Abstract Book

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LIFELINES

Linear Infrastructure Networks with Ecological Solutions

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WELCOME TO THE IENE 2020 INTERNATIONAL CONFERENCE

The University of Évora, in the framework of the LIFE LINES project, and the Infrastructure and Ecology Network Europe welcome you to the IENE 2020 International Conference. This year, due to the COVID 19 pandemic constraints, it will not be possible to host you in Évora, the beautiful World Heritage City in southern Portugal, as originally planned. The Conference was postponed to January 2021 and will take place fully online. We will be physically distant and a hand-shake or a hug will not be possible. But we are still together to share ideas and experiences that will inspire the adoption of nature friendly solutions in Linear Infrastructure Networks.

IENE 2020,
"LIFE LINES – Linear Infrastructure Networks with Ecological Solutions"

"No effort is too small to preserve biodiversity"

Humans are today the main biological influencers of ecosystems, biological communities and species survival. In 2020, the World Economic Forum recognized that "biodiversity loss" is one of the threats with plausible higher impact on Global Economic Development.

Linear infrastructure (LI) networks such as roads, motorways, railways, navigation and irrigation channels, pipelines and electric powerlines, fences, etc. have grown exponentially since the middle of the 20th century. However, most existing LI networks built before the 90th decade are not environmentally friendly, do not consider properly biodiversity conservation and have immense negative impact on wildlife.

Every year, billions of animals are killed by cars, hit by trains, powerlines collisions, electrocuted in electrical poles, drowned in artificial channels, and isolated from their natural resources and mates through insurmountable LI barriers. Light, noise and human activities associated with many of these infrastructures displace wildlife form large areas or induce stress and lowers fitness of those that remain, contributing to smaller, more isolated and less resilient populations. As the climate changes progresses, species can only survive by moving along with the shifting ecological conditions. This requires even more mobility across the landscape, worsening the already detrimental impacts of LI networks. Whether acting in isolation or synergistically, these impacts are a major step to the extinction of species and populations.

On the other hand, the habitats related to linear infrastructures, including verges, areas under powerlines poles and others, if properly managed, may play an important role as corridors or biodiversity refuges, counteracting the adverse ecological effects of LI, particularly when those are embedded in highly human-modified landscapes.

Particularly in the last two decades, Environmental Impact Assessment (EIA) processes increasingly demand new LI to be ecologically sustainable. However, very often the assessment and mitigation are focused on the new infrastructure itself discharging the larger landscape context and the integration and intervention on other infrastructures already present.

Monitoring data on ecological impacts of LI and mitigation efficacy is more available than ever. New devices taking advantage of machine-learning techniques and artificial intelligence are being tested to promote safer LI for humans and wildlife through the reduction of accidents and non-natural mortality, and promotion of safer LI crossings. Big data about species occurrences and ecological needs, increasingly detailed satellite imagery, new and progressively cheaper genetic tools and powerful computers, and modelling techniques are helping us to understand better than ever, interactions between LI and biodiversity. Landscape designers and planners, LI managers and constructors, decision makers are, like never before, aware of the risks and opportunities for biodiversity associated with LI development. No net loss politics and compensatory schemes are powerful and promising tools to prevent biodiversity decline. However, till now, they are not doing enough. Achieving ecologically sustainable LI implies to mainstream biodiversity across all phases of LI development, giving natural capital the priority it deserves in all parts of the process. So, is it time to strengthen this message to top world politicians and decision-makers.

For already existing LI, the investment towards sustainability may seem huge and impossible to accommodate in short term national or institutional budgets. However, often, simple actions, like repairing a fence, adapting a culvert, isolating an electrical cable, etc., can make a difference. When understood by local human communities and authorities these small things will easily get ingrained by people and the motto “no simple action is too simple to help biodiversity” will echo and cement the cooperation across all sectors and regions. Rushing this to happen is the responsibility of all of us, but the support and incentive of decision-makers is the master pylon to implement and spread the idea, guarantying a sustainable Earth where biodiversity, including people, may thrive.

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Part 1:

Plenary Sessions

PLENARY I MOLECULAR TOOLS TO ASSESS THE ECOLOGICAL IMPACTS OF TRANSPORTATION INFRASTRUCTURES

Niko Balkenhol

Niko received degrees in Forest Ecology, Environmental Monitoring, and Wildlife Resources. His practical experiences include working for a private consulting company where he conducted environmental impact assessments for road construction projects. He was a postdoc at the Leibniz-Institute for Zoo and Wildlife Research (IZW) in Berlin before moving to the University of Goettingen in 2011, where he currently leads the Department of Wildlife Sciences. His research focuses on ecological connectivity, which he analyses at different biological levels (from genes to ecosystems) and by combining movement ecology, landscape genetics, and simulation modelling. Many of his projects include an assessment of road effects on functional connectivity.

Molecular tools are increasingly used to address fundamental and applied questions in ecological and biological research. Here, I provide an overview of the various ways in which molecular data can help to assess and monitor the ecological effects of transportation infrastructures. I first provide a summary of our current understanding of genetic road effects and of our analytical abilities to detect such effects. Specifically, I show that genetic barrier effects are highly variable, trait- and context-dependent and that quantifying such effects is strongly affected by the spatial and temporal distribution of available data. I illustrate these points through simulation results and empirical studies from various wildlife species. Second, I call for an increased use of genetic data to monitor barrier mitigation measures, such as over- or underpasses. While several case studies have proven the usefulness of genetic data to evaluate the effectiveness of such mitigation measures, we need to apply molecular approaches more routinely in this context and over longer time scales. Third, I review how molecular tools can greatly increase our understanding of other ecological impacts of transportation infrastructures, i.e., impacts that go beyond a barrier effect on movement and gene flow. For example, non-invasive genetic sampling or environmental DNA (eDNA) can help to detect elusive species, thus providing novel opportunities to assess how transportation infrastructures affect the distribution and/or abundance of entire communities. Finally, I will highlight that transportation infrastructures might also have evolutionary consequences that are highly relevant for management and conservation.

PLENARY II CHALLENGES AND ADVANCES OF ROAD AND RAILWAY ECOLOGY IN LATIN AMERICA

Fernanda Z. Teixeira

Fernanda Teixeira is a postdoctoral researcher in the Graduate Program in Ecology / UFRGS (Brazil), where she develops research projects at the Road and Railroad Ecology Group. Fernanda is a biologist, holds a PhD in Ecology and previously was a postdoc at the Geomatics and Landscape Ecology Lab at Carleton University (Canada) and at the Environmental Analysis and Modeling Program / UFMG (Brazil). Her research interests are the mechanisms underlying the effects of roads and railways on wildlife, effectiveness of mitigation measures, and the quality and effectiveness of environmental licensing.

Latin America is a region with biological, ethnic, and cultural megadiversity that currently faces a boom in infrastructure expansion. Acting to avoid and mitigate the impacts of both the existing and new infrastructure in this region requires creativity and cooperation, as there are many unique challenges. In the neotropics, habitats have a high diversity along the vertical strata. For example, the gaps created in the canopy pose a challenge for the movements of arboreal animals, like monkeys and tree frogs, and the effectiveness of mitigation measures for these animals needs to be tested. Many species that are not recorded as roadkill may avoid clearings and may be affected by the decreased connectivity and decreased habitat quality near roads, but mitigation for these cases still need to be developed and tested. The neotropics also have social and cultural particularities, since the poverty conditions of many regions pose challenges for the installation and maintenance of mitigation, requiring creativity, participation, and co-responsibility. Studies of the impacts of linear infrastructure are being carried out at many different countries, and a large network of researchers and practitioners is being created. Due to the peculiarities of this region, acting to avoid and mitigate the impacts of the existing and new infrastructure requires creativity and cooperation. In this talk I will present some of the initiatives that are happening throughout Latin America, as well as discuss some of the gaps in knowledge and challenges for decision-making.

PLENARY III BIRDS USING (AND ABUSING OF) LINEAR INFRASTRUCTURES: STORKS AND POWER LINES

Francisco Moreira

Francisco Moreira is a Biologist and a Researcher at the CIBIO (Research Center on Biodiversity and Genetic Resources), University of Porto, Portugal. Principal investigator of the research group "Biodiversity in Agricultural and Forest Ecosystems", and chair holder of the REN Invited Research Chair in Biodiversity. Member of the Board of the Society for Conservation Biology – Europe Section. Research interests include: (a) the links between farmland and forest management and biodiversity (b) fire ecology; and (c) the biodiversity impacts of anthropogenic linear infrastructures (focus on power lines, and how they impact, through disturbance, collision and electrocution, bird population dynamics).

Power lines are increasingly widespread across many regions of the planet. Although these linear infrastructures are known for their negative impacts on bird populations, through collision and electrocution, some species take advantage of electricity pylons for nesting. We compiled historical information (1958-2014) of the Portuguese white stork *Ciconia ciconia* population to analyse long-term changes in numbers, distribution range and use of nesting structures. White stork population size increased 660% between 1984 and 2014. In the same period, the proportion of nests on electricity pylons increased from 1 to 25%, likely facilitated by the 60% increase in the length of the very high tension power line grid (holding the majority of the nests) in the stork's distribution range. The main drivers of pylon use by nesting storks were distance to major feeding areas (rice fields, landfills and large wetlands), with more intensive use closer to these features. We discuss the implications of this behavioural change, and of the management responses by power line companies, both for stork populations and for managers.

PLENARY IV THE EU BIODIVERSITY STRATEGY 2030 – PERSPECTIVES AND IMPLICATIONS

Jakub Wejchert

Jakub Wejchert is senior policy officer at the Biodiversity Unit, DG Environment, European Commission. He currently contributes to the core drafting team of the new EU 2030 Biodiversity Strategy. His main responsibilities include work on ecosystem condition, services, and restoration, as well as integration in to emerging economic and legal framings. Previously he worked on EU negotiations on the Sustainable Development Goals. He holds a PhD and BA in Natural Sciences, from Trinity College Dublin. He recently completed an Advanced Diploma at the University of Cambridge on ecological monitoring. Married, with three children, his hobbies include horse-riding, trekking and appreciating nature.

The loss of biodiversity, i.e. all life on earth, is a serious and urgent problem, comparable to, or even more serious than the global climate change. The European Commission's Political Guidelines and the European Green Deal have underlined the severity of this challenge and the need to curtail biodiversity loss. The EU 2030 Biodiversity Strategy planned to be adopted by end March will outline the EU's position internationally for the Conference of the Parties to the Convention on Biodiversity, to be held in China in October 2020. The Biodiversity Strategy will likewise outline objectives, targets and policy measures to be undertaken in the EU. My presentation will outline key elements of the strategy relating to protection, restoration and mainstreaming, and enabling conditions, as well as implications of the strategy in particular for ecosystem restoration and green infrastructure. I will also outline recent guidance documents published the by Commission to support planners, policymakers and businesses to support the deployment of EU-level green and blue infrastructure, and to integrate ecosystems and their services in decision-making. Together these will outline the range of recent EU policy developments relevant to linear infrastructure networks and ecological solutions.

Part 2:
Full Presentations

SESSION 1.1.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 1

#1 Managing knowledge after 15 years of defragmentation

Adam Hofland[1*], Camiel Meijneken[2]

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In 2004 a national multi-annual defragmentation program called MJPO was initiated to reconnect fragmented natural areas. This program took care of defragmenting nature by installing around 600 (!) structures such as ecoducts and wildlife tunnels.

Rijkswaterstaat and ProRail the two Dutch Directorate-Generals for Public Works and Water Management and Railways, are in charge of the defragmentation programme. The programme was a large investment (€ 287,5M) and delivered a significant contribution to the Dutch Nature Network and to the development of knowledge and public awareness on wildlife passages.

An often forgotten part of financing these kinds of projects and programmes is that it is not only money spent on constructing measures but also on collecting and enhancing knowledge. This knowledge is not only indispensable for future similar projects but also for the future maintenance of these structures. Especially in a sector where not every method and construction is scientifically validated yet, this anchoring and sharing of knowledge should be a significant part of the investment.

Now the Dutch defragmentation programme has come to an end, this is a good moment to evaluate on how the programme contributed to the development of knowledge about planning, designing, constructing and maintaining defragmentation measures.

To explain the anchoring and sharing of knowledge within the programme and how this can be used in other projects and programmes the scheme of Knowledge Management is recommended. Good knowledge management should be seen as a continuous circle of 5 stages:

1. USE — Gaining experience with available knowledge
2. DEVELOP — Create new knowledge (innovate)
3. FIXATE — Retaining the knowledge
4. SPREAD — The right knowledge, on the right moment and place
5. ACTIVATE — Collect and publish

Every role in every stage is necessary in this model to create synergy and enhance knowledge.

Within the MJPO programme phases 1 and 2 were mainly developed within projects. The programme management mainly focused on phases 3, 4 and 5. This interaction between projects and the overarching MJPO shows the advantage of programme management. It was a vehicle to retain, share and collect the gained knowledge from multiple projects to a larger audience.

The MJPO had several repetitive platforms for professionals to share their knowledge and experiences during preparation and execution of projects (phase 3) and therefore were able to improve measures to be taken. The website and newsletters were important tools to spread, share and activate this knowledge to similar projects in other regions (phase 4). This information was collected in handbooks and guidelines and published by Rijkswaterstaat and ProRail (phase 5) to be used by many other organizations. These concrete interpretation of the scheme of knowledge management by the MJPO are applicable for any type of infranature programme.

This way of working is prolonged after the MJPO in a Community of Practice on Defragmentation. A network of professionals within the so-called *Golden Triangle* of government, research institutes and businesses all affiliated with the topic of defragmentation. They will continue to meet and discuss the realization and maintenance of defragmentation measures, knowledge development and gaining publicity and public support. This community is now the center of all the 5 steps mentioned in the scheme above. It is therefore an durable prolongation of the MJPO and an important return of investment.

KEYWORDS: Knowledge management, Collaboration and conjunction, Research networks, Dissemination and communication

#2 "Breaking down" global defragmentation concepts to a macro-region – the example of the Danube River Basin

Anneliese Fuchs[1*], Michael Jungmeier[1]

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In a world shaped by human use, ecological connectivity is becoming increasingly important. Corridors facilitate biological processes such as dispersal, migration or the regular movement of animals and thus strengthen the spatial cohesion of the network of habitat patches, which is crucial for the survival of many species. We have investigated this question in several projects in the Danube River Basin (DRB).

The DRB comprises four main corridors, the Alps- Carpathian Corridor, the Alps-Dinaric Corridor, the Danube Corridor and the European Green Belt. The network of 12,395 protected areas is the backbone of the green infrastructure on land. The Danube itself and its main tributaries are considered key elements of green infrastructure in terms of water connectivity. Key elements for ecological connectivity in the air are the migratory routes of birds and the associated main resting spots for migratory birds, which are mostly wetlands. In addition, the Danube itself is also an important flyway for certain species. However, several anthropogenic barriers such as airports, highways, hydroelectric power plants, high-voltage power lines, dams, weirs and conurbations threaten this connectivity. With 19 countries, the DRB basin is the most international river basin, the Danube itself is the most international river flowing through 10 countries. Especially when it comes to ecological connectivity, management must also take place on a transboundary level. Joint activities, communication and exchange play a primary role.

On several occasions, we have assessed the activities in the DRB and looked at how to deal with this issue into such a large region. One of the results of our analysis was a map showing the degree of fragmentation and the spatial distribution of steppingstones. The analysis clearly shows where existing main corridors are located and gives a broad overview of areas with low general connectivity. Gaps can be seen in the Pannonian lowlands, in the lowlands between the Danube and the Carpathians in Romania and on the border to Slovakia and Austria where large areas are dominated by intensive agriculture or by conurbations.

Interreg as a funding programme that can include the stakeholders of an entire macro-region offers many transnational projects dealing with ecological connectivity. The main lessons learnt are among others that major problems can be solved by the simplest measures, such as the marking of high-power lines, which helps to greatly reduce the mortality of migratory birds and ensure continuity or WILDisland where wild islands along the Danube were identified, recognised as central elements of the green infrastructure and put under protection. The dangers of ecological connectivity have also become visible and it has become clear that, for example, if connectivity is to be promoted, defence mechanisms for invasive alien species must also be created at the same time. In the course of this analysis, guiding principles were extracted and processed into an overarching document.

KEYWORDS: Ecological corridor, Danube River Basin, Guiding principles, Transboundary projects

#3 Risks and opportunities for wildlife living in road dominated environments. What pieces are missing to complete the puzzle?

António Mira[1*], Ana Galantinho[1], Denis Medinas[1], Helena Sabino-Marques[1], Carmo Silva[1], Sara Santos[1]

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A Living on the roadside involves serious risks including restrictions to movements, disturbance of resting and feeding places, and roadkill menace. However, when crossing highly human modified areas such as simplified intensive agricultural landscapes or highly grazed areas, remnant natural habitats associated to roads (verges, roundabouts, bypasses, etc.) may be the only leftover natural areas acting as a last refuge for rare plants and small fauna. In these circumstances, there may be a positive contribution of roads and associated vegetated areas for biodiversity conservation may be considered.

In Europe, remnants of natural habits on roadsidesmay be particularly relevant for the implementation of the "European Green Infrastructure" (EGI) , defined as "… an interconnected network of green spaces in urban and infrastructure dominated environments that preserves the natural value and functions of the ecosystems and provide humans with the benefits associated with them".However, to enhancethe role of road vegetated marginal areas in the EGI there is still a long way to go and many fundamental questions need to be more deeply addressed:i) are road verges refuges or ecological traps for fauna?; (ii) what species traits makes them more suited to persist in road natural habitats remnants?; (iii) what is the relevance of verges as corridors?; (v) what surrounding landscape features are key to define the ecological role of road natural habitats remnants? What are the effects of roads on demographicparameters of populations living on the roadside?

We have accessed the role of verges as providing foraging opportunities for bats, refuges and corridors for small mammals, and ecological traps for small mammal predators. We found that when roads cross lower suitable habitat, roads verges canbe an important last remnant feeding habitat for bats.In highly grazed areas we have shown that verges are a critical refuge for small mammals, as important as riparian galleries, considered one of the most relevant habitats for fauna in the Mediterranean landscape. Using graph-theory-based connectivity metrics we demonstrated that verges contributed significantly more to the overall landscape connectivity than surrounding areas. This shows the high importance of verges as small mammal corridors, even in well preserved landscapes. We also show a strong positive association between locations of snakes, owls and mammal carnivores road casualties and the abundance on verges of wood mice and rabbits, the two main prey in the studied area. These results support the hypothesis that prey abundance on road verges may be a major driver explaining predator roadkills.

In Portugal, road verges and other road remnants of natural habitats are estimated to cover more than 140 thousand hectares, an area larger than any terrestrial protected area in the country. Similar or larger areas of remnant habitats along roads occur in many other countries. Thus, gathering further knowledge aiming to quantify and identify their role in biodiversity conservation is key to properly offset road impacts on wildlife.

KEYWORDS: Road verges, Verge habitats, Biodiversity refuges, Refuges, Ecological traps

#4 Developing mitigation strategies to reduce the impact of land transport infrastructures on Amphibian populations: the example of Denmark, Sweden, Poland, Lithuania and Estonia

Lars Briggs[1], Alix Aliaga[2]

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Land transport infrastructure (LTI) is the largest threat for Amphibians in Europe, thus by causing habitat fragmentation, habitat loss and degradation. More than half of the European Amphibians (59%) are in decline, 23% are threatened and listed under the European Red List.

In Europe, several mitigation strategies and actions to limit the impact of LTI on Amphibians have been undertaken. However, it remains a lack of homogenisation of actions and awareness of actors (e.g. local authorities, decision makers, road directorates, companies etc.) among European countries. There is a strong need to share know-how experience in order to develop a common best practice guidelines that will demonstrate the efficiency of our actions and enable us to replicate them.

Throughout five pilot projects in Europe, we present different mitigation strategies to limit the impact of LTI on Amphibian populations, where the first Amphibian tunnels have been built: Denmark in 1997, Sweden in 1998, Poland in 2000, Lithuania in 2013 and Estonia in 2015.

Several factors were affecting the design of the mitigation measures. At first, the interventions had to prioritise hot spot areas, i.e. where large-scale mortality was identified on existing roads, and where the different species were registered. The experience throughout these pilot projects has enabled us to provide recommendations and best practices, such as the optimal length of the tunnel to ensure a successful migration, the shape of the fences to guide the migrating species, and the choice of material to ensure a long lifespan of the different crossing devices.

In these five projects, pre- and post-monitoring of Amphibians have been performed to assess the efficiency of the implemented passages and other infrastructures. We present here the results of the projects and compare the adaptation of the measures, which are species-specific for large populations of *Bufo bufo*, *Rana temporaria*, *Rana arvalis*, *Pelobates fuscus* and *Ichthyosaura alpestris*. A minor occurrence of *Bombina bombina*, *Triturus cristatus*,*Pelophylax lessonae*, *Pelophylax kl. esculentus* and *Lissotriton vulgaris* also registered in some project sites, have been considered in the mitigation measures. Amphibian tunnels demonstrated to be especially effective for *Bufo bufo*, *Rana temporaria*, *Ichthyosaura alpestris* and *Pelobates fuscus*. Fences were effective in preventing all species crossing the road.

The comparison of the different actions and results among these five countries shows the possibilities to develop a common database and sharing experience between European countries.

KEYWORDS: Amphibians, Land Transport Infrastructure, Mitigation, Monitoring, Corridor

#5 Use of snow-tracking to evaluate the impact of Linear Transportation Infrastructures on wolf and ungulates

Sandro Bertolino[1], Aurelio Perrone[1], Giulia Mutinelli[1], Massimo Rosso[2], Elisa Ramassa[2], Elisa Avanzinelli[1]

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The development of Linear Transportation Infrastructures (LTI) is a major factor that undermines the connectivity of wild populations. This impact could be even worse in mountain areas, where LTI and human activities are mainly concentrated on the valleys floor.

Alta Val Susa is the area in the Italian Alps with the highest LTI mortality for the wolf (*Canis lupus*): 11 carcasses were recovered between 1999 and 2016 in a 10-km stretch of the valley.

Our study was conducted in a municipality where a wolf pack is present and wild ungulates are abundant. The valley floor is crossed by a river, a railway line, a motorway, and a main road. Three wolves died along the railway in recent years. An industrial site connected to the excavation of a tunnel for the Turin-Lyon high-speed railway line is planned. The industrial site will be 1-km long and will remain active for at least 12 years.

In 2018 we started a research, still ongoing, to assess if the animals: 1) cross LTI; 2) use the area where the industrial site is planned; 3) use under and overpasses built for hydraulic reasons and 4) to identify priority areas used by animals to cross the bottom of the valley. The monitoring was based on snow-tracking along standardized transects travelled weekly and occasional monitoring of the area. Signs of ungulates and wolves (footprints and scats) were recorded and wolf tracks were followed as long as possible. Wolf scats were collected for the genetic determination of the animals.

We followed 23 tracks of wolves' footprints on snow for a total of 20.3 km (mean length 0.8 ± 0.5 Km); ten tracks for 6.2 km were followed during systematic sampling. The highest wolf presence index (signs of presence/transects length) was recorded inside the area where the industrial site is planned. Wolves crossed four times LTI, using once the underpass and never the overpass. We recorded 729 signs of ungulate: 586 (80.4%) red deer, 68 (9.3%) roe deer, 58 (8.0%) wild boar and 17 (2.3%) chamois. Ungulates crossed LTI 16 times, used twice the underpass to cross railways and roads and never the overpass.

The results confirm that wolves and ungulates move frequently in this stretch of the valley floor, crossing LTI. The construction of the industrial site will further reduce the permeability of this area. The underpass was rarely used, probably for the presence of a construction site at one side. The overpass was never used for the presence of hydraulic barriers without passages for animals.

We propose a working program with different actions: 1) monitor transects every year during winter; 2) reduce the disturbance in the construction site at one outlet of the underpass and create passages to allow animals to overcome hydraulic barriers along overpass; 3) evaluate the installation of sensors to scare animals away from the road in sections without passages; 4) consider building a wildlife bridge.

KEYWORDS: Wolf, Ungulates, Road/railways kills, Mitigation, Monitoring

#6 The barrier effect of railways and other linear grey and green infrastructure on the small fauna

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The barrier effects of rails on the small fauna and especially on flightless insects are hardly known and respective insect studies almost completely lacking.

As a basis for improved impact assessment, we compare the barrier effects of different railway types, railway underpasses and other linear infrastructure, using ground beetles (Coleoptera, Carabidae) as indicators for the small fauna. In particular, flightless stenotopic woodland species are of interest because we expect them as most sensitive (due to the great habitat contrast between woodland and rails).

Ground beetle activity was measured by using pitfall traps and, in some cases, complementary mark-recapture studies. The activity of the woodland species at each barrier or fauna passage was compared with the activity in the respective adjacent woods. The comparison of the permeability or the barrier effects, respectively, includes:

2 high-speed railways,

1 single-track railway,

2 single-track trolley railways,

5 motorways (median strips)*,

1 paved forest road,

1 unpaved forest road,

1 power line (open-land corridor within forests),

2 newly cleared future heathland corridors (forest aisles),

5 well-developed ecoducts*,

2 newly built ecoducts,

1 narrow fauna overpass (bridge with vegetated strip),

2 large (wildlife) underpasses,

1 narrow, bat/wildlife underpass of > 100 m length,

(* = including methodically equal data from colleagues).

Some of the results were rather unexpected like the lack of woodland species but otherwise high ground beetle activity in the middle of the long and dark bat underpass, the permeability of narrow roads without kerbstones or the rather good permeability of the single-track railway (only 95 % barrier effect in comparison to more than 99% of the motorways).Although a barrier effect of 95 % is undoubtedly a significant effect, it has to be discussed that the barrier impact on insect dispersal and insect population networks can be rather low and only significant for exceptional habitat topology.

The data are compiled from different projects, funded by BfN (Federal Agency for Nature Conservation), BASt (Federal Highway Research Institute), LBV (Schleswig-Holstein Traffic Agency) and SNSH (Schleswig-Holstein Nature Foundation).

KEYWORDS: Barrier effects, Small fauna, Railways, Beetle activity, Powerline, Motorway

SESSION 1.1.2. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 2

#1 Do roadkill of different species respond in the same way to habitat and matrix? The case of four Brazilian mammals

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The Brazilian territory is divided by more than 1.5 million kilometers of roads. Despite the low proportion of paved roads, several impacts of habitat fragmentation by this kind of infrastructure is observed in Brazil: while road network expansion connects human settlements between themselves, it leads to deforestation and land use changes, reducing the connectivity between natural habitat patches, increasing roadkill risk. Roadkill of some wildlife species are common in the studies across the country, and mammals have a special attention for their high threat levels and danger of causing serious traffic accidents, as they have a larger body size. Studies have shown that in Brazilian roads more than 30% of registered mammal roadkill are concentrated in some species, in special *Cerdocyon thous* (crab-eating fox); *Euphractus sexcinctus* (six-banded armadillo); *Tamandua tetradactyla* (collared anteater) and *Myrmecophaga tridactyla* (giant anteater), this last one categorized as vulnerable by IUCN redlist. Our aim was to understand how the roadkill of those mammals could be related with land use changes and landscape features all over the Brazilian territory, and investigate if roadkill patterns differs between species. For that, we collected secondary data on mammal roadkill from several studies in different regions of Brazil (*Cerdocyon thous* n=1281; *Euphractus sexcinctus* n=589, *Tamandua tetradactyla* n=402, *Myrmecophaga tridactyla* n=422). Using MapBiomas' data on land use, we extracted landscape information around each roadkill point, considering a radius based on the mean of home range for each species, and using land cover data for the same year the register was made to have a more precise information of landscape characteristics in the period. With the proportion of land use in the influence area where the roadkill occurred, we built glm binomial models, with the presences being the roadkill points and random points were the absences on Brazilian roads. The independent variables of the models were the proportion of different land uses, like savannas, forests and human-modified environments (pasture, agriculture and forestry). For each of the four species, we selected the best models by Akaike Information Criteria. For crab-eating fox, the best model includes a positive effect of savanna, pasture and agriculture; in the same way, for the six-banded armadillo a model with anthropic use was selected. Both anteaters are affected in an opposite way by human-modified landscape, the best models show a negative effect of anthropic areas and positive relation with habitat patches, in special savanna. These four species seems to be roadkilled in different landscape arrangements, but in all cases, anthropic areas had an important influence on the models. We suppose that some species are more habitat dependent, having more roadkill occurrences near those areas, like the two anteater species. On the other hand, we have the armadillo that occurs and is road-killed in human modified landscapes with agriculture. The crab-eating fox is an abundant species, using different land use types when moving between forest fragments: maybe its moves more in fragmented areas, so the roadkill occurrences can increase the mortality of the species with the fragmentation of landscape.

KEYWORDS: Landscape, Roads, Land use, Road mortality, Savanna

#2 Do culverts contribute to reduce the number of roadkills? A study on roadkills along the Habarana-Polonnaruwa road, Sri Lanka

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Among many different types of linear infrastructures, roads are geographically extensive and exert a significant impact on global biodiversity. Roads negatively affect biodiversity mainly via direct habitat loss, degradation and fragmentation. Making such widely needed infrastructure environmentally-friendly is essential in the present era, where anthropogenically-driven extinctions are taking place at rates that far exceed any in recent geological history. The threat imposed by roads is highest for less-industrialised counties in the Tropics, where the richest and most endemic fauna in the world are found while having an increasing demand for construction and improvement such infrastructures.

Identifying and applying effective mitigatory measures is one critical step that we could take to minimise the impact of roads on wildlife. Therefore, this study correlates the presence of culverts, the only potential wildlife passage type at the study site, with animal mortality. In Sri Lanka, the practice of placing culverts is generally focused on meeting hydrologic requirements while its use by animals to cross roads is a secondary benefit. Hence, my survey focused on identifying the effectiveness of this existing mitigatory measure on reducing the number of road kills at the study road. The study road is located in the North Central Province of Sri Lanka (8° 3′49.43″N, 80°46′27.31″E). It experiences a traffic volume of about 8000 vehicles/day and traverses through a nationally protected dry-mixed evergreen forest segment. This protected area, fragmented by the study road, is a part of the largest network of dry zone forests in the country which are also the only remaining habitats for the Asian elephant (*Elephas maximus*).

Roadkill surveys were conducted along a 10 km stretch ofthe study road on monthly basis. Surveys were continued for a period of an year. A vehicle travelling at 10-20 km/h observed and documented all vertebrate carcasses on the road / shoulder of the road. A total of 96 roadkill surveys were completed during the period from January 2019-December 2019. Surveys were conducted at 0500, 1100, 1700 and 2300, continously over three consecutive days, on each month (8 surveys / month). All carcasses encountered were removed to avoid data duplication. Secondly, culverts along the marked segment were geo-referenced. Then, ArcGIS Desktop 10.5 software was used to assess the degree of correlation between the placement of culverts and roadkills.

