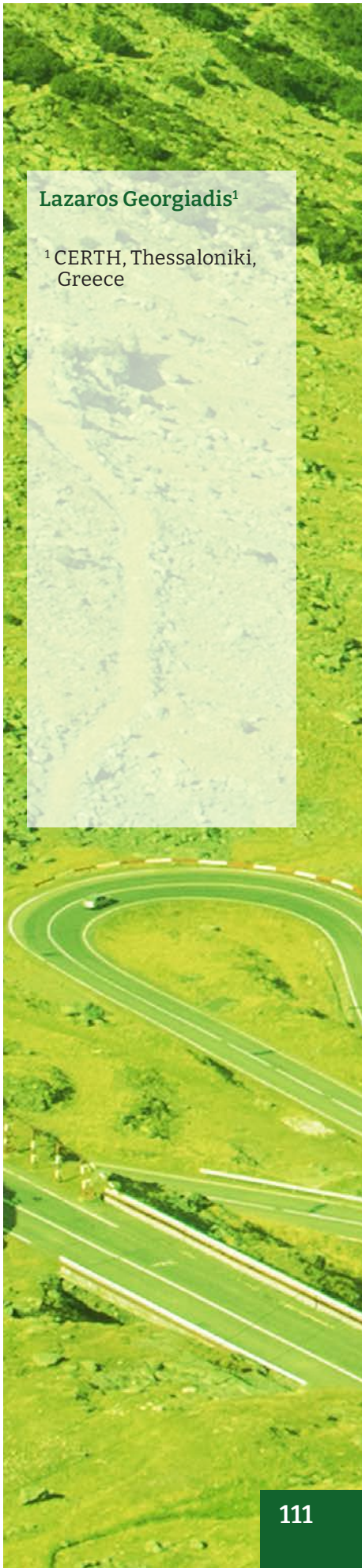

The demands of transportation infrastructure in the 21st century are increasing and assessing the environmental impact on habitat loss and fragmentation is a great challenge. At the same time, main threats are associated mainly with new transport infrastructure development. Upgrade of the technical characteristics of existing roads include several important issues on their wildlife permeability and avoiding or minimizing roadkill and connectivity effects. The implementation of Environmental Impact Assessment in Natura 2000 areas demand the implementation of an Appropriate Assessment (AA) evaluating the impacts of Priority Habitats and Species which are included in the Habitat Directive (92/43/EC).

In 2020, an AA contacted for a regional road of 8.7 km in the Municipality of Prespes, Regional Unit of Florina, Region of Macedonia, Greece. The road is located in the valley of the Ladopotamos River, a new Natura 2000 area of the National Park of Prespes. This park is part of the "Prespa Park", the Prespa Trilateral Transborder Area which is the first transboundary protected area in the Balkans, established in 2000. The keystone species for the area and the road project was the Brown Bear (*Ursus arctos*) while the Priority Habitat is impacted is the 91E0 [Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)]. The aim of the AA was related with the identification of the impacts of the road improvements on the keystone species and mainly on the brown bear.

In the study, the collection of the wildlife data was based on the following methods: (a) transects for wildlife tracks recording, (b) camera trapping, (c) recording of roadkills and (d) interviews from locals. Here we will demonstrate the results of the collection of the above information as well as the proposed proposals for improving the wildlife permeability of the road which in summary includes the following measures:

1) Improvements of bridges relevant with their dimensions and the Openness Index as well as special adaptations for species such as otter and fish.
2) Improvements and adaptations of the culverts aiming on increasing the Openness Index and their use by wildlife.
3) Creation of new four crossings for wildlife which:
   - Are proposed to be constructed in important zones of the road of increased presence of wildlife species while the same time the existed culverts are in very low density.
   - Allow the construction of the wildlife crossings due to high elevation of the road in those sections of the road.
   - Serve the local movement of livestock.

On the both sides of these crossing the installation of wooded poles used as poles supporting power lines is proposed which are used by bears, wolves and wild boar for their territories' marking.

4) Maintenance of the bridges and culverts in order to be used by wildlife.
5) Special signing of the road in critical zones with high level of crossings by wildlife.
6) Environmental monitoring during the implementation of the improvements of the road and the construction of new infrastructure.

Keywords: Transport ecology, Ecological connectivity, Biodiversity, Appropriate assessment, Natura 2000, Wildlife crossings.

TRIIAS – Applied research on management of invasive plants in infrastructure

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Biological invasions are one of the major contributors to global environmental change. Invasive alien plants (IAP) can affect native species richness and abundance, modify trophic networks, and even alter ecosystem dynamics. Aside from the ecological impacts on native biodiversity, invasive alien plants can generate high economic costs associated with vegetation and soil management. IAP can use roadsides as habitat and dispersal corridors, and roadside management practices can potentially benefit the spread and establishment of invasive alien plants in the landscape. However, the effects of different invasive plant species on nature and infrastructure can differ depending on the environmental conditions and management practices. Here, we introduce TRIIAS, a research program with a focus on generating knowledge about the effects of IAP on biodiversity in and next to roads and railways, and best practices for invasive alien plant management. To be able to control and eradicate invasive alien plants, it is necessary to develop routine control measures that are cost-effective and that reach all stages in road planning, construction, and maintenance. The research in TRIIAS includes literature compilations, case studies, and experiments in the field and laboratory. The program is performed in close collaboration with the Swedish Transport Administration, and the Agency's ongoing work with IAP can be studied as large-scale experiments. The work within TRIIAS will aim at answering the following questions:

- What are the effects of invasive alien plants on biodiversity and how do they affect the environmental quality of infrastructure habitats?
- Where are invasive alien plants distributed and how does the road network influence their spread into other habitats?
- What is the most cost-effective method for surveying invasive alien plants in road networks?
- Are the current management practices promoting the spread of invasive alien plants?
- What areas should be prioritized for the control of invasive alien plants?
- How efficient are the current methods applied for invasive plant species control?

In addition, TRIIAS will explore the potential for collaboration among different stakeholders as well as the potential for certification of contractors to achieve invasive plant species control not only in roadsides but in entire landscapes. The invasive species *Lupinus polyphyllus* will be used as a focus species, but additional invasive alien plant species that are problematic in Sweden such as *Solidago canadensis*, *Reynoutria japonica*, and *Impatiens glandulifera* will be studied within TRIIAS.

Keywords: Invasive alien plants, Soil and vegetation management, Environmental quality, Roadsides.

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Experimental animal scaring and recording devices

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The use of sensory cues to deter or alert wildlife has received increased attention by practitioners looking for less expensive and non-intrusive methods to reduce human-wildlife conflicts. Measures are asked for to either keep animals outside certain areas and/or during specific times when the risk for damages or accidents is elevated. This is particularly true in relation to traffic safety and infrastructure but also relevant for the prevention of e.g., crop damages by wildlife.

We have developed two different technical applications to study animal responses to primarily auditory signals such as natural sounds from predators, humans, and other animals, or artificial sounds, which are related to the railway, such as bells, horns or chimes. We developed a) a motion triggered device that records video while displaying sounds in a programmable way (MASS – motion activated scare system) and b) a driver activated system triggered manually by e.g., train drivers when detecting wildlife in front of the vehicle (DASS – driver activated scare system). Both units are based on Raspberry Pi platforms and can be combined with various hardware for detection and display of signals. Program code and design are open source and free to use in research or experimental settings and can easily be upgraded, adjusted, or extended. However, they are not designed for commercial use. Currently, we use these tools to study how wildlife can temporarily be deterred from railways just before they risk to collide with the approaching train. MASS units have also been used under controlled environments, at feeding or trapping sites, and at agricultural fields.

In this poster, we present the technical details and the functioning of both systems and invite the reader to develop her own device taking benefit of our technical development and experience.

Keywords: Animal deterrent, Raspberry, Sound, Fear.

Which road-related features can explain high incidence of successful crossings for carnivores?

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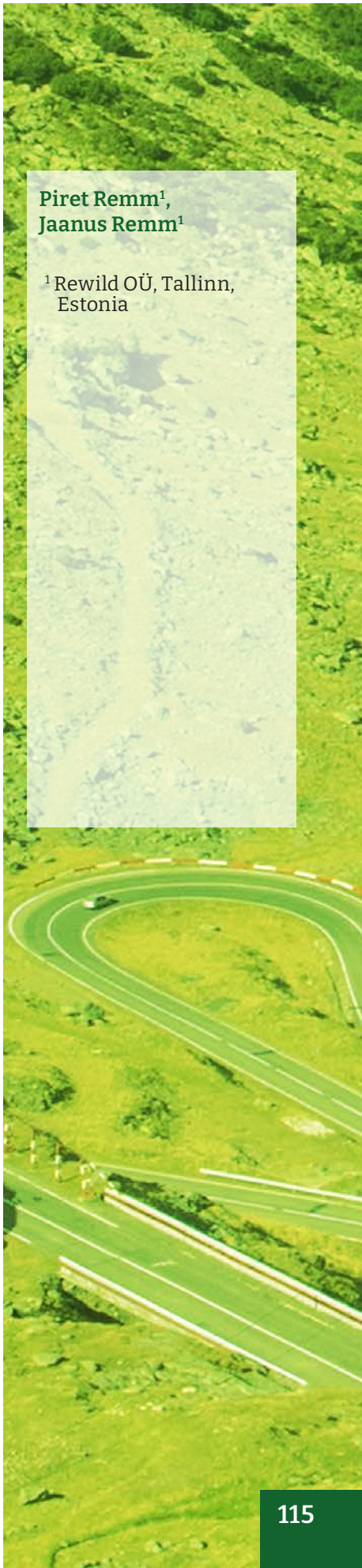
Research suggests roadkill likelihood is explained by some road-related features. However, little is known about which road features may influence individuals crossing the roads with success. We analyzed road-related features that explain carnivores crossing incidence by compiling 1,658 radio-tracking locations from eight carnivore species: Mountain Lion (*Puma concolor*), Cheetah (*Acinonyx jubatus*), Grey Wolf (*Canis lupus*), Genet (*Genetta genetta*), Eurasian Lynx (*Lynx lynx*), Stone marten (*Martes foina*), European Badger (*Meles meles*), and Brown Bear (*Ursus arctos*), from eight different countries (USA, Portugal, Spain, Greece, Norway, Poland, United Kingdom, and Namibia). We estimated the number of successful crossings in road segments of 500 m length and describe the road segments with seven road-related features (number of lanes, exclusion fence height, topography of the road, distance to the nearest curve, and road verge structure (using Google Street View). A generalized linear mixed model was created using the high and low incidence of crossings as the binary response variable to analyze the relationship with the road features and the species and study areas as random effects. We found that the probability of carnivores crossing is higher when road segments have one-lane and road verges with grassland. Roads with one-lane have a low-speed limit and less traffic volume, those factors encouraging more road crossings by carnivores and may explain the high number of crossings in segments with one-lane. Similarly, crossings were more frequent in segments with grassland features, which provide the greatest visibility of the road. Our findings suggest that the visibility and effect of roads, due to road verge structure, speed and traffic, may explain the incidence of crossings by carnivores.

Keywords: Carnivores, Mammals, Road effects, Road crossings, Road kills.

Effectiveness of small wildlife tunnels in urban context



Piret Remm[1], Jaanus Remm[1]

[1] Rewild OÜ, Tallinn, Estonia

In 2020, a 2 km section of street traversing a suburban green core area was reconstructed on the border of Tallinn city, Estonia. As part of this, three small fauna tunnels with adjacent relatively short guiding walls (à ca 80 m) were installed. Target species were amphibians and reptiles, as well as small and medium-sized mammals.

During the spring and summer of 2022, the green facility was systematically monitored with cameras to establish the effectiveness of the tunnels in mitigating the barrier effect of the road. In addition, all animals killed by traffic were recorded, as well as animals' activity on the road. Street sections with no barriers and tunnels are used as control.

Three main hypotheses were tested:
1) Tunnels with guiding walls can reduce wildlife mortality in traffic even if the wall length is limited;
2) Additional barriers on road, like curb stones and safety islands increase mortality;
3) Even quite simple tunnels could provide a safe passage for several species of small animals from various taxa.

Preliminary observations confirm that the tunnels are used by amphibians, snakes, small and medium mammals and occasionally birds. Also, several invertebrates inhabit the tunnels. The tunnels are very important for amphibians not only during spawning migration in spring, but also later in season when adults are roaming for foraging and juveniles are dispersing. This study emphasizes the importance of connecting green network in urban areas to maintain the viability of animal populations and favourable state of biodiversity in human settlement.

Keywords: Mitigation effectiveness, Road mortality, Small fauna, Amphibians, Tunnel, Urban environment.

"Road Ecology: Synthesis and Perspectives": an upcoming book on Road Ecology

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This book will comprehensively present both the state of knowledge and future developments of an emerging discipline: Road Ecology. Transportation infrastructures are one of most widespread transformations that mankind inflicted to our planet, and they are still expanding globally. While providing undeniable benefits for society, roads also promote multiple impacts on biodiversity and ecosystems, with considerable implications for sustainable development. This book is structured in four sections (each one with several chapters):

1) Road-related impacts;
2) Road Ecology research all around the world;
3) Road Ecology for different organisms;
4) Emerging topics in Road Ecology.

This will be an essential book for stakeholders (such as road authorities and wildlife managers) looking for updated information on Road Ecology and for both researchers and students from any field approaching this discipline for scientific purposes, but also for general public interested in knowing more about roads and their impacts on the planet.

Keywords: Road Ecology, Roadkill, Fragmentation, Connectivity, Barrier effect, Pollution.

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Development of Deer Deterrent Equipment for Mitigation of Deer-Train Collisions in Japan

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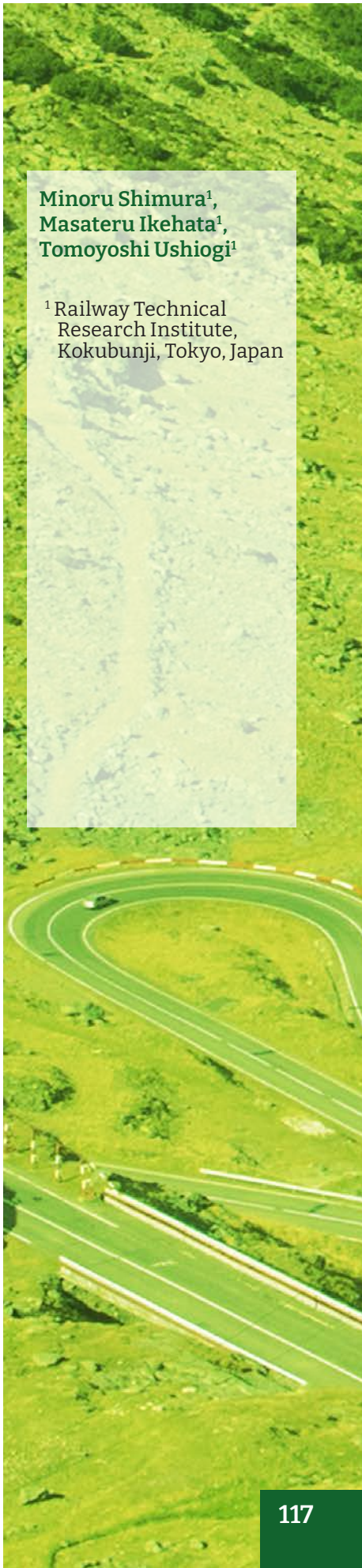


Collisions between deer and trains have become a serious problem in Japan. Deer have been observed entering tracks through gaps in fences or at level crossings. To keep deer away from railway lines, an acoustic deterrent was developed and tested for effectiveness. The deterrent consists of a device that emits deer alarm calls and dog calls. Field observations of Ezo deer (*Cervus nippon yesoensis*) revealed that playing back the deterrent sound towards deer near a track made them run away immediately. During 7 days of train runs with sound being emitted, deer were observed 82 times over the total of 1,100 km covered by train runs along the test sections. Cases where more than one deer were observed were still counted as 1, regardless of the actual number of deer. Deer were seen 90 times over a total of 660 km from trains without the sound being emitted over 4 days of control experiments. These results confirmed that the frequency in deer sightings (deer sightings/100 km of train operation) fell to 7.4 with the sound emissions from 13.5 without any sound emission. This shows that the frequency of sightings was reduced by 45% when the sound was emitted and a chi square statistic reveals that this difference is statistically significant (p=0.05).

Nippon deer (*Cervus nippon*) are the most abundant and habituated deer in Japan (other than in Hokkaido where Ezo deer occur). Field observations of Nippon deer were performed in southern part of Japan. During 4 months of train runs with the sound being emitted, deer were observed 183 times. Out of 60 cases, 58 deer (97%) were in a state of alert and 29 deer (48%) moved away from the tracks. Only 2 deer (3%) were not alert. On the other hand, deer were seen 123 times from trains without the sound being emitted. Out of 123 deer, 78 deer (63%) were in a state of alertness, 21 deer (17%) moved away from the tracks, and 45 deer (37%) were not alerted. The deterrent sound playback changed the behavior of deer and no collisions occurred if deer had left the tracks. Therefore, the deterrent sound playback from the trains will be an effective countermeasure for the collisions.