The analysis of this data is yet to be perfomed. However, a pilot survey, using the same methodology, conducted in 2018, discovered a total of 132 roadkills over a period of 12 days. This included 16 species of reptiles, 11 mammals, 4 amphibians and 4 birds. The Spearman's rank correlation test revealed that there is no significant relationship between the roadkill density recorded between two culverts and the distance between the culverts ($p = 0.42$). This pilot survey data suggested that the present culverts do not effectively reduce roadkills. These findings re-iterate the need to have targeted animal passes along roads to provide permeability in habitats for wildlife, particularly when roads are constructed through or in close proximity to protected areas. The same analysis will be performed for the larger data set collected over the year 2019 to come to a more concrete conclusion regarding the effectiveness of culverts, for the present study road, in reducing the number of roadkills.

KEYWORDS: Roadkills, Critical features, Road design

#3 Risk analysis of high-voltage power lines in Belgium to map bird collision-prone spans

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High-voltage power lines have been identified as a major human-induced source of bird mortalities. Therefore, Elia - the Transmission System Operator (TSO) in Belgium -commissioned a detailed risk-analysis of its 5.600kms of high-voltage overhead lines in Belgium, in order to map its collision-prone spans. This map is currently used by Elia to set up a priority list of overhead lines that need to be equipped with bird flight diverters in order to decrease the number of further bird collisions.

The risk-analysis was mainly carried out by Natagora and Natuurpunt - two Belgian NGO's and partners of BirdLife International. Initially, a list of collision-sensitive bird species that occur in Belgium was compiled. 'Birds-at-risk' were defined on the basis of a literature review, casualty records and expert judgment. The 'conservation value' of each species, combined with the probable population impact of additional mortality was taken into account as well. In order to facilitate the mapping, the list of 'birds-at-risk' was used to define four coherent groups of bird species: waterbirds, rare breeding birds, migratory species and widespread breeding bird species.

In a next step, up-to-date knowledge of bird distribution in Belgium was used to create maps for each of the bird species groups. Several sources of data were used: wintering waterbird counts, roost and colony counts, data of breeding bird atlases, added by millions of data derived from data-recording portals. The vast majority of these data were collected through citizen science projects. Spatial modelling was applied to obtain high-resolution maps of wide spread species, which helped to define the most important staging area for some other species.

A 'collision risk score' was defined for each span between two pylons, depending on the distance between the line and the defined important bird areas. The combination of the maps and the risk score resulted in the classification of all overhead lines according to their associated collision risk for birds. Most of the more dangerous power lines are located in areas with major concentrations of waterbirds: the polders area, the wetlands in the vicinity of the Port of Antwerp and some river valleys (Yser, Meuse, Haine). About 3.4% (or 190 kms) of the Belgian high-voltage overhead network operated by Elia has a high risk according to the model and a high priority when it comes to mitigation measures to be carried out by Elia. These 3,4 % will further be referred to as 'black' lines.

The first analysis was carried out in 2012, relying on data collected up till 2010. In 2019, the analysis was updated, including all bird data collected up till 2018. Such a regular update is necessary as bird distribution is a dynamic variable. The model has also been validated by field surveys comparing 'black' lines to 'white' lines. Natuurpunt and Natagora continue to collect data on collision victims by a citizen science project, resulting (by the time of the submission of this abstract) in 434 records (in addition to 729 records collected by professionals), in order to monitor the situation.

KEYWORDS: Citizen science, Bird collisions, Risk analysis, High-voltage power lines

#4 Maturity-index assessment: ecology adaptation within road authorities doesn't come easy

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The Dutch National Defragmentation Program MJPO started in 2004 and ended in 2019.A topic that has been worked on last year is a reflective evaluation within the responsible national road- and railroad authorities. The program caused an unprecedented infrastructural investment in defragmentation, whilst before that time there was no or little attention for road ecology in general. In general terms it is clear that this program has had a huge impact in this field. First of all because a lot of fauna passages suddenly have been added to the infrastructure. But also because of change of the general perception: These measures are visible and simply belong to infrastructure and daily management. But to what extent has the defragmentation program really changed the organizations themselves in their attitude towards road ecology? Can we measure this change? Has road ecology itself become an integral part of the organization? How mature is the organization in this area right now? And what should an organization that wants to change or improve focus on?

To answer these questions, we have used the 7S-model from McKinsey and linked a scaled index to it. The 7S-model was already published in 1981 and is developed to analyze the performance of a company. The 7s model is based on the assumption that the effectiveness of an organization can be represented in a mutual coherence of 7 variables, each interdepending and influencing one another: Strategy, Structure, Systems, Staff, Style of management, Skills and Shared Values. An organization is most effective if all factors are developed equally.

The 7S-model is very suitable to use because by filling these 7 variables with specific road ecology terminology and also indicating stages of development (0: completely unknown to 5: fully incorporated), we can indicate how effective or "mature" an organization is on road ecology. For the ProRail and Rijkswaterstaat organizations, interviews and evaluating sessions gave us qualitative data to determine the degree of development per factor, in a situation before and after the program. This is used in the model, making the maturity index visible and evaluation of organizations possible.

Even though you would expect that the organizations would have significantly changed due to the impact of the defragmentation program, we found out that indeed a change, an improvement can be seen, but also that both organizations in the area of road ecology are certainly not yet mature. Style of management and Strategy but also Skills are variables that stay behind in development and hinder effectiveness. These remain areas of attention within the organization. The cause seems logical: MJPO was set up as an implementation program and did not directly arise from and does not contribute to daily management and maintenance.

We recommend that organizations with road ecology ambitions perform a "maturity measurement" as quickly as possible. The presented model is a very easy way to do so and leads to more focused actions on the less developed factors. Style of management and Strategy in particular should be given attention.

KEYWORDS: Road ecology, Evaluation, Organization, Maturity-index, 7S-Model

#5 Developing an ecological defragmentation programme in Flanders: a challenge!

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Belgium and Flanders in particular, has one of the highest population densities and the highest level of fragmentation of landscape and nature in Europe. This is a consequence of a high share of dispersed settlement, and as a result, a high need for (traffic) infrastructure.

Infrastructure and nature partners within the Flemish Government have been working together for more than 20 years on the defragmentation of transport infrastructure, resulting projects on more than 30 national roads ranging from small ecotunnels to ecoducts, eco-valleys and landscape bridges. Experience teaches us that a solid substantiation, based on studies, reports and scientific insights, together with local experience, knowledge of the site and partnerships result in projects that are well supported.

A structurally organised and programmatic approach, as adopted in some neighbouring countries, has been lacking. For this reason, the partners within the Flemish Government took the initiative to draw up a Flemish ecological defragmentation programme. The programme aims at a structured planning and implementation of defragmentation measures for transport infrastructures and thus to contribute to the restoration of eco-systems and the expansion of a network of cohesive nature. In the long term, this must form the basis for a structural collaboration, not just within the Flemish Government but also with other authorities and organisations, at a local, Flemish, federal and cross-border level. The aim is to harmonise the defragmentation of various types of transport infrastructure so that measures reinforce and support each other.

The programme is based on the following principles:

1. We work according to an <u>area and/or species-oriented approach</u>.

2. We work on the defragmentation of <u>existing transport infrastructure</u>.

3. We work <u>together</u> with various parties involved in planning, funding and execution.

4. We are looking for collaboration with additional partners <u>across</u> administrative and competence <u>boundaries</u>.

These principles are put into practice through the following actions and instruments:

1. Database Defragmentation: all currently known bottleneck locations (over 200), revealed by studies and in consultation with experts, have been entered and will be updated yearly. These projects are given a score (priority) using ecological criteria (e.g. location near Natura 2000 area, number and conservation status of target species, barrier type etc) and feasibility criteria (e.g. financing partners, co-use, land owners, local support).

2. Five-year programme: covers those bottlenecks in the database with the highest defragmentation priority which will be prepared and/or implemented in a subsequent period of 5 years. A first 5-year programme (2019-2024) is currently being elaborated.

3. Opportunities: flexibility in planning and timing outside the five-year programme is essential in order to be able to respond to opportunities and unforeseen acute bottlenecks.

Drawing up an 'ambitious' defragmentation programme is not enough. Several challenges have emerged that are inherent to such a process and to the specific situation in Flanders. To name but a few: the lack of an approved ecological structure (cf. the Netherlands), delay and uncertainty due to elections, the search for cost-effective working methods, the necessity for additional budgets for construction, management, inspection, monitoring, communication and staff deployment, etc. make this a fascinating and instructive process. A final version is now presented to the responsible minister and implementation will start as soon as the necessary funding have been allocated.

KEYWORDS: Defragmentation program, Transport infrastructure, Defragmentation policy, Partnerships, Database

SESSION 1.3.1. INFRASTRUCTURE MITIGATION AND DEFRAGMENTATION

#1 The Corridor Map-a-Thon: crowdsourcing baseline spatial data and building capacity to assess wildlife corridor disruption by infrastructure

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Motivation and objectives:

The rapid expansion of roads and other infrastructure is a serious threat to ecosystems and biodiversity. Much of this infrastructure expansion is expected in regions with insufficient baseline data and technical expertise to evaluate environmental impacts of infrastructure. This is a significant barrier to systematic planning for avoiding or mitigating ecological impacts. Myanmar is one such country; while it has prepared a National Transport Master Plan, it still needs additional data and capacity to adequately assess how implementing this plan would impact its globally-significant species and ecosystems. We developed a rapid assessment protocol to respond to these challenges, and hosted a five-day 'map-a-thon' learning event in Myanmar that combined capacity building with crowdsourcing of spatial data. We worked with Myanmar researchers, government agencies and civil society representatives to map wildlife movement corridors through forested landscapes and developed recommendations for planning of roads, railways and other linear infrastructure development.

Methodology:

In August 2019, we worked with local participants to map land cover, linear infrastructure and wildlife corridors for several priority landscapes in Myanmar. We used Google Earth Engine (GEE), a cloud-based geospatial analysis platform with an extensive public data catalog. Participants used GEE to digitize several spatial inputs, including land cover reference locations and linear infrastructure. Participants also used literature and expert knowledge to assign wildlife travel costs for different landscape features. Our analysis pipeline then performed a land cover classification using the reference locations and GEE's catalog of Landsat imagery from years 2016-2019.The resulting land cover map and infrastructure locations were converted into a wildlife travel cost map, representing the likelihood that a species would successfully traverse each part of the landscape. Finally, a cost distance algorithm was used to calculate the total travel cost between wildlife source areas via all possible travel routes. Workshop participants then visually assessed where suitable (low cost) wildlife corridors intersected linear infrastructure and developed recommendations for avoiding or mitigating impacts. The methodology does not require advanced spatial analysis skills and was easily learned through a short introductory training.

Results:

Participants worked in groups to develop case studies for nine priority areas that evaluated current and future impacts of land use and linear infrastructure on wildlife corridors. Notable insights included identifying potential wildlife crossing hotspots along roads in Mahamyaing Wildlife Sanctuary in Sagaing Region, and wildlife corridors that are likely to be impacted by a proposed railway in Shan State. Participants now have the ability to perform several corridor planning workflows, such as 1) identifying wildlife "bottlenecks" and potential crossing locations along planned or existing roads, 2) comparing impacts of alternative road alignments on wildlife, and 3) assessing existing connectivity between protected areas.

Application:

We are exploring the potential for organizing additional map-a-thons and a data hosting platform with a leading technology hub in Myanmar. WWF and the Smithsonian Institution plan to integrate the methodology into their conservation planning and capacity building programs elsewhere.

KEYWORDS: Wildlife corridor mapping, Geospatial analysis, Habitat connectivity, Capacity building, Map-a-thon

#2 Eskom/Endangered Wildlife Trust partnership 1996 – 2020, 24 years of partnering together to reduce impacts on business and on biodiversity

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[1] Eskom / Endangered Wildlife Trust Strategic partnership

Eskom is responsible for providing electricity to meet the ever increasing needs of its end users. As a result, Eskom's linear electrical infrastructure is continuously being expanded upon to support annual load growth. Negative interactions between wildlife and electrical infrastructure take on many forms including the electrocution of birds (and mammals), birds colliding with power lines and birds and/or animals causing short circuits in the electricity supply through various activities on electricity structures. These interruptions to the power supply have dire consequences for large industries and residential areas. The challenge for Eskom is to find the balance between the electricity demands of the nation, the interests of industry, the residential electrification programme, and the effective use and conservation of natural, social and economic resources. In view of the complexity, scope and persistence of the problem of interactions between wildlife and power lines, Eskom and the Endangered Wildlife Trust (EWT) formalised their long-standing relationship by entering into a partnership in 1996 to address the problem in a systematic manner on a national basis and to establish an integrated management system to minimise these negative interactions. Twenty-three (1996-2019) years later the partnership is still going strong. The Eskom/EWT strategic partnership evolved over the years to include other facets of the business including the power generation element. Eskom identified the need for the Endangered Wildlife Trust to assist them in the management of biodiversity in and around power stations across South Africa. Activities include the assistance with the design of biodiversity action plans for all power stations, and guidance on game management, wind farm biodiversity monitoring and biodiversity mainstreaming activities. Additionally, EWT assist Eskom with the management of wildlife interactions across all Eskom infrastructure and through advising on all biodiversity related issues.

KEYWORDS: Powerlines, Partnership, Strategic, Linear, Biodiversity

#3 Building an electrocution risk map with overhead power lines for a critically endangered raptor in Portugal

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The Iberian imperial eagle (*Aquila adalberti*) is a raptor species endemic to the western Mediterranean, classified as Vulnerable globally and as Critically Endangered in Portugal. The species stopped breeding in the country in the 1980s and remained absent for more than 20 years. The population is now slowly but steadily increasing, with 17 couples established in 2018, in spite of facing reduced food resources and high non-natural mortality due to poisoning, illegal hunting and electrocution in distribution power lines.

Nowadays there are proven technical solutions to prevent the electrocution of big raptors in power lines poles. The mitigation measures implemented so far in Portugal targeted territorial adult birds but non-breeding immatures of this long-lived species are the most affected by this anthropogenic mortality source.

This work aims to develop predictive mapping to identify priority areas for immature Iberian imperial eagles. The results can be used to help prioritize management actions to mitigate electrocution risk along the distribution power line network.

Eleven juvenile birds were tracked using Move tech Telemetry's 40g solar GPS / GSM tracking devices, programmed to get a GPS fix every 20-30 minutes. Each bird was followed on average during 235 days, and we collected over 45.000 bird locations. Brownian Bridge Movement Models were used to identify settlement areas, and Maxent modelling was applied to predict areas suitable for non-territorial birds in the Iberian Peninsula.

Our model showed a good fit, indicating that the presence of immature eagles increases with higher levels of aridity, decreases with terrain roughness, and increases with cover by agroforestry systems and shrubs. In Portugal, the most suitable locations for the Iberian imperial eagle are in the interior Southern Alentejo, where there are several distribution power lines poles that pose a high risk for big raptors. These power lines should be targeted in future mitigation actions to prevent electrocutions events from this species.

KEYWORDS: Distribution power lines, Electrocution, Mitigation, Raptors, Predictive modelling

#4 Effectiveness of an anti-bird strike tubular screen in a high-speed railway

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A High speed trains run at speeds over 250 km/h, and birds which coincide in their trajectories are thus unable to avoid crashing or being affected by turbulence provoked by them. The result in the second case can be also death, since destabilized birds may end up colliding with the catenary, other railway structures or the ground. As a consequence, any bird crossing a high speed railway (HSR) through the gap between the ground and the 5.3m high power wire, or among the catenary cables, is under risk and mitigation should aim to avoid such cross-flights.

Traditional mitigation in areas of high interest for birds and in viaducts crossing them has been the installation of protection screens similar to those implemented for noise abatement. The height of such screens is strongly restrained by their aerodynamic resistance to wind and to the piston effect of passing trains, since they are built of continuous or drilled plates. Thus, they are un-frequently more than 2.5m tall and they do not cover but a small part of the risk gap. Taller designs are not feasible due to structural limitations of viaducts, increased costs of maintenance and hazard for trains in case of breaking.

A new design of anti-bird strike screen has been built and its effectiveness tested along a 400m section of HSR in regular use in the proximity of Santa Cruz de la Zarza (Madrid-Valencia line, Spain). The location was selected for its high bird mortality after one-year seasonal monitoring along 10 km of railway, and it consists of a section on an embankment ca. 6-10m high. The prototype is built of independent vertical poles 5.5m tall at 2m intervals in each side of the track so that in front-view the screen has a density of one pole by meter. Even if not a continuous barrier, it is designed under the assumption that birds (at least larger ones) will fly upwards to avoid it and cross the HSR safely above it.

After construction in 2018, the bird mortality monitoring has been replicated, and we present here the data obtained in the location of the screen and in two adjacent areas of the same length and railway topography. Results support a significant decrease (chi-squared test $p<0.05$) of bird mortality in the section covered by the screen, at least for large-bodied species: 8 death birds (20.0 individuals/km) were found in the protected section while the two control sections had 22 and 18 fatalities (55.0 and 45.0 individuals/km respectively). Moreover, all carcasses but one rock dove (*Columba livia*) found in the screen section corresponded to passerines, while in control sections 25 birds of the rock dove size or larger were found (31.2 individuals/km), outstandingly among them *Bubo bubo*.

KEYWORDS: Pole barriers, Bird mortality, Mitigation measures, Collision, Environmental impact assessment

#5 Experimental evaluation of crossing structures used by amphibians along a high-speed railway line

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Amphibians are strongly impacted by large linear transport infrastructure, but knowledge in Railway Ecology is weak or missing. This talk presents several methods used together to evaluate mitigation measure for an amphibian community impacted by a High-speed railway line (HSR). This study take place along of the HSR "Bretagne - Pays de la Loire" in western France, inaugurated in June 2017.

For this HSR, the monitoring of several locations where reduction and compensation measures have been carried out was implemented in 2017. These locations consist of a rather heterogeneous environment mixing several types of habitat with woodlands, pasture meadows and cultivated fields, with presence of ponds historically colonised by amphibians (10 species) in each side of HSR. The crossing of this environment by the new HSR leads to a very strong ecological challenge, especially regarding the amphibian community, i.e. making HSR as transparent as possible for amphibians. The reduction and compensation measures are mostly the building of new ponds in order to maintain the amphibian community dynamics, and crossing structures (tunnels) to maintain the potential exchanges from one side of the HSR to the other.

The crossing structures (hydraulic structures and dry tunnels) were built under HSR with dimensions enough to be able to be used by amphibians. Fine mesh fences have been place to prevent the intrusion of amphibians on the tracks and guide them to the entrances of the crossing structures. Small ponds were dugnear to entrance to increase tunnel attractiveness.

The evaluation of these mitigations measures were carried out with different methods. Four species of newts were monitored with a capture marking recapture protocol (PIT-tag marking) in four locations along HSR. CMR monitoring provides local population dynamics and exchangesbetween ponds in the new network of ponds, including exchanges allowed by the presence of the crossing structures. 4906 individual newts were marked, and 1070 were recaptured along 2 or 3 years. We recorded 123 exchanges between ponds including 10 with HSR crossing.

The use of the crossing structures by amphibians was studying by behavioural experiments. Several tunnels (1 x 1 m) were equipped with 4RFID antennas dispatched in the tunnel. The antennas (1 m x 0.15 m) were set on the tunnel floor and detected the PIT-tagged individuals crossing them. Seven amphibian species were tested, i.e. captured in ponds or closed to the HSR and released at the entrance of the equipped tunnels. Movements of 1296 individuals were recorded in the tunnels. Complete crossing rates vary from 3% for alpine newt to 57% for fire salamander. Other behavioural variables were recorded, such as the mean speeds or trajectories of animals, allowing testing different characteristics (ex: tunnel lengths). We also tested the effect of adding anuran calls in tunnels on the crossing behaviour of both anurans and salamanders.

Tunnels are used by several amphibian species. The exchanges are weak, representing only a small fraction of the population monitored. Crossing behaviour strongly vary among the species, tunnel characteristics and experimental conditions.

KEYWORDS: Amphibian, Movements, Tunnel, Homing, Capture-marking-recapture

#6 Acoustic Animal Deterring Device as a mitigation measure to limit collisions of rail vehicles with wild animals

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In year 2003, on behalf of the Polish Railway Lines, NEEL company started to develop a device to deter wild animals from railway tracks in order to limit the number of animal-train collisions. The device was developed in cooperation with professor Simona Kossak from the Natural Forestry Department, Forestry Research Institute in Białowieża, Poland, a specialist in wild animals' ethology. First devices were implemented on a railway line in 2004.

Wild animals do not regard trains as their natural enemies; they get used to the noise and sight of trains and accept them as part of their environment. Furthermore, the speed at which trains run today exceed the speed that animals have become familiar in course of evolution. Attempt to escape is often undertaken by the animal too late to give it a chance to survive.

Therefore, the acoustic animal deterring devices operate as an early warning for animals. The aim is to stimulate animals, such as roe-deer, red-deer, moose, wild boar, hare and fox, to leave the given site several dozen seconds before a train arrives. The warning consists of about one minute sequence of natural alarm sounds and starts about a minute before the passage of a train. Between passages of trains the devices remain silent and do not pose any barrier for animal movement.

The devices are installed in the usual places where animals cross railway lines, every 70 metres, each one on the alternate side of the railway tracks. The upper part of the device contains an omnidirectional loudspeaker that is positioned 10cm above the head of the rail to ensure omnidirectional sound emission.

Preliminary studies of UOZ-1 devices conducted by the Research Institute of Forestry, and subsequent monitoring commissioned by the PKP-PLK and conducted by team of researchers from the School of Life Sciences in Warsaw proved high effectiveness of the devices in preventing animal-train collisions. The methods include year-round 24-hour video recording, winter tracking and gathering data on animal-train collisions both on railway tracks with animal deterring devices and control areas.

It was shown that both wild herbivorous mammals (deer, wild boars and hares) and predators (foxes) respond to the sound signals first with alertness and finally with escape. During experimental period 84% of animals reacted to the alarm signals preceding train arrival with escape, compared to 68% of animals that escaped from the track area without warning devices. Also, when warned in advance, animal escaped much earlier, i.e. on average 35 seconds before the train compared to just 9 seconds without warning. The studies also implied that animals do not become accustomed to the alarm signals over time.

KEYWORDS: Animal-train collisions, Animal deterring device, Collision mitigation, Railway traffic safety

SESSION 1.3.2. NEW TOOLS AND TECHNOLOGIES TO PREVENT AND MONITOR LINEAR INFRASTRUCTURE IMPACTS – 1

#1 The conflict points between green and transport infrastructure–methodology for the multicriterial assessment

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The barrier effect splits wildlife habitats into smaller and smaller parts due to the continuous development of transport linear infrastructure, until they can lose the ability to host the population which may lead to its extinction. The needs of wildlife permeability have not been considered during the motorway design in the past in CEE countries. There is a lack of will to implement defragmentation measures due to the financial reasons and the projects which really help to restore permeability of migratory wildlife corridors are not always chosen as well.

The identification and evaluation of spatial relations between green infrastructure represented by the defined ecological network, landscape structure and transport infrastructure is the basis for the proposed procedure, which aims to define specific sites at the intersection of this ecological network and major transport infrastructure, which must be addressed as a priority in terms of preserving/restoring the highest possible level of green infrastructure cohesion.

The evaluation procedure is based on the combination of a multi-criteria evaluation with an expert qualitative assessment. The methodology determines the scope of the evaluation, input criteria and the method of calculation. However, given some of the properties of the conflicting points cannot be described using exact numerical values, the determination of their values remains on the expert's qualitative assessment. In order to limit the low transparency of the qualitative expert assessment, guideline tables are added to each of the indices evaluated.

The process of analysis consists of three basic steps:

1. definition of the network of conflict points - spatial overlaps of the given ecological network and major transport infrastructure

2. determination of the severity of conflict at individual points - evaluation of the degree of barrier effect

3. interpretation of results - determination of points' groups according to the severity of potential conflict

It is necessary to individually identify characteristics determining the level of conflict in step 2 for each conflict point. The following criteria are used:

1. degree of road resistance – construction and technical design
2. degree of road resistance – traffic intensity
3. barrier cumulation –other barriers in the vicinity of the conflict point
4. width of the migration corridor
5. environmental index - suitability and significance of the territory for migration
6. other anthropogenic disturbances
7. existing mitigation measures – the existence of a passage of suitable quality

Each of the above-mentioned criteria is characterized by a separate coefficient with the value in the range of ⟨0; 1⟩ except for the width of the migration corridor which may be ⟨-1; 1⟩. The result of each conflict point's evaluation is a dimensionless characteristic ranging from 0 to 1describing the degree of potential conflict at a location.

The analysis was practically verified in the territory of the Czech Republic where 181 critical points were identified, of which 44 were evaluated as places of highly serious conflicts within which the cohesiveness of the ecological sites is endangered by the transport infrastructure. Overall results were also processed into the map output. The practical use of the analysis is primarily within the framework of strategic documents at the national or regional level where a relatively simple assessment of the severity of individual conflicts is required and to emphasize areas where defragmentation measure is necessary.

KEYWORDS: Green infrastructure, Landscape permeability, Conflict points, Multicriterial evaluation, Defragmentation

#2 Automatic acoustic monitoring of wildlife

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Biodiversity is a key indicator of the sustainability of an ecosystem, and a critical factor in our own health. In order to evaluate the impact of conservation strategies, we need to measure this biodiversity. Current methods, based on human observers, are not scalable in space and time. Thanks to recent progress in sensing hardware and machine learning, it is now possible to continuously collect a large variety of data from an ecosystem with a very high spatial sampling rate. More specifically, it has been shown that sound is a good proxy to monitor wildlife, and automatic detection and identification of species through their vocalisations, referred to as Passive Acoustic Monitoring (PAM), is improving quickly.

While PAM has been an active research field for a few decades in the academic world, an industrial-strength solution to efficiently monitor biodiversity through sound is yet to come. At Securaxis, we believe that the underlying technology is ready and we have started to develop the main components of our Nature Sound Box (NSB), namely: the sensing hardware, the audio events detection and identification algorithms and the user interface.

The NSB sensing hardware being intended for outdoor use, it must address strong constraints, including hostile environmental conditions (rain, extreme temperature…), damages by animals or ill-intentioned individuals and likely absence of electrical power or broadband internet. Designing such a device is a great challenge and we are currently exploring various options. In the meantime, and to be able to deploy a prototype in the Spring 2020, we will be using the Audiomoth, a programmable, low-cost, low-energy and full-spectrum acoustic logger designed by Open Acoustic Devices and widely used by the bioacoustics community.

The audio data collected with the sensing device is processed to detect a set of target species. First, an acoustic activity detector, based on morphological image processing of the spectrogram, filters the audio chunks containing acoustic events. This detector is the front-end of the winning solution of the latest BirdCLEF challenge in bird identification and, because it is computationally cheap, it can be easily embedded in the device if needed. The audio events detected are then classified by a deep learning model into one of the target classes. In a first version, used as a proof-of-concept, a simple convolutional neural network trained on the 3 species having the largest number of recordings in xeno-canto.org, a collaborative database of annotated bird recordings, yields a classification accuracy >90%. The prototype under development targets around 10 species and is expected to be performant enough to be usable in the context of ecological studies.

The detection and identification processes might result in a very large amount of raw identification data that is difficult to use as such. In order to explore, visualise, summarize or further analyse this data, Securaxis, in partnership with naturalists, designed the NSB dashboard, a web application allowing an optimal exploitation of the data in different application contexts, and is working on the integration of the NSB in existing wildlife assessment protocols.

KEYWORDS: "machine learning", IoT, Monitoring, Biodiversity

#3 Using evidence-based approaches and evidence customization to improve mitigation practice

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Evidence-based approaches have revolutionised medical practice and are now an integral part of treatment and decision making. However, efforts to protect biodiversity remain largely based on expert opinion and decisions are often made without a robust examination of the evidence base. While this situation is understandable as there are substantial barriers to finding, accessing and using the evidence testing conservation actions, this lack of integration means that actions shown to be ineffective or even harmful continue to be implemented. For example, "bat gantries" were created to allow safe bat movements across roads, but despite being repeatedly been shown to be ineffective they continue to be implemented by consultants. On the other hand, amphibian underpasses remain very poorly understood in terms of actual effectiveness for some groups (e.g. caudates or juveniles). This undermines the reputation of ecological mitigation efforts and damages biodiversity conservation. We use a process we called subject-wide evidence synthesis to systematically scan the scientific literature as well as grey literature and identify studies that test conservation actions or interventions (defined simply as anything a conservationist might do to protect biodiversity). We have scanned over one million studies and we are now including non-English journals and reports. Relevant studies are summarised in plain English, in a transparent and directly comparable manner and their effectiveness is assessed using a modified Delphi technique by groups of international experts. Results are compiled in an annual volume which is freely available, called *What works in Conservation*. It currently provides assessments of the effectiveness of 1600 conservation interventions and numbers are growing every year. Some topics, such as mitigation and conservation measures for bats are now annually updated. Other chapters cover practical conservation of amphibians, birds, primates, peatlands, forests, shrublands and heathlands as well as an extended chapter on control of freshwater invasive species. We are currently developing machine learning tools to assist evidence customisation and tools to facilitate dynamic evidence synthesis that can reanalyse the data for a given context or desired autocome in real time. The accompanying website *www.conservationevidence.com* describes each of the studies individually, and provides full references, at no cost. Reviewed actions include dozens of studies that focus on the effectiveness of actions to mitigate the impact of infrastructure, including roads (e.g. Install overpasses as road crossing structures for bats or Install rope or pole (canopy) bridges for primates), airports (e.g. Scare or otherwise deter birds from airports), electricity transmission lines (e.g. Bury or isolate power lines to reduce incidental bird mortality) or wind farms (e.g. Deter bats from turbines using ultrasound). Evidence of actions is now directly integrated with IUCN Redlist species accounts and over 40 conservation journals have agreed to ask authors to check the evidence for particular actions that they are testing or discussing. We are working to get the database and this approach embeded in a range of policy-making processes (such as the Cool Farm tool) and aim to make the demonstrable verification of the evidence an integral and obvious part of decision making.

KEYWORDS: Mitigation, Evidence-based conservation, Database, Automation, Evidence customisation

#4 BioBIM – Biodiversity, BIM & Infrastructures

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The BioBIM project led by TerrOiko in collaboration with setec, aims at informing and disseminating the technical opportunities offered by the development of Building Information Models (BIM) dedicated to the conception and management of mitigation measures. In this respect, we developed a demonstrator based on an existing BIM model dedicated to the conception and management of a recently upgraded motorway engineering work in eastern France.

In this respect we developed BIM objects in the international interoperable IFC format dedicated to the conception and management of the mitigation measures resulting from the motorway upgrading. The BIM object conception was conducted to answer the following requirements:

Being able to integrate usual datas provided in the current French Environmental Impact Assessment (EIA) and mitigation measures monitoring.

Offering the possibility to integrate embeded species metapopulation dynamics simulations.

Offering the possibility to integrate embeded vegetation growth simulators.

To illustrate these applications, we integrated the existing datas from the site EIA and surveys into the BIM demonstrator, using our newly developed BIM object. We also perform *Lycaena dispar* metapopulation dynamic simulations using SimOiko to evaluate the initial metapopulation functioning and the expected functioning after the motorway upgrading and the mitigation measures achievement. Similarly, we simulate the vegetation growing within the demonstrator site. We thus embeded this two simulators into our BIM demonstrator and managed the input and output data flow using the BIM objects we developed.