To evaluate the long-term effectiveness of the deterrent sound in Nippon deer, equipment developed to enable automatic broadcasting of the deterrent sound from trains using global navigation satellite system was installed on some commercial trains. Since the equipment is not installed on all trains, we compared the collision frequency of trains with and without the equipment. Since the deterrent sound is emitted in designated sections, the number of collisions in the section was recorded for 6 months and the collision frequency (no. of collision/1,000 km) was calculated. It showed that the frequency of trains with the equipment was about 40% lower than that of trains without it.

Keywords: Deer, Train, Collisions, Deterrent Equipment.

Permeability of Wildlife Migration Corridors in the Beskydy Mountains – changes in land use over the last 30 years

Ivo Dostál[1], Marek Havlíček[1], Josef Svoboda[1], Jiří Jedlička[1]

[1] Centrum dopravního výzkumu, v. v. i., Brno, Czech Republic

The area between Czech Republic and Slovakia is a mountainous cross-border region at the edge of the Western Carpathians' arch. The region is home to many rare species and includes protected sites within the Natura 2000 network. Most notably, it features the western-most permanent occurrence of Carpathian carnivore populations of brown bear, wolf and European lynx. However, the long period of human development concentrated in deep river valleys has taken its price. The individual mountain ranges are now separated into mostly independent units as landscape connectivity was not maintained in the past. There are few last possibilities for animals to migrate between different parts of the mountains and thus genetic flow is also limited. The drivers that significantly affect habitat's connectivity and integrity in the area are the development of transport (and other infrastructure), anthropogenic land-cover change, intensive agriculture, urbanisation, and climate change.

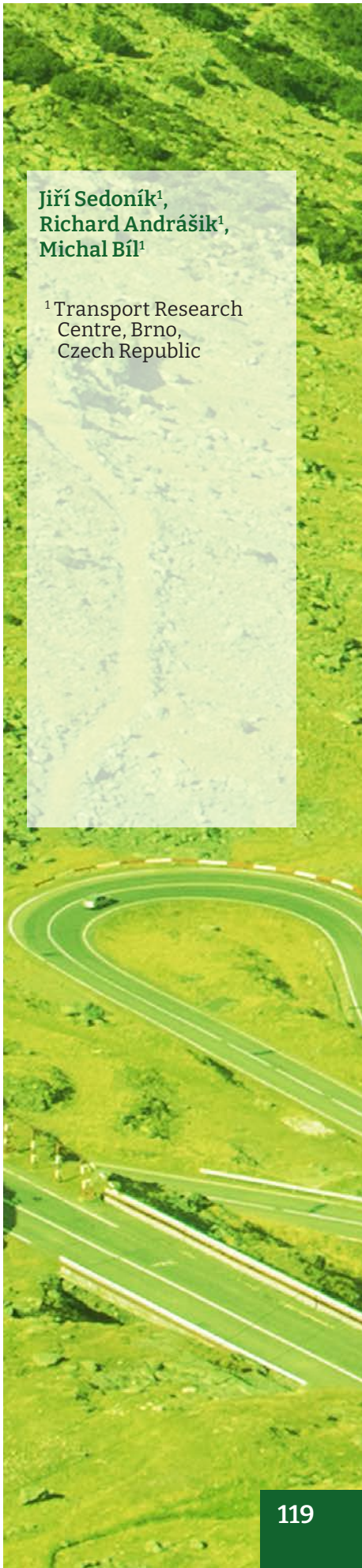
Within the SaveGREEN project, analysis of land-use change processes in six selected critical sites for the wildlife movement (carnivores as an umbrella species) was conducted to reveal how conditions for migrations have changed. The periods monitored were 1990, 2006 and 2020 based on the aerial images and 1:10,000 topographic maps. Additionally, the changes in traffic intensities according to the National Traffic Census (1990, 2005, 2020) were explored as it is also a migratory barrier.

The processes of land-use change have shown the high dynamics of development in the areas researched. The four sites were characterised by a high proportion of arable land in the early period (share 40%–61%), but this number significantly decreased over time to 2%–14.5% in 3 sites and from 61% to 44% in another one. The most intensive processes were grassing on arable land (up to 26% of actual area for 1990–2006 period) and creation of forest from grassland (from 2% to 11% for 1990–2006 and from 3% to 6% for 2006–2020 period). In certain sites a dynamic growth of built-up areas occurred (even by more than 50% in two sites). In addition to land-use, another major aspect affecting the permeability is linear transport infrastructure. Due to the lack of highway-type roads in the study area, the barrier effect of traffic is composed mainly of a dynamic component in the form of traffic volumes on national roads. Between 1990 and 2005 intensity doubled, while the further growth was significantly mild.

The potential of area to ensure the wildlife migration was impacted by land-use change in both, negative and positive, ways. The negative impacts are mainly the growth of built-up areas and the interconnection of settlement structures. The growth of forest areas can be considered as a positive trend. The growth of permanent grassland at the expense of arable land is also a positive trend, but a detailed field survey revealed, that some of these areas are fenced, and the free movement of wildlife is restricted. The transportation tends to further create barriers in the area, with existing national roads being replaced by higher type roads such as expressways. However, this doesn't necessarily mean a deterioration of permeability, but rather the opportunity, as the design of modern roads could be better adapted to the needs of wildlife.

Keywords: Critical sites, Land-use changes, The Czech Republic, Permeability.

On the Relationship between Wildlife-vehicle Collisions and Fence-ends along D11 motorway, Czechia



Jiří Sedoník[1], Richard Andrášik[1], Michal Bíl[1]

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Wildlife fences are effective measures preventing animals from entering roads, lowering thus the probability of wildlife-vehicle collisions (WVC). There are, however, certain known issues related to the possible negative effects of fences. Fence-end effect, fence construction defects or technical errors during their improper installation ranks among them. It has already been reported that WVC often occurs at those places reducing thus the fence performance. Fences are expensive installations and therefore the high reliability of these measures has to be secured.

We analyzed WVC data from fenced D11 motorway in Czechia. We applied the spatial-temporal hotspot analysis (STKDE+) in order to determine WVC hotspot locations and their temporal pattern between 2009 and 2019. The STKDE+ method is able to visually determine the stability, emergence or disappearance of WVC hotspots over time.

We consequently visited the hotspot locations and described the fence faults and fence ends. We further compared the WVC temporal pattern before and after the installation of fences. We determined, on 12 sections of D11 motorway which is 78.5 km (fenced 75.3 km) long, 25 hotspots (containing 161 out of 318 WVC, i.e., 51%) with the length 8.3 km (11%). The fence-end effect caused hotspot emergence in 16 cases, fence gap in 4 cases.

We further compared distances to the nearest fence gap or fence end between WVC and a group of randomly selected locations along D11 motorway. This was conducted using the two-sample Kolmogorov-Smirnov test. WVC took place closer to those gaps than expected. This result objectively indicates the negative influence of fence interruptions on WVC occurrence.

We demonstrated, using the STKDE+ and the statistical analysis, that the fence gaps and ends allowed animals to enter the motorway and affected the distribution of WVC. Regular monitoring of existing fencing as well as careful design of planned fences are therefore necessary for the proper functionality of these safety measures.

Keywords: Motorways, Fencing, Hotspot analysis, STKDE+, Fence gaps, Fence-end effect.

Assessment of the driver's view using a mobile lidar

Vojtěch Nezval[1], Michal Bíl[1], Vojtěch Cícha[1]

[1] Transport Research Centre, Brno, Czech Republic

Wildlife-vehicle collisions are often caused by a lack of adequate visibility on roads. The driver's view is affected by the horizontal and vertical alignment of the road, as well as by the presence of vegetation or other obstacles in the closest road vicinity. Roads with many trees or shrubs on both sides are particularly dangerous, as the dense vegetation restricts the view from the vehicle. It also presents a shelter for wildlife. While such areas generally favour wildlife connectivity, they also increase the risk of wildlife-vehicle collisions. Vegetation clearance is not always possible or applicable due to the large size of the secondary road network or land ownership relations.

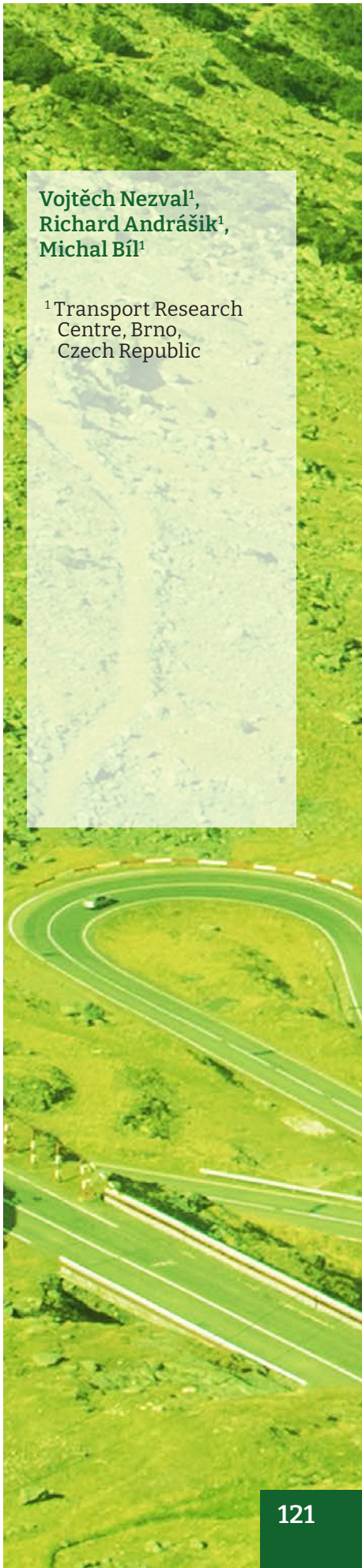
We focused on evaluating the driver's view of the vehicle. To obtain accurate data about the surroundings of the selected roads, we used a special vehicle equipped with a laser scanner (i.e., lidar). A digital surface model was subsequently created from the measured point cloud. The driver's view from specific locations is calculated based on the altitudes of the model. Finally, the visible area was compared to the area representing the maximum possible visibility.

For each evaluated point on the given road with a 5 m step, we obtained the relative value on a scale of 0 to 1 to what extent the surroundings of the road are visible. In the case of flat terrain on the one side and the presence of dense vegetation (e.g., forest) on the other side of the road, the resulting value was equal to 0.5. The closer the value is to 1, the better the driver's view of the surroundings of the road. This kind of information is an useful input as an objective value to WVC predictive spatial modelling.

Keywords: Lidar, Wildlife-vehicle collision, Sight distance, Driver's view.

IENE Infrastructure & Ecology Network Europe 2022

Identification of local factors contributing to collisions with ungulates on the Czech rail network



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Train collisions with animals are a common phenomenon in the Czech Republic, causing not only animal mortality, but also crash-related damage to trains. The factors leading, however, to these collisions have not been studied in detail. We collected 2,421 train collisions with roe deer, red deer, fallow deer, and wild boar on the Czech rail network between 2011 and 2021, to better describe the locations where the collisions occurred.

First, we selected several explanatory variables, which can be divided into two main categories. The first category includes variables related to the immediate vicinity of the railway line, such as the distance to the nearest forest, arable land, urban area, or stream. The second category includes variables related to the parameters of the railway line at a given location, such as the railway line electrification, maximum allowed train speed or railway track geometry. To test the influence of these variables on the occurrence of collisions, we built a logistic regression model.

The results are interpreted in terms of the odds ratio. We found, for example, that each 100 m increase in distance from the forest decreases the odds of a collision by 14%, or that each 100 m increase of elevation decreases the odds by 41%. In terms of railway track parameters, the influence of the maximum allowed train speed and the value of the radius of the curve was found. With the allowed train speed increase of 10 km per hour, the odds of a collision increases by 17%. With the 100 m increase in curve radius, the odds increase by 3%. Variables such as distance to the urban area, stream, the number of railway tracks, or track electrification were found statistically not significant. The results present possible factors contributing to collisions with ungulates on the Czech rail network and can be used, for example, to implement specific measures (e.g., fencing) in given places to reduce the number of collisions.

Keywords: Wildlife-train collision, Ungulate, Accident, Roe deer, Wild boar.

Wildlife mortality in energy and transport infrastructure: Calling for data!

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Roads and other linear infrastructure (railways, powerlines, pipelines, water channels, fences, wind farms) are widespread throughout the globe. Despite their valuable role in raising human life standards and development, they can represent important threats to biodiversity, namely by causing numerous non-natural mortality of animals by collision, electrocution, or drowning. In order to understand the magnitude of this impact, we need to collect broad scale information on non-natural mortality over different landscapes and animal communities.

We are calling for data to strengthen our ability to detect patterns, namely who, where, when, and by how much species are affected by non-natural mortality in energy and transport infrastructure.

All data will be available for researchers in the form of a data-paper, allowing higher analytical power in future individual studies, namely on the ability for robust comparisons with other case scenarios. We will further provide a yearly synthesis of the data collected so far, which can then be used for a more sustainable planning of these infrastructure.

All taxa and landscapes are eligible for this collection. The only limitation is to have the coordinates and date of each recording. In case of systematic data collection, information on the sampling design is also requested.

The submission process is subject to review. Where this is necessary, it may be sent to peers (e.g., if species are reported outside their distribution range). Submissions are made via standard spreadsheet files using a template file provided in the dedicated website. Data will become available, after revision, in this website.

All authors from individual studies will be co-authors (if they wish so), sorted by alphabetical order (last name). We will also provide a map depicting all individual studies and main information, allowing end users to easily select the data/studies. Detailed instructions for creating and submitting the files as well as citation and usage information may be found in the dedicated website.

Keywords: Wildlife mortality, Systematic surveys, Meta-analyses, Data-paper.

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Splitting target groups improves the detection of multispecies bird roadkill and habitat associations

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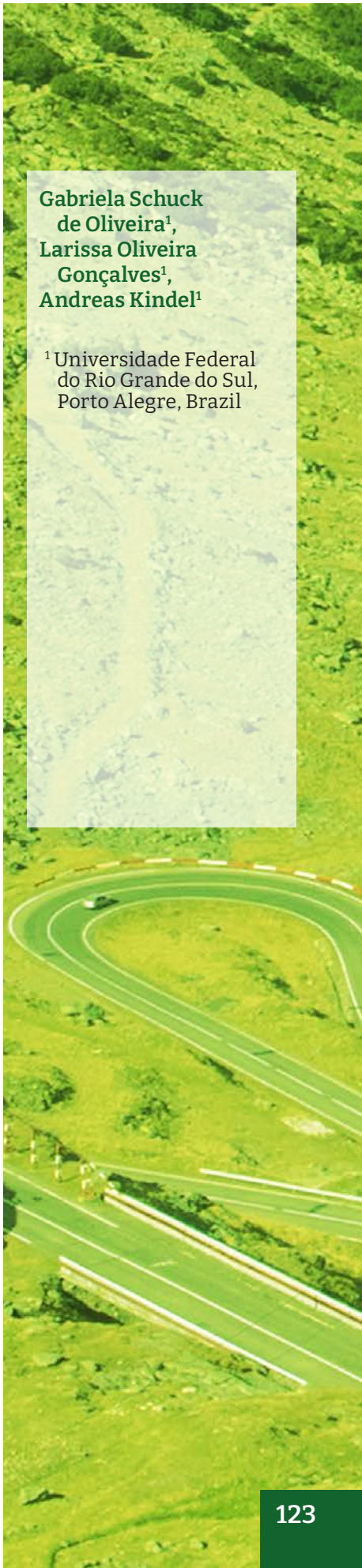

Wildlife-vehicle-collision is one of the most visible impacts of roads and birds are one of the most affected groups. However, there are few mitigation actions focused on this group since flight poses huge challenges for effective solutions. Some available measures involve the management of environmental conditions at road margins, but it is important to comprehend which conditions favor fatalities occurrence and which bird species are the most affected. Our aim was to assess which spatial features are related to bird fatality abundance on two roads in southern Brazil. We performed a road survey searching for bird carcasses during two campaigns of eight days each. We obtained land cover variables at different scales using classified satellite images from Mapbiomas; road features and their immediate surroundings were extracted from Google Street view using images from the same period of survey. We classified birds according to their frequency of use of the road surface and its associated structures like shoulders and guardrails. We fit generalized linear models with Poisson distribution and model averaging using three data sets: all recorded birds, road-user birds (32.6% of the all records), and non-road-user birds (37.9%)–29.5% of recorded birds were not identified and classified, hence they were only considered in the "all recorded birds" dataset. We found that both the variables and the effect scale vary among the datasets. Road-user birds had a positive relationship with different road structures, such as farm fencing, median strip, wider shoulders, and some aspects of vegetation the vicinity of the road. The non-road-user birds were related only to landscape variables such as the mosaic of agriculture and pasture, temporary crops, and urban infrastructure. Our findings highlighted some manageable characteristics of roads to reduce collisions with some bird species.

Keywords: Road ecology, Wildlife-Vehicle-Collisions, Bird collisions, Landscape features, Bird behavior, Google Street View, Tropical birds.

Three-year camera trap wildlife overpass monitoring feedback

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In order to help national road managers assessing the efficacity of ecological continuity restoration measures, Cerema uses camera trap to monitor two wildlife crossings. This work was conducted for three years (2019–2021) on a 38 m wide and 30 m long overpass, connecting the Retz forest (Aisne, France) on both sides of National Road 2 (RN2), constructed in 2014.

The objectives of this work were to collect information on the use of this structure (funded by public investment) by local fauna as a way to assess its efficacity over the following five years after its commissioning. However, the three first years of data have already permitted a more thorough monitoring and lead to new hypothesis concerning local species.

Each year, two camera traps were set on the overpass for three weeks, every season. Sampling effort was based on both minimum needs for monitoring and financial as well as time-consumption constraints. The two camera traps screen the totality of the passage in a continuous way, and duplicate contacts were eliminated from the dataset.

The parameters considered for the statistical analysis are: date of passage, hour of passage, period of the day (daybreak, day, sundown, night), direction, number of individuals, and species.

Results showed a significant increase in daily frequentation for elk (*Cervus elaphus*) and wild boar (*Sus scrofa*), as well as a significant difference in motion direction depending on the period of the day for the same species.

For other species, such as roe deer (*Capreolus capreolus*), fox (*Vulpes vulpes*), badger (*Meles meles*) or brown hare (*Lepus europaeus*), data from the camera traps weren't sufficient to conclude on significant trends.

Such results lead to new hypotheses concerning links between overpass frequentation patterns and population patterns. Future work will need to assess whether the changes in overpass uses are due to population evolution (population growth or displacement) or to real usage habits (habituation to the overpass, feeding and/or resting habitats). These hypotheses will be compared to data obtained at the site by local Federations of Hunters.

Keywords: Wildlife overpass, Mammals, Monitoring, Camera trap.

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Ecological integration of the bicycle highway along the former rail road Coal Track In Limburg (B)

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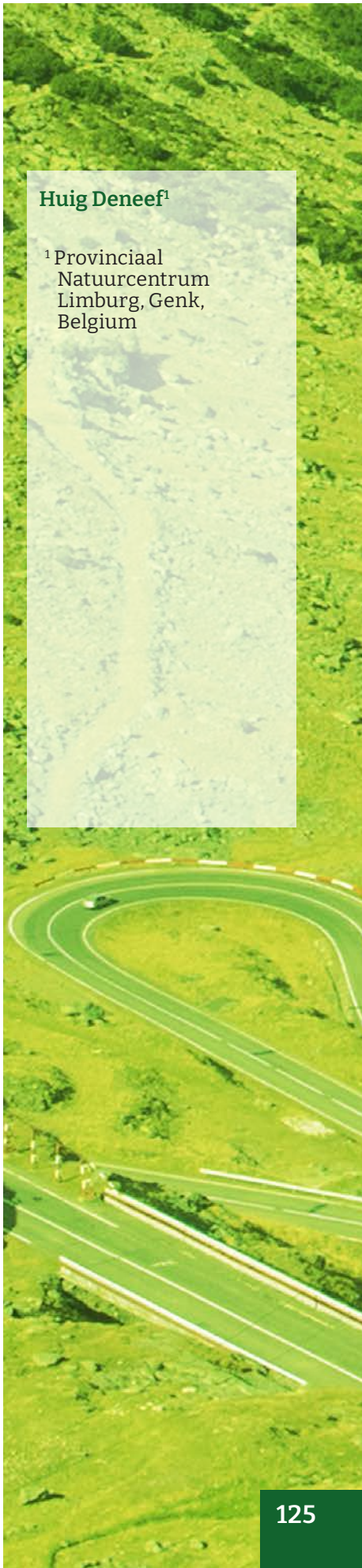

Flanders wants to realize an extensive network of fast conflict-free bicycle connections. The "Coal Track" (or Kolenspoor) is a former railway line that served as a freight and passenger railway. Due to the closure of the coal mines (closed in 1992), the rail road track fell into decay. The province of Limburg purchased the eastern section in 2019 to develop it as a bicycle highway.

The Kolenspoor connects various landscapes with unique natural values and therefore has a high potential as a landscape and ecological connector. Nature interacts with the former rail road track on 3 scales:

- macro as a nature connection between large landscape entities;
- meso as a habitat for various species;
- micro as an ecological cross-connection.

The Kolenspoor runs through different landscapes with area-specific biotopes and species. In each of these landscapes, the Kolenspoor can play a role in terms of ecological "connection" and "defragmentation".

The functional development of the ecologic landscape in favour of vulnerable species is based on a demarcation of the route in gradients and associated ecoprofiles. The ecoprofiles form a grouping of species with similar ecological requirements. Three types of natural gradients are distinguished to which various ecoprofiles are linked:

- species of open water and swamps in open to semi-open landscapes (e.g., crested newt);
- species of grassland – heath – forest (e.g., smooth snake);
- species of current water in open to closed valley landscapes (e.g., otter).

For each segment, conceptual solutions have been developed based on the habitat requirements for existing species, like herpetoducts (smooth snake), ecoducts (wild boar), fish passages for migration, but also verges and adjacent natural zones that will be colonized by butterflies, grasshoppers and birds.

The linear green structure along the former rail road track is also a habitat and migration route for various species of bats. At the moment, there is still a lack of reliable data to include well balanced measures to safeguard the presence of bats. This will be further investigated, mainly as an assessment framework for determining where public lighting is possible or not.

Hence, the ecological measures were integrated in the traffic engineering and implementation study. The integrated study will serve as the basis for the application for an environmental permit to start the works in 2023.

At the same time, work is being done to draw a nature management plan. This is an instrument of the Flemish government to support increase biodiversity in a specific area. A nature management plan is being drawn up for the next 24 years. Annual subsidies are provided to implement the nature management plan.

Keywords: Ecological integration, Bicycle highway, Former rail road Coal Track Belgium.

Use of a canopy bridge and underpasses by arboreal mammals and long-term roadkill monitored on a Brazilian coastal road

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Roads disrupt the canopy and can affect arboreal animals in different ways, such as reducing canopy connectivity, generating habitat loss and degradation, and increasing direct mortality. Here, we aimed to describe the use of a canopy bridge and multiple underpasses by arboreal mammal species and compare these data with roadkill records of the same species in the vicinity of the crossing structures. We surveyed a 67.5 km Brazilian road (ES-060), a 75 m long canopy bridge, and seven different types of underpasses. The canopy bridge was monitored for three years and the underpasses and roadkill survey were both monitored for 16 years. The use of the crossing structures was monitored with sand track beds installed at entrances on both sides and crossing was considered successful if tracks of the same species were recorded on either side of a structure and showed opposite movement trajectories. The roadkill monitoring was conducted eight times per day at every three hours. We calculated monthly crossing and roadkill rates and also ran a hotspot analysis for the arboreal species recorded using the crossing structures, which were: *Callithrix geoffroyi* (tufted-ear marmoset), *Coendou insidiosus* (Bahia-hairy-dwarf porcupine), and *Didelphis aurita* (Brazilian common opossum). In the canopy bridge, we observed a rate of 0.16 crossings/month for *Callithrix geoffroyi*, 7.79 for *Coendou insidiosus*, and 0.46 for *Didelphis aurita*. In all types of underpasses combined, we observed a rate of 0.33, 1.94, and 8.43 crossings/month for each species, respectively. The single concrete box was the underpass most used, representing 59.52% of the crossings, being used by all three species. We observed a rate of 1.41, 0.78, 2.94 roadkills/month for *Callithrix geoffroyi*, *Coendou insidiosus*, and *Didelphis aurita*, respectively. Although the three species have been registered using the crossing structures, for all of them we identified hotspots overlapping crossing structure's locations. Our study demonstrated the use of a canopy bridge and surprisingly different types of underpasses by arboreal mammal species. As roadkill hotspots occurred in the same segments where mitigation crossing structures are installed, our results indicate that important improvements are needed to mitigate roadkills of arboreal mammals in this area, mainly preventing their access to the road, as using effective fences. Also, we registered only three arboreal species, but are aware that at least eight occur in the study area, our results highlight that each species may require different crossing structure design attributes in order to be attracted to and amenable to using different structures. We present recommendations for a research agenda to support mitigation planning for arboreal mammals: (1) testing the efficiency of different canopy bridge designs for multispecies mitigation, (2) testing the use of connecting structures, such as ropes that connect to the surrounding forest, to encourage underpass use by arboreal species, and (3) testing fence adaptations to block the access of arboreal mammals to roads and direct them to the crossing structures.

Keywords: Connectivity, Crossing structure, Mitigation, Road ecology, Roadkill, Hotspots.

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The Trial of a Roadside Deer Detection System in Hokkaido, Japan

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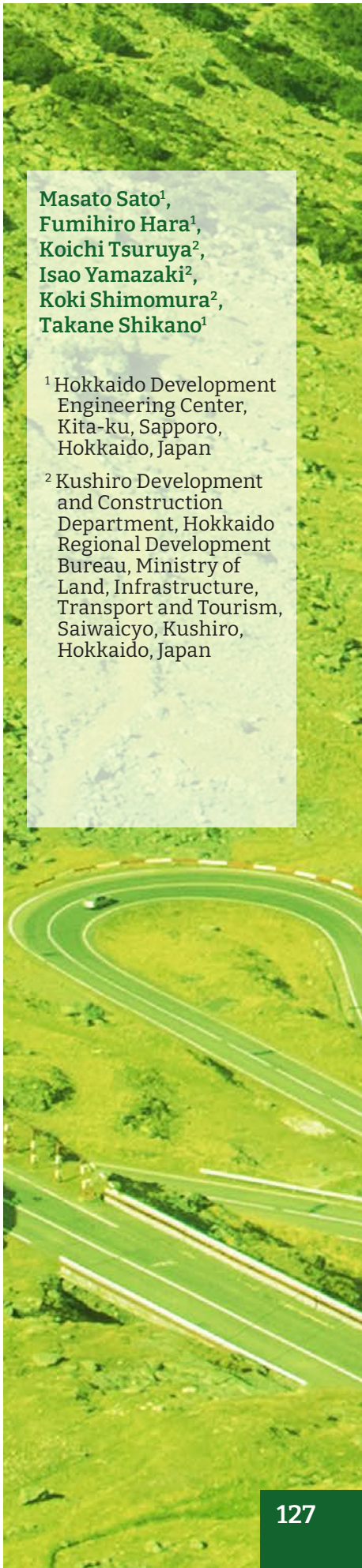

In Japan, the problem of traffic accidents involving wildlife arose with the development of transportation infrastructure. Countermeasures mainly involve hardware, such as facilities aimed at protecting rare species, including overpasses (e.g., squirrel bridges) for mammals and bird protection poles for birds. Measures for large mammals include the installation of traffic safety facilities, such as animal intrusion-prevention fences that aim to prevent serious collision accidents involving large mammals. In Europe and North America, animal detection systems have been installed as ancillary facilities on roads, and there are reports that they have been effective. In Japan, an animal detection system aimed at protecting Amami rabbits (*Pentalagus furnessi*) is being trialed on Amami Oshima Island.

Sika deer are large mammals in Hokkaido that are commonly involved in serious animal–vehicle collision accidents. We examined and trialed an animal detection system to mitigate traffic accidents involving Sika deer.

First, we examined sensors for detecting animals. For the sensor, we chose a light, for the purpose of inexpensive operation. We tested the detectable range and ease of installation for three types of light: visible light (red), infrared light, and laser light. The visible light (red) was found to be suitable for the sensor, and we started the trial construction of the animal detection system. When deer pass the sensor and block the light, the system detects them. The system turns on a lamp at the roadside to alert the approaching driver of a potential deer incursion. The system is powered by solar panels that feed storage batteries.

The trial was conducted for 3 years. Based on the results of a monitoring survey, we improved the animal detection system in terms of the sensor installation technique and the ways of informing drivers of the presence of the system on the road section. The deer detection rate at the end of the study period was about 90%, with a false detection rate of about 10%. As for improving the method of notifying the driver, the light on the system was improved and information on the meaning of the animal detection system at the roadside was disseminated at roadside rest areas. The warning light and the information on the presence of the system are considered to have caused the average vehicle speed on the test section to decrease by between 1.8 and 6.5 km/h.

These results verified that the installation of the animal detection system contributed to decreased vehicle speeds, so the risk of collision accidents involving wild animals is considered to have been reduced. The animal detection system was found to be effective as a measure against animal–vehicle collisions on roads.

Keywords: Animal detection system, Animal–vehicle collisions, Sika deer.

A magnitude study of roadkill to enhance ecologicals networks: methodology, results, partnerships

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The Loire-Atlantique Department (CD44), which manages the departmental road network (4,500 km), has drawn up a White Paper "Roads of the future" (December 2018). It sets out 11 departmental commitments including: "No. 7: Preserve biodiversity and protect natural and agricultural areas".

This intention has been translated into the 2019–2021 Action Plan entitled "Departmental commitment to shared, safe and sustainable travel" by axis 4 "Promote biodiversity on roadsides". Studies on terrestrial and aquatic ecological network have been undertaken to help achieve these objectives.

In addition, the CD 44 has launched a study to implement actions to improve ecological network on the departmental roads located on the land of the former Notre Dame des Landes airport project (NDDL). The CD 44 wishes to display a strong operation on this emblematic site.

It was deemed necessary to have sufficiently robust data on the movement of species before concisely positioning works to restore ecological network in a way that respects public money.

Given the knowledge of the habitats and species already acquired in this area, the evaluation of animal mortality with traffic appeared to be the most relevant solution.

Roadkill survey was therefore carried out over a full year (October 2020/October 2021) on 20 km of departmental road, on a round trip basis, performing by bicycle.

The total of 149 counts conducted revealed the collision of 1,082 animals, i.e., 54 animals/km/year. If we exclude a communal road with very small traffic (less than 20 vehicles/day), this index rises to more than 60 animals crushed/km/year. This is a considerable roadkill rate compared to the 3.5 collisions/km/year recorded on the DIRO network (surveys carried out from 2014 to 2021 on 1,500 km of 2×2 lane roads). It should be noted that none of the 149 passages collected any data.

In terms of numbers, with 396 data collected (36.6%), amphibians are in first place among all taxonomic groups impacted. Birds came next, with 282 carcasses, followed closely by reptiles with 254 carcasses and finally mammals with 150 carcasses.

This magnitude study achieved its objective of identifying precisely the sectors of high animal mortality linked to traffic. It also allowed us to objectively observe the considerable impact of road traffic on wild fauna, particularly on small species (amphibians, reptiles, small mammals, passerines). 80% of the species surveyed are protected at national level. The chronic impact of roadkill is inevitably a factor in the degradation of the conservation status of the populations of these species, here in the Loire Atlantique department, but also everywhere in France where the road network is dense.

The results of this study demonstrate the need to restore ecological network that has been disrupted by the road network. The mitigation measures are currently being defined.

Keywords: Methodology, Roadkill, Ecological network, Carcasses survey.

Noise and biodiversity in France: state of play and perspectives

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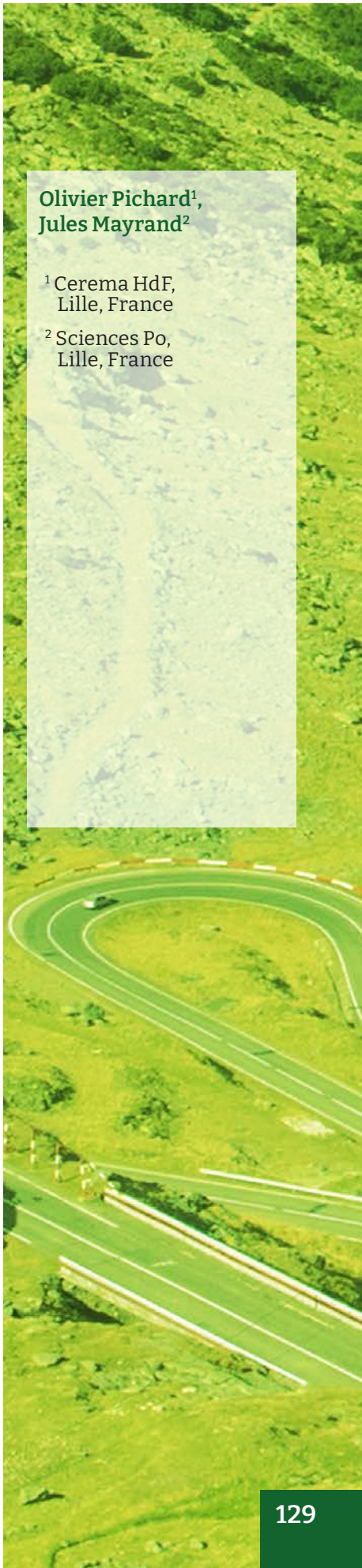

In 2022, Cerema carried out a "state of play" assessment of the impact of noise on biodiversity. While the subject of light pollution has grown significantly in recent years, with greater consideration into public policies and development projects, noise pollution is still too often approached from a human health perspective.

However, numerous scientific studies clearly demonstrate the negative impacts of transport and human activities noise in general on biodiversity. These impacts include the masking effect, which reduces acoustic communication and disrupts prey-predator relationships, and the scaring effect, which causes the most sensitive species to flee. These impacts have effects on fitness and more broadly on the trophic balance of ecosystems. These studies and systematic reviews reveal that the main taxa studied are birds, followed by mammals and amphibians. The main effects studied are those related to communication, behaviour and reproduction.

It is necessary to continue efforts to understand the effects of noise on biodiversity, particularly on little-studied groups such as insects or plants. A multidisciplinary approach bringing together behavioural ecology, ethology, neurosciences, landscape genetics, soundscape ecology, bioacoustic, ecoacoustic and even social dimension should lead to a better understanding of the effects of noise at the scale of an individual, a population, a species and the effects induced on the ecosystem and society (cumulative effects in particular).