Throughout the demonstrator, we illustrated some of the opportunities offered by the BIM to ecological engineering in terms of mitigation measures conception and management, but we also open the field of project management, skills to deploy, further functionalities existing in BIM for building which should be adapted to ecological issues, etc, that could deeply change the way mitigation measures are conceived and survey.

KEYWORDS: BIM, Biodiversity, Infrastructure, Project management, Computer science

#5 The TRANSGREEN Project – Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature – a cross-sectoral contribution to the improvement of permeability of linear infrastructure in the Carpathians

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The Carpathian Mountains represent a biodiversity hotspot in Europe with extraordinary natural treasures. Still, a low degree of landscape fragmentation allows healthy populations of large carnivores roaming the area. On the other hand, the network of highways and railways that connects key areas of Central and Eastern Europe to the rest of the continent has already entered the planning and partly, the implementation stage. As it stands, this substantial infrastructure in the Carpathians threatens to fragment, divide and disturb valuable ecosystems in protected natural areas across the Carpathian Mountains, including Natura 2000 sites. In order to prevent, or at least diminish these threats and pressures on nature, the TRANSGREEN Project aimed to develop an environmentally-friendly and safe transport network in the Czech Republic, Hungary, Romania, Slovakia and Ukraine using the **Mitigation Hierarchy Principle: Avoidance, Mitigation and Compensation**.

From January 2017 to June 2019, TRANSGREEN demonstrated how a multi-sectoral planning process for transport infrastructure development can look when key sectors collaborate; the transport sector represented by motorway companies and ministries of transport; the environmental sector represented by authorities and NGOs; and the research sector represented by institutions, such as transport research centres and technical universities.

TRANSGREEN provided a sound scientific knowledge base, including new data with a focus on the four pilot areas. Ecological corridors were identified, wildlife was tracked and monitored, traffic data was collected, and existing paths along transport routes were analysed. The newly established database served as the basis for the proposal of concrete measures to minimise conflicts between transport infrastructure planning and green infrastructure objectives (Natura 2000, wildlife corridors, road-less areas, etc.).

At the local level, stakeholders were involved in the development of the **Catalogues of Measures for the four pilot areas**.

At the **national level**, multi-sectoral meetings on different topics took place at the ministerial level, e.g.: in Romania, such meetings were organised to elaborate the adaptation of the **Wildlife and Traffic Guidelines** to Romanian conditions.

At the **transnational level**, the Project brought substantial input to the development process of the **Carpathian Convention Joint Strategic Action Plan** related to **the Transport Protocol** that will be up for adoption at the 6th Conference of Parties in autumn 2020.

At the **European level**, TRANSGREEN collaborated with the **European Strategy for the Danube Region (EUSDR) Priority Areas PA1b Road & Rail** and **PA6 Biodiversity** handed in concrete recommendations toward the revision of the **EUSDR Action Plan**. TRANSGREEN was included as a best practice case study in the "Guidance on EU-level Green and Blue Infrastructure Projects." Furthermore, experts representing the **Infrastructure and Ecology Network Europe** (IENE) became engaged and brought in knowledge expertise on the topic that positively impacted the quality of TRANSGREEN outputs.

The collaboration resulted in **Planning Toolkit** comprising "Wildlife and Traffic in the Carpathians" Guidelines on integrated linear transport infrastructure planning addressing planners, implementers and politicians, recommendations to fill the gaps at the policy level, a roadkill registration application and more.

The Project concluded with the Final Conference Declaration addressed to EU, EUSDR and national decision-makers in June 2019.

KEYWORDS: Green Infrastructure, Linear transport infrastructure development, Cross-sectoral cooperation

#6 ICF Ecosystem Connectivity Planning Tool: A Web-based Tool Identifying Opportunities for Improved Ecosystem Connectivity

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Habitat connectivity is essential to maintaining and conserving fish and wildlife species populations and important ecological processes. Species must be able to move to access habitat to feed, breed, seek shelter, migrate, and recover from perturbations. For many species, connectivity is substantially obstructed and fragmented by infrastructure which can result in species population declines and imperilment. Methods to remediate fish and wildlife movement barriers along roadways and other infrastructure have been implemented globally for decades. Wildlife barrier remediation typically involves constructing a combination of wildlife crossings (in the form of culverts, bridges, or standalone wildlife crossings), combined with wildlife fencing. Fish passage barrier remediation typically involves engineering culverts or bridges with appropriate size, slope, velocity, and substrate to accommodate fish passage. These measures ensure fish and wildlife can access historical habitats and allow safe movement across roadways and other infrastructure. For both fish and wildlife this remediation results in improved access to feeding, breeding, and shelter and constitutes important conservation actions which facilitate continued species existence and conservation. Despite our understanding of the importance of species movement and habitat connectivity and our global progress in incorporating fish and wildlife connectivity considerations into standard practices, there is room for improvement to ensure that fish and wildlife connectivity are adequately considered and that wildlife movement is integrated into fish passage barrier remediation projects. Interestingly, fish and wildlife barrier remediation efforts have largely been conducted within separate subdisciplines and largely uncoordinated with one another. For instance, many fish passage barriers also experience adjacent wildlife-vehicle collisions (WVCs) and are in locations which warrant improved wildlife crossing design considerations. Additionally, infrastructure development projects may also miss opportunities to remediate WVCs and fragmentation if proper assessments and data review have not been conducted. These opportunities are demonstrated with our proof of concept Ecosystem Connectivity Planning Tool which identifies locations which warrant consideration of wildlife passage assessment and design considerations. The tool identifies locations where fish and wildlife movement are impeded and where wildlife-vehicle collisions (WVCs) and public safety are also a concern. The tool allows for deep exploration and visualization of WVC and connectivity data including multi-scale hot spot and cluster analytics, ecological data, infrastructure planning data, and more. Priority locations can be easily located within the tool's viewer facilitating locating and prioritizing locations for wildlife connectivity enhancements. The tool is highly customizable to allow the objectives and priorities of each user to be integrated and adapted. Such tools provide a simple to use and cost-effective way to identify and prioritize connectivity enhancement opportunities early in the planning process to facilitate connectivity for a larger suite of species, improve road safety, and prevent further lost opportunities in enhancing and restoring habitat connectivity.

KEYWORDS: Connectivity, Roadkill, Wildlife-Vehicle Collision, Fish passage, Analytics

SESSION 1.3.3. ROADS AND MAMMALS: ECOLOGICAL IMPACTS AND SOLUTIONS

#1 Effectiveness of wildlife fences in reducing Key deer road mortality on the Florida Keys, USA; the importance of implementing mitigation measures at the appropriate spatial scale

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We investigated Key deer mortality data on the Florida Keys, USA, between 1966 and 2017 and found that about 75% of all reported Key deer mortalities were related to collisions with vehicles. We investigated where the greatest concentrations of Key deer-vehicle collisions were after the eastern section of US Hwy 1 on Big Pine Key was mitigated with a wildlife fence, 2 underpasses, and 4 deer guards. We also investigated the effectiveness of these mitigation measures in reducing Key deer-vehicle collisions. The wildlife fence and associated mitigation measures along the eastern section of US Hwy 1 on Big Pine Key were highly effective (81.3-93.9%) in reducing Key deer-vehicle collisions along that road section. However, there was an increase in collisions in the unmitigated section of US Hwy 1, both in absolute numbers and expressed as a percentage of the total Key deer population size. Thus, the overall Key deer road mortality on US Hwy 1 was not reduced but it was moved from the mitigated section to the unmitigated section of US Hwy 1. After mitigation, a significant hotspot of Key deer-vehicle collisions appeared at the western fence end indicating a "fence-end run". Additional significant Key deer-vehicle collision hotspots occurred further west along the unmitigated highway section on Big Pine Key. The results illustrate the need to implement measures at the appropriate spatial scale. In order to reduce the overall number of Key deer-vehicle collisions along US Hwy 1, the entire section of US Hwy 1 on Big Pine Key would need to be mitigated. Ideally, the wildlife fence should be extend to the western side of Big Pine Key with additional safe crossing opportunities for Key deer and other wildlife species. However, the western section of US Hwy 1 that is currently unfenced has many buildings and access roads for business and residences. Rather than recommending a particular mitigation option for this road section, we summarized the pros and cons of eight different strategies aimed at reducing Key deer-vehicle collisions along the developed section of US Hwy 1, including a "No Action" option.

KEYWORDS: Collisions, Deer, Effectiveness, Fence, Mitigation

#2 Dry pathways and flowing water within culverts jointly promote crossings by carnivore mammals

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Roads are linear infrastructures causing high wildlife mortality. Transportation administrations make large investments on mitigation measures to promote safe road crossings by wildlife. Yet, many roads worldwide rely on culverts as the only passages available for fauna even though they were primarily designed to drain water. Indeed, culverts inundate repeatedly, becoming unavailable to most terrestrial fauna during rainy periods. How much this pervasive flooding affects the crossing of culverts by animals remains unknown. This was addressed in an Action of the LIFELINES project (LIFE14 NAT/PT/001081) focusing on the effects of flooding on mammal crossings. In this context, we covered wet and dry seasons along three national roads in the Alentejo region of southern Portugal, to understand if water-related variables (pathway dry width, water cover, and water depth at crossing time) explain differences in the probability of crossing by medium-sized carnivore mammals and if they are correlated with crossing frequency too. We also wonder whether crossing frequencies would be similar between seasons. We hypothesized that carnivores would overall be less likely to cross and cross less often if the culvert had more water (e.g., narrower dry width), possibly leading to more crossings during the dry season. To assess carnivore crossings, we installed track stations inside 30 drainage culverts (out of 307 crossing passages inventoried), which were spaced 2 km apart along the roads. According to the degree of flooding, the plates were raised using roof tiles and stone blocks up to 10 cm or lowered when the culvert was drier. We also developed an evaluation to distinguish animal visits to the culverts from actual crossings and used only the latter for analysis.To further validate our crossing assessments using track stations, we concurrently used infrared cameras in 20 of the culverts. We recorded 1211 crossings, averaging 0.96 and 1.01 crossings / day over the wet season and dry season, respectively. Egyptian mongoose (*Herpestes ichneumon*), European badger (*Meles meles*), Common genet (*Genetta genetta*) and Eurasian otter (*Lutra lutra*) were the species that crossed most. Except for otters, as expected, greater dry widths increased both the probability and the frequency of crossings through the culverts. Dry width was the only significant predictor for the probability of crossing by genets. From our model for all species combined, enlarging the dry width from 0.5mup to 1 or 2m increased the probability of crossing by ~11% and~35%, respectively. Surprisingly, the presence of flowing water within the culverts also correlated positively with crossings by most species in addition to the positive effect of the increase in dry width. For the species most represented in our study, the Egyptian mongoose, contrary to expectations, was more likely to cross culverts when they had ~30 to ~60 % water cover than when they were drier. The significance of the difference in crossing frequencies between wet and dry seasons varied with the species. Broadly, our results show that flooding degree and dry width together influence the probability and frequency of crossing by these carnivore species.

KEYWORDS: Mitigation measures, Road ecology, Dry ledges, Fauna passage, Wildlife corridors

#3 Why, When and How Giant Anteaters Cross Roads? Understanding Impacts and Effects of Roads on Giant Anteater Populations

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A The main goal of the Anteaters & Highways Project is to understand and quantify the impacts of roads – road-kills and barrier effect – and their consequences for Giant anteater densities, population structure and health; and to define landscape and road management strategies to prevent potential Giant anteater local population extinctions in Mato Grosso do Sul, Brazil. Entering in its final year, we provide in this talk an overall summary of the main findings and how they will be used to delineate regional planning toward the mitigation of road impacts on this Vulnerable species. So far, we have surveyed ca. 77,000 km (transects totalling 1,337 km, surveyed every 2 weeks), in which we recorded 10,194 roadkills, including 689 giant anteaters. We tracked 44 giant anteaters, of which four were road-killed during the study. The movement data allowed us to identify different individual behaviours toward roads, which vary significantly with traffic volume (lower crossings in high traffic road). Yet, a great variability of behaviours was observed, reflecting individual reactions to road presence, ranging from frequent crossings to absence of crossing events. Face-to-face structured interviews were conducted with truck drivers (n=126) to collect information about the human dimensions of wildlife-truck collisions. Necropsies performed in 59 giant anteaters allowed us to test if health and body condition were affecting the roadkill likelihood. Finally, ongoing estimation of animal density near the studied roads will allow us to model the impact of roads on giant anteater population persistence using population viability models. Such output is being processed, but preliminary results suggest a significant impact on population viability. Overall, the project outputs suggest that the giant anteater populations are at risk, and the ongoing expansion of the road network may constitute a serious threat to its persistence in Brazilian Cerrado. Careful road planning and mitigation, integrating the information of land use changes and human population is needed, particularly in Brazilian Cerrado in face of the new massive infrastructures planned to be built therein.

KEYWORDS: Population persistence, Population viability, Roadkill, Animal movement, Brazil

#4 New approaches to avoiding and mitigating the effects of streetlighting on bats

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Artificial light in the nighttime environment has increased massively over the last 50 years, with much of this increase being derived from road lighting. Many species of bats are highly light averse, but must travel large distances to reach foraging and roosting areas. Streetlights have been shown to adversely affect bat behaviour close to roosts, however the implications of lighting in the wider landscape are less clear.

Greater and lesser horseshoe bats are given strong protection under Annexe II of the habitats directive. This means that there is an obligation to ensure that new linear infrastructures, or changes to existing ones, do not impact on local bat populations. Using extensive acoustic surveys in paired lit and unlit locations in the UK, we have shown that bat activity is significantly depressed in lit locations across the landscape. Further, the effects of light interact with those of road type, with lights on minor roads have a greater impact than those on major roads. This suggests that the current focus of resource towards monitoring and mitigating for lighting on major roads may be misplaced.

To assist planners in understanding and avoiding these negative impacts of these road-related pollutants, we have developed a spatially explicit modelling system, based on Circuit-theory, which enable users to assess the impacts of roads of different types, and of potential mitigation measures, on the movements of bats. Finally, we have also formally assessed, through controlled experiments at 6 study sites in the UK, the potential value of red, rather than white, LED streetlights as a mitigation technique in situations where street lighting cannot be avoided entirely.

KEYWORDS: Lighting, Bats, Modelling, Spectral composition, Mitigation

#5 Effects of roads on European badger occurrence in intensively used Mediterranean farmland

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Understanding how transportation infrastructure affects wildlife is a key goal in conservation biology. This goal is particularly relevant in intensively used landscapes, where species are potentially impacted both by roads and the scarcity of suitable natural habitats. We investigated how road density and landscape composition and configuration affect the occurrence of the European badger (*Meles meles*) in intensively used Mediterranean farmland. Although most studies documenting road impacts on carnivores species in Mediterranean areas have been largely focused on the factors driving mortality at roads or habitat use near and far from roads, few have explicitly assessed how road density impacts species occurrence, particularly in intensively used farmland, where their preferred native woodland habitats are relatively scarce. Based on badgers' presence signs surveys conducted in three occasions (spring, summer and autumn) across 60 landscape units (3.14-km^2 circles) scattered through SW Portugal, we used occupancy-detection modelling to quantify the effect of paved road density on the occurrence of the species in intensively used Mediterranean farmland. In addition, we tested the prediction that forestry plantations and hedgerows embedded in the agricultural matrix should in turn result in increased probabilities of badger occupancy, as these habitats should provide substitute refuge areas for the species. According to our predictions, badger occupancy significantly decreased with increasing paved road density, and increased with increasing amount of forestry plantations and arboreal hedgerows. These results suggest that badger conservation in intensively used Mediterranean farmland requires the protection of areas with low road density, and the retention of wood cover, even where these are mostly forestry plantations and arboreal hedgerows.

KEYWORDS: Agricultural landscapes, Carnivores, Land use cover, Road effects, Tree plantations

SESSION 4.1.1. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 1

#1 Infrastructures, human activities and biodiversity in co-evolution: the examples of Upper-Rhine, Danube and Inn

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Humans have strongly shaped rivers, notably by constructing hydro power plants, dams, roads, railways, waterways, and harbours. Therefore, river spaces present particularly interesting cases when it comes to exploring the triple relationship between infrastructures, human activities and biodiversity. The ongoing "Interconnect" study focuses on six small-scale zones located in two river systems: (i) the French-German Upper Rhine area between Karlsruhe and Basel, and(ii) Danube and Inn in the region where these rivers form the border between Germany and Austria. Our work analyses the progressive expansion of energy and transport infrastructures in these river spaces and how these have been involved both in the development of human activities and in biodiversity changes. To explore this question, we aim to fruitfully combine two kinds of data. First, biodiversity changes from the early 1950s until around 2015were assessed through a substantial interpretation and digitalization of aerial and satellite pictures, focusing on the evolution of riparian forests. Specific metrics were developed, using the multiplying coefficient (Cm), which is calculated between the oldest date (1950/1951) and the most recent date (2010-2015-2016).Second, we analysed how human activities in the selected areas have changed with the expansion of infrastructure networks. For this, we mainly drew on the data from around 30 collective and individual interviews and on historical pictures gathered in archives.

Our data indicates that infrastructures area crucial (but not the only) element for explaining both, the evolution of biodiversity and the dynamics of multiple human activities, which are organized with and around such infrastructures. Regarding human activities, we found that the construction and expansion of transport and energy infrastructures have not only served the original, economic purposes (freight shipping, electricity generation) but also strongly affected the performances and spacing of leisure time activities such as fishing, rowing or biking. With respect to the changes of riparian forests, our results show that forest surfaces in all sites except one have overall stagnated or, in the case of two sites, even increased ($Cm \geq 2$).Using transition matrix modelling, we found that waterways, power plants, their water reservoirs, harbours, and settlements have occupied substantial previous forest zones, while former abandoned or sold agriculture spaces and green lands have progressively turned into new forest areas. However, for four out of six sites those forests are more fragmented and "hard" transitions to infrastructures or settlements are more frequent than before. In addition, it remains unclear to which degree today's forests still resemble former alluvial forest and thus are able to fulfil similar ecological functions supporting rivers' ecosystem services.

Bringing together findings from biodiversity and activities research on our six sites, we suggest distinguishing three ideal types of infrastructure-activities-ecology-arrangements. First, in "zoning" constellations, economic activities, in particular freight shipping and electricity generation, leisure time activities and biodiversity restoration tend to be spatially and institutionally separated. Second, in "activity coexistence" settings, economic and leisure time activities have co-evolved in largely harmonious relationships with and around infrastructure networks, however potentially at the expense of ecosystems, which experience increased use pressure. Finally, in a third arrangement, first attempts have been undertaken to reconcile all three societal objectives, economic development, a high quality of life for residents, and biodiversity restoration. This happens in particular by rewilding artificial river banks and re-inserting gravel banks which not only support biodiversity recovery,in particular fish reproduction, but also present very attractive areas for leisure time activities, without interfering with economic activities.

KEYWORDS: Rhine and Danube, Human activities, Alluvial forests, Transport and energy infrastructures, Historical evolution

#2 Biological control of invasive Tree of Heaven *(Ailanthus altissima)* along linear infrastructures using Ailantex®

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Tree of Heaven (*Ailanthus altissima*) is an invasive tree species with a high rate of dissemination and the potential to replace indigenous plants. It has become a major problem on ruderal areas, fallow land, and nature reserves, in forests as well as on disturbed urban land in the warmer climatic zones of Europe and all other continents. Within the last decade, Tree of Heaven increasingly has become established along linear infrastructures in many European countries and is nowadays abundantly found along railway tracks, roadways, waterways and electric power lines. There it causes problems due to its very fast growth and extensive reproduction by stump sprouts and root suckers, which require frequent and recurrent control measures. Due to its high root growth force and its low requirements concerning soil quality, site and climate, *A. altissima* also poses a threat to infrastructural constructions such as bridge foundations, retaining walls, road-, river- and railway-embankments and sometimes it even grows out from brickwork or sprouts between pavement and the foundation of constructions.

However, mechanical treatment such as partial girdling of *A. altissima* is expensive and often unsuccessful. A treatment with chemical herbicides (e.g. stem injections with Glyphosate) is not a desirable option in various areas (e.g. near water protection areas, national parks or conservation areas) and often did not result in mortality of trees. Thus, a new biological control method was developed at BOKU-university that allows an efficient, inexpensive and sustainable control of Tree of Heaven. The method is based on the mycoherbicide Ailantex®, which contains a fairly specific isolate of the wilt-inducing fungus *Verticillium nonalfalfae*, originally obtained from wilting *Ailanthus*-trees in Austria.

Ailantex® was successfully applied on sprouts, saplings and mature *Ailanthus*-trees on road-, river- and railway-embankments. The mycoherbicide is directly inoculated into the living sapwood using a gouge and syringe for inoculum application and utilizing the tree transpiration system for the uptake of the conidial suspension. For the inoculation of a high number of trees, other easy-to-manage application techniques such as Hypo-Hatchet® Tree Injector and BITE („Blade for Infusion in TrEes") are available and have already been successfully tested. Wilt and dieback of *Ailanthus* occurred within 4 – 6 weeks after treatment with Ailantex®, mostly followed by tree mortality in the same or in the following year. Currently, the effectivity of Ailantex® is tested for the first time on Tree of Heaven formerly treated with Glyphosate on a track area of the SBB (Swiss Federal Railway).

Due to the fact that experimental as well as field studies with Ailantex® showed promising results whereas none of the tested "non-target" species exhibited any symptoms of Verticillium-wilt so far and because effective alternative approaches for the control of Tree of Heaven are lacking, Ailantex® was approved in Austria as plant protection product according to article 53 para. 1 of Regulation (EC) No 1107/2009 in 2017, 2018 and also in 2019. Such an "emergency authorization" will be applied for also in other European countries in order to make it available there until the final goal of the approval of Ailantex® as bioherbicide/arboricide according to EU-regulations has been met.

KEYWORDS: Biological control, Tree of Heaven, *Ailanthus altissima*, linear infrastructures, Ailantex

#3 Citizen participation improves the quality of green infrastructure at road verges in Poland

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A Trees accompanying transport infrastructure are an essential part of green infrastructure in many European landscapes, both urban and rural. In these anthropogenic environments, they help to maintain biodiversity and ecological equilibrium as habitats and ecological corridors. Insects, birds, lichens, fungi, and mammals use avenues and other trees in open environments and urban areas. The role of roadside trees as green infrastructure for biological diversity is increasingly appreciated by the general public and city authorities. Also, their contribution to climate change adaptation and mitigation is gaining more and more recognition.

However, in Poland, too many infrastructure managers overlook the services provide to the society. Numerous road authorities and municipalities still view trees as a nuisance and an obstacle to modernisation rather than as an asset. Roadside trees have been disappearing in recent decades from roads and streets due to hasty upgrade of infrastructure and mismanagement. Replanting has been insufficient. Relaxation of Poland's tree removal permitting procedures in early 2017 led to a felling spree by private land owners. All these sparked a lively grassroots movement in support of trees. Civil society (grassroots) initiatives were born mostly in cities but also in small towns and villages. Not being able to count on local or central governments, groups of citizens are standing up for trees. A measure of this phenomenon is the number of interventions by the tree conservation help desk at the Foundation for Sustainable Development: it tripled between 2016 and 2017.

In Wrocław, civic movement forced the City Hall to reverse its' lax policy on green spaces that favoured development over trees. Lately, public outcry over mismanagement of a park leads to a more nature-friendly maintenance of parks and road verges (differentiated mowing regimes to foster biodiversity and adapt to climate change).

A citizen's initiative in a small town of Brwinów forced the mayor to redesign a road renovation project to retain a popular lime avenue. A similar process is under way in ObornikiŚląskie.

Under public pressure, the authorities of the capital city of Warsaw, redesigned the Green Spaces Department and charged it with the task to create procedures and guidelines for tree management.

The Foundation for Sustainable Development supports grassroots activism in defence of trees. The activities of the Foundation for Sustainable Development to protect roadside trees gained momentum in 2009, with launching of the Roads for Nature programme. Three thousand tree officers and road service employees were trained and avenue management strategies were created in 90 communes, tree management manuals were published. Civic activism was supported across the countries through holding Tree Friends Fora and trainings. Currently, the work continues in the framework of the “Trees for Europe’s Green Infrastructure” project, with focus on creating standards for tree management. Both projects were possible thanks to support of EU LIFE+ programme and to cooperation with a German partner: BUND Mecklenburg-Vorpommern.

KEYWORDS: Public participation, Green infrastructure, Roadside trees, Avenues, Trees

#4 Factors driving the distribution of an amphibian community in stormwater ponds: a study case in the agricultural plain of the Bas-Rhin, France

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A During road construction, stormwater ponds are created to ensure sanitation, water treatment and the containment of any accidental pollution. These environments are not intended for use as habitats, so exclosure measures are implemented to prevent animals to gain access to them. However, the modification of the natural landscape for human needs resulted in the disappearance of most wetlands. Our hypothesis was that depending on the water pollutant concentrations, the stormwater water ponds could serve as refuge habitat for wetlands species like amphibians.

Thus, we evaluated the suitability of stormwater ponds as a habitat for amphibians by studying 82 such structures in the agricultural plain of the Bas-Rhin. The proportion of stormwater ponds hosting amphibians and specific species abundances and richness were quantified. Factors such as pond design, pollutants, land use and exclosure measures were used to explain the community characteristics of stormwater ponds. Significance of factors was assessed by Boosted Regression Tree models. Species dependent effects were studied using detrented correspondence analysis.

Amphibians were found in 84% of stormwater ponds, with an average 19.51 adults and 2.44 species per pond. We found 83% of the species recorded in the Bas-Rhin, including rare and protected ones.

Neither exclosure measures nor pollutants were correlated with community and species characteristics. The best explanatory factors were land use and pond design. The surface and the perimeter size of ponds were positively correlated with amphibian abundances. Some pond equipment were mortal traps for amphibians but also for other species. Ponds with temporary water were mortal traps for larvae during droughts. Among land use factors, a strong barrier effect of road was observed when ponds were surrounded by them. An unexpected positive correlation was observed between amphibian abundances and areas of annual crops, suggesting a refuge effect when no semi-natural ponds are available in the landscape.

For ponds with similar pollutant concentrations to those observed in this study, we recommend reallocating the efforts made for exclosure measures to pond design and to the creation of semi-natural ponds as additional compensatory measures. Design of stormwater ponds should be systematically validated by a herpetologist to avoid creating mortal traps. Ponds should be large and have a permanent minimum water level even in droughts.

KEYWORDS: Refuge habitat, Retention ponds, Pollution, Modified landscape, Farmlands

#5 Maintenance of ecological asset on transport infrastructure: new chapter in the online 'Wildlife and Traffic' handbook

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Long-term preservation of the functions of ecological assets in transportation infrastructure requires new multidisciplinary approaches in traditional road and railway operation and maintenance. The increasing number of accidents due to animal-vehicle collisions, as well as environmental legislation demands and awareness of the effects of biodiversity loss have led to the development of a wide range of ecological assets in recent decades.

Guidelines that help practitioners involved in infrastructure operation to properly maintain these ecological assets are crucial to preserve their role in relation to traffic safety and to reduce wildlife mortality and disturbances. Moreover, they should contribute avoid the spread of invasive alien species, maintain ecological connections across linear infrastructures and support the provisions installed or constructed to enhance biodiversity on elements of the infrastructure. Best maintenance practice must also help to get the best value for money invested in ecological mitigation and to improve future design, construction and maintenance practices for ecological assets.

Based on a literature review and information gathered in research projects funded by the Conference of European Directors of Roads (CEDR) Roads and Wildlife Programme Executive Board, a set of guidelines have been produced. The instructions are focused on best maintenance practices for wildlife fencing and screens, wildlife crossings, wildlife warning signs and detection systems and appropriate management of verges, retention ponds and other elements of drainage systems are addressed to enhance the value of these elements as wildlife habitats while preventing them from becoming ecological traps. The actions should help to meet legal obligations, particularly regarding the management of road and railway sections crossing protected areas or landscapes hosting valuable flora and fauna species and ecosystems. The guidelines also encourage cooperation with all stakeholders involved in the management of land adjacent to infrastructure. Some examples are nature, water and land planning administrations, municipalities and local communities, landowners, and non-governmental and research organisations.

The guidelines have been developed by an interdisciplinary team including both transportation and wildlife experts, with strengthened cooperation between the CEDR and the Infrastructure and Ecology Network Europe (IENE) organisations. The output is being included as a new chapter in the online 'Wildlife and Traffic European Handbook' prompted by the IENE and including the document produced 15 years ago in the COST 341 Action, as well as a portal to access handbooks on transport infrastructure and ecology published worldwide. The Handbook is focused on identifying conflicts and providing solutions to mitigate habitat fragmentation due to transportation infrastructures, and is now being updated under the initiative of the IENE in cooperation with CEDR and supported by the Swedish Transport.

KEYWORDS: Ecological asset, Maintenance, Mitigation, Verges, Guidelines

#6 Introducing 'www.TransportEcology.info': An online, open access resource to globally share information, knowledge and experience in ecologically-friendly linear infrastructure

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There is much concern globally about the current and proposed massive investment in linear infrastructure development. An additional 25-million lane km of new roads will be built by 2050, and 90% of this will be in non-OECD countries, and railways, pipelines and power lines are similarly expanding. Much of this expansion is occurring within formal protected areas as well as in other areas with high levels of biodiversity. Of significant concern is that many countries and regions lack the expertise, resources and experience to implement ecologically-friendly infrastructure development.

Two of the greatest challenges to achieving ecologically-sustainable roads, railways, pipelines, power lines and canals are (1) a lack of knowledge and awareness of best practise by governments and industry and (2) being risk averse – not wanting to be the 'first' to try something if it is expensive or if it is perceived as having a high risk of failure.

www.TransportEcology.info will be a freely accessible resource for linear infrastructure planners, designers, ecologists, engineers, funders, approvers and construction teams to incorporate world's best practise in their projects. Importantly, this project will also give the same information to the general community, informing them of new initiatives and world's best practise, thereby allowing them to genuinely participate in the decision-making process.

Description

TransportEcology.info will be comprised of three primary components, namely (1) research summaries on latest findings in road ecology; (2) best practice information on how, when and where to avoid, minimise and mitigate impacts; and (3) mitigation case studies. Additional streams that may be developed include discussion forums, industry contacts etc.

Research Summaries: will summarise peer-reviewed journal articles and reports that describe research findings using a blog-style approach. These research summaries will ensure that the key findings of important research are visible and accessible to practitioners, and not hidden behind paywalls and scientific jargon. Research summaries will be written in a conversational scientific style and will 'tell a story' that practitioners who are planning, designing, building or managing roads and other linear infrastructure need to know about. The summaries will include links to the published research and other source material, allowing people to find and download the primary publications if interested.

Best practices: although there is an abundance of publications on the impacts of linear infrastructure and use and effectiveness of mitigation, there is comparatively little on how, when and where to 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.

Mitigation Case Studies: will be written to 'tell a story', using a blend or combination of both a 'conversational' style and a 'scientific' style. 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 will include references to provide supporting information or evidence sources (where relevant).

In this presentation, I will describe and officially launch www.transportecology.info and invite participation from IENE delegates.