Environmental assessment procedures for projects must take into account all the dimensions of noise, through the "one health" concept for example, to include all the effects of noise on all living organisms.

In France, we see a growing interest in the link between noise and biodiversity. On January 2021, a law protecting the "sensory heritage" of its rural areas was passed, in the face of complaints about the typical noises and smells of the countryside. However, this law goes further, as it enables to include the sounds in the Environmental Code as a "common heritage of the nation" on the same level as natural land environments, living beings and biodiversity. In addition, the new national strategy for biodiversity 2021–2030 includes objectives for maintaining and restoring sounds ecological continuity and combating noise pollution from the point of view of air pollution.

Keywords: Noise, Biodiversity, Transport infrastructure, Nature in the city, Soundscape ecology, Bioacoustics, Ecoacoustics.

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www.transportecology.info: A globally relevant, open access resource to share information, knowledge and experience in ecologically-friendly linear infrastructure

The impacts of transportation infrastructure on wildlife, habitats and ecosystems are profound and growing. Unless carefully planned and well-designed, these networks of new and expanded infrastructure will continue to wreak havoc on the natural capital that underpins society. A safe, efficient and ecologically sustainable transport system is also critical to economic growth and development, improving human health and wellbeing, and protecting the environment.

Governments, industry practitioners and communities need access to scientifically robust information to inform their planning and guide the decision-making process. www.TransportEcology.info is a globally-relevant resource providing open access information to assist all stakeholders. Importantly, this project will give the same information to the general community, informing them of new initiatives and world's best practise, thereby giving them the tools to participate in the decision-making process.

TransportEcology.info has three main components: (1) research summaries on latest findings in transportation ecology; (2) mitigation case studies; and (3) best practice information on how, when and where to avoid, minimise and mitigate impacts.

Research Summaries: Transportecology.info has now published over 25 research summaries since its creation in 2021. They summarise peer-reviewed journal articles and are written in a conversational scientific style which presents the key findings of important research. Summaries are visible and accessible to practitioners, and not hidden behind paywalls and scientific jargon.

Mitigation Case Studies: these are currently being written using a blended "conversational" and "scientific" style and showcase the real world implementation of new, environmentally-sustainable infrastructure projects and mitigation strategies on pre-existing infrastructure. The conversational style will ensure chapters are readable and understandable by laypeople. The scientific style will ensure the "story" is reliable and evidence-based, and can include references to provide supporting information or evidence sources.

Best practices: although there are many publications on the impacts of linear infrastructure and the use and effectiveness of mitigation, there is comparatively little on how, when and where to actually mitigate. Researchers and practitioners will be invited to provide accessible information about methods that can be used to quantify the impacts of linear infrastructure and inform where, when and how to mitigate those impacts.

You are invited to subscribe to the site or follow on social media (LinkdIn, Twitter, Facebook, Instagram) to receive periodic updates. You are also encouraged to submit your research, case studies and best practise to the site and to share your experience with a wide audience.

Keywords: Linear infrastructure, Resources, Training, Website, Research, Case studies, Best practice.

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The planned M2 motorway in a transition landscape of the Carpathian Basin Analysis in the frame of Cross-Sectoral Operation Plan of the region of the planned M2 motorway in Northern Hungary

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Our poster aims to highlight the method of analysis of the landscape level effects in case of the planned M2 motorway in the north part of Hungary. This motorway is planned to increase border crossing opportunities in the Hont-Parassapuszta border area between Hungary and Slovakia and to divert transit/cross-border traffic to the outskirts of the settlements. The new motorway project is expected to bring positive changes in cross-border cooperation (e.g., connecting the Nitra region with the Budapest agglomeration), support the further development of the economic potential of the border regions and improve the quality of the environment in the settlements but at the same time it will have drastic effects on the landscape connectivity. The planned M2 motorways will lead through a diverse, transition landscape between the Nógrád basin and on the peripheries of mountain Börzsöny Mountain, and crosses valley of River Ipoly.

Here, we will give a complex overview about the effects of the motorway. We elaborated a landscape level assessment using GIS software. We assessed the landscape character types, the hemeroby, connectivity, fragmentation level of the landscape, the quality of green and blue infrastructure, ecological corridors, density/location of cultural heritage, structure of cultivation and land use. Based on the multi-level assessment we explored the critical sections of the planned infrastructure.

Due to the specific conditions, the landscape is crossed by several watercourses representing the most important ecological corridors connecting core areas. The most dominant feature of the hydrography of the area is the River Ipoly. Some of the watercourses originate from springs on the Börzsöny Mountain side in the Hont area and flow northwards into the River Ipoly, while others originate in the Nagyoroszi area and flow northwards towards Drégelypalánk and eastwards and north-eastwards towards Patak and Ipolyvece.

In our evaluation, we revealed the most important critical sections of the planned M2, namely the crossing zones of the watercourses.

Based on the complex analysis we formed cross-sectoral proposals to mitigate the negative effects. We compared our proposals with the planned mitigation measures of the AA and EIA study. Our research results would improve the planning practice and EIA approach.

This study was financially and technically supported by projects Interreg-DTP SaveGreen.

Keywords: Planned motorway M2, Landscape level assessment, Green and blue infrastructure, Ecological network.

Reducing risk of wildlife-vehicles collisions in the Pyrénées-Atlantiques department: from research to implementation at scale

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In charge of 4,500 km of road network in France, the Pyrénées-Atlantiques departmental council has decided to commit itself to better understanding and reducing the impact of the largest road surfaces on wildlife. This local authority has two objectives: to improve road safety and to protect biodiversity. Since 2019, the Pyrénées-Atlantiques has been deploying the collision survey protocol (wildlife/vehicle) developed by the MNHN and CEREMA for national roads on its road network. Involvement in this scientific monitoring protocol has made it possible to identify road sections that are really dangerous for wildlife. This practical monitoring complements a theoretical model developed by the Occitania hunting federation. The latter highlights potential road mortality zones by superimposing ecological continuities for roe deer, mustelids and badgers with the presence and road traversability. Following this preliminary study, concrete and targeted experiments aim to reduce the risk of collision (warning reflectors, floating footbridges, road signs, etc.).

We are conducting research to identify the explanatory factors of the distribution of road collisions. We propose to look at the spatial interactions between habitat continuities, the potential dispersal of species and local characteristics of the road landscape. The land use data aims to characterize under GIS, at the scale of the department, the spatial frameworks by type of habitats, wetlands, open habitats, forest habitats. The ecological characteristics of species, their preferred habitat, their power of dispersal and their sensitivity to disturbances make it possible to build ecological networks specific to each species by defining potential corridors using the method of least-cost paths (GRAPHAB method). The mortality data allow the determination of mortality hotspots (Kernel method) which are explained by the local variables of the landscape, the road features, the road traffic and the proximity of the potential corridors. We aim to answer several questions: In particular, are mortality hotspots correlated to the type of road, ecological corridor, or local landscape?

Our results show the factors that influence road mortality for different species. For the hedgehog, road width, protective barriers, road sectional profile, local land use and level of connection help explain the existence of these hot-spots. The level of habitat fragmentation at the departmental scale is seen as a key variable of wildlife connectivity in the landscape and therefore of road impacts. We hypothesize that taking into account the many disturbance that affect the quality of these corridors (noise, light, human frequentation) will make it possible to refine the identification of the least cost paths and therefore of the spatial interactions between ecological networks and transport networks. The results are linked to the type of species, each with its own ecological affinities and behavior.

Keywords: Roadkill, Ecological continuities modelling, Multicriteria analysis, Road landscapes.

IENE Infrastructure & Ecology Network Europe 2022

Using models and media to rank road safety in Central Brazil and support decision making

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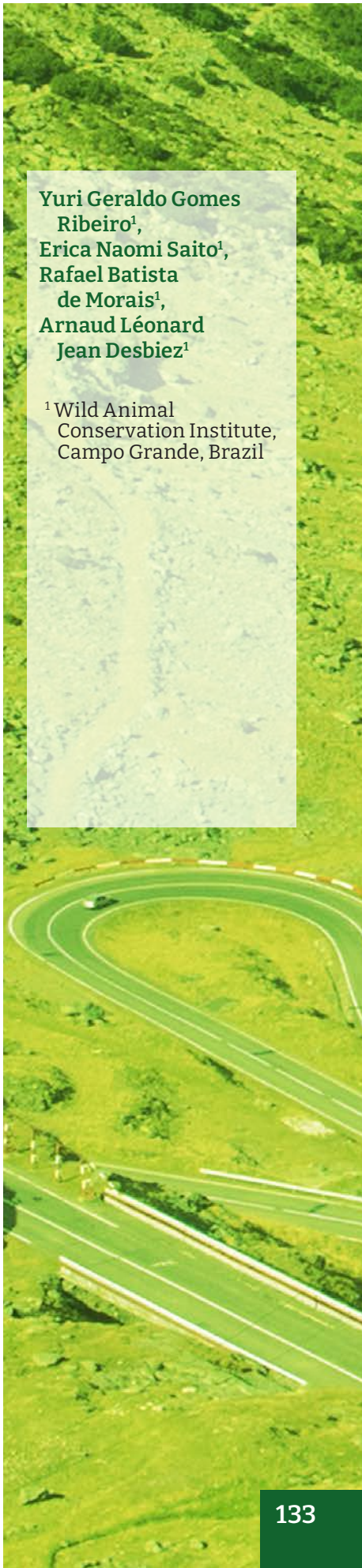
[1] Wild Animal Conservation Institute, Campo Grande, Brazil

Wildlife-vehicle collisions (WVC) might be one of the biggest threats to biodiversity and represent a real threat to human safety. However, data on roads safety for both people and wildlife are usually not easily available. Information on critical locations for allocation of resources and mitigation measures is an important step to prevent WVC from occurring. Here we aimed to rank highways in terms of safety, and also assessed media mentions of road accidents that are available online. Results should help prioritize which highways are most in need of mitigation measures by public authorities. This exercise was conducted for the state of Mato Grosso do Sul in central Brazil. The state currently holds one of the highest rates of WVC in Brazil.

We used different criteria to rank road safety. The first criteria were data extracted from a road segment prioritization map. The prioritization map was made using species occurrence in road vicinity areas models for the following species: lowland tapir (*Tapirus terrestris*), giant anteater (*Myrmecophaga tridactyla*) and capybara (*Hydrochoerus hydrochaeris*). The species selected represents a threat to human safety during WVC due to their large size. We used environmental predictors and the Maxent software to generate the models. We classified roads based on the proportion of critical risk segments compared to road length. The second criteria were obtained through records of federal road police of accidents involving animals. We were not able to distinguish whether accidents were caused by wildlife or domestic animals, since the date were not discriminated in the database. Data on accidents were only available for federal roads. We then calculated the percentual of accidents per road length. Finally, we used media mentions of WVC available on internet to compare results. Media mentions was considered a potential measure of public opinion on road safety.

Our findings revealed that based on the first criteria the top three federal roads for human safety risk were: BR-163 (44.15%), BR-262 (39.24%), and BR-359 (17.43%). For the state roads, the top three roads for human safety risk were: MS-244 (54.16%), MS-382 (48.03%), and MS-156 (45.16%). Following the second criteria, our findings revealed that the top three federal roads based on accidents registered were: BR-262 (21.69%), BR-163 (21.64%), and BR-158 (15.52%). However, the roads that most appear in media due to accidents involving wildlife were BR-262 (no. of news: 20) and MS-395 (no. of news: 11). We believe that these three approaches to ranking differences between roads in terms of safety can be complementary in the decision-making process. We are currently developing a method to combine these approaches. We believe that our results will help to prioritize which roads require the most urgent investment in mitigation measures.

Keywords: Rank, Wildlife-vehicle-collision, Human safety, Decision making, Roadkill, Public policy, Media.



Best Photo – “Flora and fauna in relationship with linear infrastructure” Category & The OVERALL WINNER

Invisible death in our daily lives

Gabriela Schuck de Oliveira, Brazil

2020, January – Brazil, Rio Grande do Sul

Amphibian roadkill found during road survey in Brazil, Rio Grande do Sul.

2022

IENE

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Panel Discussions & Networking

IENE Infrastructure & Ecology Network Europe 2022

Mobility and Biodiversity: interactions and synergies between mobility and wildlife, international projects and cooperations; Future needs of cooperation between IENE and PIARC

Elke Hahn[1,2], Lazaros Georgiadis[1], Yannick Autret[3], Lea Balavoine[3], Carme Rosell[1], Anders Sjölund[4], Hildegard Meyer[5], Eric Dimnet[3,6]

[1] Infrastructure and Ecology Network Europe

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[3] GCSD

[4] CEDR

[5] WWF-CEE

[6] PIARC

In recent years, international cooperation on taking into account the interactions between mobility and wildlife has moved to a higher level. For instance the BISON project was launched in 2021 as part of the H2020 and Horizon Europe framework programmes for research and innovation of the European Commission. Meanwhile, PIARC (World Road Association) has, for the first time in its history, included the subject of the interaction between road infrastructure and wildlife in its 2019–2023 strategic plan. It has become one of the topics dealt with by the technical committee (TC) 3.4 dedicated to environmental sustainability.

International initiatives are multiplying on this issue and the aim of this discussion is to present what has already been done in this area and to suggest avenues that could unite efforts around new projects. How can the IENE environmental objectives and actions contribute to the environmental policies of PIARC. What are common fields of working together, which synergies can we use?

The expected outcome of this discussion is to inform about the existing projects and those in the process of being set up. Thereby, we hope to arouse vocations to collaborate and set up new initiatives of international cooperation in the field of interaction between mobility and wildlife.

Keywords: Mobility infrastructures, Mainstreaming biodiversity, Wildlife.

The role of Professional Networks and Conventions in shaping sustainable transport infrastructure worldwide

Lazaros Georgiadis[1], Cristian-Remus Papp[2]

[1] CERTH, Thessaloniki, Greece

[2] WWF Romania, Bucharest, Romania

Motive: Professional networks and conventions can have a great role as well as influence in shaping sustainable transport infrastructure. The networks can share and transfer relevant pieces of know-how, best practices and experience, while the conventions can frame key documents and policies at regional level.

Objective: The objective of the workshop is to provide a genuine interaction and dialogue between professional networks and conventions. The participants will have the opportunity to ask relevant questions related to the potential of networks and conventions to shape and improve transport infrastructure development.

Structure: The moderated panel discussion will be available for both in-person and on-line participation.

Best practice examples of how networks and conventions influenced and improved transport development will be highlighted and discussed.

Expected outcome: A report of this workshop will be compiled and made available on the IENE 2022 Conference and IENE websites.

Implementation: Available for both in-person and on-line participation.

Keywords: Professional networks, Conventions, Sustainable transport.

Young Researchers and Practitioners in Road Ecology

Manisha Bhardwaj[1], Cristian-Remus Papp[2]

[1] University of Freiburg, Freiburg, Germany

[2] WWF Romania, Bucharest, Romania

Motive: Young researchers and practitioners can have a major role in further developing road ecology, especially by conducting e.g., innovative research or comprehensive monitoring studies. However, they face various challenges which will be further explored during the workshop.

Objective: The objective of the workshop is to position the role of young researchers and practitioners into the wider community of road ecologists, as well as to explore what can be done in terms of better supporting these groups in their work and endeavours.

Structure: The moderated front-end brainstorming will be available for both in-person and on-line participation. Ideas will be collected from the audience on how to best support young researchers and practitioners.

Expected outcome: A report of this workshop with recommendations will be compiled and made available on the IENE 2022 Conference and IENE websites.

Implementation: Available for both in-person and on-line participation.

Keywords: Young researchers, Practitioners, Road ecology.

Manisha Bhardwaj[1]

[1] University of Freiburg, Faculty of Environment and Natural Resources, Chair of Wildlife Ecology and Management, Freiburg, Germany

WIRE: Women in Road Ecology

Motive: To bring together members of the IENE network and provide networking opportunities.

This event will be a networking opportunity, designed to bring together women working in road ecology. The event will be loosely structured, and that will involve a bit of experience sharing, but will mostly be about getting to know each other.

Note: While we use the term "women" in road ecology, everyone is welcome to join us.

Structure:
00:00–00:45: Introductions
00:45–00:90: Open forum for discussion

Expected outcome: An active network of "women" working in linear infrastructure ecology.

Implementation: Regular meetings and an active online presence (e.g., through an emailing list).

Keywords: Networking, Sharing experiences, Building cooperation, Building collaborations.