KEYWORDS: Open-access, Linear infrastructure, Resources, Training, Website

SESSION 4.1.2. NEW TOOLS TO MONITOR ECOLOGICAL IMPACTS OF LINEAR INFRASTRUCTURES

#1 Evaluating the impacts of highway mitigation measures for fish connectivity using radio-telemetry and RFID PIT-tagging technologies in France

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Since the 1950s France has developed a large highway network; this was identified over the last decade as being responsible for breaks in terrestrial and aquatic ecological continuity.

Starting in2010, Vinci Autoroutes has undertaken work to reduce the impact of river structures on fish migration: removal of sills, construction of fishways, and specific equipment for crossing culverts. These devices are rarely evaluated in terms of the ecological gain generated. As a result, VINCI Autoroutes have undertaken investigations dedicated to the objective assessment of these potential gains. Two sites were the subject of this study.

The first concerns a 104-meter long culvert equipped with macro-rugosities on a small river, the Durolle (Auvergne region, central France). The target species is brown trout, who are likely to migrate at different stages of their life cycle, especially on small spatial scales. The second site is located on a large river, the Allier (Auvergne region, central France), where a highway bridge is equipped with a stabilization weir. This weir has recently been fitted for the passage of all fish species (partial levelling and integration of an asymmetrical rough ramp). Here, the target species is Atlantic salmon, who achieve a unique, long and perilous an adromous reproductive migration.

Two distinct technologies were used to address the morphology of the two species, to adapt to the spatial dimensions of the studied environments and to accurately answer the posed questions i.e. are the culverts passable, and what are the crossing times of the partially levelled dam of the Allier?

Passive telemetry (RFID) was chosen for the trout in the Durolle river. Over 800 individuals of all sizes were equipped with 12 or 23 mm pit-tags. The monitoring device for the culvert crossings was based on two fixed antennas ("passover" type) placed at the outlet upstream of the culvert. Seven mobile surveys were also carried out over a period of 2 years (2017 to 2019) to cover the study area (400 m upstream, 1,700 m downstream of the culvert).

Active telemetry (radio-tracking) was selected to track 24 salmon movements on the Allier river. Individuals were trapped and marked intragastrically. The study area, spread over about 60 kilometres, was equipped with 8 fixed monitoring stations in order to precisely limit the study area and to frame the river transverse structures. Mobile surveys on foot and by boat were used to track tagged salmon between fixed stations. The study period lasted 9 months (2019).

The operating principles of the two technologies will be presented, as well as the experimental designs that were implemented on each of the sites.

On the Durolle river, the crossing of the culvert seems to be effective over the whole period monitored. No selection on trout size was observed and crossings were mainly recorded at low flow rates. On the Allier river, the results show that the delay effect of the weir was eliminated following the works. The rates of progress of the salmon marked at the weir are comparable to the rates observed on natural areas without any structure.

Beyond the technology and the biological results, it will be interesting to explain the teachings obtained with regard to the functionality of 2 types of works, frequently encountered on the highway network in France. These results will make it possible to evaluate the actions and investments involved and will serve as feedback for future developments.

KEYWORDS: Fish, Telemetry, RFID, Ecological gain, Highway-river crossings

#2 Monitoring the expansion of alien species along roads with remote sensing

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Invasive species are one of the most important threats to biodiversity and ecosystems. Monitoring invasion status is necessary for the implementation of mitigation measures and conserving biodiversity. Remote Sensing (RS) is the best Earth Observation tool for monitoring biodiversity as it provides data at several spatial and temporal resolutions. We used RS data and techniques to monitor the expansion along roadsides of five invasive tree species and giant reed (*Acacia dealbata*, *A. melanoxylon*, *Robinia pseudoacacia*, *Ailanthus altissima*, and *Arundo donax*). We hypothesise that roadsides are the main path of expansion for invasive species in Mediterranean landscape, and that the expansion is human mediated, as lands along roads have a strong agricultural management.

The study area was located in the intervention area of the project Life LINES, one of the main transport routes between Portugal and Spain. We used aerial photographs from three different periods: 1995, 2010, and 2016. The 2016 set had a spatial resolution of 0.1 m, and Red-Blue-Green (RGB) and infrared bands. The 2010 and 1995 sets had a spatial resolution respectively of 0.5 m and 1 m and RGB bands. We obtained training data for each invasive and native species with a real-time kinematic GPS receiver. The aerial photographies were segmented using the multi-resolution algorithm and an object-oriented classification (Nearest Neighbour classifier) in eCognition Developer software. The photographies were posteriorly classified through a sequential process. We did a first classification to exclude all the non-vegetation objects (e.g. roads). Then, we did a second classification to classify the five invasive species and other plant species. We assessed classification accuracy with the overall accuracy and Kappa index metrics.

Invasive species expanded in the study area between 1995 and 2016 along the roads, mainly close to anthropic areas. In the last 6 years (2010-2016), *A. donax* expanded more than the other invasive species. In some cases, the invaded area duplicated between 1995 and 2016. During this period, human management hampered the expansion of invasive species by cutting down individuals.

Remote Sensing proved to be an efficient tool to measure expansion of invasive species along roadsides with an easy and replicable method. Our results are essential to plan the management of roadsides.

KEYWORDS: Monitoring, Invasive species, Aerial photography, Expansion patterns, Temporal data series

#3 Mobile mapping system (MMS2) for detecting Roadkills

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Roads affect negatively wildlife, from direct mortality to habitat fragmentation. Mortality caused by collision with vehicles on roads is a major threat to many species. Monitoring animal road-kills is essential to stablish correct road mitigation measures. Many countries have national monitoring systems for identifying mortality hotspots. We present here an improved version of the mobile mapping system (MMS2) for detecting Roadkills not only for amphibians but small birds as well. It is composed by two stereo multi-spectral and high definition camera (ZED), a high-power processing laptop, a GPS device connected to the laptop, and a small support device attachable to the back of any vehicle. The system is controlled by several applications that manage all the video recording steps as well as the GPS acquisition, merging everything in a single final file, ready to be examine by an algorithm at posterior. We used the state-of-the-art machine learning computer vision algorithm (CNN: Convolutional Neural Network) to automatically detect animals on roads. This self-learning algorithm needs a large number of images with alive animals, road-killed animals and any objects likely to be found on roads (e.g. garbage thrown away by drivers) in order to be trained. The greater the image database, the greater the detection efficiency. This improved version of the mobile mapping system presents very good results. The algorithm has a good effectiveness in detecting small birds and amphibians.

KEYWORDS: Roadkills, Life Lines, AI, Machine Learning, Mobile Mapping

#4 Improving Wildlife Fencing for Herpetofauna to Ensure Effective Implementation: An Analysis of Global Mitigation Case Studies

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A Wildlife fencing is used as a global mitigation solution for herpetofauna species to prevent road kill. 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 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 and often end up being fined, delayed or paying for repairs.

Through collaboration and private-public partnerships we have analysed 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, Herpetofauna, Mitigation, Best Management Practise, Innovation

#5 A simulation of WVC underreporting to hotspot spatial stability

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Reliable localization of wildlife-vehicle collisions (WVCs) hotspots is an important safety issue. One of the most promising methods addressing this issue is the KDE+ method. Since underreporting (i.e., missing data) is a frequent problem in many databases, the stability of the method is an essential feature. Furthermore, a stable method should also be able to eliminate possible mistakes in the database. We focused on the stability of the KDE+ method with respect to "spatially random" underreporting in the database of WVCs.

The Czech road network in question consisted of 28,028 km. The WVC database contained 55,150 records which occurred over the period 2009 – 2018. Each WVC was localized by a police officer with the use of a GPS device.

The KDE+ method identified 6,635 statistically significant clusters (hotspots) containing 42.5 % WVC and covering 3.17 % of the road network. We consequently performed a simulation study to estimate the effect of underreporting for these results. The strongest ten percent of hotspots were examined for their positional stability (i.e., hotspots remaining at the same location) while one or several WVCs within the same road section were spatially removed randomly. More specifically, we performed 1,000 simulations for each step related to random WVC data removal.

The results demonstrated the stability of the KDE+ method with respect to underreporting and possible errors in a database. Almost all the most important hotspots were likely to be identified when underreporting was below 25%. However, even if under reporting up to 57 % occurred, the majority of the most important hotspots were still likely to be found. Additionally, more important clusters were less prone to disappear when some records were missing in the database. In other words, more important hotspots were more spatially stable. These results support the KDE+ application for underreported data.

KEYWORDS: KDE+, Clustering, Underreporting, Stability, Hotspots

SESSION 4.2.1. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 1

#1 Monitoring a mature ecoduct: Intensive camera surveillance confirms significant increase in crossing rates and diversity after 13 years

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Assessing the use and effectiveness of crossing passages is typically limited in duration and typically occurs early in the life of the structure. We have been actively monitoring a major fully-vegetated fauna overpass in subtropical Australia continuously for 15 years. This has included specific studies of terrestrial mammals, arboreal mammals, birds, reptiles and amphibians and most recently, microbats. During this time, the planted vegetation growing on the structure has developed dramatically to now closely resemble that of the forests on either side of the road. As well as the comprehensive fauna surveys, we have recently pioneered an intensive camera trapping program which aimed to detect effectively all terrestrial fauna using the structure continuously throughout the day and night for over a 60 day period in summer. This approach was designed to provide reliable quantitative data on individual movements, crossing rates, species richness and use by invasive predators. The array included a total of 22 non-baited cameras which were checked weekly (to replace cards and batteries), only six times during the study. A total of 518 individual animals were detected, comprising 25 species (16 mammals, 6 birds and 3 herptiles). Almost 20% of individual animals were invasive species, especially red foxes. There was a 23% increase in species richness since the start of monitoring in 2005. Significantly, this approach enabled the confirmation of crossings by individuals of several significant species, most importantly, the koala which is the main mammal species of conservation concern in the surrounding reserve. This innovation allowed recognition of individuals of sensitive or rare species without the need for capture and related disturbance. This investigation also provided important insights into the changes in fauna use of a crossing structure over a prolonged period.

KEYWORDS: Intensive monitoring, Camera traps, Ecoducts, Acclimation

#2 Mitigating barn owl traffic victims using innovative design and citizen science data

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Owls, and specifically Barn owls *Tyto alba* are the most common traffic victim among birds in both the Netherlands and many other parts of Europe. Due to their low flight altitude during hunting, and the habit of hunting for insectivores and rodents in road verges, they are vulnerable to traffic mortality. A dataset of over 8500 recoveries of ringed owls was obtained in three regions of the Netherlands, stemming from citizen science. These citizens ring juveniles and report recovered rings, collected in the period 2002-2016 that were used to analyse the spacing and timing of victims, their age and origin using mark-recapture statistics. The majority of the victims were younger than 1 year and were killed within 30 km of their place of birth. Most victims die in winter months, when these subadults are dispersing.

The recoveries of (ringed) traffic victims highlighted a number of clear hotspots of victims. From locations we inferred that most victims occur when animals are flying towards, or sitting on low road signs close to the road. This was supported by anecdotal evidence and more recently, camera trapping and radio tracking. In two multi-year experiments, these hotspots have mitigated using an innovative adaptation in construction, developed by a citizen scientist in cooperation with a bird rehabilitation center. The principle of this construction is to make unsafe perches on road signs unusable with rollers, and placing higher perch placed further from the roadside ensuring verges remain hunting habitats in winter. It was easy to include inspections of functionality of the measures in the regular road inspections. Little maintenance was necessary, and consisted of replacing stolen perches or damaged rollers. In this talk we present test effectiveness, costs-benefit and maintenance this mitigation method.

KEYWORDS: Mitigation, Barn owl, Tyto alba, Citizen science/volunteer, Roadkill

#3 Development and Challenge of Green Highway Construction in China

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China has experienced the great development of highway network with a scale of 1.28 million kms in 1998, to 4.85 million kms in 2018. During the period, in order to effectively solve the problem of environmentally sustainable development brought by highway planning and construction, the content and mode of green highway construction has been explored with several important actions and has experienced four phases of development. To review the main process and get a summary of the experience and lessons could help both to China's improvement of governance but also to the highway development of other countries .The first phrase is roughly before 2004, when tremendous expressway system experienced an early climax, symbolized by expressway greening technology led by construction contractors. The 2nd phase is from 2004-2010, when the highway survey and design conceptwere emphasised to both the resource conservation and environmentally friendly design, and the flexible highway design concept was introduced to help the highway design. The third phase is from 2010 to 2015, more attention was paid to energy-saving and emission reduction in highway construction, when CO_2 emission and standard coal saving were taken as important quantitative indices to highway construction by a series of method of energy saving counting, guaranteed by matching fiscal subsidies. The fourth is after 2015, which is all-round development of the green highway, highlighting the resources and environment conservation, ecological environment protection, pollution control, quality engineering construction. The 2nd to the fourth phase are guided by the Ministry of Transportation by several guidance documents and corresponding typical demonstration highway projects selected form every province. The process is also strengthened by the continually strict requirements of law or standards by the environment/resources departments, which including the application of Planning Environmental Impact Assessment, Environmental Impact Assessment, Water & Soil Conservation Program, Environmental Supervision & Monitoring Scheme etc. The guidance and ratified demonstration projects by the MOT provided lots of case study for various projects by various forums and hence enhanced the whole green level of every province, and help the rapid extension of some excellent practices. There are still some challenges should be alerted for the modernization of institutional governance in the future, such as non-coordination among departments involved in the land use especially farmland utilization along traffic corridor, inconsistent requirements and tangling need of various sensitive area related to highway planning, balance of road system or tourism development for the people in various ecological sensitive areas and environment protection, sound links between specific environmental requirements and construction activities, discrepancy of the roadside management for sustainable upgradation and for land use, insufficient summary or post-evaluation of policy-making, lack of effective technical means for life cycle assessment and wildlife passage selection etc. Both the experiences and the lessons of China have to be carefully treated to guild scientific manage of future infrastructure planning and construction.

KEYWORDS: Green highway, Development, Challenge, China

#4 Protecting the protected through assessing driver behaviour in protected areas of South Africa

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The Endangered Wildlife Trust (EWT) has improved our understanding of the impacts of road infrastructure on wildlife in South Africa through implementing a number of research projects, countrywide. Most of the research has been undertaken on regional and national roads, but in response to social media discussions, which highlighted public concern for roadkill inside protected areas, the EWT commenced its 'Roads in Parks' Project in 2014.

South Africa's protected areas are the prime custodians of biodiversity, for which tourism is an important revenue earner, currently accounting for 7.9% of GDP and supporting one in every 12 jobs in South Africa. With approximately 10 million visitors per year, wildlife is a key product of protected areas and highly sought after by visitors. However, with large numbers of visitors, Wildlife-Vehicle Collisions (WVCs) commonly occur. Tourism is expected to grow significantly in South Africa by 2030, leading to more vehicles within protected areas and the potential for more WVCs. Innovative strategies are required to minimise the ecological impact of roads as well as improve people's livelihoods.

Social media discussions highlight public concern for wildlife-vehicle collisions (WVCs) inside protected areas. Using a quasi-experimental field trial, we investigated factors affecting the likelihood of WVCs within Pilanesberg National Park, South Africa, and assessed the comparative effectiveness of wildlife-warning signage (WWS) for altering driver behaviour. We laid a dummy snake crosswise on roads across four combinations of habitat and road shape and recorded 10 driver-related variables for 1454 vehicles that passed the dummy snake, including whether there was a collision. An interaction between speeding and driver occupation (staff/visitor) was the best indicator for WVC. When driving below the speed limit, visitors were almost three times more likely than staff to hit the dummy snake. Collision probabilities increased when speeding and became more similar between visitors and staff, although still significantly higher for visitors. We then investigated the effectiveness of roadside signage in modifying driver behaviour by erecting four variations of WWS, depicting a snake or a cheetah, and in photographic or silhouette form. We positioned the dummy snake 100 m or 1 km after the signage and recorded our 10 variables (n = 6400 vehicles). Sixty-one percent of drivers who passed a WWS changed their behaviour when they saw the dummy snake, compared to 37% with no sign present. Further, this behaviour change significantly reduced collisions, where 98% of drivers who changed their behaviour avoided a collision. Finally, an interaction between the animal depicted and distance before the dummy snake affected collisions. A WWS depicting a snake, and placed 100 m before the dummy snake, was most effective at reducing collisions. Our results suggest that drivers adapt their behaviour to signage that portrays smaller animals and awareness retention is low. Ultimately, to reduce WVCs within protected areas, we suggest steeper penalties for speeding and WWS placed in WVC hotpot areas.

Our findings of the project will contribute towards a traffic management plan for protected areas.

KEYWORDS: Mitigation, South Africa, Visitors, Wildlife-vehicle collision, Wildlife-warning signage

#5 Estimating roadkill risk when there is no roadkill data

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The most common way to quantify roadkill risk in different sections of infrastructures is to collect information on the location of casualties and then, model the probability using the environmental and infrastructure variables associated with the roadkill sites. This approach is not applicable in roads with low traffic intensity as they have a small number of victims (e.g. unpaved roads), where there is a high removal rate of casualties by scavengers (e.g. in natural areas), or when it has to be estimated before the infrastructure is built. We developed an indirect approach to evaluate the risk of collisions with wildlife within Doñana Natural Area (SW Spain), considering the abundance and phenology of species, the characteristics of the environment, and traffic intensity. First we characterized the road network, corresponding to 2190 km of roads (4.04 km/km2) of which only 2% were paved; and extracted environmental variables for the complete network in sections of 200m. Then, we characterized the traffic using data from automatic counting systems for main roads and for the rest we built a model of traffic intensity using data from a stratified sampling design in 62 sites using magnetometers, estimating traffic intensity to the whole network of roads. We characterized the abundance of multiple species using track censuses in 183 sites using 200 m transects; obtaining information on abundance, crossing intensity and the distance moved along the road (estimator of the time of exposure to vehicles or exposure). With this information we created a model of the number of crossing events per species in sections of 200 m using environmental predictors and applied the models to the whole network of roads. We estimated the roadkill risk using the index risk = log (no. crossings x traffic intensity x exposure), standardized between 0 and 1. We calculated the index for the whole network of roads. As an example, we show the predictions corresponding to the roadkill risk for several species, clearly identifying areas of high risk which are localized along roads with high traffic intensity and within them, specific sections with maximum risk. The predictions matched well with the observations of road-killed data recorded in the area

KEYWORDS: Roadkill risk estimation, Indirect methods, Regional scales

#6 Roadkill as a Threat to Global Mammal Conservation

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The ongoing expansion of the global road network and the associated growth in traffic intensity represent a threat for many vertebrate species. With 25 million kilometres of new roads expected by 2050, largely in developing countries with exceptional biological diversity, we urgently need to understand how roadkill (mortality from collisions with vehicles) impacts wildlife. Here we present a new framework combining a global dataset of observed roadkill rates, life-history data, and geographic distribution maps to identify which terrestrial mammal species worldwide may be at risk of extinction from roadkill and the world regions where these vulnerable species occur. We compiled a total of 1310 roadkill rate records of 392 different mammalian species from 177 references. We found that populations of four species may be at risk of extinction if observed roadkill levels persist on the roads around the studied areas: maned wolf *Chrysocyon brachyurus*, little spotted cat *Leopardus tigrinus* (both in Brazil), brown hyena *Hyaena brunnea* (Southern Africa) and leopard *Panthera pardus (*North India). The global assessment for 4,664 mammals revealed that roads can pose a threat to both common, non-threatened species, as well as to mammals already threatened by other human activities. Species vulnerable to roadkill and higher road densities coincide in South Africa, Ghana, central and Southeast Asia, parts of the Malay Archipelago and the Andean regions. Worryingly, these are areas with high biodiversity and likely to see road expansion in the future. Our study emphasizes the need to extend research beyond roadkill counts to evaluate the long-term consequences of this added mortality. The proposed framework offers a tool to identify species for which road mortality can increase risk of extinction and thus, can be useful to prioritize conservation and mitigation efforts.

KEYWORDS: Roadkill rates, Mammals, Age-structured models, Risk of extinction

SESSION 4.2.2. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 2

#1 Factors affecting usage rates of wildlife crossing structures – a systematic review and meta-analysis

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Current knowledge regarding the effects of structural attributes of wildlife crossing structures (WCS) on usage rates by wildlife species does not fully capture the large variation in structural attributes of WCSs worldwide and the profound differences among the species that use them. Often, research scope is confined by the availability of crossing structures in the study area and by the composition and characteristics of the local fauna. Therefore, it is difficult to generalize the effects of multiple WCS attributes on the usage rates of various wildlife species from individual studies. To overcome this limitation, the objective of this research is to analyse the effects of WCS attributes on the use by wildlife species using a comprehensive meta-analytical approach, encompassing the international knowledge base currently existing on wildlife crossing structures.

We conducted a systematic review of the scientific and professional literature, followed by a meta-analysis in order to aggregate the results of worldwide studies on WCS usage rates for multiple taxa across different geographic regions. We used a pre-determined string of keywords to search within twelve major databases for articles, conference papers, theses and reports in the field of habitat fragmentation mitigation. We included all papers that present data regarding the use of WCS by wildlife, and attributes of these structures and their surroundings. Only empirical field studies were included, using either tracking beds, radio-tracking methods, cameras or human observation to identify crossings through structures and approaches towards the structures.

We identified a total of 273 papers that include these types of data, from countries across all continents. From these studies, 117 reported counts of crossings, while 70 reported usage rates, i.e., the ratio of completed crossings to approaches. 43 studies reported a mean or total of crossings for several structures and 24 studies reported presence of species using the structures. The rest of the studies only reported statistical results without presenting raw data. For the meta-analysis, we only used the papers that reported usage rates, which is an unbiased measure of the crossing structure's effectiveness that can be compared among WCSs. Out of 70 papers reporting usage rates, 32 were suitable for the meta-analysis, reporting results for 80 species and 145 WCSs overall. These studies originated from the United States, Canada, Australia, Germany and France.

For statistical analysis, species were grouped by body size and ecological function. These groups include ungulates, large carnivores, small carnivores, small non-carnivores, amphibians and reptiles (herpetofauna), and macropods. Data was analysed using a generalized linear mixed model. We found significant effects of structure type and structural attributes on usage rates for all species groups. Some effects were similar for multiple groups, and some were distinctive. For example, underpass length was negatively correlated with usage rate by ungulates and by herpetofauna but was positively correlated with usage rate by small carnivores and small non-carnivorous mammals. These results are valuable for the application of robust, cost-effective mitigation measures worldwide, and will be further used to develop a novel optimization method for effective wildlife crossing structure implementation.

KEYWORDS: Wildlife crossing structures, Meta-analysis, Usage rate, Mitigation, Effectiveness

#2 Roadkills in Europe: areas of high risk of collision and critical for populations persistence

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Roads and other linear infrastructures are among the largest and most visible human-made artefacts on the planet today and represent a threat for both endangered and common species, mainly due to additional mortality from collisions with vehicles. There is strong evidence that additional non-natural mortality affects many species and a growing number of populations could have increased risk of extinction unless effective mitigation actions are applied. At a global scale, Europe is among the regions with highest transport infrastructures density. Between 1970 and 2000 the kilometres of built roads more than tripled in several countries in Europe (EU-15) reaching up to 3 million km of which around 51 500 km consisted of motorways (1.7%). Currently, 50% of the continent is within 1.5 km of transportation infrastructure which may lead to declines in birds and mammals.

We urgently need to advance our understanding of how roads affect biodiversity through two steps: 1) identifying which species and regions are more at risk from infrastructures; and 2) determining where those risks result in impacts (loss of biodiversity). Road ecology as a discipline has largely focused on the first step. In Europe, roadkill rates have been estimated for a wide range of vertebrates with millions of casualties detected each year. However, we still lack estimates for all species or areas, even in well-studied regions.

The aim of this study is to determine which species are at risk due to roads and where roads can impact population persistence and biodiversity. We focused on bird and mammalian species in Europe as a case study. First, we developed a predictive model of roadkill rates based on diverse species traits which allowed us to predict rates for all European terrestrial bird and mammal species and to map the potential incidence of roadkills. We fitted trait-based random forest regression models separately for birds and mammals to explain empirical roadkill rates. We used all available roadkill rates and the following predictors: species trait data, multiple characteristics of the study (latitude and longitude and survey interval) to account for species abundance and detectability, and taxonomic order to account for evolutionary relationships. Second, we used a generalized population model to estimate long-term vulnerability to road mortality. We estimated ~194 million birds and ~29 million mammals may be killed each year on the European road network. Overall, species with higher roadkill rates differ from those in which roadkill is likely to affect long-term persistence. Simplified models of species traits and wildlife-roads interactions at a macro scale allow a first assessment of the road mortality on wildlife and implications on population's persistence. This macroecological approach provide guidance for national road planning, support the definition of target areas for further testing at a finer-scale resolution, and ultimately prioritize site-specific areas where mitigation would be most beneficial.

KEYWORDS: Roadkill rates, Life traits, Trait-based models, Spatially explicit models

#3 A national program to monitor fauna roadkills in Portugal

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Infraestruturas de Portugal (IP) is the Portuguese public company holding a long term concession contract of the national road and rail infrastructures in Portugal. IP manages around 14,000 km of roads and over 2,500 km of railways providing a public service in areas such as funding, maintenance, operation and development of the Road and Rail Networks. Environmental sustainability is one important goal of IP and is incorporated in IP's procedures. IP recognizes habitat fragmentation and mortality as a major threat to biodiversity and has included Fauna Roadkills in its Environmental Indicators.

In this context, IP has implemented a National Program for Fauna Roadkills Monitoring, which is executed by several road inspectors, with a weekly periodicity. The results are integrated in a database and analyses are made annually, to find hotspots. Each hotspot is observed more closely in order to identify solutions to mitigate the mortality. Priorities are defined by criteria concerning the frequency of each hotspot and ecological value of the affected species. The results of the Program are also used to establish the need of considering preventing measures in the projects for improvement and maintenance of existing roads.

The Program has methodological constrains in what concerns the data collection. Moreover, implementing the best solutions is not always possible due to project constrains. Articulation between project demands, human safety and biodiversity protection, along with a strategic, broad and integrated perspective, is the key to achieve optimized and viable solutions

KEYWORDS: Long-term monitoring, Fauna roadkills, Roadkills database

#4 Wildlife-vehicle accident maps – a new support tool for mitigation planning and communication in Sweden

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Wildlife-vehicle collisions (WVC) have been steadily increasing in Sweden over decades despite numerous education campaigns, comprehensive road fencing and, more recently, the construction of wildlife crossing structures. Since 2010, car drivers are legally obliged to report any road incident with ungulates and large carnivores to the police who then informs contracted hunters to take care of the injured or dead animal. These reports produce comprehensive statistics that include both time and place of the accident. Nearly 80,000 accidents have been registered in 2018 and both citizens and agencies are concerned of the unbroken upward trend in accident statistics. One important step towards a greater awareness and an efficient mitigation is to visualize the spatial (and temporal) pattern in WVC. For this, aggregated information is needed that cleans the underlying pattern from the large random variation in the distribution of individual accidents.

We developed a set of WVC maps that allows both citizens and planners to identify areas and road sections where WVC are most commonly occurring and where the risk for the individual driver is elevated. They also provide the means to evaluate the overall effect of mitigation measures and help planners to design more appropriate and focused mitigation objectives. The maps present accident frequencies per km road, accident frequencies within defined hotspots, accident-density maps (Kernel) and accidents risk maps related to traffic flow per km. Standard KDE analyses of WVC positions provide the base maps that delineate road sections with average accident frequencies above 1 per km and year for a given five-year period. In addition, WVC frequencies were calculated per road links in the network of primary and secondary roads. Maps were produced for moose (Alces alces), roe deer (Capreolus capreolus), fallow deer (Dama dama), red deer (Cervus elaphus), wild boar (Sus scrofa) and rein deer (Rangifer tarandus).

We present the methodologies used to produce the maps and discuss their limitations and multiple use for communication, evaluation and research. With this, we encourage other countries to develop their own set of aggregated WVC maps.

KEYWORDS: Traffic mortality, Wildlife vehicle collisions, Hotspot, Kernel density estimation

#5 Scary sounds as a tool to prevent moose – train collisions in Norway and Sweden

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Collisions between trains and free ranging animals (moose, reindeer, deer, fallow deer) have become a serious problem in Norway and Sweden. The animals forage on food resources close to the railway and often use the railway as movement corridors in the landscape. Especially when the snow is deep in winter, the railway is preferred. To keep the animals away from railway lines, a motion activated scare system (MASS) was produced and tested for effectiveness in a field experiment during winter 2020. The field experiment was conducted at feeding stations for moose in the valley Østerdalen (inland area in southern Norway). The MASS unit consists of a motion activated device (MP3-player) that emits preselected sounds from a loudspeaker. To survey the animal response to the different sounds, cameras (3 cameras covering a sector of 105 degrees, with feeding stations in the center of the sector) were activated 20 seconds before the sound was activated (the sound was activated for 20 sec). The cameras were recording a total of 60 sec. each time the MASS unit was activated. A total of five different sounds were tested: 1. "no sound" to control that the animals don't react when the MASS unit was activated, two natural sounds; Black woodpecker and Boreal owl and two scary sounds; human talk and barking dog. From the videos, we sorted the animal responses to the different sounds in following categories: browsing, moving, vigilant, standing, laying and social interaction. We registered if, when and at what speed category the animals moved away from the area (i.e. were "scared").

Preliminary results are promising. Moose show a stronger response to the scary sounds versus control sounds, i.e. an increase in vigilance and moving, and a decrease in browsing and resting. Scary sounds seem to illicit the desired response that moose move away from the area. Hence, natural informative sounds of a predator can potentially be used to scare moose away from the railway and prevent moose-train collisions.

KEYWORDS: Scary sounds, Moose, Train collisions

#6 Roads as overlooked drivers of change in bird communities

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Road networks are expanding globally, promoting numerous impacts on biodiversity, resulting in important changes in species occurrence patterns, but there is still a lack of knowledge regarding the effect of roads at the community level, namely species richness, diversity and trait selection. Birds are key components of ecosystems, providing a multitude of ecosystem services, and are also well-studied across Europe, thus allowing testing hypothesis on road effects at the community level. Using a citizen-based European wide dataset we tested if, all else being equal, increasing road density leads to *i*) a reduction in species richness, *ii*) an increase in composition dissimilarity, and *iii*) a higher prevalence of species traits that allow them to cope with the changing environment. Using a subset of data available in eBird database, we related species occurrence with road density and environmental variables, including land use and climate. Increasing road density was related to a decrease in species richness and an increase in compositional dissimilarity. Species with higher body mass, predominantly feeding on invertebrates, nesting on the ground, and with higher relative brain mass tend to avoid areas with higher road density; whereas those species that are city dwellers become more common in areas with increasing road density. Moreover, species currently showing a positive population trend were related to areas with higher road density. Overall, we show that roads are probably changing bird communities, altering the species richness and composition, and by filtering species traits. Such outcomes suggest that roads can alter the ecosystem functioning and integrity as well their ecological networks, particularly on species interactions, and may ultimately lead to evolutionary changes.

KEYWORDS: Compositional dissimilarity, Community change, Species richness, Species traits, Road effects

SESSION 4.3.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 3

#1 The use of culverts in road networks as roost sites to maintain landscape connectivity for a trawling bat: a case study of the large-footed myotis *(Myotis macropus)* in Australia

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Anthropogenic environments can fragment habitats and introduce barriers to movement between populations, and this can have a profound effect on the population structure and viability of wildlife populations. The large-footed myotis (*Myotis macropus*) is a trawling bat with a specialisation for foraging directly over water surfaces and movement across landscapes is restricted to riparian corridors. This species has adapted to roosting and breeding in concrete culverts under roads. However, little is known about the roost selection of these artificial sites and how much gene flow occurs between individuals roosting in an urban environment. We investigated *M. macropus* roost selection at two spatial scales and population structure in a large subtropical city in eastern Australia. We surveyed 365 concrete culverts, identified 23 roosts and collected wing tissue samples from 72 bats.

Using generalized additive models, we found the distribution of *M. macropus* roosts in concrete culverts can be predicted at a landscape level using the variables stream order, channel width and waterway density, and culvert height. Bats preferred culverts >1.2 m in height, and a preference for box culverts was detected although pipe culverts were also occupied. Predictive modelling identified that culvert roosts were a limited resource with only 5.5% of culverts identified as potential roosts.

We examined roost selection at the roost scale by comparing roost culverts to available culverts. Roost culverts differed significantly from available culverts and the primary difference was the availability of microhabitat (lift holes and crevices). Roost culverts had lift holes that had greater cavity dimensions than available culverts and crevices were only found at roost culverts. Culverts containing microhabitat were a limited resource in this urban landscape.

We used single nucleotide polymorphisms and the mitochondrial cytochrome b gene to study gene flow. We found evidence of female philopatry with related females within roosts. Gene flow was moderate between peri-urban roosts and restricted between urban roosts. Moderate levels of relatedness between peri-urban roosts indicate *M. macropus* roosting in culverts are part of a larger, outward breeding population with greater availability of roost sites. Comparatively, the urban roosts in our study had more related pairs than the peri-urban roosts, indicating reduced gene flow in urban culvert roosts. This finding reflects the limited availability of urban culvert roosts in our study.

This study found that culvert roosts were limited at two spatial scales and that gene flow was restricted between urban culvert roosts. These findings suggest that disturbance to, or removal of, a culvert containing a roost has the potential to be a significant impact to an urban population of *M. macropus*. Disturbance impacts are not equal across culvert roosts, and the impact of disturbance can be partially alleviated by increasing the number of culverts available for roosting. Road networks provide an opportunity to provide permanent roost sites for *M. macropus*. Additional culvert roost sites can be created by providing microhabitat in existing culverts by simply leaving lift holes unsealed, and this would increase the availability of urban culvert roosts. Increasing the amount of potential roost habitat available will maintain landscape and genetic connectivity and contribute to the viability of urban *M. macropus* populations.

KEYWORDS: Culvert, Myotis, Roost, Microhabitat, Connectivity

#2 Road effect zones of major prey species in roaded landscapes in India

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The road effect zone is the spatial extent of significant ecological effects from the edge of a road, and is an important indicator of the impacts of roads on wildlife. The aim of the present study was to determine the road effect zone for major prey species in India, viz. spotted deer (*Axis axis*), sambar deer (*Rusa unicolor*), wild pig (*Sus scrofa*) and Asian elephant (*Elephasmaximus*).

The study was carried out on forest areas intersected by different road types - NH44 (Pench Tiger Reserve), SH26 (Kanha Tiger Reserve), NH930 (Tadoba Tiger Reserve) and SH 33 (Nagarhole TR).

The presence and activity of prey species was surveyed through pellet plots and camera traps placed in forest habitats at increasing distances from major roads (0 – 2000 m). Regression models were used to determine the relative effect of major roads on the presence probability of animals. Interpolation techniques were used to map presence probabilities of species under different road conditions to deduce the spatial extent of road effects.

Presence probability did not vary near narrow roads with low traffic volume. Across all road types and traffic volumes, wild pig presence did not show any significant reduction because of proximity to roads. Presence probability of sambar decreased by 3% for every 100 m increase in distance to major highway with high traffic volume. At the temporal scale, use of roadside habitat along high traffic road was lesser during the day than that during the night for sambar, and no significant change was observed for spotted deer. In road sections with traffic restrictions, significant but low difference in habitat use was observed for sambar, while no significant impact was observed for chital, wild pig and elephant.

The road-effect zone is a function of road, environmental and species characteristics. While a reduction of potential habitat available for use (18.8% for sambar) may reinforce the barrier effect, habituation to road-related disturbance by some animals (like wild pig and chital) makes them more vulnerable to road-related mortality. Installation of mitigation measures on high traffic roads may reduce the extent of road-effect zone as well as roadkill vulnerability for multiple species.

KEYWORDS: Road ecology, Barrier effect, Habitat loss, Avoidance

#3 Speed thrills but kills: Roadkill scenario in National Highway 715 (new) passing through the Kaziranga National Park, Assam, India

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Linear infrastructures such as roads and railways play an important role in our daily commute and are an integral part of human society and economy. When such structures pass through a protected landscape, it creates an unending linear barrier for the wild animals. Thus, effecting flora and fauna adversely, following the discontinued habitats. The National Highway - 37 or (NH - 715 new) passes through a stretch of 64 km along southern boundary of Kaziranga National Park (KNP). The vehicular density is much higher, as it connects upper Assam to state capital and also to neighbouring country, Myanmar as Asian Highway (AH - 1). Wild animals crossing road are often hit by high speed passing vehicles. Our study tries to assess the adverse impacts of vehicular traffic on Amphibia, Reptelia, Aves and Mammalia. One potential contributor to global herpetofaunal decline is mortality due to vehicular traffic. Most studies of road-kill are focused on large mammals, with relatively less importance and research data on impact of road-kill on herpetofauna, birds and small mammals. This study helps in understanding the severity of the situation for long term conservation actions. Hence, even if we cannot stop mortality, we can at least make efforts to reduce them. Nevertheless, this study indicates that roads have a high impact on wildlife. The study was carried out from October, 2016 to September, 2017, for 12 days every month using a motorbike at a steady speed of 25 – 35 km/h. On each encounter with a carcass, species, number of individuals and status of the kill (fresh/old) were recorded. Carcasses were photographed and identified to the lowest possible level using respective fieldguides and were then removed from the road to avoid double counting. We found a total of 6,315 roadkilled individuals during the study period with highest record in the month of July 20.73% (n = 1,309), followed by February and August 12.49% and 10.88% respectively. There were differences in the average roadkills across different seasons. It has been recorded highest during Retreating monsoon (10.96 ± 0.32), followed by Monsoon, Pre-monsoon and Winter 7.83 ± 0.02, 5.04 ± 0.80 and 2.18 ± 0.75 respectively. Similarly, there were differences in the average number of roadkills following flooding (6.49 ± 0.03, n = 2,356) and non-flooding (5.59 ± 0.10, n = 1,695) period. The class Amphibia was found to be the most affected group with a mortality of 57.62% (n = 3,639) followed by Reptiles, Birds and Mammals 20.29%, 11.27% and 8.92% respectively. Though there were 1.90% (n = 120) of roadkills remained uncategorised due to their extreme distorted condition. Most frequently roadkilled species found to be Common Indian Toad *Duttaphrynus melanostictus* that comprises 31.56% (n = 1,993) of all species, followed by Oriental Garden Lizard *Calotes versicolor* 3.37%. Common Myna *Acridotheres tristis* and Buff stripped Keelback *Amphiesma stolatum* found to be the third highest roadkilled species with a mortality record of 2.25% (n = 142) individuals. Mortality rate (kills/day) was found to be 43.85 individuals (n = 144 days), and mortality rate per kilometre (kills/day/km) was 0.34 (n = 128 km) for the overall study period.

KEYWORDS: Animal mortality, Barrier, Road ecology, Wildlife corridor, Vehicular collision

#4 Graph-based multi-attribute decision making: Impact of barriers on ecological network

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Roads are linear infrastructures that fragment habitats and disconnect populations, creating barriers to animal movement, thereby reducing dispersal and gene flow. For rare species, roadkill may be a limiting factor or even a factor leading to the extinction of populations.

Conservationists and transport decision makers must consider many competing criteria in order to find the optimal connectivity of habitat patches that maximize the ability of organisms to traverse a landscape successfully. As such, there is increasing interest in the prioritization of habitat patches in terms of their contribution to overall landscape connectivity. Different indices are used to quantify structural and functional landscape connectivity. However, landscape connectivity indices alone do not clearly define conservation priorities for habitat patches.

In this study, we analysed the effect of road fences (barriers) on the Lithuanian ecological network (network). Ranks for each available habitat patch were calculated using multiple attribute decision making (MADM) techniques, tightly integrated into the geographic information system (GIS) environment. Spatial properties of the graph-based elements (habitat patch size, number of corridors connected to the habitat patch, total length of corridors connected to the habitat patch and total area of adjacent habitat patches) were used to characterize each habitat patch and for their ranking. The importance of each criterion was assessed using objective weighting techniques.

In order to rank habitat patches, graph-based network connectivity rules were defined and applied. Habitat patches that were abundantly connected (largest habitat patch area, largest number of directly connected corridors, shortest corridors and largest area of adjacent habitat patches) received the highest ranks. Habitat patches with the opposite characteristics (sparsely connected) received the lowest ranks, this indicating the habitat patches were the least connected within the network.

In order to identify which losses (or partial losses) of habitat patches within a network were more important, any fences that intersect the corridors were introduced into the analysis and habitat patch ranks were recalculated.

Simulations in the case study of Lithuania showed that barriers (road fences) may realign complexes of ecological networks by reducing the importance of adjacent patches and increasing the importance of more distant habitat patches. Distant habitat patches may become essential, and can sometimes be the only elements preserving the realigned network.

Criteria-based ranking of habitat patches using the graph-based network connectivity rules indicated critical habitat patches better than the connectivity index alone, especially when changes in the ecological network occurred.

KEYWORDS: Landscape connectivity, Habitat patches, Graph elements, Multiple-criteria decision-making, Ecological network

#5 Multi-level landscape analysis of wildlife vehicle collision sites in Estonia

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Green infrastructure planning is a complex procedure that needs high precision for long term functioning. A critical part of good practice is the utilisation of wide range of available base information of biodiversity placement and landscape usage. We analysed 19,126 wildlife vehicle collision (WVC) sites registered from 2009 to 2018 on 16,000 km of Estonian roads. Placement of the accident sites was correlated for three species: moose, wild boar and roe deer. Among the landscape variables there were 7 metrics, all of which were analysed in two spatial scales, 100 m radius and 1 km radius. As a result, we positioned more than 8,444 road sections of high probability of wildlife accidents with precision of up to 50 m. The most important landscape variables determining the accident sites are density of human settlement and proportion of forest cover. However, the landscape relationships are often nonlinear. It appears that landscape composition has a good predictive power on mapping wildlife-road interactions. As a result, the planning of road safety and population connectivity measures is faster, more precise and more efficient. This has given better opportunities for cross-border collaboration and public communication. We conclude that knowledge of landscape utilisation by wild roaming species and knowledge-based planning procedures are essential for a functional green network, successful conservation, and the road safety.

KEYWORDS: Landscape, Hotspots, WVC

SESSION 4.3.2. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 3

#1 A green light for blue wildlife reflectors?

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A Wildlife fences have been proven to be effective in reducing deer-vehicle collisions (DVC), if properly designed, installed and of sufficient length. Fences, however, cannot be installed everywhere due to, e.g., the costs of installation and maintenance or esthetical reasons. For this reason several less costly and less conspicuous mitigation measures have been developed. One of these is wildlife reflectors, which can be installed in road verges. They are supposed to reflect the lights of passing cars into the surrounding habitat, aiming to stop deer from crossing the road when there is traffic. Currently a variety of wildlife reflectors are on the market. One of the more recent types are blue wildlife reflectors. In the Netherlands, these blue reflectors were quickly adopted by road managers and hunters, as they perceived them to be effective. Within a few years hundreds of roads have been equipped with these blue wildlife reflectors. Yet, no scientific study has been carried out to support the claims that the blue reflectors reduce DVC. Our objective is to test whether blue wildlife reflectors reduce DVC, and if so, to what extent. We collected roadkill data of roe deer (*Capreolus capreolus*) on 37 roads (total road length: 26.8 km), both before and after the installation of the blue wildlife reflectors. As the year of installation differed between roads, the number of years before mitigation varied between 5 and 8 years, and the number of years after mitigation varied between 2 and 5 years. Therefore, we analysed two scenarios: (1) 5 years before and 2 years after (n=37 roads), and (2) 5 years before and 5 years after (n=18 roads). We used the two-sample Poisson-test to assess whether a statistically significant ($p<0.05$ significance level) change in DVC before and after mitigation occurs. Our null hypothesis was that the average number of DVC before and after mitigation does not differ. For both scenarios we could not reject the null hypothesis. In scenario 1 average yearly roadkill was, respectively, 24.4 and 24.5 before and after mitigation. In scenario 2 average yearly roadkill was, respectively, 24.4 and 24.2 before and after mitigation. Population numbers in the areas surrounding the studied roads declined with, respectively, 9% (scenario 1) and 17% (scenario 2) before and after mitigation. If we correct for these trends in population numbers, assuming a linear relation between population numbers and roadkill, we found a trend of 10% (scenario 1) and 19% (scenario 2) increase of roadkill after the reflectors had been installed. Our study emphasizes the need for evaluations of road mitigation measures prior to large-scale implementation. It shows that signals from practitioners about mitigation effectiveness can be biased and therefore should be treated with care. Our findings reflect the outcome of recent studies carried out elsewhere in Europe. Hence, no green light for blue wildlife reflectors yet.

KEYWORDS: Road mitigation, Wildlife reflectors, Roadkill, Roe deer

#2 Evaluation of an Animal Detection System (ADS) as an alternative for large defragmentation infrastructures

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The Kamperbaan N73 in the east of Flanders is a regional road that cuts through a large military domain of 55 km². This is one of the biggest natural heath landscapes in Flanders. The domain is used as a training ground and therefore not accessible for the public.

The military domain covers 19 European protected habitats for 22 European protected species such as Smooth Snake, Swamp Frog, Spadefoot Toad and European Nightjar. More recently also the Wolf has appeared.

The area is also the habitat of Wild Boar, causing many car accidents on the N73. In addition, traffic does not comply with the speed limit of 90km/h. At night, speeds above 120km/h are common. Politicians are very interested in solutions to enhance traffic safety. Fencing the road would be the easiest solution but this increases fragmentation. It is an important principle never to fence roads without providing crossing possibilities for animals.

The scenic context makes it difficult to build large defragmentation infrastructures. The alternative is the installation of an Animal Detection System (ADS). Given that systems that warn animals would be constantly activated because of the busy traffic, we opted for a system that alerts the drivers about approaching animals.

This is a pilot project testing 2 detection systems. Depending on the results, the principle may be applied to other locations as an alternative to expensive infrastructural solutions.

The road, 4km in length, is fenced along both sides with 2 gaps for spots where animals (even a radio-collared wolf) regularly cross the road. Along the fences 9 cattle grids, 12 gates and 20 escape ramps were installed.

The gaps are equipped with 2 different types of detection system: a line detection (AIR-sensors) on the northern side of the road and infrared detection (PIR-sensors) on the southern side. In addition,8 dynamic traffic signs warn drivers about the possibility of animals crossing. The system is operational since 25th March 2019.

The system itself will be managed by the supplier (Prowild / Traffic2000).In order to evaluate this solution and respond to the expectations of the politicians, monitoring is organised in relation to the objectives of the project:

Goal 1: Improving traffic safety (reduce number of collisions): evaluated based on number of fauna collisions and the reaction of the drivers to the dynamic speed signs;

Goal 2: Ensure passage for local fauna: monitored by camera traps. The images and data will be processed by the Agouti-system. Parallel scientific research will evaluate the population and migration of wild boar in the area.

Goals 3: Evaluation of the whole system: additional cameras will observe animal behaviour in combination with traffic. The Research Institute for Nature and Forest will also analyse the datalogs of the warning system.

During the first year the monitoring method will be tested and evaluated. The actual monitoring starts in the second year.

KEYWORDS: Animal Detection System, ADS, Evaluation, Car accidents, Alternative solution, Wild Boar

#3 Hit the road Jane! Roads decrease the relatedness for females lesser horseshoe bats

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The understanding of how human-induced habitat disturbance shapes the contemporary population structure and gene flow at fine-spatial scale is key for adequate management of species with small and fragmented populations and with limited dispersal abilities. To date there are few studies focusing on how barriers (e.g. roads, habitat fragmentation) might influence gene flow at fine-scales. Roads are known for causing millions of roadkill severy year and for causing movement disruptions mainly for species with low dispersal abilities, thus changing the genetic structure of these populations. Some bat species, despite the high potential for dispersal, may show low dispersal movements due to high flight costs, which combined with a high vulnerability to roadkills, can have a strong effect on population structure. Moreover, differential sex-specific dispersal, often biased towards males is commonly observed on bat populations. Thus, we expect that females will possess strong local affinities, whereas males may act as genetic mediators among colonies. In this study, we investigated how landscape features drive the gene flow and sex-specific relatedness structure on a lesser horseshoe bat (*Rhinolophus hipposideros*) population. We combined multiple regressions on genetic distance matrices and spatially explicit analysis to fit models of genetic individuals-relatedness to landscape resistance surfaces. Genotyping involved 2,837 SNPs and 327 bat samples collected across a Mediterranean agroforestry system of southern Portugal. Our analysis based on relatedness structure supported the male-biased dispersal hypothesis. Females are thought to be philopatric, whereas males display uniform levels of relatedness throughout the landscape. Furthermore, we demonstrated that the effect of the landscape features could also be sex-specific. The relatedness analyses showed that the female´ colonies bisected by roads were less related between them-

selves than to those where no roads were present. In fact, relatedness among female' colonies was negatively correlated with proximity of roads, unlike males. However, the long-generation time for lesser of horseshoe bat, jointly with time lag since the road construction may not be sufficient to detect a clear genetic signal of isolation. Thus, main finding of presented study is that the roads reduced but did not halt the gene flow, although they may be major drivers of contemporary genetic population structure with medium to long-term consequences on the local bat populations. Furthermore, our results yield evidence that unsuitable habitat, such as presence of agricultural areas, is important factor mediating population connectivity between colonies. This study underscores the potential of conducting sex-specific analysis by identifying landscape elements that differentially promote or impede functional connectivity between sexes, particularly when studying species with different sex-dispersal abilities, as may uncover processes that may otherwise remain cryptic. Our findings are important for lesser horseshoe bat conservation, road planning schemes and habitat management, due to the threatened conservation status and species-specific traits (e.g. low flying, high-road mortality), that increases the risk of road barrier effect. The strong effect of roads at fine-scale on the contemporary genetic structure shows that effective management measures are required to increase across-roads connectivity allowing to preserve high survival rates of breeding females and maintaining continuous exchange individuals between colonies.

KEYWORDS: Lesser horseshoe bat, Landscape relatedness, Road barrier, Relatedness structure, Sex-biased

#4 Mapping and monitoring large mammal underpasses on motorway A29

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In Greece, the brown bear (*Ursus arctos*) is a priority species listed in Annex II and IV of the EU Habitats Directive (92/43/EEC) and thus, it is implied that Member States should avoid the deterioration and disturbance of bear habitats. However, motorway A29 cuts through brown bear habitat in northwestern Greece and acts as a barrier which restricts gene flow, isolates populations and ultimately, reduces overall landscape connectivity.

Within 5 years of operation, more than 20 bear-vehicle collisions occured on A29, until a bear-proof fence was installed in 2014 to prevent animals from reaching the roadway. This resulted in the drastic reduction in bear-vehicle collisions with only one incident ever since. Nonetheless, this bear-proof fence also increased the barrier effect and thus, the need for evaluation of the motorway's permeability is undeniable.

In the framework of the LIFE SAFECROSSING project (LIFE17NAT/IT/464), we performed field inspections along the motorway and identified potential passages for brown bears and other large mammals. We recorded all crossing structures, inspected and registered their condition and relevant features (i.e. size, surrounding landscape, evidence of use by smaller or larger mammals). We also identified barriers to animal movement, and places where there is access to the road surface due to problematic fence-ends or human tampering with the fence. Following, we selected 45 structures to be monitored (spring/summer 2019-spring 2020) via solar-panel/battery powered cellular (4G) cameras. The monitoring system is supported by a back-end infrastructure capable of passages visualization on map, along with associated info, automated camera snapshots/videos storage, snapshots depiction per passage, statistics per passage, etc. via a user-friendly graphical environment. The monitoring system was installed on underpasses along the 55km segment and underpass selection criteria were primarily evidence of use by large mammals and even distribution throughout the motorway, and secondarily, theft/vandalism risk and network reception

We found that along this motorway there are ca. 140 underpasses of variant size and the calculated Openness Index ranges from values close to 0 (culverts with a 2x2m entrance and length >100m) to 175, which is the maximum value calculated at a viaduct (height: 35m, width: 125m, length: 25m).

The first pilot camera was installed in March and the rest 44 in July (2019). Five cameras have been installed at underpasses with no reception and are manually checked periodically. Today, only after a couple of months, we have already collected thousands of pictures and accompanying videos, which attest the use of underpasses by both humans and large mammals. Recorded wildlife species which use the underpasses to cross the motorway, include brown bears, wolves (*Canis lupus*), wild boars (*Sus scrofa*), foxes (*Vulpes vulpes*), mustelids (e.g. *Meles meles*) and small mammal species. Recorded use by humans usually involves vehicles used in the primary sector, shepherds with livestock herds and occasional passersby.

According to our findings, improvement actions will be proposed to increase attractiveness of the underpasses for animal use. Hopefully, in this manner we will guarantee a safe and permeable motorway, as well as robust mammal communities.

KEYWORDS: Mitigation measures, Underpasses, Monitoring, Brown bear, *Ursus arctos*

#5 The value of a non-scientific approach for road agencies

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It is often difficult for roads agencies to initiate scientific studies on road ecology that include before- and control-measurements (i.e., BACI design). Difficulties may lie in financial constraints, but also in mismatches between the moment that a before-measurement would need to be carried out and the moment that planning approval is secured, and between the location where a control-measurement would need to be carried out and the spatial scope of the project. Here, we present the case of a highway expansion in the Netherlands where a non-scientific approach has produced considerable value for the roads agency. We started combining available funds with funds from the provincial and railway agencies to solve common issues. The local nature conservation organisation also joined in. Badgers were captured near highway A27 to attach GPS collars while applying for planning approval. In addition, camera traps were placed at all existing badger underpasses. These efforts were justified by our need for data to formulate legally required mitigation and compensation measures for the construction phase. During the tender for the road expansion, we challenged contractors to continue as much of our monitoring as possible. Monitoring plans were reviewed by the roads agency and the quality of the plans increased contractors' chances to win the tender. The winning contractor continued the full monitoring scheme (i.e., capturing additional badgers and continuing the use of camera traps) throughout the construction phase. Value for the roads agency consisted of: (1) insight in changes in sizes and positions of badger territories, and in changes in the use of setts, road verges and underpasses (2) immediate availability of information for the competent authority when a sett was unexpectedly discovered in a road verge and required a permit to remove it, (3) availability of information that enabled adjustments to facilitate the execution of the project, and (4) a semi-scientific paper presenting results for use in future road expansion projects. Although scientific approaches provide most certainty about effects and effectiveness of measures, we believe that non-scientific, opportunistic approaches can still provide considerable value for roads agencies.

KEYWORDS: Badger, Disturbance, Effect distance, Habitat use, Road construction

#6 LIFE SAFE-CROSSING: A new international project for preventing large carnivore road mortality in Europe

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The presence of roads has a significant impact on wildlife conservation, since it is as an important cause of direct mortality of individuals as well as a factor of habitat fragmentation. The LIFE SAFE-CROSSING project (https://life.safe-crossing.eu/) aims to mitigate the impact of roads on three priority species in four European countries: the Marsican brown bear and the Wolf in Italy, the Iberian lynx in Spain and the Brown bear in Greece and Romania.

Based on the best practices developed during the previous LIFE STRADE project (www.lifestrade.it) the current project started in September 2018 and will last until August 2023.

The main activities of the project are:

- Identification and monitoring of the high-risk road segments;

- Implementation of actions to prevent animal-vehicle collisions (AVC) and to reduce habitat fragmentation;

- Raising awareness of drivers and of policy makers on the risk and prevention of AVC.

In order to select the road segments where to implement the prevention actions the "Kernel Density Estimation Plus (KDE+)" method was applied, using over 500 cases of road collisions with large carnivores and with other medium and large sized mammals. We also analyzed the telemetry data of radio-tagged animals in order to identify the road segments with the highest crossing rates. An accurate monitoring of hotspots of road kills has then been made to select the exact locations for the installation of the AVC prevention tools, and we also monitored the number and speed of vehicles on the target roads on 24 hours.

On the basis of these activities 27 AVC Prevention System, developed in the LIFE STRADE project, will be installed and 30 km of roads will be equipped with innovative road side active reflectors. To favor habitat connectivity 80 existing underpasses will be readapted to increase their use by wildlife.

The innovative "neuromarketing" technique is being experimented in order to produce road signs specifically designed for raising awareness of drivers about the road kill problem and to encourage them to adopt an adequate driving behavior. A specific information campaign is carried out with the local driving schools, and a thematic video-game will be developed to involve and attract young people.

The LIFE SAFE-CROSSING project therefore is a tool to face the problems of the impact on roads on biodiversity involving associations and private bodies at international level. The main characteristic of this initiative is to act in different ways against road kills and habitat fragmentation and to provide an example for future cases of replication.

KEYWORDS: AVC, Roads, Underpasses, Large carnivores, Public awareness

SESSION 4.3.3. CHALLENGES AND OPPORTUNITIES FOR BIODIVERSITY CONSERVATION IN LINEAR INFRASTRUCTURES

#1 How do roads affect the ecological processes and biodiversity? – summing up a systematic literature review for the decade 2008-2018

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Roads affects ecological processes at a range of spatial scales, and studies document both negative and positive effects on natural capital and ecological processes. Still there are too large knowledge gaps and geographic and taxonomic biases to draw conclusions and guide road authorities.

We used a systematic review approach to synthesise current knowledge and identify knowledge gaps. We used a broad search string and limited our search to the period 2008 -2018. This gave a total of about 2000 unique papers. Title and abstract screening reduced this to 473 papers where we included studies that estimate, model or review effects of roads on population processes, demography, distribution, occurrence, abundance, biodiversity, behaviour and landscape connectivity. Papers that passed the initial screening criteria were screened on full-text, grouped into themes and explored in more detail to detect patterns related to geography, road types, habitat types, management and responses recorded. This grouping was based on whether papers addressed invasive species; population genetics; edge effects, landscape perspectives; population processes; biodiversity; dispersal and connectivity; roadside construction and management; verges as habitats and resource; ecological traps; roadkill; pollution and ecotoxicology; verges as refugees and conservation approaches; noise; urbanisation; or ecosystem services. These groups of papers were then reviewed using a narrative approach.

Biodiversity was addressed in 175 papers as the largest category of papers, mainly with a focus on taxonomic diversity and often within a narrow phylogenetic focus. 130 studies addressed different landscape perspectives, some in combination with details on fragmentation, population genetics, dispersal and connectivity. The majority of papers on movement and dispersal, however, addressed processes at smaller spatial scales. A good number of papers (124) explored the role of road verges as habitats or providers of resources. In a subset of the papers, this was linked to the role of roadsides as refuges or their role in conservation. There were over 100 papers addressing demography and population processes involving a broad range of measured or estimated effects and only a few in combination with population genetics. Edge effects were also rather well described for a wide range of organisms (108 papers) sometimes linked to abiotic explanatory variables.

We found that, despite strong negative effects of processes and factors such as noise, barrier effects, vehicle collisions and landscape fragmentation, HTI can contain considerable biological diversity and species richness, contribute to structural and resource heterogeneity in the landscape, and function as corridors for a diverse set of organisms. However, evidence of these contributions is fragmented, with high species-specificity in responses (especially in animals), but also a strong impact of the landscape configuration and resources. A shift in focus from species occurrence to processes and functions at population and community level; addressing the importance of connectivity towards and away from the roads, integrating habitats along roads in a larger landscape; and approaches to identify and prioritise critical components and trade-offs during road construction and maintenance are among the major knowledge gaps to be addressed in future research.

KEYWORDS: Road ecology review, Effects, Landscape

#2 The Brazilian Network of Transport Ecology Specialists (REET Brasil)

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The Brazilian Network of Transport Ecology Specialists (REET Brasil) is an association formed by researchers, consultants, environmental advisors and managers, public service professionals, and technical representatives of private companies who work with transport ecology. This work aims to show REET Brasil to the international community. REET Brasil proposes to improve and disseminate expertise on the subject in Brazil and, consequently, to improve the environmental impact assessment mechanisms and the management of highways, railways, waterways and airports distributed throughout the national territory. REET Brasil's mission is to promote, defend and disseminate technical and scientific information related to transport ecology, in order to encourage sustainable development and biodiversity conservation in Brazil. REET Brasil was started in 2019 and has 121 members. Most members are biologists (87%), but there are some lawyers, engineers, geographers and veterinarians; most of them with postgraduate degrees (86%). Most members are academics (45%), environmental consultants (32%) or NGOs' representatives (12%), but some are from government agencies, companies that manage different modes of transport or representatives of the judiciary (11%). Most members work on highways (68%) or railways (17%), but some work at airports and waterways. REET Brasil members work in the Southeast (37%), South (14%), Midwest (12%), Northeast (10%) and North (7%) regions of the country, and some work throughout the whole country (20%). REET Brasil aims to be a reference entity for expertise in Transport Ecology in Brazil. To achieve this goal, REET Brasil supports training courses conducted by members, participates in scientific events and meetings involving different social actors engaged in transport modes, promotes the interaction of its members, disseminates themes related to Transport Ecology, produces manifests on environmental conflicts associated with transport modes and participates in discussions on regulations for activities related to transport ecology. Our biggest challenges are to disseminate knowledge in the area of Transport Ecology in the North and Northeast regions of the country, in the airports and waterways, and bring the academy closer to other social actors related to Transport Ecology. In addition, REET Brasil intends to empower its partners to participate in decision-making and to represent REET Brasil in their regions, seeking participation, and dissemination of the democratic scientific vision of REET Brasil.

KEYWORDS: Transport ecology, Brazilian association, Applied research, Dissemination of knowledge, Environmental impact assessment

#3 Creating high voltage power lines green corridors: how to demonstrate a win-win strategy?