Transport4Nature: Best practices taken voluntarily by companies involved in the transport infrastructure sector to preserve biodiversity

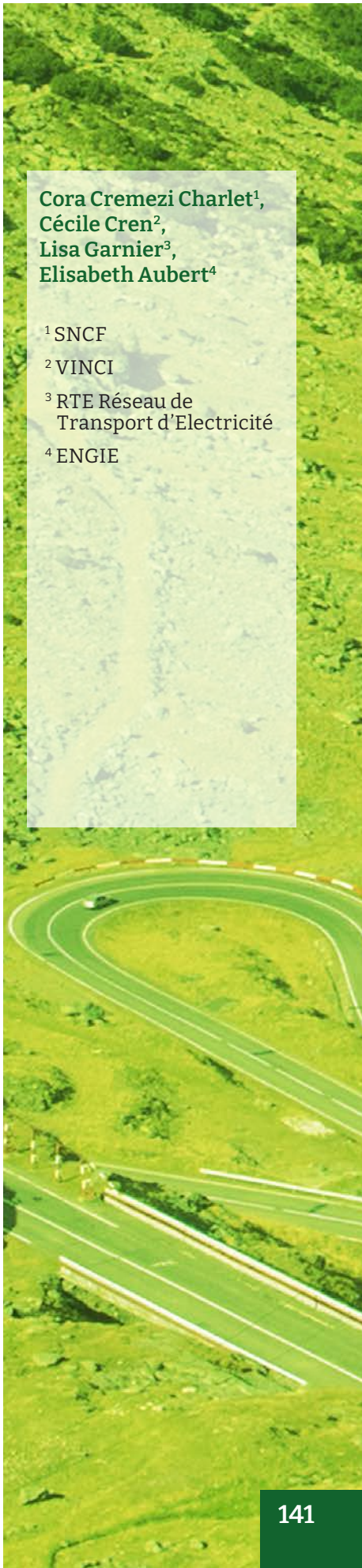
Cora Cremezi Charlet[1], Cécile Cren[2], Lisa Garnier[3], Elisabeth Aubert[4]

[1] SNCF

[2] VINCI

[3] RTE Réseau de Transport d'Electricité

[4] ENGIE



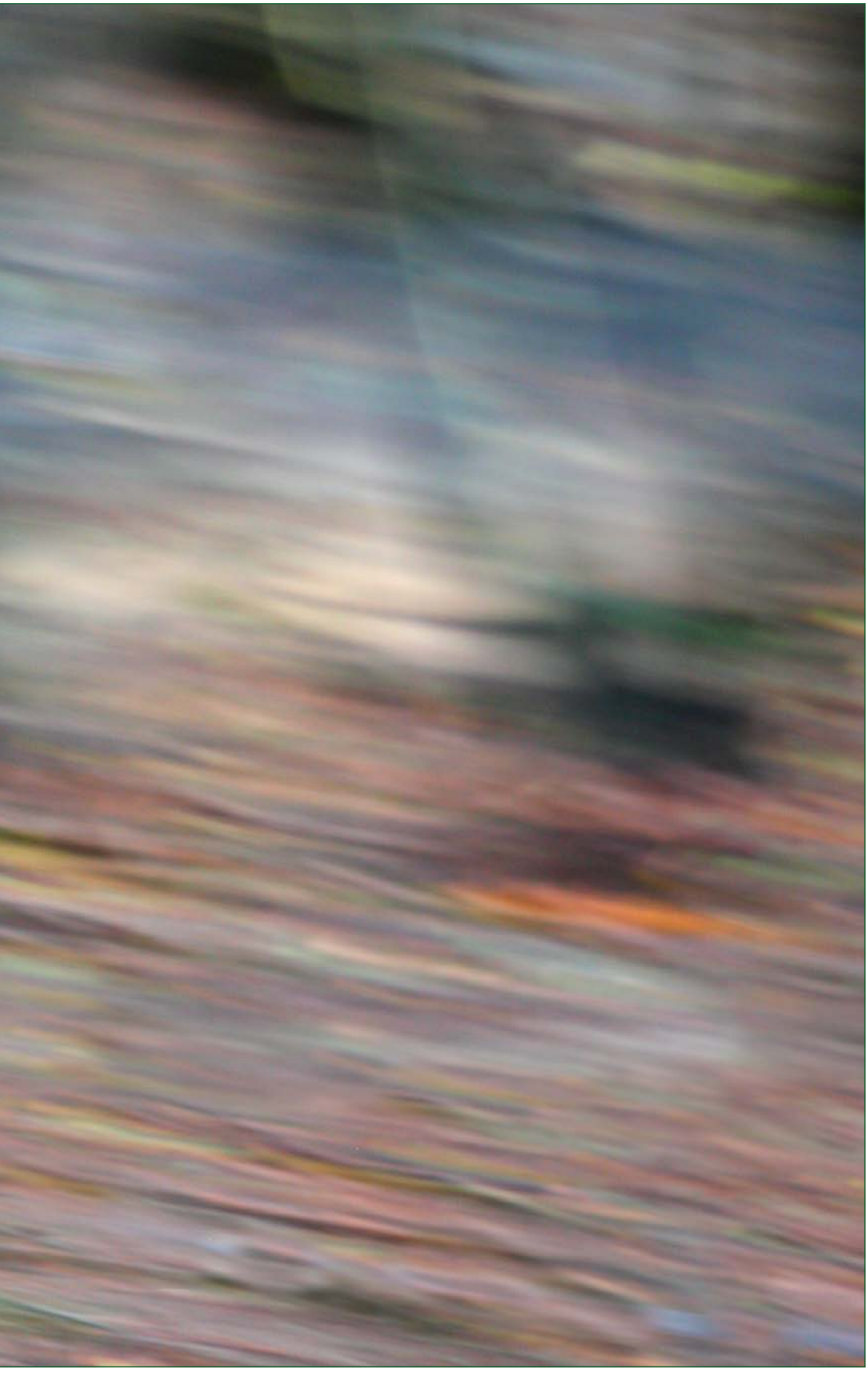
Transport4Nature is an initiative aiming to mobilise through their CEOs the companies involved in the transport infrastructure sector in Europe to voluntary commit to biodiversity-sensitive approaches.

Objective: The objective of this panel is to showcase some of the best practices taken by companies in the framework of Transport4Nature, to interact with the audience and to foster further engagement of companies from transport infrastructure sector to making commitments to biodiversity.

Relevant companies from each type of infrastructure (road, rail, airport, waterway, energy) will present examples of SMART commitments made through their involvement in Act4nature or Transport4Nature.

Expected outcome: A report of this workshop will be written and made available on the IENE and IC22 websites.

Keywords: Business, Best practices, Transport4Nature, Mainstreaming biodiversity.



A brown bear on the move

Radu Moț, Romania

Moving freely across the landscape is important for both humans and wildlife but, unfortunately, our transportation corridors represent barriers for most of the wildlife. Requiring large areas of natural or semi-natural habitats, the brown bear is one of the umbrella-species at landscape level – implementing functional solutions for it would ensure connectivity for a wide range of species.

2022

IENE

Infrastructure & Ecology
Network Europe

Workshops

IENE Infrastructure & Ecology Network Europe 2022

Strategies for the valorisation and exploitation of research results in infrastructure and biodiversity to support operational action

Yannick Autret[1], Annette Mertens[2], Maros Finka[3], Lea Balavoine[1], Elizabeth Losos[4]

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[2] AGRISTUDIO, Firenze, Italy

[3] STUBA, Bratislava, Slovakia

[4] Duke University, Durham (NC), USA

The proliferation of research work and actors dealing with the subject of infrastructure and biodiversity has led to a rapid increase in the number of resource centers, observatories, data collection and management centers with different research methodologies, not to mention the initiatives linked to each project itself. The research results proposed tend to be either very broad and high level covering all types of infrastructure in all ecosystems or, at the other extreme, very specialised and reductionist. In the end, several hundred knowledge resource centers are now available throughout the world, and this figure is increasing. A consensus has been building of the need for coordination and articulation of infrastructure and biodiversity at the national and international levels.

One of the main potential weaknesses is linked to the fact that very few of these online resource centers have engaged in a quality process that would allow the research on which they are based to become more general (Grout 2021). Another potential weaknesses is linked to the fact that most x research entities studying infrastructure and biodiversity are primarily focused on their specific system and context and do not emphasize processes that would generalize their findings and mark them more accessible to other researchers and practitioners.. However, the cross-cutting nature of the subject of infrastructure and biodiversity poses a major challenge in terms of convergence. Similarly, the need to support the training of practitioners in biodiversity issues explains their growing involvement in the development of original solutions that often go beyond the direct scope of research.

Several initiatives are already underway, such as the BISON project, the UNEP Sustainable Infrastructure Partnership (SIP), etc. are currently ongoing. Their main aims are focused on how to develop and produce sustainable infrastructure.

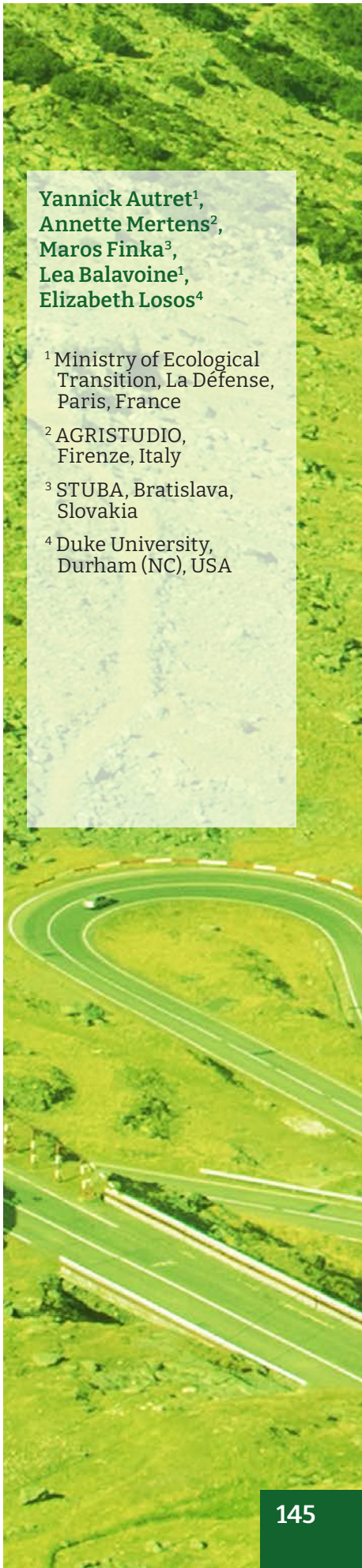
This workshop aims to develop actionable recommendations on how to better translate, generalize and share research findings on transportation and biodiversity research to allow for greater uptake and integration by researchers and practitioners across the globe. The workshop is open to all participants of the IENE Congress.

After the testimonies of resource websites accompanying the development of researchers' skills and the intervention of a panel of practitioners such as infrastructure developers and biodiversity conservationists reporting on their needs, the workshop will aim to establish a list of recommendations for developing the valorisation and utilization of research results. It will aim to identify ways of improving knowledge sharing, in particular by identifying how the European research and innovation community can improve its exchange processes while supporting the development of the skills of actors in third countries.

The results of this workshop will be formalised in a summary note addressed to the IENE Executive Committee and made available to interested actors.

Results will also be integrated into the BISON project report sent to the European Commission and the UN Environment Programme in the framework of SI-COL.

Keywords: Valorisation of research, Transfer, Formation, Continuous professional training, Websites, Capacity training, IENE.



Future to actions: Prospective scenarios concerning mainstreaming biodiversity into transport infrastructures

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The BISON project is the first CSA issued by the EC on the topic of transport and directly integrating biodiversity issues as well as the fight against pollution or climate change. Regarding this, it needs also an open reflection for exploring what could be done in the future for mainstreaming biodiversity into transport infrastructures life cycle. For this to be achieved, 2–4 prospective scenarios will be examined through a participatory approach, building on the emerging trends and looking at how it will impact the stakeholders' needs and requirements defined. These scenarios will also feed the future European Strategic and Research Agenda (that will be developed within the BISON project). On this purpose, we need to receive feedback from European and/or international experts on these scenarios and obtain their expertise on the critical paths to achieve the desired future trajectories.

This workshop aims at involving an international expert group (30–50 actors) to discuss the future scenarios in terms of beneficial or non-beneficial consequences for their activities, and identify the critical paths and technical or organisational solutions to achieve the desired future trajectories.

After a short presentation of BISON project and the prospective through scenario methodology (10 minutes), the workshop will be divided into two interactive sessions:

- The first interactive session (40 minutes) aims at validating the 2–4 future scenarios and their narration. Therefore, the participants will be asked to work in small groups to evaluate each scenario in terms of its credibility and probability, and to describe their beneficial or non-beneficial consequences. We will ask participants to identify the synergistic or antagonistic dimensions between infrastructure and biodiversity in each scenario;
- The second interactive session (40 minutes) aims at matching technological and organisational solutions to the scenarios and their trends. The solutions will be printed on cards and will be given to the participants, who will continue working in small groups and they will select the most effective solutions from their point of view for each scenario matching them to thematic dimensions (EU policies and regulations, etc.).

The outcome of the workshop will clarify the gap between the most plausible vs. the most desired future trajectories. It will help to provide argumentation in the degree of ambition in the next Strategic Research and Deployment Agenda that will be developed within the BISON project on the topic of mainstreaming biodiversity into transport infrastructures. It would also provide international expertise on solutions and critical paths that can be mobilised to achieve a common desired future.

The feedback that will be collected by the experts during this workshop will be integrated in the outcomes of the BISON project regarding the identification of the future scenarios (ranging from the most probable ones to other more extreme ones) about the Strategic Research and Deployment Agenda.

Those scenarios, as well as their related features (including relevant past and future trends, research hypotheses, research and users/stakeholders needs, etc.) will be consolidated and presented in details in the BISON Deliverable 5.5 (due date May 2023), while this information and the respective conclusions will be also integrated in the final Strategic Research and Deployment Agenda that will be produced with the BISON project.

Keywords: Prospective scenarios, Biodiversity management, Transport infrastructure life cycle, Strategic agenda, European commission.

IENE Infrastructure & Ecology Network Europe 2022

Priorities to overcome fragmentation effects caused by European Transport Infrastructure – content and use of the European Defragmentation Map

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The expansion of European transport routes is in full swing. The Trans-European Transport Network (TEN-T) will be developed until 2050 as a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals. Extensive impacts to Europe's Green Infrastructure are anticipated and must be avoided, mitigated and compensated. For protection and safeguarding the Ecological Networks as important parts of Europe's Green Infrastructure we develop a European Defragmentation Map (EDM) within the BISON project (2021–2023; https://bison-transport.eu). Here we want to identify areas of conflict (as overlaps) between the TEN-T and the ecological networks of European importance.

The workshop will:

a) Topic 1, inform about the used methodology of the EDM and help to find priorities for defragmentation at European level that could be supported by the countries. How to deal with differences of the eco corridor concepts and data of the countries? How to deal with eco-regional differences?

b) Topic 2, discuss the most appropriate criteria and indicators for assessing fragmentation effects and localization of prior conflict areas for further development and/or improvement of the EDM. Which ecological and which land use information should be provided, which information can be obtained within the next 5 years (useful methods, e.g., remote sensing, AI, modelling) and what are the consequences, if important information (e.g.,habitat topology, species distribution) are missing.

Structure:

- Welcome and introduction to the workshop procedure (5 minutes);
- Short Presentation on Topic 1 of the current state of the European Defragmentation Map with its integrated data and criteria for the determination of conflict areas between Ecological networks as important parts of the European Green Infrastructure and the Grey Transport Infrastructure development of the TEN-T. The EDM was developed as a GIS-based overlay of selected TEN-T infrastructure and Ecological Assets (Natura 2000, National Protected Areas and Ecological Networks) and first ideas for a hierarchical evaluation system. The unweighted result indicates a five-digit number of potential conflict areas (15 minutes);
- Brainstorming and discussion about ways to detect the most important areas for immediate action from the EU before 2024 (30 minutes);
- Short presentation on Topic 2, future possibilities to improve the EDM (EDM 2028; using indices for undissected functional areas, mobility models, models for large distance dispersal corridors, etc.) (10 minutes);
- Discussion about best criteria and indicators (20 minutes);
- Summary (conclusions of the workshop) (10 minutes).

Expected outcome: Compilation of best ideas for application and future development and research needs of the European Defragmentation Map.

Implementation: Direct input in the European Defragmentation Map and the Work Package 5 ("Towards deployment") of the BISON Project.

Keywords: Trans-EuropeanNetwork-Transport (TEN-T), Transport infrastructure, Green infrastructure, Ecological network, Ecological corridors, Barrier effects, Defragmentation, Indicators.

Relevance and prioritization of research actions for biodiversity-friendly transport infrastructures in Europe

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[5] Amphi International ApS, Denmark

Through topic MG–2–10–2020, the call 2018–2020 Mobility for Growth was the first one issued by the European Commission on the topic of transport that directly integrates biodiversity issues. The Coordination and Support Action BISON (Biodiversity and Infrastructure Synergies and Opportunities for European Transport Networks, 2021–2023) was selected in response to this call. One objective of the CSA BISON is to identify research and innovation needs for a better integration of biodiversity with transport infrastructures all along their life stages. The methodology used to elaborate the so-called strategic research agenda (SRA) for more biodiversity-friendly transport infrastructures in Europe takes into account points of view of all types of stakeholders (operators, authorities, agencies, associations, consultancy, research, etc.) as fundamental inputs, as well as for the agreement on the research agenda (endorsement of necessary actions and their prioritization). It happens that the timing of the IENE conference coincides perfectly with the last stage of the process timetable, where stakeholder consultation on the draft research agenda (version 1) is widely open to all stakeholders outside the BISON consortium in view of final validations and amendments. The workshop provides the timely opportunity of a live consulting and working session with stakeholders on the SRA V1.