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When power lines network 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). Seven field actions promoted biodiversity while continuing to offer the same guarantees of electrical risk control. The feedback of this LIFE project has been used to define BELIVE, a RTE's project. BELIVE aims 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, 200 ha will be restored over the 2018-2021 period in three different regions. For now, vegetation layout are edges, pastures, meadow and ponds. BELIVE needs also to develop expertise and feedback for vegetation maintenance: the integration of practices favourable to natural habitats and species in the daily tasks through partnerships with civil society (private and public owners, hunting and agriculture community, etc.). BELIVE seems to respond to territory expectations: the need to control wild boar populations or to develop pastoral activities for example. But BELIVE has to demonstrate its financial viability: how a new vegetation management practice based on biodiversity and ecosystem services reduces costs in the everyday vegetation management? This aspect is fundamental to adapt existing power line infrastructures for ordinary biodiversity. In Belgium, it proved to be concluding. It showed that the biodiversity-friendly management (extensive pasture, grassland) was 1.4 to 3.9 less expensive than traditional management. In France, we tried to estimate on former experimental plots, the same benefits. We discovered that grazing lands are reducing costs by a factor of 5 to secure power lines. Additionally, we assessed by the costs method two ecosystem services, "food provision" and "hunting", and the ecological function "habitat maintenance". The benefit for farmers, calculated as a food cost saving for grazing animals, was comprised between 390 and 875 € / ha / year (Audoin, 2018).

Finally, a new LIFE project (Grid4LIFE), led by RTE and involving 7 countries has being drafted for filing in 2020. It aims to manage 600 ha of forest rights-of-way in the European high voltage network and to analyse the governance of this type initiative (legal obstacles, feedback...). BELIVE and its successor are long-term projects. They need a

financial demonstration but benefits are more than economic: they reduce pressure on biodiversity and its resilience to climate change.

KEYWORDS: Biodiversity, High voltage lines, Ecosystem services, Vegetation management, Forest corridor

#4 Protection of birds on power lines in the Czech Republic – from monitoring to practical measures

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Protection of birds on power lines has been given attention in the Czech Republic since the 1980s. According to law, only bird-safe structures avoiding electrocution can be used for building new power lines and reconstruction of existing ones in the Czech Republic since 1992. Despite this fact thousands of birds die due to electrocution and collision with the wires every year. The reason was the lack of knowledge about which structures are really safe and where, on the contrary, bird mortality occurs. For this reason an extensive study on bird mortality has been initiated in the Czech Republic in recent years.

During 2015 - 2016, about 76.000 power poles and 6.400 km of power lines (about 10% of the country's total) were inspected. The aim of the study was to identify types of poles which are dangerous for birds from the point of electrocution and also the number of birds dying on individual types of poles. Based on collected data, a total estimate of at least 117.000 birds dying due to electrocution and collision with wires in the Czech Republic every year was calculated. Raptors represented a very strongly affected group. The most common victim was common buzzard with 35.000 deaths each year. However, among the victims of power lines were found even very rare species such as golden eagle, white tailed eagle, saker falcon or osprey.

Based on this study a close cooperation between Nature Conservation Agency, Czech Society for Ornithology and energetic companies has been established. A safety assessment system for new constructions has been introduced as a product of this cooperation. New solutions can be used only after approval by the Nature Conservation Agency. A new guideline for protecting birds from collisions with power lines is currently being prepared. However, there are still thousands of old structures that are fatally dangerous for birds throughout the landscape and reaching a complete solution to the problem in the Czech Republic may take another 10 - 20 years.

KEYWORDS: Electrocution, Collision with power lines, Bird mortality

#5 Assessing Biodiversity in Railway Dry Grassland Patches

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Infrastructure habitats are receiving increasing attention as important habitats for endangered species. In Sweden there are about 200,000 ha managed grasslands along linear infrastructure such as power lines, national road network, airports and railways. The Swedish Transport Administration has documented, through a series of years, the diversity of insects and plants in railway environments in different regions. Therefore, we know that over 2,000 species of insects and vascular plants have their habitat in a railway environment. Among these species, about 100 are included in the national red-list. In this work we present a method to assess, categorize and handle railway environments on a national basis. The method consists of three steps: remote assessment, field visits and biodiversity action plans. The remote orthophoto assessment selects railway environments to be visited in field based on a set of parameters such as visible structures and soil characteristics. The next step, field visits, focuses on recording habitats for vascular plants and insects and includes a survey of plant species. The status of 12 pre-defined habitat structures are targeted and assessed in the field. These pre-defined habitats are each represented by a unique combination of flora and fauna, containing one or more protected species. An example of a pre-defined habitat includes dry and sunny gravel with dense patches of the herb *Herniaria glabra*. This plant species is common on patches dominated by sand and gravel in urban and rural areas, but very warm and sunny patches are unusual. Much of the railway environment with *Herniaria glabra* is indeed in a warm and sunny microclimate. Therefore, the red-listed moth *Coleophora scabrida*, which larvae are monophagous on *Herniaria glabra*, is frequently documented in railway environments. Outside railway areas this moth species has become very rare in Northern Europe. The field visits conclude an overall classification (1-5) based on the biodiversity parameters. The class 4 (low capacity) and 5 (lack capacity) will not be considered for action plans. The railway environments classified to 1 (very high conservation values), 2 (high conservation values) and 3 (moderate conservation value) are subject to a specific action plan. The purpose of these action plans is to secure and develop the biodiversity along the railway environments. So far, these action plans are not connected to other conservation measures, e.g. green infrastructure strategies. Currently, all Swedish 1,400 railway stations have been surveyed. The results show that 230 railway stations include dry grasslands that are high-ranked (1, 2 or 3). Action plans have been produced for a set of railway stations. In 2021 we anticipate finalizing the action plans for the remaining high-ranked stations. We hope that this methodology will trigger a valuation and ranking of the natural assets of railway environments. We further believe that this national survey will push biodiversity issues to be part of the regular management of railways.

KEYWORDS: Railway, Biodiversity, Red-listed, Pollinator, Insect

#6 Determination of the bird protection effectiveness of animal deflectors on railway overhead lines

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In contrast to other transportation systems, railway systems feature special characteristics which may, from the point of view of nature conservation associations and authorities, cause specific hazards to birds. Among other things, there is the risk of electric shocks due to the cause of short circuits.

To protect the birds and minimize the short circuit events, the German railway has installed so-called animal deflectors on the insulators of the overhead lines. Since this effort, the number of short-circuit events of the respective sections has strongly decreased. The mechanism of action of the animal deflectors is based on mechanical defence combined with electrostatic discharge on contact. Due to the placement of the animal deflector next to an electrical field, a capacity may first get charged and discharged by physical contact with a bird. This may generate an electrical shock in birds.

Although the number of short circuit events has been reduced by using animal deflectors, there is concern that the animals could be harmed by the electrostatic shock. This can either happen passively, by collapse due to the electrostatic shock, or directly by a lethal shock.

To get an idea about the intensity of the possible electrostatic shock, the German Centre for Rail Traffic Research, the University of Applied Science of Zittau and the TU Dresden conducted experimental investigations.

This paper handles the electrostatic mechanism of action concerning the current peak at the moment of contact (closing the switch) and the static current by constant contact (closed switch). The current was measured for different isolator states and different body resistances of birds (5 kΩ, 3 kΩ, 1kΩ, 0.5 kΩ). To simulate the resistance of bird bodies, technical resistances were used; no animal tests were conducted.

The investigated states of the insulators were:

1. Clean and dry
2. Clean, wetted by rain
3. Polluted (light and very heavy) and dry
4. Polluted (light and very heavy) and wetted (by rain and clean fog)
5. Iced

KEYWORDS: Bird protection, Animal deflectors, Transmission line, Insulator state, Electrostatic shock, Railway, Overhead lines

SESSION 5.1.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND RESTORATION – 1

#1 Make amphibian defragmentation infrastructures great (again?)

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Amphibians are especially vulnerable to habitat fragmentation. Because of the seasonal movements to and from the reproduction sites and because of their slow speed, many amphibians are killed when crossing roads. In Flanders, Belgium, with its very dense network of roads (5 km road/ km^2), Natuurpunt volunteers registered over 240,000 amphibian victims since 1987.

Different approaches have been developed to address this huge number of roadkills. In Flanders there are more than 270 sites where deflection screens prevent amphibians to access the road, and lead them towards pitfall buckets. Volunteers then carry them safely across the road. Another approach is to construct defragmentation infrastructures for amphibians, mostly consisting of small tunnels under the road allowing amphibians to cross safely.

This study aimed to evaluate defragmentation infrastructures at multiple levels. First: a survey was conducted to determine the number of defragmentation infrastructures for amphibians installed in Flanders. We found 93 locations.

Of these, a subset of 25 infrastructures was studied thoroughly in the field.

Main questions were:

Were the amphibian defragmentation infrastructures installed at the correct spot (i.e. the place where amphibians migrate across the road)?

What are the technical specifications of the infrastructure?

Are there visible shortcomings of the infrastructure, and how can these be mitigated?

This survey indicated that the variation between infrastructures is substantial. Most were situated at the correct location but due to a lack of maintenance, many showed large flaws which rendered the guidance screens and tunnels useless and/or contra productive.

Next a subsample of 10 infrastructures was monitored in detail during two amphibian migration seasons in 2018 - 2019 and 2019 - 2020. Infrastructures were monitored using a standard protocol. We quantified the species and number of amphibians using the infrastructure to cross safely, the animals trying to bypass the infrastructure, and the number of casualties.

This analysis indicated that the effectiveness of infrastructures ranged from very good, with only some small improvements desirable, to completely dysfunctional. Main problems were related to the state, length or height of the deflection screens. Even when structural adjustments are made to enhance the performance of the structure, a thorough check, by volunteers or the infrastructure maintenance personnel, just before the start of each migration season (and further adjustments, if needed) remain essential.

Without adjustments, maintenance and optimisation of many infrastructures, the accumulated losses of individuals and species remain so high that the long-term survival of local populations can be endangered. We suggest that the construction of a defragmentation infrastructure is only useful when combined with a strict maintenance schedule. If sustained maintenance of structures cannot be guaranteed, it is better not to build it, but to support volunteers to carry on with rescuing migrating amphibians manually.

KEYWORDS: Amphibians, Maintenance of defragmentation infrastructures, Quantitative analysis, Volunteers

#2 AMPHIbianCONservation and habitat restoration (LIFE AMPHICON)

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Decline of amphibian populations due to habitat fragmentation, increasing traffic and loss of landscape connectivity poses a serious threat for amphibians in Europe, Slovenia included. The main objective of LIFE AMPHICON (2020-2026) project is to improve the conservation status of amphibian target species (*Triturus carnifex* and *Bombina variegata*) in three Natura 2000 areas in Slovenia through restoration of ponds and land habitats, improving habitat connectivity, reducing road mortality and improving coherence of all project sites.

"Toad patrol" actions are organized on 4 hot spots of roadkills in 3 project sites and over 20,000 animals are carried safely over the road by volunteers every spring in the last 10 years, with several dozens of target species among them. In order to mitigate this, app. 60 road tunnels with fences are planned. Surrounding habitats (ca 23 ha) will be improved and 90 ponds constructed in order to create safe home ranges for the species. Additionally, buffer zones and greening between intensive farmland, roads and habitats will be created; thus, connectivity of habitats (stepping stones) and water quality (reduction of influences of agricultural chemicals and road salt) will be improved. If necessary, artificial hibernation sites will be created.

Networking with international partners (Denmark, Germany), capacity building, replication and transfer will be assured by exchange of best practices and hands-on experiences at national and international level. Coordination Centre for Amphibians in Slovenia (CCA) in the form of help desk will be established. It will offer expertise, organisation and analysis of Citizen Science projects on amphibian road mortality and other conservation issues in the country. Important part will represent further development of existing database of amphibian migratory crossings on the roads in Slovenia. We would like to further this activity by establishing a national network of "Toad patrols" and co-ordinate the information towards road administrators (national and local) and Natura 2000 managers for the implementation of best practice solutions in the future.

KEYWORDS: Amphibians, Road mitigation measures, Habitat restoration, Green infrastructure

#3 Assessing the ability of modern metapopulation models to mimic real life using genetic data

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Face to the global reinforcement of environmental regulation within the EU to achieve the biodiversity "No Net Loss" (NNL) goal, environmental assessment (EA) has to estimate actual impacts of projects on species metapopulation functioning at larger and larger spatial scales and with more and more accurate and realistic evaluations of this functioning. In this respect, modelling tools may contribute in improving the current EA practices by providing large scale metrics of metapopulation functioning. However, as emphasized by previous works, modelling tools often suffer from a lack of *in situ* testings and validation.

In the CIRFE project, we compared the results of field work landscape genetics survey with an agent based spatially explicit stochastic metapopulation model outputs. In this respect, the meadow brown (*Maniola jurtina*) and the midwife toad (*Alytes obstetricans*) benefit from a three year individual based genetic survey in a 30 km² study area in southern France with a cumulation of 5 major infrastructures (national road, motorway, railway, power line and pipe line). This survey, led to 132 genotypes of midwife toads and 900 for the meadow brown. At the same time, metapopulation dynamics simulations were conducted using SimOiko which is a spatially explicit agent based model where each simulated individual carry its own genotype. Simulations were performed at the study site scale assuming that at the initialization of the simulation the populations are at the Hardy-Weinberg equilibrium. Then simulations are run during 50 years and replicated 50 times. At the end of the simulation, we simulate a genetic sampling following an equivalent protocol as deployed on the field and analysed the virtual genotypes following the same procedure as for the field data.

We compared the genetic diversity predicted by the model with the observed diversity in the field for both species using regressions. Preliminary results shew r^2 values ranging from 4.10^{-6} to 0.45 depending on the species and the spatial resolution of the simulation input map. Then, we analysed how the genetic variances are spread within the landscape using spatialized multivariate analysis. This second analysis shew a good overlap of the genetic variance spatial distribution between observed and simulated data for both species. The good overlap of the genetic variance tends to shew that the gene spreading within the landscape and the low r^2 values that the study site history must be taken into account to interprete the results.

Thus we shew that the model is able to predict relevant genetic variance spatial distribution for both species, but also that the ability of predicting the genetic diversity of individuals depends on the species life-history-traits. If these results must be extend to other taxas, such an ability of mimicking the actual population functioning may constitute a relevant prospective decision making tool from the landscape (planification) level to the ecological engineering project (mitigation measure) level by permitting to evaluate the environmental debt at the species level and estimate the expected mitigation measures cost-efficiency which are from prime interest when considering the NNL objective.

KEYWORDS: Simulation, metapopulation dynamics, connectivity, landscape genetics

#4 Road proximity affects reproductive investment in lizards: a two-years translocation experiment

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Worldwide roads are in continuous expansion, with an expected increase of >60% by 2050. This may increase selection pressures on wildlife, urging applied ecologist to investigate the adaptive potential of populations to forecast long-term effects. Most of the works to date have been individual-focused, obviating the potential evolutionary impact of these infrastructures on populations of small vertebrates with low migration capability (e.g., lizards). Pressure associated to road proximity can be indirectly derived from habitat transformation and degradation. We hypothesize that we can demonstrate the selective effects of a road by comparing lizard phenotypes between subpopulations differing in proximity to the linear infrastructure. Thus, to investigate selective effects as a function of road proximity, we selected two150 meter-wide sampling bands of terrain that were one close to a road and the other one 500 m away from it. We studied differences in vegetation cover, prey availability, abundances of aerial predators and lizards, female phenology, and hatching date as indicators of habitat quality, associated to the presence of the road, and as possible drivers of subsequent differences in the lizard traits between subpopulations. Mean values of head and body size, body condition, ecto- and endoparasite loads, tail state, and male nuptial coloration (all traits associated to individual quality) were compared as base-line indicators of disruptive selection. Near-males had an earlier investment of nuptial coloration in life, but coloration was of poor quality as compared to far-males. Hatching date was earlier in the far subpopulation, and juveniles were bigger prior to hibernation there. In addition, during two years, we carried out a two-step capture-recapture translocation experiment. In the spring of the first year, we individually marked 120 males, 60 per sampling band, and translocated 30 of them from close to the road to far from the road, and *vice-versa*. The remaining 60 males formed two control groups, close and far from the road, respectively. A balanced subsample of 25% of the males was recaptured ~30 days, in average, after the first capture. Intergroup differences in individual change of body condition, parasite load, and sexual coloration were calculated and used to quantify the response of the lizards to the road proximity. We found an effect of the treatment on the lizards: translocated lizards lost weight. However, control individuals far from the road significantly increased their body condition compared to the rest of experimental groups. Interestingly, these same lizards reduced their endoparasite load, suggesting a selective impact of the road because no differences were initially detected in parasite load or body condition between subpopulations. This was confirmed during the spring of the second year when 30% of the lizards, marked the previous year, were recaptured near the road. The variation observed in the traits measured confirmed that far-males had higher individual quality. All this together supports the idea that the road exerts a selective effect, producing disruptive selection on the lizards' phenotype and, therefore, may have an evolutionary impact on this population.

KEYWORDS: Disruptive selection, Individual quality, Population dynamics, Road Ecology

#5 ControlInRoad: Controlling invasive alien plant species along roads

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Invasive alien species (IAS, including plants, animals, microorganisms) are a threat to the biodiversity in Europe. The cost to the European economy is estimated to be at least €12 billion per year in different sectors of the economy (https://ec.europa.eu/environment/pdf/13_07_2016_QA_en.pdf).

Road and traffic areas are more and more seen as a major threat to biodiversity because they are impacted by a growing number of IAPs of concern which need to be eradicated or at least controlled. Through road maintenance activities, seeds of invasive plants can be easily dispersed 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 heavily on mechanical and chemical methods to control weeds and IAPs along roadsides. The use of chemicals has been debated for several years and also finds less and less acceptance by the general public. Moreover, the registration of herbicides is debated at the political level and some active ingredients will be most likely withdrawn from the market in the next few years.

The ControlInRoad project (http://www.controlinroad.org) assessed the occurrence of IAPs along roadsides, reviewed current control methods and regulations across Europe and tested different control methods. A list of relevant roadside IAPs in Austria, Germany, Ireland, the Netherlands, Norway, Slovenia and Sweden was compiled, and a booklet with the description and control methods of the most abundant IAPs was elaborated. In 2018 and 2019, field trials were performed with common ragweed (*Ambrosia artemisiifolia*) and knotweed (*Fallopia* spp.). For the control of common ragweed several of the tested methods such as hot foam (Weedingtech), electricity (Electroherb™), infrared (Brühwiler) and pelargonic acid (Belouka) applied twice and up-rooting were successful. For knotweed, the plants treated with electricity were smaller than the untreated plants; however the number of plants did not differ. The results obtained should still be validated under other environments.

To evaluate the applied methods in terms of costs, a cost-benefit analysis was carried out analyse the benefit of a certain measure in relation to normal daily vegetation management in different scenarios of IAP invasions on three different plant species, common ragweed, knotweed and giant hogweed (*Heracleum mantegazzianum*). For the different scenarios and plant species, the chemical treatment shows the best cost-benefit ratio. After the chemical treatment, a different treatment method with the best cost-benefit ratio was determined for each of the different plant species and scenarios.

In our analysis it became evident that a management plan must be drawn up to successfully combat IAPs. The action plan should include the following points: Documentation of the IAP invasion, schedule of treatment according to plant species and waste disposal and monitoring the success of the treatment. To achieve this, an adequate budget is needed, as well as clear competence and accountability in the management of the IAPs.

The findings and recommendations can be found on the project website http://www.controlinroad.org.

KEYWORDS: Invasive alien plants, Road margins, weed control methods, Cost benefit analysis

SESSION 5.1.2. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 2

#1 Risky wandering close to the railway: flight behavior of birds across the platform and viaducts in a high-speed railway

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Running trains kill birds, and this problem is foreseeable larger in high speed railways (HSRs). However, HSRs have been planned and built over years with scant knowledge of this impact, leading Environmental Impact Assessment and mitigation to be backed mainly on intuition or soft data. A special focus has been devoted to viaducts in valleys, where bird protection barriers are prescribed assuming without formal evaluation their high risk nature due to corridor effects and the elevated position of the railway there. Better knowledge of bird behavior around railways is thus needed to inform the environmental decisions for the expected increase in the extent and traffic of railways. In this context, we present results from a two-year study of bird flight patterns over an 8-km stretch and three viaducts (656m, 334m and 460m length) in the HSR line around León (NW Spain).The study is based on 10' bird observation stations (N=2,342) devoted to the census of flying birds across 120m stretches of the railway (each flock or solitary bird denoted as a 'crossing'). Since train-kill may happen when birds fly across the gap between the rail and the catenary, total frequency of bird crossings and the percentage of crossings through the risk area where our target variables. Our results show that bird crossing of the railway is frequent and rather dependent on very local conditions. Thus, in the study area bird flight across the viaduct over the Esla River (average 47.0 crossings/km*h) was less frequent than over other adjacent sections (69.6 crossing/km*h); and both these features much larger than those observed in the two viaducts over the Bernesga River (18.7 and 16.5 crossings/km*h) in the same railway. Regarding the proportion of flights across the risk area, it was higher where the railway runs over embankments (45.5%) than in any viaduct. The percentages of risk crossings were rather similar among these, though a bit lower (23.7%) in the one protected with 2m opaque screens than in the unprotected ones (32.2% and 27.5% respectively). Several common species (e.g. Columba palumbus, Fringillidae, Hirundinidae), but also others of more conservation concern (e.g. Milvusmigrans, Circus aeruginosus, Buteobuteo), were found to cross frequently through the risk area in both the viaducts (with or without barriers) and the flat sections of the railway. We conclude that (i) many birds cross routinely the railway under the risk of being killed and (ii) this situation is very dependent on local conditions, forcing a detailed analysis of future HSR lines during planning and the development of extensive bird studies in order to properly evaluate the environmen-

tal impacts and locate and design the mitigation measures. Moreover, (iii) viaducts may not be always the most risky sites for birds, and (iv) bird protection screens should be taller than those routinely used for noise protection, since they do not dissuade birds to cross the gap between the rail and the catenary. Extensive basic studies like this one are also needed due to the huge gap of knowledge existent on railway effects on wildlife.

KEYWORDS: Bird protection screens, Environmental impact assessment, Mitigation, Mortality, Roadkill

#2 Linking habitat composition, local population densities and traffic characteristics to spatial patterns of ungulate-train collisions

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The total length of railways worldwide exceeds 1 million kilometres and recent railway development directly impacts wildlife because of animal-train collisions. Few studies, however, have analysed factors driving ungulate-train collisions. We analysed over 3500 ungulate-train collisions including roe deer, red deer, wild boar, and moose collected in 2012-2015 in Poland. The data on train collisions with wild ungulate species in Poland were available from the Bureau of Environmental Protection, Polish Railways PKP S.A. which is a state-owned company being the largest railway infrastructure manager in Poland. We compared train traffic characteristics (e.g. traffic intensity, speed, rail curvature), land-use and habitat characteristics (e.g. share of forests and build-up areas) and local ungulate population densities at collision sites and we contrasted them to 10,689 sites randomly distributed along the rail network. In the years 2012 to 2015, roe deer (n=1,886) and wild boar (n=1,012) were the most common species involved in recorded collisions, followed by red deer (n=505) and moose (n=160). The collisions were recorded across the whole country, except for moose where almost all collisions were recorded in east Poland. Our results showed that forest coverage generally increased, while urban areas decreased ungulate collision risk. Local density of ungulate species had a strong positive relation to the relative collision risk in all four ungulate species, but above certain densities, the risk levelled off for all three species (marginally non-significantly for roe deer). Train speed and train traffic intensity were positively associated with elevated collision risk in all four species, but the latter in a non-linear manner reached an asymptote at the level of ca. 10 trains per day. Rail curvature also increased probability of collisions with roe deer and red deer and possibly also wild boar. Mortality rate of ungulates on railways in Poland is estimated to be 0.13-0.42% of annual hunting bags of studied species assuming that only one individual is killed at each occasion and ignoring undetected collisions. These values are expected to increase in near future due to increasing train speed in Central European countries. To reduce collision risk in a cost-effective way, we suggest prioritisation of mitigation actions at sections of the railway characterized by those factors, e.g. by fencing and various warning devices. Due to nonlinear correlation between collision risk and population density, reducing density of ungulates will most likely reduce collision risk only marginally, and only in regions of low population densities where collision risk is relatively low anyway.

KEYWORDS: Collision risk, Moose, Red deer, Roe deer, Wild boar

#3 Are railways really detrimental to bird populations? The case of the new Bothnia Line Railway in northern Sweden

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Common sense tells us that railways and trains should be detrimental to bird faunas. Birds lose their habitat, are killed in collisions, and survivors scared away by sonic, visual and human disturbances. Even scientists tend to embrace this negative effect opinion. Is their evidence solid? I tested potential effects of the construction of a 180 km long new railway on birds in agricultural landscapes in a before-during-after control-impact (BDACI) study with 13 impact and 6 control sites. The design had an additional phase when the railway was physically ready but train traffic had not yet started. In 2002-2015, I monitored species richness, numbers of breeding territories and estimated positions of territory midpoints. Species richness at large was stable in control sites and increased in impact sites. Trends were negative in one impact site (8%) and positive in three (23%). In a mixed effect model, numbers of observed bird species during the successive phases were not significantly different from the Before phase. In line with the widespread negative trend in farmland bird numbers, numbers of territories decreased in very similar ways in impact and control sites. Overall numbers for impact sites showed negative trends in four cases (31%) and a positive trend in one (8%). In this latter site, a massive compensation program was carried out over the course of the study. At species level, the trend analyses revealed a fuzzy pattern of possible winners and losers, e.g. Meadow Pipit and Northern Lapwing, respectively. Median distances from territory midpoints to an arbitrary baseline increased in control sites but distances to the railway line decreased in impact sites. This contradicts a general "scaring off" effect by construction activities and train traffic. This lack of repelling effect was also found in the mixed model analyses. Overall, this BDACI study provides no evidence for a widespread negative impact on bird populations caused by the introduction of a new railway on agricultural land in boreal landscapes, rather the opposite. Time to re-evaluate common sense and previous science?

KEYWORDS: Railway, Birds, BDACI study, Agricultural landscape

#4 Bird mortality by collision with transmission power lines: analysis of 15 years of impact assessment in Portugal

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The global increase in power consumption, in last decades, has led to a large expansion of the electricity transmission grid, with increasing biodiversity impacts. In Portugal, where the network of Transmission Power Lines (TPL; 150-400 kV) is managed by REN – Redes Energéticas Nacionais, there is a substantial amount of data, accumulated over the last ~15 years, regarding bird mortality caused by collision with these structures. This information was collected mainly in the scope of monitoring programs of Environmental Impact Assessment processes but included also specific monitoring programs carried out by NGO's along with REN and the national authority in nature conservation (ICNF). However, such information was, until recently, almost totally unexplored for science.

REN Chair in Biodiversity is a partnership (2015-2020) between CIBIO (University of Porto), REN and Fundação para a Ciência e a Tecnologia, with the main aims of (1) developing scientific research related with bird-power line interactions and (2) promoting the transference and application of such knowledge to REN and other stakeholders operating in the area.

Within the scope of the planned activities of the REN Biodiversity chair, we analysed the final reports of 34 bird mortality monitoring studies in TPLs between 2003 and 2015 in Portugal, mainly to describe the type of data, methods and survey effort. Besides data on bird mortality rates (by collision), these studies frequently included tests to evaluate survey bias, namely carcass detectability and removal by scavengers. In this communication, we will make a general characterization of bird collision patterns in TPL, based on a database composed by more than 3400 carcasses found, from ca. 130 species, resulting from the systematic survey of 700 km of power lines across the country and encompassing a total (accumulated) survey effort of 13400 km. Seven percent of the carcasses belong to (19) threatened species in Portugal, from which the Little bustard (*Tetrax tetrax*) and the Great bustard (*Otis tarda*) clearly stand out, and both are in the top 20 of the species with higher number of collisions. Overall, mortality rates appeared to be affected by season (highest in autumn and lowest in spring) and region (higher in south than centre and north of the country), but without clear patterns when comparing lines with 2 against 4 collision planes (horizontal and vertical circuit configuration, respectively). Despite being in a preliminary state, the exploration of these data illustrates its high potential to improve the current scientific knowledge on bird collision with transmission power lines, with conservation implications, such as the relative susceptibility of different species to this kind of impact.

KEYWORDS: Biodiversity impacts, Overhead wires, Species' susceptibility, Mitigation

#5 Effects of linear infrastructures on the composition of local vertebrate scavenger guilds and bird carcass removal patterns in two Mediterranean agricultural landscapes

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Vertebrate scavengers provide an essential ecosystem service through the removal of carrion in natural landscapes, including wildlife casualties caused by linear infrastructures (LI). It is known that local scavenger guilds and their foraging behaviour are greatly influenced by landscape features and carrion availability (among other environmental factors). Thus, there is a growing perception that opportunistic scavengers take advantage of the presence of the LI and increase their predation rates within power line or road rights-of-way (compared to the surroundings), leading to increased bias in the studies aiming to quantify the impacts of these infrastructures on wildlife. Few studies have, however, truly assessed how different types of LI shape the local scavenger community and its cascading effects on carcass persistence.

In this study, we used camera traps to assess the effect of the presence of power lines and roads on the identity of the vertebrate scavengers responsible for removing bird carcasses in two Mediterranean agricultural landscapes (both located in central Portugal but with different management regimes) and its effects on overall carcass persistence. During the winter seasons of 2017 and 2018, we monitored for 21days the scavenging of 250 carcasses of free-ranged quails (*Coturnix coturnix*) placed along the rights-of-way of two transmission lines (≥150 kV)and a two-lane paved road (each comprising ca. 8 km in length), as well as on two control areas (one in each agricultural landscape).Survival analyses were conducted to assess the effect of type of agricultural landscape, treatment (Power line, Road and Control) and Scavenger group(Raptors, Corvids, Carnivores and Cats/Dogs) on time elapsed until the first scavenging event and time until complete carcass removal.

Our results show that avian scavengers tend to find the carcasses before mammals (~1.2 days and~2.6 days, respectively). Nonetheless, most of the scavenging in both agricultural landscapes was carried out by carnivores, with Red foxes (*Vulpes vulpes*) being responsible for more than45% of the scavenging events. The effect of LI presence on scavengers' identity and carcass removal rates was not consistent across agricultural landscapes, suggesting that broad generalizations about LI effect on scavenging patterns may not be appropriate. Contradicting common assumptions, LI presence had either no effect or a positive effect on carcass persistence. Carcasses placed next to roads were not removed faster than the ones placed below power lines or at control sites. This result suggests that bias in small- to medium-sized bird mortality estimates

resulting from scavengers' activity at roads may be negligible, particularly when compared with carcass removal resulting from traffic.

KEYWORDS: Roads, Power lines, Carcass persistence, Bird mortality, Scavenging bias

#6 UIC Ecological Effects of Railways on Wildlife project (rEvERsE)

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Ecosystems are degraded by transportation infrastructure as a result of land consumption, landscape fragmentation, barrier effects, emissions and wildlife mortality from collisions with vehicles. These can threaten the viability of sensitive populations and alter ecosystem dynamics. Railways will play a much more important role in future transport systems due to their climate-friendly and resource efficient operation. Therefore, a number of global activities to enlarge railways transport capacities, both on existing lines as well as on newly built lines, can be expected. Biodiversity is a crucial topic for the environmental performance of railways, equally important as its contribution to climate protection. Railways can contribute to biodiversity protection in various fields, but so far, they are not aware of the important role they are playing and are not integrating biodiversity into their environmental management and communication, to the same extent as they do with climate and energy. Railway properties like embankments, ditches, forests, ecological compensating areas, shunting areas, built infrastructure, etc. are highly valuable migration corridors and retreat areas for many rare species.

The impacts of railways on wildlife have received less attention than those of roads probably because wildlife-train collisions are not visible to the general public and constitute no safety risk to train drivers or passengers. The traffic flow is much lower on railways and railway corridors are much narrower than roads, therefore, railways have lower wildlife mortality. Ordinarily, only the train crews are aware of the animal mortality caused by collisions, as railways have typically restricted access. Trains cannot evade wildlife nor stop quickly.

Our purpose in this project is to compare railway's negative impacts on the loss of biodiversity and habitat between project participants, as well as the positive impacts railways can have if managed in a biodiversity sensitive way. Furthermore, sustainable railway transport can help achieve multiple United Nation Sustainable Development Goals (UN SDGs) for the participants. To this effect, the UIC rEvERsE project can be seen as a contribution of railway to the SDG 15 (Life on land). In addition, this project aims to provide solutions and best practices for the correct development of an environmentally responsible railway transport system in Europe.

- The objectives of the project are to:
- Avoid habitat fragmentation and enhance biodiversity conservation on railways by sharing experiences and knowledge,
- Describe and promote measures that constitute a railway contribution to the UN SDGs
- Provide a general understanding of the issues to meet global challenges,

- Identify how railways threaten the survival of wildlife in Europe, and how these threats can be overcome.

Each participant will have a chance to study biodiversity issues on an international level and benefit from the results. Studies will be initially conducted across Europe and will aim to improve the future rail network to be as sustainable as possible, particularly in regions where the rate of railway construction is currently high or set to increase. Europe's railway system will become a global frontrunner and model for a sustainable transport system that takes social, economic and ecological aspects equally into account.

KEYWORDS: Railway ecology, Sustainable transport system, Wildlife-train collision, Biodiversity

SESSION 5.2.1. GREEN INFRASTRUCTURE NETWORKS: POLICY AND STRATEGIC PLANNING

#1 German's federal waterways – A linear infrastructure network for nature and transport

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Major rivers are unique linear structures because they serve different purposes simultaneously: habitat and dispersal route for flora and fauna as well as navigation route, site for recreational and economic activities and source for drinking water and irrigation. They link up cities and ports. The energy of their running water is used to generate power. Today, however, we also know that we have a special responsibility to sustainably manage achievements we have inherited from the past. Our waterways must be developed in an economic, environmentally sustainable and socially responsible manner. The great challenge now is to establish a balance between transport systems and the natural world.

How can we integrate all these functions with as little conflict as possible? The Federal Ministry of Transport and Digital Infrastructure (BMVI) and its specialised agencies – the Waterways and Shipping Administration of the Federal Government (WSV), the Federal Institute of Hydrology (BfG) and the Federal Waterways Engineering and Research Institute (BAW) – are aiming to achieve this goal together with the Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Agency for Nature Conservation (BfN) by integrating environmental issues into the development and maintenance of waterways. This happens on the basis of progressive legislation, political programmes, applied research projects (Status report of German Floodplains) and local projects. Building fish passes, creating bypasses in floodplains, riverbank restoration - where possible, and the development of innovative groynes and training walls are some practical examples - under the umbrella of the "building with nature" approach.

Some minor waterways in Germany are no longer used for the transport of goods. For these waterways, development strategies to reduce infrastructures that are no longer required and the enhancement of opportunities for ecological development and recreational activities are planned. The integrated LIFE-project "Living Lahn" (2015 – 2025), conducted by the federal states of Hesse and Rhineland-Palatinate, together with the WSV and BfG aims at restoring/preserving the "good ecological potential" of the federal waterway Lahn, e.g., through the restoration of near-natural shores, floodplains and linear patency. At the same time, the interests of shipping and other competing uses will be integrated in accordance with ecological requirements. Natural water retention will be promoted, as well as an ecologically compatible discharge regulation. This project creates best-practice examples for other rivers.

"Germany's Blue Belt" is one of the BMVI's new flagships. It is a Federal Government programme in cooperation with the BMU and the BfN. After completing the conceptual preparatory work, the operational phase of the "Blue Belt" programme started in 2019. It aims at developing a system of interlinked biotopes of national significance along Germany's federal waterways within the next decades. One important part of the implementation is the Federal Floodplain Programme which is managed by the BfN. Measures strengthening lateral connectivity between rivers and floodplains are of special significance within the programme. In parallel, the objectives of the Water Framework Directive (WFD) and the Natura 2000 Directive are supported.

To enable the WSV to manage all these tasks in an appropriate manner, the BMVI and the BMU strive for an extension of legal tasks to allow the WSV to support the goals of the WFD to an extended degree.

The presentation will illustrate examples of building fish passes, riverbank restoration, innovative groynes and training walls as well as details of the LIFE-project "Living Lahn" and "Germany's Blue Belt". The status of implementation of the strived extension of legal tasks to support the goals of the WFD to an extended degree will be reported.

KEYWORDS: German waterways, Biodiversity, Water Framework Directive, Germany's Blue Belt

#2 Developing projects for harmonization of Green and Grey Infrastructure (the HARMON project experience in the Danube Region)

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Grey (linear transport) infrastructure is one of the key elements to support socio-economic development, with a high (geo-) strategic and political significance; therefore its importance is easily recognized at all social levels.

Green infrastructure, on the other hand, is a relatively new concept, more complex and therefore more prone to different interpretations. Although it is considered as one of the key instruments to address specific societal needs by EU strategy and adequate to address climate change effects, the implementation of a Green infrastructure strategy seems impacted primarily by the lack of coherent and uniform definition of the concept.

At present, Grey infrastructure is one of the main causes of biodiversity loss through landscape fragmentation, therefore it is affecting the very goal of Green infrastructure – supporting the natural flow of processes, movement of individuals and transmission of genes.

Both the ongoing economic development in relatively unfragmented landscapes and the already fragmented landscapes of developed countries demand urgent actions for ensuring Grey and Green infrastructure harmonious coexistence. The harmonization of Grey and Green Infrastructure should ensure ecological connectivity while developing sustainable and resilient linear transport infrastructures at national and international scales.

In order to operationalize the status and needs of harmonization, we are proposing a list of parameters, structured on four levels: A) Policy and strategies, B) Planning and environmental impact assessment, C) Implementation and management and D) Education, awareness, consultation and communication. This four levels approach was adopted also by IENE's Global Strategy for Ecologically Sustainable Transport and other Linear Infrastructure.

In the HARMON project (funded by EU ERDF / Seed Money Facility of Interreg Danube Transnational Programme) we used this original approach for assessing the status quo of harmonization of green and grey infrastructure in four project countries of the Danube Region (Austria, Bulgaria, Czech Republic and Romania). A Logical Framework facilitated our engagement with stakeholders in order to evaluate each parameter in each country. A compiled Logical Framework with data from all countries led to a strategic action plan which highlighted gaps (which could be translated in goals for future projects), needs (future objectives), possible actions and relevant target-groups for future projects targeting harmonization.

We consider this to be a useful tool for multi-country projects and we did use it to support the development of a project proposal involving 34 partners from 10 European countries (*SaveGREEN - Safeguarding the functionality of transnationally important ecological corridors in the Danube basin*, EU Interreg Danube Transnational Programme).

SaveGREEN's main objective is to foster cross-sectoral and transnational cooperation and building of know-how towards developing concrete solutions to improve, restore, and preserve the functionality of key ecological corridors in Carpathian, Alpine and Bulgarian mountain valleys, where human activities as well as critical points for wildlife migration concentrate and thus conflicts are highest. The project will seek to achieve results of common interest (i.e. cross-sectoral operational plans, capacity building programme and policy actions) and will foster exchange of know-how across project countries (i.e. mapping and monitoring best practices, ecologically based management measures etc.).

KEYWORDS: Green Infrastructure, Grey Infrastructure, Harmonization, Parameters, Action plan

#3 From technology to strategy: developments and perspectives of research in infrastructure and ecosystems

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While infrastructures are one of the main factors of biodiversity loss, it is paradoxical to observe that there are no specialized research centres on this subject. For more than 40 years, the term "road ecology" has been gradually emerging. In parallel, the need for dedicated research has never weakened. To this end, national and local authorities or companies working in this field have supported, in a fragmented way, without real capitalization of knowledge, the development of researches, mainly oriented in terms of engineering techniques (civil or environmental) and of directly operational solutions mainly, sometimes at the expense of robust research protocols.

This highly fragmented approach has for a long time been based on a predominant road sector, considered as the prevailing factor of biodiversity loss, without really taking into account convergent needs or potential synergies with other types of transport or energy infrastructure. Interdisciplinary dialogue has also often, but not always, been set aside for disciplinary approaches in silos. This connection between transport and biodiversity, was made complex by the need to develop a systemic approach and this complexity has installed a mutual, long-lasting misreading.

Recently, for less than a decade, isolated national initiatives, that are now turning more global, have been initiated to develop a structured research on the subject, able to fulfil the cross-requirements of the States, planners, investors, populations and, of course, ecosystems. The importance of adapting the existing stock as amass of future projects has been translated in many ways: COP 14 and 15 of the CBD (mainstreaming infrastructure and biodiversity), G7 transport announcements (same level of interest for GHG fight and preservation of biodiversity), growing interest of the World Bank or of the EBRD in their medium and long-term strategies, the first appearance of the theme infrastructure and biodiversity in the H2020 transport research program... All these elements are many signals indicated that the situation is changing and that it is essential to support quality research on the subject, capable of supporting the development of breakthrough innovations, associating institutions, research laboratories and private actors in a joint process.

Based on the French experience with the national research program ITTECOP, on the evolutions of the role played by the IENE network since 1996 as well as on the approach undertaken in the framework of the H2020 transport program, we will present the key elements to support the development of structured European research on infrastructure and ecosystems. This approach, partnership-based, open, interdisciplinary and resolutely turned towards an ambitious research associating innovation must be able to bring the necessary elements to establish a strategic dialogue with the decision-making bodies integrating these stakes at the highest level.

KEYWORDS: Linear infrastructure, Research, Innovation, Public-private partnerships, Strategy

#4 The SaveGREEN Project – Safeguarding the functionality of transnationally important ecological corridors in the Danube basin

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Many valuable ecological corridors of the Carpathian and other mountain ranges in the Danube region are impeded or threatened by economic development such as linear transport infrastructure construction or intensive agricultural, forestry, or water management practices. The reason for this conflict is that economic projects are not sufficiently planned with the goal to maintain ecological connectivity and the flow of multiple ecosystem services that these Green Infrastructure elements provide. Mitigation measures such as green bridges are often missing or dysfunctional because of inadequate design, location and inappropriate management of surrounding land use by e.g. agriculture or forestry.

The project SaveGREEN, co-funded by ERDF, aims to demonstrate ways of designing appropriate mitigation measures and maintaining or improving the functionality of ecological corridors through integrated planning. It thereby builds on key results of the Danube Transnational Programme projects TRANSGREEN, ConnectGREEN, and HARMON. Monitoring the impact of such measures will help us to learn and derive proper recommendations for follow-up action and policy design. The focus of the project will be on conflict areas in critical ecological corridors located in the Alpine-Carpathian Corridor, the Kobernausser forest (Austria), the Beskydy region (Czech-Slovak cross-border area), in Novohrad-Nógrád Hungarian-Slovak cross-border area, in the Mures valley in Romania, the Zakarpatska region in Ukraine, and the Rila-Verila-West border mountains in Bulgaria impacted by linear transport projects and unsustainable land use. We will foster cross-sectoral collaboration, build capacity for replication of pilots and upscale results through improved policy frameworks.

Expected outputs comprise (1) robust method for monitoring structural and functional ecological connectivity including an application toolbox in order to analyse the functionality of crossing structures and the surrounding land thereof, (2) cross-sectoral operational plans to safeguard the functionality of eco-corridors in 7 pilot areas involving relevant stakeholders, (3) transnational workshops in the pilot areas to build on-site solutions, (4) capacity building program and training events for public authorities and other key stakeholders on how to plan infrastructure projects in an integrated way with a focus on EIA, SEA, cost/benefit analysis and mitigation measures, and (5) a high-level joint political declaration in the frame of the European Strategy for the Danube Region (EUSDR) and (6) recommendations towards integration of mitigation measures into the national and EU level policy processes.

The project partnership covers key sectors to be involved in integrated planning of mitigation measures: nature conservation(ministries, agencies, authorities, NGOs), research and education (universities, research institution), transport (ministries, motorway companies) and consultancy business (limited company) and associated strategic partners from complementary sectors from Austria, Bulgaria, the Czech Republic, France, Germany, Greece, Hungary, Romania, Slovakia and Ukraine.

KEYWORDS: Ecological connectivity, Linear transport infrastructure, Functionality of ecological corridors, Cross-sectoral cooperation

#5 Mapping ecological corridors to educate policymakers and the public

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Out of the 5 Flemish provinces Limburg has the largest surface consisting of nature. Yet biodiversity suffers from a strong fragmentation. The central location of Flanders in Europe makes it an important junction of infrastructure.

The Provinciaal Natuurcentrum Limburg (PNC), a service of the provincial government, is responsible for the themes biodiversity and nature and environmental education. The Provinciaal Natuurcentrum takes both a role in policy support as well as in on-site implementation of biodiversity measures.

The last couple of years the PNC is working on the implementation of a network of ecological corridors in Limburg. The support of policymakers and staff of governments turned out to be very important and should not be underestimated.

In 2011 the province of Limburg has produced a map with 80 preferred ecological corridors, designed for a set of indicator species. The design of these corridors was based upon scientific literature and according to the nature and spatial planning policies of the Flemish government.

The map is a guideline for the policy of the province of Limburg concerning spatial planning and licensing policies. It also forms a basis for the practical implementation of ecological corridors. In 4 cases ecological corridors and stepping stones were realised. For 4 more corridors plans are being made. In 2 cases these plans are in a final stage of design. Our main partner of the linear infrastructure operators is the Flemish department of transportation. We rely on the technical expertise of the civil engineers to design an achievable solution. We have 2 interesting cases we will highlight in which we are currently working on the development of ecological corridors on two abandoned railroads. These railroads will be developed as functional bicycle highways. Our aim is to reconcile the functional needs with the European nature goals (The Habitat directive).

The PNC experienced a certain reluctance about the subject with other provincial services and Limburg municipalities. This often seems a consequence of a lack of knowledge about ecological corridors or the making of wrong presumptions.

That's why the last few years the PNC paid a lot of attention at the development of social support for the network of ecological corridors.

In 2018 the PNC developed a series of municipal nature reports in which it combined the explanation of terminology, figures about the state of nature in the municipality, the main nature policies, a practical map of the ecological corridors in the municipality and a list of possible partners for collaboration. The reports are a reference for every municipality that wants to participate actively in the subject.

The PNC works proactively to familiarise other provincial services and potential stakeholders with the concept of ecological corridors. Attention goes to terminology, the ecological needs of species and the impact of practical measures. The dialogue starts from the mindset of the stakeholder. We experience that the reluctance of stakeholders is often inspired by the lack of understanding and knowledge about ecological processes. Once it is obvious that ecological solutions are possible without blocking functional needs, collaboration is possible.

In the near future the PNC wants to combine the network of corridors with the concept of green blue grids, a theme that has recently become a hot-topic in the spatial planning vision of the Flemish government.

Furthermore the PNC will keep on approaching the subject of ecological corridors in a functional and integrated way. Ecological corridors must be designed starting from the functional ecology of species. An integrated approach offers the biggest opportunity to a sustainable conservation of corridors and to a broad social support by stakeholders.

KEYWORDS: Network ecological corridors, Policymaking, Educate, Social support, Collaboration partners

SESSION 5.2.2. CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY – 1

#1 Are largescale citizen science data precise enough to determine road-kill patterns?

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Roads are one of the most transforming linear infrastructures in human-dominated landscapes, with animal road-kills as their most studied impact. Therefore, there is the need to gather road-kill data and in this sense, citizen science is gaining popularity as an easy and cheap source of data collection that allows large scale studies that may otherwise be unattainable. However, citizen science projects that focus on road-kills tends to be geographically localised, therefore, there is a debate about whether large-scale data collected by citizen scientists can identify spatial and temporal road-kill patterns, and thus, be used as a reliable conservation tool.

We aim to assess whether citizen science data contained in the Spanish Atlas of Terrestrial Mammals (henceforth "Atlas"), can be as valuable and accurate as road-kill surveys undertaken by experts in detecting road-kill hotspots and establishing road-kill rates for different species of carnivores. Using Linear Models, we compared species-richness, diversity and abundance of road-killed carnivores between Atlas data and our own road-kill survey database. We also compared (per species) the observed road-kills in our road survey with the expected road-kills based on the species abundance from the Atlas.

In our Linear Models we did not find a significant relation between the road-kill data and the Atlas data. This suggests that data from the Atlas are unsuitable to determine road-kills patterns in our study area. This could be due to the lack of control over the sampling effort in the Atlas data, and the fact that the Atlas has a sampling scope that is not fitted for road mortality studies. When we compared observed road-kills (per species) with those expected based on Atlas abundance, we found that some species are road-killed more (or less) than expected. This may be due to ecological or behavioural traits that make some species more (or less) prone to be road-killed.

To summarize, our findings suggest that occurrence in Atlas data does not mirror road-kill patterns, likely due to both several biases in Atlas data and to species-specific responses to roads. Thus, to study road-kill rates and patterns, we suggest the use classical road-kill surveys, unless correcting approaches to citizen science datasets are applied. This is especially important when the study aims to determine species' specific road-kill patterns.

KEYWORDS: Carnivores, Citizen science, Road Ecology, Wildlife-vehicle collisions

#2 Using citizen science to survey roadkill at wide spatio-temporal scales

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As the global road network expands, roads pose an emerging threat to wildlife populations. One way in which roads can affect wildlife is wildlife-vehicle collisions (WVC), which can be a significant cause of mortality. In order to successfully mitigate these problems, it is vital to understand the factors that can explain the distribution of roadkill.

Preventing WVC begins with recording locations of conflict, such as vehicle crashes, animal carcasses, or animal behaviour around roads, such as avoidance of roads or crossing-behaviour. These data are ideally used to inform transportation policy and planning and to retrofit roadways to reduce conflict. Globally, a number of organisations manage regional and national systems for reporting WVC, both in developing and developed countries.

As a developing country, the work of the Endangered Wildlife Trust (EWT) has improved our understanding of the impacts of road infrastructure on wildlife in South Africa. Collecting the data required to enable this can be expensive and time consuming, but there is significant potential in partnering with organisations that conduct existing road patrols to obtain the necessary data. Repeated road surveys conducted by trained personnel are the ideal way to monitor the impacts of roadkill on wildlife populations but are impractical to conduct over large areas. However, the development of public participation for data collection (often dubbed 'citizen science') has facilitated monitoring at broad spatial and temporal scales, far beyond the limit of traditional field studies. Similarly, the global ecosystem of systems for recording WVC use a range of methods and devices that contribute a wide range of decision-support.

Although large-extent WVC systems have been deployed throughout the world, there have been few evaluations of their features and no recommendations for future developers. Using South Africa as a case study, I report on the range of data collection methods, contributing populations, data management systems, and data visualizations. The majority of our systems have combined global goals of protection of wildlife and driver safety and as records become more standardized, more people are participating in volunteer observations of all kinds, including of the environment.

However, the reliability of data provided by citizen scientists for roadkill studies remains largely untested, although with support and guidance it is possible for citizen scientists to provide reliable data for roadkill studies when it comes to identifying general patterns and high risk areas. Thus, citizen science has the potential to be a valuable tool for identifying potential roadkill hotspots and at-risk species across large spatial and temporal scales that are otherwise impractical and expensive when using standard data collection methodologies. This tool allows researchers to extract data and focus their efforts on potential areas and species of concern, with the ultimate goal of implementing effective roadkill-reduction measures.

KEYWORDS: Citizen science, Data, Roadkill, WVC, Wildlife-vehicle collision

#3 Using citizen science to uncover temporal patterns of wildlife roadkill in the UK

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Using a dataset of 40,000+wild vertebrate roadkill records collated over a period of six years by 'Project Splatter', a 'citizen science' crowd-sourced data collection project, we analysed temporal patterns of roadkill mortality, and consequent roadkill biomass of the 18 most commonly reported roadkill taxa in the UK (comprising 84% of all roadkill reports). The majority of species (16 out of 18) showed consistent seasonal variations in road mortality; all fitted one of three seasonal patterns; bimodal, unimodal or none. The three observed temporal patterns of wildlife roadkill are consistent with species-specific seasonal changes in behaviour, including mate-searching followed by juvenile dispersal (e.g. European polecats in spring and autumn) increased foraging activity (e.g. grey squirrels in autumn), and adaptation to urban habitats (e.g. foxes) where seasonality is absent. Additionally to these behaviour-driven annual patterns, some abiotic factors (temperature and rainfall) explained inter-annual variance in roadkill patterns. Notably, high rainfall was associated with decreased observations of several species (gulls, magpies, pheasants, tawny owls, hares, and rabbits).The high number of wildlife-vehicle collisions creates substantial roadkill biomass, in excess of 32,400 tonnes each year, and likely represents a large and relatively stable food resource for scavenging species such as foxes and corvids. By quantifying seasonal patterns in roadkill and biomass we highlight how modern landscapes interact with wildlife to shape their population dynamics, with likely impacts on their evolution. Doing so also allows us to mitigate against such effects to some extent, by providing a useful tool for directed mitigation, for example, seasonally targeted awareness campaigns.

KEYWORDS: Citizen science, Roadkill, ecology, Wildlife behaviour

#4 Integration of sensory qualities in landscape modelling and its effect on infrastructural resilience

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The present proposal derives from work being developed on the ongoing project *Métaboliser les invisibles,* one of the seven proposals selected for the consultation on prospective visions for Greater Geneva and its ecological transition. We will focus on a specific part of this project: how landscape as an assemblage between the cultural and the living, can act as both resource and support in the transformation of two cantonal routes in Switzerland into multimodal infrastructures that thread embodied mobilities of different ranges of velocity and practices, while taking into account the role and temporalities of the different actors involved, both the living and the non-living. In this presentation, we will analyze how the use of integrative valuing strategies of sensory qualities of landscape in the modellings used in processes with stakeholders can have an important effect on infrastructural resilience.

In a first moment, we will begin by surveying the possibilities offered by new approaches to social participation understood as a socioecological praxis. This means moving beyond the divide between expert-only knowledge and popular knowledge about the environment in order to find common grounds where the scientific and the embodied everyday experience of the citizen can act and critically transform and enrich each other. We will explain this by focusing on a series of spatial modellings addressing ecological, social and embodied dimensions which have, for different reasons, hitherto remained invisible to discussion. We will describe how these modellings can be used to assure infrastructural sustainability into the future by focusing in the factors and ways in which they raise deeper forms of attachment between user and environment.

In order to do this, we will first explain the need to move beyond the notion of visualization and towards the more inclusive notion of spatial modelling. Visualization risks reducing the experience and reality of these landscapes into either data and/or simply objects to be visually grasped. The notion of spatial modeling we advance, instead, considers landscape as a complex sensible experience that demands tools capable of dealing with ambiguity, the indeterminate and complex temporalities, both historical and geological. A modelling thus understood stresses the material and tactile dimensions of the tools used within participatory practices to communicate and discuss through them that complexity and multilayered nature of the environment. We will explain the processes and tools employed for the integration of key sensory and kinaesthetic dimensions of the user's experience within landscape into the modellings used in conversations with stakeholders. We will explore the possibilities opened up by the notion of 'sense scapes', as recently developed in the field of geography, and strategies of 'rhythm analysis' to understand the cohabiting rhythms and temporalities of the different agents (both living and non-living) within a linear landscape infrastructure.

This integration of sensory qualities in landscape modelling can promote stronger civic engagement in landscape infrastructure planning today by turning the user's embodied experience into a lever which, in turn, can become useful when considering questions of infrastructural sustainability and resilience as tighter forms of attachment between user and environment emerge.

KEYWORDS: Embodied mobilities, Landscape modelling, Socioecological praxis, Multimodal infrastructure, Landscape infrastructure

SESSION 5.3.1. MANAGING BIODIVERSITY ALONG ROAD VERGES

#1 Integrating the ecological quality of highway verges in the road assets: a new evaluation tool

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The Swiss federal road guideline ASTRA 18007 on highway verge design and management set nine main objectives: enhance integration of the infrastructure in the landscape, 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. The guidelines require that 20 % of verges be set aside as biodiversity priority zones. However these guidelines alone are insufficient to guarantee that goals are met.

To measure how well these objectives are being met along the highways, an assessment tool has been developed. The tool uses an approach comparable to inspection guidelines for bridges or other road assets.

Five potential condition classes have been defined, going from good (scale 1) to alarmingly poor (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 an insufficient condition (scale 3 on 5). Not only the physical state of the verges but also the ecological function is assessed. How well maintenance personnel is trained to perform the job is also evaluated. The physical state includes the mowing regime (respecting 10 cm minimal height), invasive plants, ecological structure diversity, hedges and biodiversity are examined. Function assesses such aspects as verge stability, design, maintenance of fauna passages and functionality of the ecological corridor. Whether a hedge borders the outer side of the wildlife fence is important for the ecological corridor function. Easy access to the verges is also evaluated. Photos of different conditions illustrate the assessment scale. The state of highway verges should be assessed every 5years to permit corrective measures and guarantee a long-term sustainable maintenance of highway verges. The stretches examined will be rotated, so that every year another highway stretch comes up for evaluation. The tool is to be published on the federal highway website under ASTRA 8B10. First evaluations should start in 2020.

KEYWORDS: Highway verges, Biodiversity, Corridor function, Asset management

#2 Testing wild plants seed mixtures along grey infrastructures

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Linear infrastructures, like roads and railways, exist all around the world and spread throughout a great variety of environments. Despite their known negative impacts, these grey infrastructures have the potential to contribute to biodiversity conservation in fragmented landscapes since they can constitute pools of biological diversity and, thus, corridors between ecosystems, increasing habitat connectivity. Native plants, particularly endemic or threatened species, can be promoted by sowing around these infrastructures.

Our work is integrated in the LIFE LINES project and aimed at promoting the creation of a demonstrative Green Infrastructure to support conservation, and improving the local biodiversity. To achieve this, we developed two types of seed mixtures using wild native species, one for roads and other for disabled railways (currently used as ecotrails), to enhance plant diversity. The composition of the road mixture took into account road security and prioritize the promotion of native species, contrary to the existing commercial mixtures, which usually add exotic species. The ecotrails mixture favoured species with a more diverse morphology, with aesthetic potential and suitable to enhance fauna's refuge and food resources.

The selection of species to be used in each mixture type comprised several sequential steps. A preliminary set of species were sort for being native to the Iberian Peninsula, resist to drought and endure the regular mowing of the vegetation. Afterwards, two different assortments of each mixture type were tested in 12 *ex-situ* plots installed at Herdade da Mitra (Évora, Portugal) in autumn 2016, respecting the following proportions: 30% Fabaceae, 30% Poaceae and 10% Asteraceae. The performance and sustainability of these mixtures were evaluated through the assessment of species frequency, abundance, and biomass production in spring 2017 and 2018, in order to choose the best option for each mixture type. Ultimately, these final assortments were sown in 21 *in-situ* plots along road verges and ecotrails during autumn 2018. The performance and sustainability of the final seed mixtures were also evaluated through the assessment of species frequency and abundance in spring 2019.

The germination of sown species was registered in all the *in-situ* plots, most of them being endemic and more fragile species. Some species did not germinate in *in-situ* plots (e.g. *Dactylis glomerata*), while others only germinated here (e.g. *Campanula lusitanica*). Also, most of the species were able to produce flowers and seeds, which is a good indicator of sustainability. These preliminary results showed that the local plant diversity increased, suggesting that the final seed mixtures tested are suitable to be used in the south of the Iberian Peninsula. Given the small number of mixtures tested in a Mediterranean context, this study constitutes a basis to improve management standards, that should consider the ideal time for mowing. Nevertheless, further monitoring of the seed mixtures dynamics and evolution will be necessary, since some changes may occur over the next years, and adjustments to species composition or proportions may be required.

KEYWORDS: Biodiversity, Linear infrastructure, Restoration, Species selection, Sowing experiments

#3 Using remote-sensing to map suitable road verges for a rare small mammal, the Cabrera vole (*Microtus cabrerae*)

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The Cabrera vole (Microtus cabrerae) is a rare Iberian endemism, classified as "Near-threatened" by IUCN, and "Vulnerable" in Portugal and Spain. The species has a restricted range and a fragmented distribution, occurring mostly in patches of tall and dense wet grasslands in a structured meta-population system.

Spatial and temporal variation on species' resource availability poses difficulties when it is necessary to define which specific areas are most important to protect. On this issue, species distribution models (SDMs) are often used to obtain detailed geographical distribution of species, which are then used to define effective conservation and monitoring actions. However, SDMs applications on Cabrera vole, and other rare species, at a local or regional scale are still challenging, likely due to their low detectability, narrow distribution, and short-term occupancy of suitable patches. In addition, most available digital environmental information may not reflect spatial and temporal ecological conditions required for the Cabrera vole occurrence. Nowadays, remote-sensing provides information on landscape structure and associated biophysical products at areas on able time frequency and at an unreleased fine spatial resolution, which might be a solution to increase the accuracy of models, as availability of resources and its variation through time is better described. Our aim was to investigate the usefulness of ESA Sentinel-2 products for the prediction of suitable habitat patches for the Cabrera vole in a Mediterranean agro-silvopastoral system. We aimed to 1) identify which Sentinel-2 derived predictors are best surrogates for occupied habitat patches; and 2) quantify its importance when compared with other classic/static predictors.

The study was conducted in the Alentejo region, Southern Portugal, in which herbaceous patches were surveyed in Spring 2017 and Autumn 2018, through presence signs and then classified into presence/absence. Dataset was filtered to retain true absences by excluding patches classified as absences with potential habitat. Thereafter, we calculated 85 predictors from Sentinel-2 images as well as from other sources (Topographical information and Landscape element proximity). Specifically, each satellite image was composed of 10 multispectral bands, combined to describe spectral, biophysical and structural landscape properties for each of the two seasons. To identify predictors to retain, their ecological importance was quantified by utilizing Cabrera vole presence/absence data as response variable through a Random forest model accounting for multi-predictor relationships. A total of 11 uncorrelated predictors were identified as important, namely a distance-based measure, road proximity (~27% importance), while from remote-sensing data were NDI45 "Spring", SWIR "Autumn", RAO's Q "Spring", NDRE1 "Autumn", Green "Autumn", BI2 "Spring", GLMC_Cor "Spring", RAO's Q "Autumn", Blue "Spring", GLMC_Con "Autumn", together contributing with ~73% of importance. Cabrera vole presence is more likely in areas close to roads, and associated to remote-sensing indices translating vegetation with intermediate chlorophyll contents and water retention, and more local scale vegetation heterogeneity.

Road verges can act as relatively stable refuges in Mediterranean landscapes, especially when the surrounding matrix becomes environmentally prohibitive, such as when under intensive agriculture or livestock farming practices. Our approach is useful for identifying undiscovered suitable areas, and for planning the placement of mitigation/conservation measures along the road verges as well under other priority areas.