The objective of the workshop is to gather feedback from participants on proposals of the draft version (V1) of the SRA. The relevance of any proposed research action could be commented on by participants. Further refinement of its definition and scope could be suggested. The infrastructures involved and their specifically concerned life stages can be checked. The desired time horizon to see a research action to produce its expected results, because of its importance and/or the knowledge gap, could also be expressed. Last, experts could provide additional information on the state of knowledge relative to certain research proposals. To enable this broad overview of proposals, the workshop will be open to all types of stakeholders (operators, authorities, agencies, associations, consultancy, research, etc.) for the various types of transport infrastructures considered in the SRA (roads, railways, waterways, power lines, pipelines, airports, and harbours). In advance, as a working document, the registered participants will receive the draft version of the SRA i.e., the full series of proposed research actions, with their concerned transport infrastructures and life stages and the proposed timeframe for their achievement.

To optimise time for the active work in the workshop, the whole process of construction of the SRA will have been presented previously in an oral communication in the conference (Development of a strategic research agenda for biodiversity-friendly transport infrastructures in Europe, ID 73437). The workshop can start directly with the presentation of the objective and the organisation of work (10 minutes). Participants will be divided into five groups of equal size, mixing countries and stakeholder types as much as possible (5 minutes for installation). Groups could be prepared with the list of registered participants, complemented with possible late participants (40 persons max.). A moderator from BISON will be allocated to each group to provide any necessary explanation on proposals. Opinions collected in each group will be registered by a rapporteur chosen among participants (35 minutes). To optimise exchanges within groups, each one will be assigned a different part (20%) of the list to expertise in priority i.e., around 25 research actions (fast groups can move to the next parts). Rapporteurs will prepare report (10 minutes) and report to the whole participants (5×4 minutes). Lastly 10 minutes will be for open talk on conclusions and perspectives for the SRA.

The workshop will allow to strengthen the relevance of the proposals of research actions supported by the participants and to reveal possible points of discussion or misunderstanding. It will also allow to improve the definition of research actions of the agenda as well as to feed their timetable of desired achievement. As participants will come from various areas in Europe, facing different realities, threats and needs, the workshop will also be the opportunity to collect comments on the relative importance of the various proposals depending on different contexts and European ecoregions. This could feed the final step of the SRA redaction with identification of most relevant actions for certain European regions (e.g., Communication on the SRA at the Central Europe workshop in Brno in 2023).

The formal findings of all working groups will be merged by their rapporteurs and moderators, as a single report of the workshop, for traceability and use for the amendment of the SRA. All the outcomes of the workshop (formal or contextual) will serve to improve the final version of the BISON project SRA in terms of relevance, accuracy and usefulness. This work will help to strengthen the value of the agenda in view to present the document to other kinds of transport stakeholders less familiar with biodiversity issues than IENE participants. The step provided by this workshop will be mentioned as part of the methodology that will precede the description of all research actions in the final version of the SRA (BISON public deliverable D4.2).

Keywords: Consultation, Endorsement, Expertise, Need, Priority, Relevance, Research, Region, Roadmap, Strategy.

Lazaros Georgiadis[1,4], Radu Moț[2,4], Cristian-Remus Papp[3,4]

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Towards a Road map for facilitating mainstreaming biodiversity into transport in South East Europe: Challenges and opportunities, transferability of existing knowledge and adaptation to the specific context

While growing transportation networks, included in Grey Infrastructure, are necessary to meet economical and societal needs, Green Infrastructure is considered a fundamental natural capital providing important ecosystem services for human wellbeing and biodiversity. Following an increasing economic development trend in the South East European countries, over the last years many new large scale linear transportation infrastructure projects are in planning and construction process. While fragmentation is recognized in Western Europe and special defragmentation programmes are completed or under development, in South East Europe the challenge is to avoid fragmentation and to preserve the natural capital while rapidly developing a modern transport infrastructure.

GreenWeb is a platform created by a core group of experts and organizations working under the umbrella of IENE towards securing ecological connectivity and ensuring the ecological functionality while developing linear transportation infrastructures in South East Europe. GreenWeb Platform aims for a proactive engagement and colaboration between relevant stakeholders as a requirement for finding the best solutions to meet the objectives of EU policies for economic development, biodiversity conservation and the United Nations' Sustainable Development Goals in order to maximize the harmonization of Grey and Green infrastructures coexistence in South East Europe.

The objectives are to engage the participants into an interactive working session that should:

- highlight the specific of the South East Europe in terms of transport and biodiversity, facilitated by presentations of representative examples of harmonization of transport and biodiversity objectives from the region;
- to use the opportunities that are created from the IENE 2022 International Conference in Romania as the first IENE conference in Eastern and South Europe;
- identify challenges and opportunities for mainstreaming biodiversity into transport in South East Europe;
- support the development of a regional road map adapted to the local needs and benefiting from the Western experience.

In the workshop the future and the needs of mainstreaming biodiversity into transport in virgin landscapes of Eastern Europe and Balkans will discussed based on the following basic elements:

i. The currents and future demands of transport development;
ii. The current and future demands of biodiversity protection and nature conservation;
iii. The role of fragmentation due to LTI on biodiversity conservation and species survival;
iv. The implementation of the development of TEN-T and TEN-N in Eastern Europe and the Balkans under the status of EU development and nature conservation policies (Green Deal) and the running restoration decade 2020–2030.

The workshop will be consisted in four parts:

- The first part will set the stage for discussions – a short introduction to the topic and the challenges on mainstreaming biodiversity into transport in South East Europe (10 minutes);
- The second part will include a series of short interactive presentations of case studies from the region (i.e., Greece, Bulgaria, Romania, Croatia) aiming to highlight concrete challenges, gaps and needs and potential solutions (30 minutes, in total);
- The third part will consist in a brainstorming and interactive work session with invited guests (i.e., IENE, The Secretariat of the Bern Convention, The Carpathian Convention) aiming to identify the strategic approach towards achieving environmental sustainability on transport development in South East Europe, based on knowledge and good practice exchange (30 minutes);
- The fourth part, conclusions and next steps will be discussed as a roadmap and a framework of future cooperation towards a regional Action Plan (20 minutes).

The interaction with the participants will continue after the workshop, with the integration of its conclusions and agreed next steps into a GreenWeb platform and IENE strategy to promote Transport Ecology in the East and South Europe.

As the IENE 2022 International Conference is the first in Eastern Europe, a general interest on the topic is foreseen and a considerable number of participants are expected to participate.

The GreenWeb Platform, a first core group of interested experts and organizations, has been shaped in 2017 as a result of a similar workshop in Făget, Romania.

The main expected outcome is to develop a road map for mainstreaming biodiversity into transport while strengthen of the interest and participation of more experts and organizations into a regional Working Group of IENE for more active action in South East Europe.

The results of the workshop will be used under the framework of IENE development in South East Europe towards increasing the implementation of transport ecology principles in practice considering the local specifics.

One foreseen concrete possible follow-up is the organization of similar workshops in each of the South East Europe countries.

Keywords: South East Europe, Transport ecology, Biodiversity, Mitigation hierarchy, Precaution principle, Strategic planning, Sustainability, Proactive engagement, Concrete collaboration, Road map, Action plan.

The Draft CEDR Biodiversity Manual – I Round-table Discussions

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CEDR would very much welcome the views of the IENE audience on the draft manual.
Objective: To achieve industry buy-in to the new manual.
Structure: This format is intended to solicit feedback from the quieter members of the audience. It will be in the following stages:

a) Introductory presentations to outline the draft recommendations;
b) Twenty minutes of breakout sessions with 6 groups, each discussing a separate topic (below);
c) Twenty minutes in which each group chair reports their group's findings;
d) Twenty minutes in which everyone wanders around the room. Posters placed around the room will summarise the main recommendations (the same 6 topics as listed below). Individuals will have two kinds of post-its: (i) Small ones to indicate things they like and things they don't like (green and red) and (ii) Larger ones in which they can attach comments to particular recommendations. This format will also apply to online participants through the MIRO software system.

The proposed six topics (tentative list) for discussion are as follows:
Group 1 – Recommendations for Construction I (Early Planning Stage)
In the early planning stage (route selection), these things that should be considered:

- Clearly best to avoid biodiversity priority areas (as roads usually have an adverse effect);
- But some habitats are less impacted by roads than others;
- Identify where the road may fragment habitat;
- Identify potential for valuable habitats to be created during construction (e.g., cuttings through low-nutrient soils);
- And potential for road to connect habitats through areas of low biodiversity value (e.g., intense agriculture);
- Higher and wider verges have more potential;
- Larger areas of verge have more potential (or network of verges reasonably close together);
- Other recommendations for routes selection?

Group 2 – Recommendations for Construction II (Impacts and their Mitigations)
Group 3 – Recommendations for Construction III (Mitigations in Sensitive Landscapes)
Group 4 – Maintenance I (Plan)
NRAs should develop a detailed management plan for the network according to these principles:

- No one solution for everywhere – the plan needs to be diverse;
- There will be priority (and non-priority) areas – some verges are not valuable for biodiversity;
- There are a finite number of different targets for verges: Flowers for pollinators; Food sources for invertebrates, birds or small mammals; Hedgerows providing nest sites, food and shelter for birds; Habitats (e.g., for caterpillars and butterflies); Specialists (e.g., thermophilic insects); Other.

Group 5 – Maintenance II (Cutting Frequency)
Group 6 – Maintenance III (Removal of Cuttings)
Expected outcome: Agreement on the CEDR Biodiversity Manual.
In the month following the IENE conference, the new CEDR Biodiversity Manual will be finalised and published. This is likely to form the template for national policies in many European countries.

Keywords: CEDR Biodiversity Manual, Roadside, Verge, Biodiversity, Maintenance, Roadside mapping, Maintenance masterplan.

The Draft CEDR Biodiversity Manual – II Panel Discussion

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CEDR would very much welcome the views of the IENE audience on the draft manual.

Objective: To achieve industry buy-in to the new manual.

Structure: At this 2nd of two workshops, all major draft recommendations will be posted and discussed by the audience and the panel in a Panel Discussion format.

The idea is that a panel of 6 to 8 experts will sit at the front. Each panelist will make a brief (perhaps controversial) statement to get the discussion started. This will take about 20 minutes (7 statements @ 3 minutes). Then, the discussion will be thrown open to the audience and the panelists will have the opportunity to answer the questions raised over the remaining 40 minutes.

Panelists may include experts such as: Vincent O'Malley, Transport Infrastructure Ireland, Pia Bartells, BASt, Hans Martin Hanslin, NIBIO.

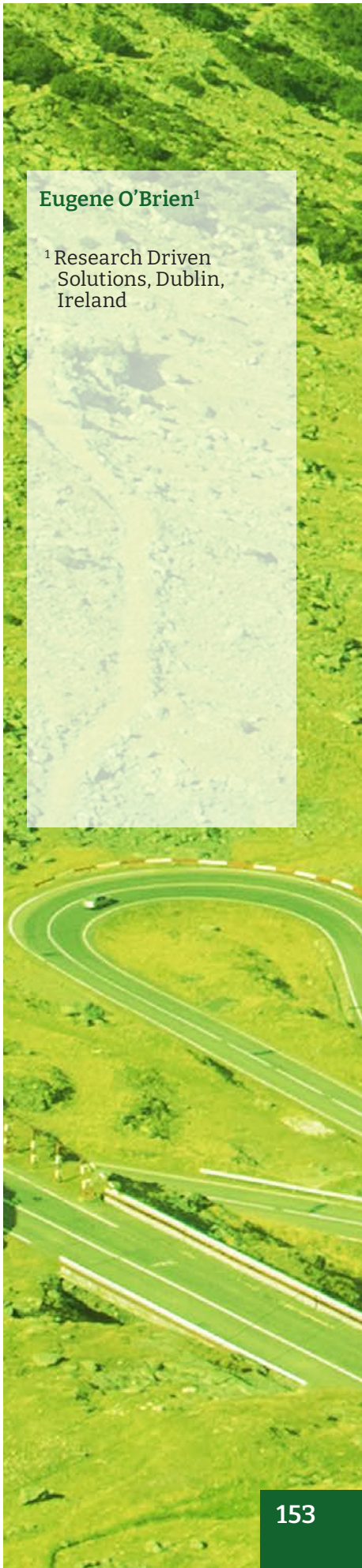
Statements from the panelists might include things like:

- "We should identify cuttings in proposed road routes as verges with the potential to add value to biodiversity";
- "In the absence of particular circumstances, the default timing and frequency of mowing should be once per year in late Autumn".

Expected outcome: Agreement on the CEDR Biodiversity Manual. This is a very important document and will likely form the basis for national road biodiversity manuals throughout much of Europe in the coming years. The IENE conference and the timing of the publication of this manual provides an unique opportunity for a near-final draft to be presented to the audience and discussed at the conference while there is still time to make changes. A draft of the recommendations will be published online two weeks prior to the conference to allow delegates to get advance access. At the 1st workshop (with breakout sessions), the main findings will be on posters and small groups will discuss particular issues and recommendations. At this workshop, there will be a final opportunity for the entire audience to discuss the issues together and with the panel of experts.

In the month following the IENE conference, the new CEDR Biodiversity Manual will be finalised and published. This is likely to form the template for national policies in many European countries.

Keywords: CEDR Biodiversity Manual, Roadside, Verge, Biodiversity, Maintenance, Roadside mapping, Maintenance masterplan.



Identification of gaps and barriers to mainstream biodiversity in transport infrastructure

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Increasing knowledge about the interactions between transport and ecology and implementation of measures is helping mitigate the negative impact and enhance the potential positive effects of transport infrastructure towards biodiversity. However, important obstacles remain which hinder the effective replication and widespread implementation of Good Practices.

Within the framework of the HORIZON 2020 BISON project, extensive research has been conducted to collect Good Practices being applied in Europe related to mainstreaming biodiversity and transport infrastructure. Based on this data and on the information gained from a questionnaire completed by stakeholders from the biodiversity and transport sectors, an analysis has been conducted to identify potential "Gaps and barriers" that need to be fulfilled or overcome to achieve the goal of mainstreaming biodiversity in transportation infrastructure.

The motivation for the workshop is to undertake a structured discussion with stakeholders from both the biodiversity and transport sectors to complete the identification of these "Gaps and barriers" and test the degree of consensus surrounding them.

Specifically, the workshop is aimed at practitioners and researchers with expertise on the topic from administrations, infrastructure design and operation companies, consultants and researchers.

The objectives of the workshop are:

i) To introduce the "Good Practice to mainstream biodiversity in transport infrastructure" list and gather complementary information on the topic;
ii) To complete the list obtained by the BISON project of "Gaps" and "Barriers" that are hindering the mainstreaming of biodiversity on transport infrastructure by undertaking a structured dialogue between the workshop participants;
iii) To test the degree of consensus among stakeholders from different sectors and eventually, collect ideas about how to overcome such obstacles to achieve a more sustainable and resilient transportation network.

The workshop will be undertaken applying the "World Café" method and will be divided into three parts:

1) Introduction and framework. A short presentation about the BISON Project and the methodology followed in composing the different lists will be presented. The goals and the organization of the workshop will be explained. Duration: 10 minutes;

2) Break-out groups. Participants will be divided in groups that will be rotating through "thematic tables" where different lists of Gaps and Barriers related to knowledge, legislation, communication and other topics will be presented. Each table will have a facilitator to lead the conversation and enrich the discussion with the comments from previous groups and a person responsible to take notes. Duration: 60 minutes;
3) Common presentation and conclusions. Final results obtained in each thematic table will be presented to the participants and a final discussion and conclusions will be undertaken. Duration: 20 minutes.

The workshop is presential but it could be considered if an additional online group could be included.

A consensual diagnosis about current situation in Europe regarding two main aspects: i) identification of Good Practices to mainstream biodiversity into transport infrastructure, and ii) what are the "Gaps" and "Barriers" that are limiting their implementation is expected to be achieved.

Overall, this exercise will enhance the understanding between stakeholders from both sectors, biodiversity and transportation, while contributing to the promotion of inclusive tasks where obstacles are faced jointly. This will create opportunities for collaboration between disciplines and, therefore, increase the range of successful options, moving closer to the achievement of a more sustainable transportation network.

The list "Best Practice to mainstream biodiversity into transport infrastructure" will be included in a report to be submitted to the European Commission by the end of the year. Furthermore, through dissemination activities planned within the BISON Project we expect to encourage and promote the replication of these practices throughout Europe and worldwide.

The final consolidated lists of "Gaps" and "Barriers" will also be included in a report to be submitted to the European Commission. Furthermore, they will contribute to developing the Strategic and Research Deployment Agenda that will be produced by the BISON Project to establish research and funding priorities for upcoming years to achieve a more sustainable and resilient transport sector.

Keywords: Gaps, Biodiversity, Good Practice, Transport Infrastructure, BISON.

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Recommendations towards the integration of the EU Strategy on Green Infrastructures (EU SGI) into the national policy and legislation systems of EU Member States, regarding transport infrastructure development

Transport networks are considered to be a commonplace of the European landscape that facilitate the connection of people but also influence the environment around them. The loss of biodiversity has become one of the main environmental challenges, and it has been at the heart of European policies for a long time. The EU actions, aiming both to protect the elements of biodiversity and to reduce the nuisances that affect the environment, even though have brought positive developments, biodiversity losses continue to exist.

The BISON project aims to identify the level of integration between the provisions set by the EU Strategy for Green Infrastructure (SGI), supported also by actions under target 2 of the EU Biodiversity Strategy, and the transport policy and legislative frameworks of the EU Member States. For this, an alignment assessment of national transport policies and legislation with the EU SGI was implemented, identifying gaps for the EU Member States (EU MS) and considering all transport modes, while it was reviewed how EU SGI & biodiversity issues are integrated into the National Transport Master Plans and the Strategic Environmental Assessments. The workshop aims to present the outcomes of this work and engage the participating stakeholders in a brainstorming discussion regarding the development of recommendations towards policy and legislation harmonisation.

This workshop aims at involving an international expert group from both the transport and biodiversity sectors to discuss on future recommendations towards achieving policy and legislation harmonisation of the EU MS to the EU SGI and other relevant EU actions.

More specifically, the objectives of this workshop are:

i) To introduce the findings on the level of integration between the provisions set by the EU SGI and the transport policy and legislative frameworks of the EU Member States and gather new information in the topic;
ii) Test the degree of consensus among the stakeholders about the aforementioned findings and the initial list of recommendations for policy and legislation harmonization;
iii) To undertake a structured dialogue to complete the list of "Recommendations" obtained by the BISON project research team. By collecting the workshop participants proposals, a more accurate diagnostic on what are the main future steps and solutions that need to be adopted in order to address the harmonisation lack between the national and European levers, regarding the co-existence of Green and Grey infrastructure and the protection of biodiversity is planned to be achieved.

The workshop will be divided into 3 main parts:

1) Introduction. A short presentation about the BISON Project and the methodology followed to assess the alignment level and define some initial recommendations for policy and legislation harmonisation will be presented. The goals and the structure of the workshop will be explained. Duration: 10 minutes;
2) 1st interactive session aims at validating and enriching (a) the preliminary findings of the BISON project regarding integration level of EU SGI in the transport policy and legislative frameworks of the EU Member States and (b) the identified gaps and barriers towards achieving alignment. Emphasis will be given in collecting feedback concerning different EU Members States, ensuring geographical balance. The session will have a facilitator to lead the conversation and a person responsible to take notes. Duration: 40 minutes;
3) 2nd interactive session aims at identifying recommendations for addressing the gaps and barriers regarding policy and legislation harmonisation. Different aspects will be covered within the suggested recommendations (e.g., identification of policy/legislation recommendations, recommendations for their interpretation, researcher priorities, etc.). The session will have a facilitator to lead the conversation and a person responsible to take notes. Duration: 40 minutes.

With this workshop we aim to achieve a consensual description of the current situation regarding the identified gaps and barriers for the EU Members States to achieve alignment towards provisions set by the EU SGI, while also identify some respective recommendation for addressing those gaps and barriers towards policy and legislation harmonisation.

This exercise will also enhance the interrelation between stakeholders from the transport and biodiversity. This will allow common obstacles to emerge and promote the realisation of joint tasks, while it will offer further opportunities for collaboration between the different sectors and disciplines improving success possibilities towards a sustainable transportation network.

The feedback and the outcomes that will be produced by this workshop (e.g, gaps and barriers and recommendation identification) will feed into the BISON report, "Recommendations for policy/strategy harmonization" that will be submitted to the European Commission by the end of the year. Furthermore, through dissemination activities planned within the BISON Project, these outcomes will be further promoted throughout Europe and worldwide.

Finally, they will contribute to develop the Strategic and Research Deployment Agenda that will be produced by the BISON Project to establish research and funding priorities for upcoming years to achieve a more sustainable and resilient transport sector.

Keywords: Green Infrastructure, Transport infrastructure, Integration, EU Policy, Strategic planning, Legislation.

Identification of Natura 2000 sites/natural protected areas potentially affected by an infrastructure project

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In most cases of Environmental Impact Assessments done for new infrastructure projects, the methodology for identifying potentially affected protected areas is not clear, insufficiently explained or incomplete, not taking into account all of the potential causes for an impact.

Different countries have different requirements for establishing potentially affected protected areas due to new infrastructure projects, while the European Commission also brings a new set of recommendations for this issue. The workshop intends to present a case study for the complete identification of potentially affected Natura 2000 sites, done for a new motorway project in Romania, the Târgu Mureş – Târgu Neamţ motorway as well as to clarify certain issues related to the methodology proposed by the European Commission for establishing the likelihood for a site to be affected by a project.

The main objective of the workshop will be to showcase a real and tested methodology for establishing potentially affected Natura 2000 sites, based on a cause and effect relation, while taking into consideration potential cumulative impacts, as well as long distance potential impacts.

The main target group towards which the workshop is aimed at is the practitioners in the field of EIA, especially EIA done for the transport sector. The workshop will allow the practitioners to understand how to provide an adequate and complete identification of potentially affected Natura 2000 sites in view of the projects they are responsible for assessing (either infrastructure projects or other types of projects).

The workshop will also be beneficial for representatives of infrastructure developers as well as for environmental authorities and NGOs, as it will allow them to understand how this identification should be done, thus providing a framework for independently analysing and assessing the work done on various projects.

The workshop will be structured in a series of interactive exercises, preceded by a short presentation (maximum 10 minutes). The interactive exercises should allow the participants to apply certain criteria for identifying potentially affected protected areas in an example project. There will be four separate exercises, each aimed at one of the four main criteria necessary to be used for identifying potentially affected Natura 2000 sites (as stated by the European Commission). The participants will be split into four groups, each group being responsible for identifying potentially affected Natura 2000 sites based on one criterion. The time frame for the exercies will be 35 minutes.

After the completion of the exercise, the last 15 minutes will be dedicated to questions and discussions on the results achieved by each of the four groups.

The main expected outcome is to allow the participants (stakeholders, interested parties) to understand the extent of the potential impacts of infrastructure on environmental components, and thus make better decisions regarding environmental impact assessments in which they might be involved. Understanding the methodology for identifying potentially affected Natura 2000 sites will allow the EIA practitioners, infrastructure developers, authorities, NGOs and other stakeholders to have a common understanding of the potential impacts of infrastructure, based on a clear scientific reasoning.

The outcome of the workshop will contribute to improving environmental procedures done in different countries, due to a better understanding of potential impacts of infrastructure projects.

The implementation of the methodology for identifying potentially affected Natura 2000 sites will allow the EIA practitioners to base their identification on clear scientific evidence. It will also allow other stakeholders to verify, through the same methodology, how this identification was done and to request revisions if necessary.

Overall, it will allow every interested party to analyse independently and to identify the Natura 2000 sites potentially affected by a project. This is a completely new approach, especially in Romania, where in most cases it is considered that a project will only affect the Natura 2000 sites it directly intersects, without any consideration for potential long distance impacts or impacts on ecological connectivity (e.g., ecological corridors that are not included in Natura 2000 sites, but are crucial for maintaining the site's integrity).

The methodology proposed for this workshop is a novel approach that is proposed by the European Commission in their latest Guideline on Appropriate Assessment, published in 2021. A version of the methodology will be included in the revised legislative requirements on Appropriate Assessments in Romania, expected to be published later this year. We are not intending to publish this methodology separately, but are in charge of developing the new guidelines that will be the basis of the legislative changes mentioned above, thus will ensure that the methodology is included as a national level requirement for all Appropriate Assessments.

Keywords: Natura 2000 impact assessment, Road ecology, Ecological connectivity, Long distance impacts, Cumulative impact.

Identifying best solutions to mitigate impacts of roads on large carnivores: a multi-stakeholder approach

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Cooperation between different stakeholders is vital to the design, application and monitoring of measures which reduce impacts of linear infrastructure on wildlife. Specifically, the solutions applied on roads to reduce risk of collisions with large animals (i.e., ungulates and large carnivores) require the participation of multiple stakeholders. Infrastructure operators, wildlife experts and local stakeholders (landowners, farmers and forest managers, local authorities) as well as governments and regional management authorities, are obliged to cooperate in identifying and applying effective solutions. This process creates notable challenges that need to be tackled collectively to succeed.

The LIFE SAFE-CROSSING Project is an example of a multi-stakeholder approach to the design and application of mitigation measures to reduce large carnivore road mortality risk in Southern European countries. The project includes the identification of roadkill hotspots, the application of several types of mitigation measures (systems to reduce risk of collisions (AVC-PS and others), adaptation of transversal structures and targeted communication campaigns. Throughout this process researchers, ecologists, nature and road authorities and private businesses have joined their efforts to mitigate large carnivore roadkill in Southern Europe.

The LIFE SAFE-CROSSING project is also an example of how to use EC funding to deal with the impact of roads on wildlife.

The motive for this workshop is to share this experience with stakeholders from different countries and sectors, and to discuss the opportunities and challenges for replication of this approach in other parts of Europe.

The main objective of this workshop is to promote a dialogue among stakeholders from different countries and sectors, which will evaluate potential benefits and challenges of applying a multi-stakeholder approach to the process of designing, implementing, and monitoring measures to reduce large carnivore road mortality risk. Opportunities for replication of this scheme could be identified thus maximizing the positive outcomes from the Life Safe-Crossing Project. This should also encourage the relevant decision makers to take action to implement actions to reduce the impact of roads.

Additionally, the workshop could contribute to improving the methodology followed in the LIFE SAFE-CROSSING project considering the input from other countries.

The workshop will provide a short introductory overview of the LIFE SAFE-CROSSING Project including a description of the stakeholders involved in defining and applying mitigation measures. Short descriptions of study cases will follow, specifically Maiella National Park, Abruzzo, Lazio Molise National Park, in Italy and Egnatia highway in Greece. Finally, slides summarizing the main questions for discussion will be presented.

Duration: 20 minutes.

Afterwards, participants will be divided into groups including different stakeholders. Each group will discuss which stakeholders must be involved and how they can contribute to different parts of the process and different types of measures (fencing, fauna passages, AVC-PS and other devices, etc.). Participants will discuss how to improve the application of a multi-stakeholder approach, identifying potential challenges and proposing solutions to overcome them.

Duration: 40 minutes.

Proposals from different groups will be shared and discussed with all participants, summarizing opportunities and challenges of a multi-stakeholder approach and producing recommendations to improve it.

Duration: 30 minutes.

The workshop is presential.

This workshop will help to identify general recommendations relating to the multi-stakeholder approach to applying solutions which reduce road mortality risks affecting large carnivore. These could be included in guidelines that will help replicate the work undertaken in the LIFE SAFE-CROSSING in other countries. This will be a tool that helps to better tackle challenges that may arise in the process.

These conclusions could be published to increase its reach and benefit other projects worldwide.

The potential for the implementation of this workshop's results are i) the recommendations provided could be applied to other future actions in Europe. These projects will benefit from the cooperation of multiple stakeholders from different sectors and countries, which increases the applicability of this methodology; ii) the project could benefit from the ideas for future maintenance and monitoring of the mitigation measures that are being implemented and iii) other stakeholders or decision makers could implement one or more of the interventions carried out in the project, with the technical support of the project staff.

Keywords: Large carnivore, Road mortality, AVC, Transport Infrastructure, Multi-stakeholder, Replication.

A discussion on the registration of Animal-Vehicle collisions

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We want to use the insights of the participants, ideally ecologists working in road-networks with high traffic density and many junctions (places where you cannot simply block access to the road for all wildlife), in deciding how to implement the recommendations from a recent project on AVC's on the Dutch road network. From these insights we hope to formulate an approach to dealing with AVC's (prevention, registration, and disposal). Last, we hope to integrate an international approach to dealing with AVC's in the Netherlands.

The objective of the session is to share knowledge between researchers who are working on intersection between infrastructure and ecology. The audience should be willing to discuss the various aspects in which we can consider AVC's and the impact of AVC's on road safety and fauna mortality, not only from the ecological perspective but also considering the view of policy makers. In the Habitats directive article 12§4 the EU commission asks for the monitoring of all accidental (protected) fauna mortality. This includes the fauna mortalities due to AVC's. In the recent project "dieraanrijdingen en verkeersveiligheid" the registration of AVC data was analyzed. The main finding in this project was that the registration of AVC's in the Netherlands can and should be improved in terms of reliability, specificity, and comprehensiveness. Therefore a number of recommendations have been done for improving these aspects of the registration. An improved registration would lead to better insights in high risk locations "hot spots" for AVC's, both in terms of road safety and for the safety of (protected) fauna.

The results and recommendations from this project will be presented, after which we will have a brainstorming session with the participants. The results of this session will be a starting point for improving AVC registration in the Netherlands and elsewhere while simultaneously initiating a discussion on international AVC registrations registration.

We will start the workshop with a short presentation (~10 minutes) explaining the results, main outcomes, and recommendations of the project "dieraanrijdingen en verkeersveiligheid". This project has a number of follow-up questions that the participants will discuss in smaller breakout groups.

During this workshop, and dependent on the backgrounds and number of participants in the workshop we want to address the following discussion points:

- Which audience should we target in creating a sense of urgency to the registration of AVC's? And how should we attempt this?
- How do we decide what constitutes as a "hotspot" location in order to give extra priority to improving such a location? Should we focus more on fauna mortality or on vehicle safety?
- What variables should we take into account in standardizing registration of AVC's and how should we standardize the registration of AVC's for national and international applications?

After about 30 minutes we will continue with short presentations by each break-out groups (15 minutes total) in which the groups view on the question and how to go about answering it is discussed, followed by a general discussion with all participants (25 minutes). In this discussion we will consider the various presentations and we will discuss what some of the issues are that could arise. The final 10 minutes will be used to wrap up the discussion and for early conclusions, we will attempt to conclude with a plan as to what future efforts should focus on, how the registration could be improved, what audiences should be considered to increase the coverage of registrations of fauna mortality and in what format and using what variables this registration should be set up.

We expect to come to preliminary conclusions as to how a European-wide registration and handling of AVC's could be organized. Furthermore, we expect to gain insights in the motivations for approaches in registering AVC's in various countries. The conclusions of the sub questions considered in the workshop will be considered as a whole so as to formulate one view in how AVC's should be considered within Europe. These findings will be shared in the form of summarized sheets. If concrete steps can be made within in the IENE network to improve pan-European registration this will also we communicated with the network with the option to be kept in the loop for these developments.

First, the outcomes will be used to improve the Dutch standard of handling and registering AVC's. Second, the outcomes will be used to decide on a pan-European approach for how AVC's should be handled.

Keywords: Animal-vehicle collision, Registration, International, Hotspots, Standardization.

Strategies for stakeholder outreach and involvement around ecological connectivity – an experience exchange with members of the SaveGREEN Project

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In the course of the project implementation of the Interreg Danube Transnational Programme Project SaveGREEN – Safeguarding the functionality of transnationally important ecological corridors in the Danube basin, of which all 4 proposal authors are team members, the engagement of stakeholders (environmental and spatial planning authorities, representatives of the agriculture, transport and forestry sectors, local decision-makers, hunters, farmers, etc.) has repeatedly proved a significant challenge. The overall aim of the project is to demonstrate ways of designing appropriate mitigation measures and maintaining or improving the functionality of ecological corridors through integrated planning. Supporting these efforts, the outreach work in the project focuses on winning support among the mentioned important target groups as well as the general public for the protection of ecological connectivity and specific mitigation measures implemented in or close to their communities. The complexity of the issue, perceived clash with other interests (safety of livestock and crops, economic profitability of land, road safety, etc.), and lack of financial incentives have often rendered the engagement of stakeholders around the improvement of ecological connectivity a complicated task. The workshop in the frame of the IENE 2022 Conference is to serve as a forum for experience exchange among SaveGREEN experts and other Conference attendees having faced similar challenges in their line of work in order to jointly brainstorm potential solutions to such challenges.

The objective of the workshop is to share experiences made in stakeholder outreach and engagement on the issue of ecological connectivity, highlighting both challenges and useful tools and strategies to break possible impasses. An interactive exchange between workshop participants will provide both them and the organizers with insights into the possible conflicts that can arise when seeking to drive stakeholders towards increased action for the improvement of ecological connectivity in their spheres of influence. A subsequent brainstorming session on available tools to solve such conflicts will equip the workshop attendees with an array of potential tools that they can apply in the event of future challenges in communication of a similar nature.

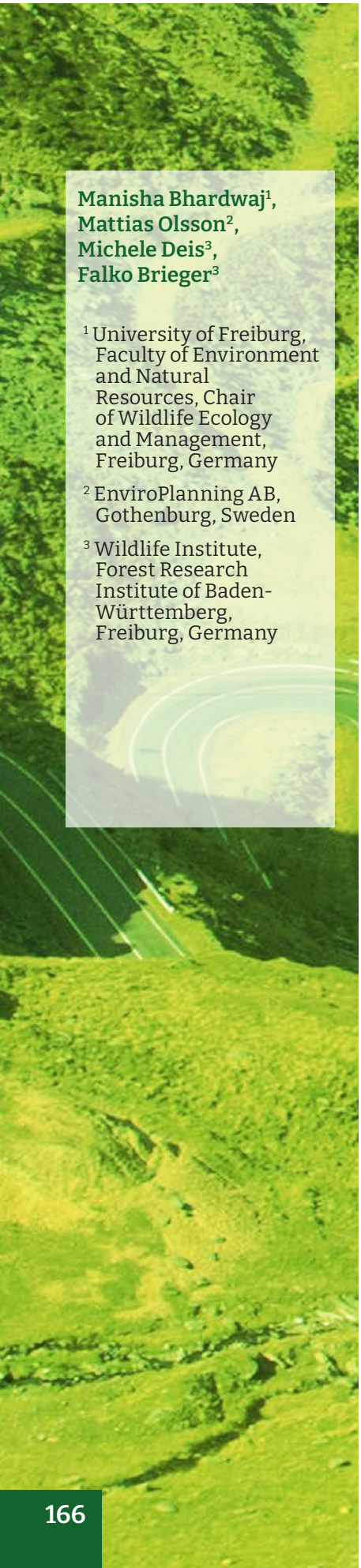
Structure:

- 10–15 minutes introduction to experiences in stakeholder engagement made during the implementation of the SaveGREEN project;
- 20 minutes break-out group session for experience exchange with workshop attendees;
- 20 minutes exercise (break-out groups): "Problem ownership window" applied to previously shared experiences;
- 20–25 minutes plenary session: Sharing and harvesting of insights gained.

At the end of the workshop both organizers and attendees should have gained further insights into the complexities of stakeholder engagement related to ecological connectivity. This heightened awareness coupled with shared methods for conflict resolution and positive examples will equip the workshop participants with a "Communication Toolbox" from which they can draw when they next find themselves facing skeptical/belligerent/passive stakeholders whose support they hope to secure. The main take-aways of the "Communication Toolbox" from these shared methods and positive examples will be gathered in an output document for further dissemination. The gathered insights will not only be at the disposal of participants and other recipients of the output document, but will also directly feed into the continuing work of SaveGREEN. Other content of the "Communication Toolbox" will be a collection of best practices, and a methodology catalog with practical information on implementation on how to arouse interest in stakeholders and with tips on each method where and how to use them successfully. To ensure the wider outreach of the "Communication Toolbox" we'll share it on social media as a post series dedicating each method a post and provide further capacity building events in case of interest.

Ecological connectivity is a strongly transboundary and cross-sectoral issue. Proponents seeking to improve the status of ecological corridors must inevitably engage with a variety of stakeholders to secure their support. Strategies and insights harvested at the end of the workshop will be recorded and made available to all workshop participants in the form of an output document within the "Communication Toolbox" to support them in future communication challenges faced in their respective lines of work.

Keywords: Ecological connectivity, Stakeholder involvement, Deep listening, Non-violent communication, Green infrastructure, Gray infrastructure.



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Roadside Animal Detection Systems/Wildlife Warning Systems: Different names but the same goal – A workshop to bring together global experiences in warning drivers of wildlife near the roads

Roadside Animal Detection System (RADS, also known as Wildlife Warning Systems, or Animal Detection Systems, among other names), are a potential solution to reduce wildlife-vehicle collisions. Around the world, there are many existing independent projects which aim to study the effectiveness of RADS. However, since there is little communication among these groups, each has created their own system that is unique in some way, for example, in the technological solutions, data collection, storage and analysis methods, or reporting style. Thus, despite sharing a common goal, each working group is acting independently and cannot take complete advantage of existing knowledge or expertise. To address this gap in communication, we will use this workshop to promote networking and knowledge sharing among those that work with RADS. The ultimate goal of this workshop is to lay the foundation of an international collaborative working group of those working with RADS, with the intent to improve the use and effectiveness of RADS, and create a forum to share data and develop new projects together.

In this workshop, we aim to bring together researchers, practitioners, engineers and government officials to discuss their experiences with using Animal Detection Systems. We will focus our discussion methods for collecting data and reporting results, however we also encourage members with technical experience to join us. The main goal is to discuss the pros and cons of the different technological set ups used, and what are the appropriate ways to collect data for different research questions/focuses. We see the opportunity to collect authorities and researchers from around the world that are working with some kind of "animal warning system" to form a working group that can start to discuss standardizing efforts from the technical aspects, to data collection, and analysis. The workshop will also serve as a networking opportunity for those working on this topic to get to know each other.

Structure:

00:00–00:15: Introductions and brief summary of workshop objectives. Organizers will lead brief introductory presentations.

00:15–01:00: Group discussion about wins and challenges each participant has experienced. The main point is to find common challenges and potential solutions. The discussion will be open and facilitated by the organizers. Discussion points include (but are not limited to):

- Establishing the research question;
- Defining effectiveness;
- Data collection;
- Data collection set up;
- Type of data (e.g., collisions, behaviour, etc.);
- Centralization of data storage;
- Data analysis;
- Quantifying effectiveness;
- Sharing findings;
- Identifying common challenges and potential solutions to those problems;
- Weaknesses in the design.

01:00–01:15: Discussion of next steps for potential international collaborations, for example by developing a Working Group, meeting again outside of the conference, and sharing data to create a collective output. Collective outputs can be decided upon in the group, and some ideas include: guideline on technological implementations, guideline for data storage, sharing, analysis and reporting, or a meta-analysis using data contributed from participants.

01:15–01:30: Closing and wrap-up.

We will create a report at the end of the workshop, which will summarize the main discussion and identify gaps in knowledge and needs for collaboration. We will also strive to establish an active working group under IENE, and decide on the next "immediate" steps for this group.

Once the working group is formed, we will organize future meetings in order to continue networking and to streamline efforts related to implementing and studying RADS. Future meetings will focus on specific aspects of RADS, for example we will have specific meetings about technological solutions or about data analysis. Within the working groups, we will create collective outputs for example, best practice guidelines or a meta-analysis using data shared among participants.

Keywords: Wildlife Warning Systems, Roadside Animal Detection Systems, Data collection, Data analysis, Animal behavior.

Tackling climate change and biodiversity – nature-based solutions and their role in economic transition. Examples of Transport4Nature commitments

Lisa Garnier[1], Elisabeth Aubert[2], Cora Cremezi Charlet[3], Carme Rosell[4], Joanne Schante[5], Dorothée Labarraque[6]

[1] RTE Réseau de Transport d'Electricité

[2] ENGIE

[3] French National Railway Company (SNCF)

[4] Minuartia/BISON

[5] LGI Sustainable Innovation

[6] EGIS

Motive: Companies are now seeking to implement nature-based solutions to the environmental and societal challenges they face.

Objective: This workshop will provide an opportunity for an exchange between companies, practitioners and ecologists to put into perspective the challenges and opportunities of nature-based solutions in the transport infrastructure sector.

Structure: This moderated workshop will be an opportunity for practitioners, ecologists and companies to discuss:

- what is meant by nature based solutions;
- examples of good practices that are starting to be put in place;
- the challenges and opportunities;
- European and international incentives for the implementation of these practices.

Expected outcome: A report of this workshop will be written and will be made available on the IC22 and IENE websites.

Implementation: Hybrid.

Keywords: Nature based solution, Business, Best practices, IUCN.

IENE Infrastructure & Ecology Network Europe 2022

SaveGREEN: A matrix of problems and solutions to be considered for safeguarding structural and functional connectivity at landscape level

Radu Moț[1], Hildegard Meyer[2], Christophe Janz[2], Roland Grillmayer[3], Christoph Plutzar[3], Katrin Sedy[3], Florian Borgwardt[3], Emma Gileva[4], Rumyana Ivanova[5], Petko Tzvetkov[5], Miroslav Kutal[6], Radek Křček[6], Ivo Dostál[7], Viktoria Selmeczy[8], Gabriella Mária Nagy[8], Csaba Mezei[8], Eszter Sebestyén[8], Ildikó Varga[8], Thor Morante[8], András Weiperth[9], László Kollányi[9], Krisztina Filepné Kovács[9], Florina Ciubuc[1], Răzvan Rohan[1], Marius Nistorescu[10], Alexandra Doba[10], Silvia Borlea[10], Cristian-Remus Papp[11], Diana Cosmoiu[11], Ioana Ismail[11], Bianca Stefănuț[11], Andreea Danciu[11], Adrian Grancea[11], Milan Janak[12], Barbara Immerova[12], Lukas Holasek[12], Romana Uhrinová[12], Vladimír Ondrejička[13], Milan Husár[13], Lazaros Georgiadis[1]

[1] Association Zarand, Romania

[2] WWF Central and Eastern Europe, Austria

[3] Environment Agency, Austria

[4] Black Sea NGO Network

[5] Bulgarian Biodiversity Foundation

[6] Friends of the Earth

[7] Transport Research Centre, Czech Republic

[8] CEEweb for Biodiversity

[9] Szent Istvan University, Hungary

[10] EPC Consultanță de Mediu, Romania

[11] WWF, Romania

[12] WWF, Slovakia

[13] SPECTRA, Slovakia

SaveGREEN project developed a logframe to assess the needs for safeguarding connectivity at landscape level. Starting from general sectoral pressures or threats, general objectives to address these threats have been standardized. Based on the local experience from 7 countries where 8 Cross-Sectoral Operational Plans (CSOPs) have been developed in pilot areas, a collection of problems and measures have been produced.

This logframe aims to support a better structured assessment of connectivity-related projects and to facilitate the understanding of multisectoral implications and an efficient communication and engagement with a diverse range of stakeholders.

The aim of the workshop is to present the results of SaveGREEN to a range of international experts (cca. 30), to engage them based on examples from the field and to gain their feedback in order to test, improve and to facilitate the further use of the project's output – the logframe of CSOPs and the collections of problems and measures.

The workshop will be integrated in the SaveGREEN-sponsored field trip and will take place in-person-only.

A short presentation of the SaveGREEN project and the structure of the CSOPs logframe will be presented to the participants during the buss drive towards the pilot area (cca. 30 minutes).

During the field trip, we will explore a range of situations relevant for landscape connectivity and will relate with the problems/measures proposed by CSOPs. Participants will be asked to note their suggestions/comments based on their own experience on files dedicated to several relevant sectors.

The third part of the workshop will be organized as a word-café when participant will be asked to give their feedback on each sector of interest (transport, agriculture, forestry, water management, hunting, nature protection, communication, etc.) (60 minutes).

The conclusion and next steps will be discussed during the return drive (cca. 15 minutes).

The workshop aim to improve the SaveGREEN's CSOPs logframe and to develop it and a reference tool for investigating potential problems and for adapting local solutions to address them in any connectivity-related project/initiative.

The feedback collected from international experts during this workshop will be integrated in the outcomes of the SaveGREEN project: the "Cross-Sectoral Operational Plans (CSOPs)" and will be used as concrete examples/case-studies for the "Handbook of best practices for planning and implementation of mitigation measures at landscape level".

Keywords: Cross-sectoral operational plans, Structural and functional connectivity, Landscape approach, General threats and objectives, Matrix of problems, Collection of integrated solutions, Stakeholder engagement, SaveGREEN.

Application Toolbox for Functional Monitoring

Roland Grillmayer[1], Florian Borgwardt[1], Florian Danzinger[1], Mořic Jurečka[1,2]

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For the evaluation of the functional connectivity of ecological corridors, area-wide data on land use and land cover, specific habitats that promote connectivity, barriers and crossing structures as well as evidence or abundance of indicator species is required. However, high-quality datasets on the occurrence and abundance of umbrella species are still scarce to address numerous unanswered scientific questions on the functional connectivity of ecological corridors. The workshop introduces a method for the creation and interoperable exchange of harmonized datasets on functional connectivity, and thus makes a valuable contribution to improving the availability of these rare datasets on species distribution.

After the workshop, the participants will have a basic understanding of the functional connectivity approach. The generic harmonized data model and its importance for the standardized and consistent recording of all landscape objects like over – and underpasses, barriers, hedges and trees and target species, relevant for functional connectivity analysis, will be presented. The participants will learn how to apply this generic harmonized data model in their own projects and how to extend it for further questions. Furthermore, the participants will learn how to map different objects relevant for the analysis of functional connectivity using different mobile applications created within the Interreg Danube project SaveGREEN.

Target groups for the use of the generic model and the developed application toolbox are on the one hand all ecologists working in the field of habitat connectivity and landscape connectivity analysis and on the other hand transport planners and similar disciplines who want to analyse wildlife crossing structures and their acceptance by wildlife. The Application Toolbox thus provides methods and tools for the analysis the continuum of a corridor in the surroundings of wildlife crossing structures. The results of these analyses are an important contribution to develop a better understanding of the required habitat equipment and the best possible embedding and integration of wildlife crossing structures into the ecological corridor and the landscape in general.

Starting with a general introduction to the topic of functional ecological connectivity the workshop will define the most important terms on this topic. Subsequently, the "Application Toolbox for the Functional Monitoring" (AT-FM) will be introduced. The approach has been developed within the INTERREG Danube project SaveGREEN to monitor the ecological connectivity of corridors in eight pilot areas across Central and Eastern Europe. The presentation includes a discussion of the generic data model, the software components and mobile applications that together build up the AT-FM. In the practical part, the participants will learn how to record different object types using the mobile applications of the AT-FM. After the participants have recorded different objects with the mobile software clients on their own, the process of data quality assurance up to the data import into a central database and the creation of interactive web maps will be elaborated in the workshop.

Draft workshop-program (duration 210 minutes):

- General introduction concepts on functional ecological connectivity (15 minutes);
- Presentation of the Application Toolbox for the Functional Monitoring (15 minutes);
- Discussion on generic model for the functional connectivity monitoring (15 minutes);
- Hands-on session using AT-FM Software: Mapping of object types like over – and underpasses, barriers, landscape elements, wildlife tracks and other activity signs (45 minutes);
- Coffee-break (30 minutes);
- Demonstration data integration procedure (15 minutes);
- Demonstration of final data and analysis products (e.g., maps of species distribution in the ecological corridor, species acceptance of wildlife crossing structures, etc.) (15 minutes);
- Closing Discussions (30 minutes).

The overall aim of the workshop is to convince the participants to design their future data models based on the generic data model developed in the AT-FM. Such an approach would ensure the standardization of collected data sets across countries and regions, and thus their compatibility and comparability. Furthermore, this approach would ensure a largely standardized and interoperable data exchange, and thus facilitate the reuse and further processing of already existing data sets. In the long term, this approach should have a positive impact on the availability of relevant data sets that are essential for answering numerous questions in the field of functional connectivity. Against this background, this workshop provides a platform for information, discussion and exchange as well as debating different definitions and interpretations of the concepts of functional monitoring and functional connectivity.

The experience gained during the workshop will be taken into account in the further development of the AT-FM. Specifically; the workshop will be used to discuss the generic data model, so that any missing content can be taken into account in the final version of the data model.

Keywords: Functional monitoring, Functional connectivity, Ecological corridor, Field mapping, Data standardization.

Connecting people, connecting landscapes

A system of mitigation solutions (bored tunnels, greenbridges, viaducts, underpasses) will be implemented in the ecological corridor that links Western and Southern Carpathians, in Romania. This last segment will complete a critical motorway and will represent a good practice example in the country and region as well.

2022

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IENE Awards

IENE Awards

IENE recognizes and awards outstanding efforts made to reduce the detrimental effects of transport infrastructure on nature and enhance its potential for a positive influence. The IENE awards comprise a public recognition and do not include any grants.

The **IENE Personal Award**, appreciates outstanding engagement and special achievements made by individuals that are not necessarily related to a particular activity.

The **IENE Project Award**, appreciates extraordinary work accomplished by initiatives, activities or plans.

The IENE Personal and Project Awards are granted by the IENE Governance Board.

The **IENE Best Poster Presentation Award**, appreciating the highest-quality poster presentation during the Conference, has been decided through the voting of the participants.

In 2022, an **IENE Special Award** and **Best Photography Awards** were granted as well.

The IENE 2022 Personal Award

was presented to **Anders Sjölund** for his special efforts made for the protection of nature and biodiversity, for his long term commitment to improve the environmental impact of transportation infrastructure, and for supporting colleagues, new ideas and projects in Europe and on other continents in the name of Infrastructure Ecology Network Europe.

The IENE 2022 Special Award

was presented to **Anabela Belo**, **Ana Sampaio**, **André Oliveira**, **António Mira**, **Carla Cruz**, **Carmo Silva**, **Denis Medinas**, **Dinora Peralta**, **Eduardo Ferreira**, **Francesco Valério**, **Giovanni Manghi**, **João Craveiro**, **Luís Guilherme Sousa**, **Graça Garcia**, **Mariana Fernandes**, **Nuno Pedroso**, **Paula Matono**, **Pedro Salgueiro**, **Sara Santos** and **Tiago Pinto** (University of Évora) in appreciation of their outstanding achievements and personal engagement in organising the IENE 2020 International Conference "**Life Lines – Linear Infrastructure Networks with Ecological Solutions**" in Evora, Portugal, under the most difficult circumstances of the Covid pandemic.

The IENE 2022 Project Award

was presented for the contribution **Concrete Shell (PFHC): An innovative type of greenbridge with reduced carbon footprint** to **ÖBB–INFRASTRUKTUR AG/ Thomas Schuh** and **Karin Gradenegger** for special efforts made to reduce the detrimental impacts and to enhance positive effects on nature generated by construction, use and maintenance of transport infrastructure.

The IENE 2022 Best Poster Presentation Award

was presented to **Huig Deneef** (Provinciaal Natuurcentrum Limburg, Genk, Belgium) for the contribution **Ecological integration Ecological integration of the bicycle highway along the former rail road Coal Track in Limburg (Belgium)**.

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Acknowledgements

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See you in 2024!

The next IENE International Conference will be held in the campus of Czech University of Life Sciences, in Prague, Czech Republic, from September 9 to 13, 2024.
The conference will be organized by the Nature Conservation Agency of the Czech Republic in collaboration with the Czech University of Life Sciences and the Transport Research Center.
For more info, please visit www.iene.info

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