KEYWORDS: Remote sensing, Sentinel 2, Species distribution models, Road Ecology, Road verges

#4 How roadside belts can be managed for a sustainable environment?

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Road transportation is the biggest source of air pollution of the century. Vehicles powered by fossil fuels are the main contributors of noxious air pollutants causing global warming. These pollutants not only are a hazard for the environment, but they are also responsible for dangerous health conditions in humans because they negatively impact nearly every organ system of the body. Roadsides are hotspot belts enriched with various carbon and nitrogen compounds and heavy metals. Vehicle emissions can be reduced significantly by electric car, bus and truck adoption, and by funding incentive programs to help companies and cities achieve these goals. However the story doesn't end here. The vehicle emissions are also of non-tail pipe origin e.g. tire particulates, and brake wear etc. The metals produced through vehicle body parts pose a great threat to ecosystem and human health by contamination of soils and plants after they settle down from air. For these reasons, native vegetation plays a significant role along roadsides. It has never been grazed or cleared for the most part. In fact, it could be the only lasting example of the original native vegetation in some areas. Maintenance of roadside vegetation should involve specific management strategies keeping in view the concerns about contaminated nature of these corridors. Native vegetation involving grasses and shrubs not only helps prevent erosion, weed invasion, maintain road safety and reduce roadside management costs. But, some of them are very effective in absorbing the toxic pollutants such as heavy metals from roadside soils. Hence, we performed studies along two busy roads in the Punjab province of Pakistan in different seasons to evaluate the potential of wild native flora to absorb toxic pollutants (heavy metals such as Pb, Cd, Zn, and Ni, and carbon and nitrogen compounds) of vehicular origin. We also studied various biochemical (chlorophyll a, b, and carotenoids), physiological (photosynthetic rate, stomatal conductance, transpiration, internal CO_2 concentration), and defense system (total soluble proteins, amino acids, antioxidant activity) attributes of these plants to assess the adverse impacts of pollutants. Our results indicated that *Ricinus communis*is very effective in accumulating Cd, Pb, Ni, and Zn heavy metals from roadside soils. It is also proved to be a good sink for various carbon and nitrogen compounds emitted from vehicle exhausts. Similarly *Calotropis procera* and *Xanthium strumarium* also have ability to absorb and tolerate large quantities of automobile related metals. *Datura alba*, however, found to be affected by the vehicle pollutants. Hence it can be used as bioindicator plant species to study the biological impacts of vehicle born pollutants. *Cenchrusciliaris*, *Avena sativa*, and *Cynodon dactylon* grasses are effective roadside tolerant phytoremediator plants. Other shrubs like *Nerium oleander*, *Mirabilis jalapa*, and *Lantana camara* proved to be roadside tolerant and metal accumulator ornamental plants. Proper management and restoration of roadsides with such native plants can lead to a sustainable development of these corridors which will provide minimal contamination of the environment and agricultural lands beside roads.

KEYWORDS: Roadside vegetation, Heavy metals, Vehicle pollution, Phytoremediators

#5 Road Ecology, Challenges and Mitigation: A case study from Abohar Wildlife Sanctuary, Fazilka, Punjab, India

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Road ecology is one of the vibrant fields of conservation biology, which recently get decisive attention in developing countries. It is a study of the ecological effects of roads and highways, especially on wildlife and its habitat. India is the second-most populous country in the world, having one of the highest economic growth rates. Transport plays a vital role in the sustained growth and development of a nation. However, it negatively impacted on the wildlife and its habitat. The ecological effects of the roads were less studied until the recent past. The present study was conducted in the Abohar Wildlife Sanctuary, which is Asia's lone open wildlife sanctuary. Once harbor, the viable population of the Indian antelope *Antilope cervicapra* now has been declined drastically due to unpremeditated linear infrastructure development. A pilot survey was carried out for road profiling along with the newly proposed widening of the road from Abohar to Dabwali, Fazilka, Punjab. The total length of the proposed widening of road was 50 km, of which 17 km fall under Abohar Wildlife Sanctuary. Furthermore, we had also estimated the encountered rate for nilgai and blackbuck, which was 0.04 per km, respectively. We used secondary data of large mammal-vehicle collision from the last seven years and suggested the mitigation plan for the connectivity of the habitat and long term survival of the large wild mammals. We suggested underpasses and larger mammal crossing points for the hassle-free movement of the wild animals.

KEYWORDS: Road ecology, Large mammal vehicle collision, Habitat connectivity, Mitigation Plan

#6 Results of the management on biodiversity along species rich roadsides in Sweden

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Most of the conservational work along public roads in Sweden consists of the appointing of species rich roadsides and their management. Species rich roadsides are areas close to roads with an abundance of flowers, with red listed species, and/or with important structures favourable for insects. Each year roadsides are surveyed, old objects are revisited and new objects of interest are found and added by Swedish Transport Administration. Today there are 2896 species rich roadsides along public roads in Sweden, described in a special database for biodiversity values in the infrastructure.

The management of the designated roadsides primarily consists of a late mowing regime. There are three different maintenance categories: late mowing, extra late mowing, and late mowing with collection of the mowed material. This year, two new maintenance categories have been added, combining both early and late mowing. This maintenance is regulated in contracts and performed by entrepreneurs procured by the road administration.

When they are surveyed, the roadsides also are assessed due to the occurrence of less favourable plants, as massive grass dominance suppresses flowering herbs (late successions). We also search for the occurrence of invasive species, unwanted bushes, lack of bare soil, occurrence of crushed stones etc. Our inventories in the western region shows that there are invasive plant species in about 50 % of the species rich areas. Our data also suggests that we have a bad or rather bad conservational status in a third of the species rich objects. With these factors as a background, the administration has started a more elaborated restoration of natural roadside habitats in some areas, in contrast to the more schematic maintenance regimes described earlier.

The tools for this are either a) specialized maintenance descriptions that detail actions to be performed over time on a certain roadside to promote certain species or habitats or, b) temporary restauration plans. The actions performed often start with clearing of trees and shrubberies to keep the ground open and let light come down. Targeted efforts to combat invasive species are also basic activities. Next level is scraping of soil to opening up for new plants, or the denudation of soil or sand to favour different insects. A more advanced level is that in some cases meadow plant seeds can be sowed. All these actions usually go beyond the regular contracted maintenance, and are so far funded nationally in a special project. The results of all these activities are leading to more flowers in roadsides, promoting interesting species typical for seminatural grasslands, promoting certain red listed species, as well as insects. We take actions for threatened species for example Pasqueflower, Hairy Greenweed and Northern Eyebright, which are declining in our farmland landscape.

It is obvious, that species rich roadsides need elaborated habitat and species related activities, in order to keep or enhance their biodiversity values. An understanding of vegetation dynamics and techniques is necessary to make plans and guide contractors through the practical aspects of this work. Disturbance of the ground and renewing of grassland successions are key factors. These new forms of maintenance will be more costly than the regular late mowing activities, but can lead to a much better development of biodiversity in Sweden's species rich roadsides.

KEYWORDS: Species rich roadsides, Biodiversity, Maintenance of vegetation, Restoration

SESSION 5.3.2. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 4

#1 Ecological efficiency of an eco-bridge: Lessons from the Adrets-de-L'Esterel eco-bridge on the A8 Highway (Southeast of France)

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As part of improvements to its concession contract, ESCOTA implemented a "Highway Green Package", consisting of a series of operations to improve environmental conditions. These operations included the construction of several eco-bridges, including the Adrets eco-bridge which was studied, to allow fauna to safely cross the highway through suitable structures.

Two years after the end of the construction, what is the ecological efficiency of the Adrets eco-bridge, a double vaulted structure made of prefabricated reinforced concrete?

The structure and layout of the eco-bridges surroundings were designed for a wide range of terrestrial, semi-aquatic and avifauna target species. They included: topsoil cover modelling, adapted plantations, temporary water points, ruiniform swaths, stony elements, wooden fences on the edge and anti-intrusion barriers.

The ecological performance of the structure was assessed through an advanced ecological monitoring carried out for the entire faunal groups (23 days and 18 visits):

- Chiropterans: Use of autonomous recording sensors (Batcorder 2.0), survey to record ultrasounds (Pettersson D1000X); in-house 3D trajectography using echolocations (Bat3Data ®) (3/year),

- Large and small terrestrial mammals: trace (16/year), ink (3 campaigns of10 days each) and photographic traps (4 cameras, 16/year), micromamifera capture (2/year, 26 Sherman traps),

- Entomofauna: inventory adapted to each group (Rhopalocera, Odonata , Orthoptera, Hétérocera, saproxilic coleoptera, Mantoptera, Ascalaphes) (1 to 5/year),

- Amphibians: visual and audio inventories (2/year),

- Reptiles: visual inventories, sunshine plate and endoscope (7/year),

– Avifauna: visual and auditory inventories (2/year).

The results show that the structure was functional very early on, with a proper vegetation growth.

At the center of the eco-bridge, records analysis showed the presence of ten species of chiropterans, including the Great Horseshoe Bat (*Rhinolophus ferrumequinum*) and the Euryal Rhinolophe (*Rhinolophus euryale*), which are particularly sensitive to the natural fragmentation. The Bat trajectography illustrates that the majority of the bat movements were along the eco-bridge North to South axis. A very few echolocations were traced above the highway. Most of the activity was recorded above the eco-bridge and corresponded to a transit and/or hunting activity.

Concerning avifauna, the structure was directly used by many species coming to feed, some of which were breeding in the immediate vicinity of the structure.

As of today, the eco-bridge is poorly colonized by reptiles, which seems normal because of the low degree of dispersion of this type of species. It is interesting to note that a juvenile Hermann's Turtle was observed. However, the natural occurrence of the species is still to be confirmed.

Initially, no amphibian species were present. The creation of temporary water points allowed the Mediterranean Tree Frog *(Hyla meridionalis)* and the Green Frog *(Pelophylax kl. esculentus*) to use the structure.

During insect surveys, more than 60 species were recorded on the eco-bridge.

As a conclusion, the functionality of the eco-bridge structure is already confirmed. However, its functionality and success is hampered by men using the structure to cross the highway.

KEYWORDS: Eco-bridge, Ecological transparency, Chiropterans, Avifauna, Insects, Mammals, Wildlife crossing

#2 Importance of roadside habitats for biodiversity: what do we know?

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In an ever-expanding world, impacts of human activity on the global environment are inevitable. The construction of roads and other linear transport infrastructure leads not only to the destruction of habitats, but has long-term impacts on populations and biodiversity, including the introduction of edge and barrier effects, mortality of individuals in vehicle collisions, facilitation of invasive species dispersal, and numerous others. On the other hand, roadsides have been found to have positive effects on biodiversity, as they can constitute important habitats for some species. Previous studies have quantified negative or positive impacts of roadside habitats on select species or under select management regimes, but the grand picture of the importance of roadside habitats for biodiversity conservation remains unclear. In EpicRoads, a project by the Conference of European Directors of Roads (CEDR), we aimed to quantify impacts of habitats related to transport infrastructure (HTI) on a range of taxa through meta-analyses. We used an existing database from a similar project by the Swedish Mistra Council for Evidence-Based Environmental Management (EviEM), while expanding our search to include studies carried out in more recent years. We quantified HTI impacts on species richness, a community-level measure, and on population abundance, a population-level measure. HTI impacts are measured through variables like road presence (versus absence), distance to road, and different variables related to roadside vegetation and road-related disturbance. Results from the meta-analyses will be presented to give an overview of what has been found in the past 10 years regarding positive and negative effects of factors related to HTI on all taxa with sufficient data. One of our objectives is to enhance our understanding of the extent to which HTI can be beneficial for biodiversity conservation and how observed patterns vary among species and road types. Thus, the results of this study are relevant for making decisions on road construction and roadside management, as they offer a multi-species perspective regarding impacts of HTI. However, in addition, our study will identify important knowledge gaps that can direct future studies in road ecology.

KEYWORDS: Linear transport infrastructure, Biodiversity, Meta-analysis

#3 Monitoring of green bridges in Austria

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The increasing realization of large-scale linear infrastructure projects constitutes a major challenge due to the fragmentation of habitats representing major risks to biodiversity. To address this concern, it became common to install crossing structures like green bridges in order to extend wildlife migration and to reduce conflicts between wildlife and roads. Among the local population as well as at political level these high-cost investments for animals are often questioned critically and faced to other investment needs e.g. noise protection walls. Thus, it becomes quite important to stress necessity of green bridges for biodiversity.

This project focuses at investigating the efficiency of18 green bridges in Austria along motorways as mitigation tool and habitat for the whole range of species.

The monitoring campaign was conducted at the same period of time from February to December 2018. Animals with large (mammals e.g. red deer, *Cervus elaphus*) and small action ranges (ground beetles e.g. *Carabus spp.*) were investigated as well as ground-based (reptiles e.g. sand lizard, *Lacerta agilis*) and flying species (butterflies e.g. *Pieris rapae*). The objective was to evaluate 1) the acceptance of the green bridges by target species, local and regional species as well as by less mobile species, 2) if the buildings do also serve as habitats and 3) whether the bridges are used by particular valuable species for cross-linking of habitats. Data were collected by the use of lures, photo-trapping, pitfall traps and hair tubes. Green bridges were chosen covering key performance indicators such as various regions, building methods and species. Another focal point was the analysis of possible differences between old and new buildings.

Results indicated red deer (*Cervus elaphus*) as a target species at three different green bridges and proved local crossing of roe deer (*Capreolus capreolus*), hare (*Lepus europaeus*) and wild boar (*Sus scrofa*). Valuable species like European ground squirrel (*Spermophilus citellus*), edible dormouse (*Glis glis*) and scorpions (*Euscorpius germanus*) has been observed and it was demonstrated that green bridges provide sustainable habitats for invertebrates. Concerning the relevance for less mobile species like reptiles and ground beetles the surface design of green bridges turned out to be a key factor.

Respective insights will be integrated into future planning processes and serve as a basis for standards and guidelines.

KEYWORDS: Green bridge, Monitoring, Habitat fragmentation, Wildlife corridor, Biodiversity

#4 The SLOSS dilemma of road ecology – Single Large Or Several Small fauna passages?

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Road ecologists are often asked by planners "How wide does a fauna passage have to be?", and however appealing, "The larger the better" is only rarely the wisest answer. The width tend to be one of the most cost driving factors for fauna passages at linear infrastructures, and in the planning reality cost—efficiency have to be considered.

In this presentation I address *the SLOSS dilemma of road ecology*, i.e., the discussion whether a Single Large Or Several Small fauna passages would produce the most benefit for wildlife. I point out risks (ecological as well as practical) with investing in one large passage, and list a number of situations where it may be more beneficial to distribute the conservation efforts in the landscape by constructing several smaller passages rather than a single large:

In relatively intact or homogenous landscapes where animal movements are dispersed.

In situations where the animal movement routes are expected to change over time due to landscape changes.

In situations where animal movement habits simply are not known.

When fauna passages are constructed for multiple species with different habitat choice, and therefore no ideal site can be appointed.

When target species are territorial and there is a risk that individual animals monopolize the area in and around the passage.

When target species are sensitive to hunting, poaching or predation; enemies (human or natural predators) may ambush at sites where movements of prey are pinched.

In areas where future human development (housing, mining, forestry etc.) cannot be controlled, and natural habitats surrounding passages may suddenly disappear.

I argue that such situations are in fact what infrastructure planning normally faces, and that the default strategy therefore should be to distribute rather than to concentrate passage opportunities along major transport infrastructures. With this strategy follows an increased focus on how to make also narrower passages functional, e.g., by adapting vegetation and limiting human disturbance in and around passages. Single large fauna passages should be selected in sites where it is likely that they can serve a large proportion of target animals (species and individuals), and where their long-term functionality can be guaranteed, for example in areas that are legally protected or when agreements can be made with adjacent land users to protect the passage and its surroundings from significant impacts.

The SLOSS issue calls for partly new directions in road ecology research, e.g., studies of the effectiveness of narrow passages and non-wildlife passages, animal behaviour and interactions in and around passages, population biology of focal species, and the importance of co-management with surrounding land owners.

KEYWORDS: Fauna passage, Road mitigation strategy, SLOSS Dilemma

#5 Towards next level in Road Ecology: from counting road-kills to assessing population impacts

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Roads are currently one of the main attributes of human-dominated ecosystems. Aimed to improve the socio-economic conditions of local communities, the global road network is exponentially developing associated to the increase of gross domestic product in several world regions. Roads have negative impacts on wildlife, and these impacts are studied by Road Ecology. However, studies to date are mainly focused on individual-level approaches, even though population-level studies have greater power to understand road impacts, as they focus on the persistence of whole populations. Here, we review the literature on road-kill and fragmentation studies, and their corresponding mitigation measures, emphasizing those employing population-oriented approaches.

Road-kill rates are especially high when species occurrence and behaviour matches high traffic flow and speed. Those species that do not avoid roads undergo higher mortality rates. Species abundance, foraging behaviour or being ectotherms, make species more susceptible of being road-killed. On the contrary, species that avoid roads are more prone to undergo connectivity reduction. This avoidance can be due to the road itself, to vehicle emissions or to the vehicles themselves. It is expected that those traits influencing the impact of general habitat fragmentation, like low reproductive rates, long generation time or large area requirements, are also important for road-mediated fragmentation.

Fencing road sections is the most effective mitigation measure to reduce road-kills. Unfortunately, fencing also reduces habitat connectivity which developers try to minimize with the construction of wildlife passages. Some methodologies which explore the effectiveness of mitigations, like carcass counts or passage use, do not provide information on their effectiveness for population persistence, which should be a priority of research.

Rather than limiting data collection to detect road mortality, reduced connectivity or passage use, road ecologists should strive to quantify whether ecosystem functionality is being altered by roads, and whether it has been restored (if necessary) after mitigation actions. For these purposes, a priority should be to explore the demographic impact of roads on population persistence probability, and how this increases after mitigation. To this end, genetics are useful to identify population substructuring due to road presence, to know effective population sizes, breeding rates or to identify individuals. Population modelling using demographic approaches can be employed to explore how populations respond to road mortality, to select the least impacting construction alternative, as well as to identify the sections where mitigation measures maximizes the functional connectivity. Finally, the huge development of road networks in environmentally vulnerable countries will benefit from the input of ecologists during the planning process, from the integration of roads within Strategic Environmental and Social Assessments, and from the inclusion of targets explicitly focused on linear infrastructures on the Strategic Plan for Biodiversity by the United Nations.

KEYWORDS: Barrier effect, Large scale, Population dynamics, Road Ecology, Roadkills

#6 Is Connectivity Conservation via Wildlife Corridors/Linkages Sufficient?

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The idea of wildlife corridors/linkages (C/L) appears to have two primary origins: 1) with the idea that conservation planning for individual or multiple species is best accomplished by identifying "core" habitat areas with "corridors" among them, and 2) that ungulates seem to migrate along related paths from year to year and other species may too. I will discuss the following main observations about C/L from a US and global perspective. It is important to note that besides some evidence for ungulate re-use of parts of the landscape for movement, there is little evidence that the majority of ground-dwelling vertebrates (or other species) naturally use C/L, unless these are the remaining features in a developed landscape. Even then, there is ample evidence that wildlife will "stray" beyond the natural strips to forage, disperse, explore, or exercise other biological imperatives. Even if C/L provide only incidental advantages for most ground-dwelling vertebrates, they provide considerable benefits to conservation planners and public and private development entities (e.g., land and infrastructure developers). Proposing C/L in geographic information systems (GIS) has spawned a mini-industry and suites of GIS tools and has led to myriad "connectivity maps". Though these maps are speculative and at most provide testable hypotheses, they are described as "data" and "science" by conservation planners and development interests. The primary benefit of connectivity maps to development interests is the predictability that comes with these maps. This approach is evident throughout the US; for example, in California, un-tested C/L maps are used as the basis for tens of millions US$ of state funding per year. Because the models vary in how they characterize connectivity, their logic operations, and assumptions about animal movement, they may also vary in their representation of wildlife movement. The assumptions for virtually all of the models include, but are not limited to: 1) predictable gradations of habitat permeability for species, regardless of life-stage, gender, activity, time-scale, or time-of-year; 2) movement by individual animals as if they had fore-knowledge of the landscape and could choose the most-permeable path; 3) consistent resource selection and movement choices among individuals within a species; and 4) that one species can represent others in terms of habitat use and movement. The modeling approaches invariably produce map outputs that can be tested with data from collared animal studies, WVC data, and camera trap observations. I posit that wildlife C/L are generally not emergent features of ecosystems, but instead of joint conservation/development planning. I will provide evidence from published literature and from my own research in the US that: 1) from an animal's point of view, C/L do not exist, 2) after over 20 years of using this approach, there is no evidence that these planning tools provide sufficient land or connectivity to conserve any wildlife species, and 3) protecting permeability at the intersection of nature and infrastructure is the appropriate target for connectivity conservation.

KEYWORDS: Wildlife corridor, Wildlife linkage, Connectivity, Wildlife, Mitigation

SESSION 5.3.3. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 4

#1 Wildlife hotspots prediction with artificial intelligence algorithms, geographic information systems and multispectral image processing

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The roadkill of fauna is a phenomenon that arises from the fragmentation of ecosystems by roads, limiting the mobility of individuals and putting at risk the stability of populations by increasing mortality. This is studied by different disciplines integrated into the field of knowledge called Road Ecology. Colombia is not unaware of the problem of the running over of wild fauna, evidenced in different scientific publications that describe the phenomenon of the running over of wild fauna in the roads of the country. Although the rise of artificial intelligence has significant advances in the prediction of spatial phenomena in recent years, it has not yet been sufficiently explored by Road Ecology. For this reason, this research had the objective of developing a methodology to predict the sites of more significant accumulation of fauna run-over on roads of the Antioquia East based on artificial intelligence algorithms, geographic information systems, and multispectral image processing. During the development of this research, it was identified that the characteristics most related to the roadkill of fauna in the study area are: Distance to Forest, Distance to Biological Corridor, Ground Resistance to Movement, Cost of Movement, the bands of the Landsat 8 satellite: band 9, band 10, band 11 and the normalized burning index. From this set of characteristics, different machine learning algorithms were compared (nearest k-neighbours, vector support machines, random forests, and neural networks). SMOTE and ADASYN balancing techniques were applied. The results obtained allowed us to identify that the randomized forest (RF) algorithm with ADASYN balancing is the method with the best performance when subjected to cross-validation (AUC-ROC 0.78 ± 0.12), surpassing the results achieved by previous researches. Finally, the methodology was validated through a transference exercise, training the RF-ADASYN algorithm with three zones of the eastern Antioquia region and validating on a different section (AUC-ROC = 0.87±0.09), retraining the initial model with 5% of data from the validation database.

KEYWORDS: Artificial intelligence, Spatial Analysis, Pattern Recognition, Prediction

#2 A simple analytical model for predicting the fence-end effect and the minimum length for wildlife fencing to be effective

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The most important mitigation measure for reducing road mortality is wildlife fencing, because more effective measures, such as placing roads underground or raising roads on pillars, are often unrealistic, whereas less expensive measures, such as wildlife warning signs and reflectors, have been shown to be ineffective. Fences are very effective at reducing roadkill and are often used in combination with wildlife passages. However, wildlife passages alone, i.e., without fencing, do not reduce road mortality (Rytwinski et al. 2016). Fencing the entire road network is not always possible and mortality-reduction graphs can be used for prioritizing road sections for fencing, following an adaptive fence-implementation plan (Spanowicz et al. 2020). If the fences were 100% effective, fencing many short road sections would require less total fencing for the same predicted reduction in mortality than fencing a few long road sections. However, animals frequently move around the fence ends. Therefore, longer fences reduce the risk of such a "fence-end effect" and are more effective because animals moving along the fence are likely to change course before arriving at the fence end. The trade-off between the total number of fence sections and the length of the fences has been called the FLOMS (few-long-or-many-short) fences trade-off by Spanowicz et al. (2020). As a result of the fence-end effect, how long is long enough for a fence to be expected to be effective? We present a novel analytical model for predicting the fence-end effect as a function of fence length (L). We consider four variations of the model and compare the predictions with empirical data. In the most basic form of the models, effective fence-length results in surprisingly simple formulas: $L_{eff} = L - R$ in Model A, $L_{eff} = L - 0.5\,R$ in Model B, $L_{eff} = L - 0.4521\,R$ in Model C, and $L_{eff} = L - 0.226\,R$ in Model D, where R is the radius of the home range of the target species.

Accordingly, the probability of fence success is $P_{FS} = 1 - R/L$ in Model A, $P_{FS} = 1 - 0.5\,R/L$ in Model B, $P_{FS} = 1 - 0.4521\,R/L$ in Model C, and $P_{FS} = 1 - 0.226\,R/L$ in Model D. We use these models to predict the minimum length of wildlife fencing to be effective for various species. We also present modifications to these models for fences that are occasionally penetrated or climbed by some species or that are not properly maintained. The models can be included in the calculation of mortality-reduction graphs to predict the effectiveness of fencing at reducing wildlife mortality. This approach will help planners design more effective and more efficient configurations of fencing.

KEYWORDS: Effective fence length, Fence-end effect, FLOMS, Roadkill, Wildlife fencing

#3 Prioritizing road sections for wildlife fencing: Including the fence-end effect

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Road mortality has detrimental negative effects on the abundance, persistence probability, and genetic diversity of wildlife populations. Available evidence indicates that wildlife fencing usually is the most effective among all realistic mitigation measures for reducing road mortality. Due to financial constraints, it is rarely possible to fence the entire road, and fencing particular road sections may be more efficient than fencing other sections.

If the fences were 100% effective, fencing many short road sections would require less total fencing for the same predicted reduction in road mortality than fencing a few long road sections. However, since animals may move along the fence until the fence end and cross the road at grade, the reduction in mortality depends on the length of the fence sections implemented, and the movement distances of the target species. The fence length that can maximize the benefits of the fence would be short enough to placed only at the sections where high roadkill aggregations occur, but still long enough to ensure a reasonable chance of success by keeping the influence of the fence-end effect relatively small. This trade-off between the number of fence sections and the total length of the fences has been called the FLOMS (few-long-or-many-short) fences trade-off by Spanowicz et al. (2020).

To help managers to predict the effectiveness of various configurations of fencing, we analyzed the spatial pattern of roadkill along Hwy 175 in Quebec (Canada) at four scales (300 m, 500 m, 1000 m, 2000 m). Using an analytical model for predicting the fence-end effect and the probability of success of a fence as a function of fence length (L) and the radius of the home range of the target species (R) (see presentation by Jaeger and Re), we estimated revised mortality-reduction graphs that take into account the presence of the fence-end effect.

In particular, for any section of fence created according to the four scales, we calculated the primary mortality reduction (the reduction of road mortality obtained by assuming that the animals within the fenced area would be prevented completely) and combined it with the probability of fence success (probability that the road mortality within the fence would actually be prevented).

By comparing the revised mortality-reduction graphs according to the four scales, we were able to estimate the percentage of road mortality that would potentially be avoided by the implementation of each configuration of fencing along the highway. On this basis, we identified the most efficient scale for identifying roadkill hotspots and for fencing the highway.

To further increase the effectiveness of the mitigation measures, we considered the information provided by several scales simultaneously, and we took into account the

existing and potential future wildlife crossing structures along the road. We generalized our results in the form of an Adaptive Fence-Implementation Plan that creates configurations of fencing that will always lead to a stronger mortality reduction than any configuration based on a single-scale analysis. This approach will help planners increase the effectiveness and efficiency of future configurations of fencing.

KEYWORDS: Fence-end effect, FLOMS, Mortality-reduction graphs, Roadkill, Wildlife fencing

#4 Standardized WVC Data Collection at Large Extents

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Traffic safety is a priority for State, regional and local transportation agencies. Understanding proximate causes of accidents depends on analyzing past incidents, which in turn depends on having accurate information about these incidents. Transportation agencies also have a responsibility to limit impacts to the environment, including to wildlife. These two priorities – safety and wildlife interactions, coincide in the problem of wildlife-vehicle conflict (WVC). Over the last decade, the Road Ecology Center (REC), California, US, has developed several useful tools for reporting wildlife carcasses on roadways (https://wildlifecrossing.net/california), real-time traffic and WVC incident-reporting, and automated WVC analysis system (https://roadecology.ucdavis.edu/hotspots). These systems are based on standardized data-models, data formats, programming workflows, and database management systems. They serve as examples for systematic reporting of all traffic incidents on roadways, within and outside the US.

Current approaches for recording WVC varies widely among countries, states within countries, and even at very local levels, which reduces opportunities for sharing tools and software and creates barriers to effective analysis and mitigation planning. To record WVC, transportation entities and their partners variously use paper forms, spreadsheets, online forms, and in a few instances smartphones. There has been no effort to standardize these approaches, though the types of data collected and the uses of the data in planning are similar. In conversations with the Road Ecology Center, US transportation agency staff have expressed the need for new, or updated approaches and tools for collecting, managing, and querying WVC data. The lack of standard specifications for data and metadata is a serious barrier to providing affordable and easy-to-use software approaches for collecting, managing and analyzing data. It may be the most significant barrier to cost-effective mitigation that also improves driver safety and is ecologically-effective.

Based on our California experience and a review of global systems, I will present software-development approaches based on international standards that can be used to standardize WVC data collection, management, sharing, querying, and quality control. I will describe the types of specifications needed to bring WVC data collection and management systems into line with conventional standards for similar "Big Data" systems. Types of specifications for WVC reporting systems include: data formats, data tracking and verification, data management, security and sharing, image management, long-term archiving (decades), and data transfers among evolving platforms. I will discuss the importance of these specifications for analyzing WVC datasets and to support mitigation decisions, from the level of analysis to combining with other types of data and supporting specific mitigation decisions.

KEYWORDS: Wildlife-vehicle conflict, Roadkill, Wildlife, Mitigation

#5 Road mortality mitigation measures: concrete fence for amphibians

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Habitat fragmentation is one of the most significant threats to biodiversity. Linear transport infrastructures (LTI) such as roads and railways can be ecological barriers to animals' movements. According to IUCN, amphibians are most affected by such fragmentation because these species perform migrations in spring and autumn, making them particularly sensitive to landscape throughout their life cycle. To reduce habitat fragmentation, roads are increasingly equipped with fences on their sides and with underground passages to prevent amphibians to cross on the roads. Different types of fences do exist (e.g. fine metal mesh; metal fence; concrete barriers) but their efficiency has been poorly tested both in real and in controlled conditions for amphibians.

In Alsace, NE of France, an amphibian endangered species (the European green toad EGT *Bufotes viridis*) is of high concerns because of the high road density. In 2019, we tested if a 40cm high concrete fence (high commonly used along the roads) prevents amphibians to cross. The experiment was conducted for the Natterjack toad (*Epidalea calamita*, a substitute of the EGT), the Agile frog (*Rana dalmatina*), and the Smooth newt (*Lissotriton vulgaris*), separately, by night, in a PVC arena consisting in two parts separated by the fence to be tested. This fence could be humid or not at the same time to simulate rainy conditions. Individuals were placed in the departure (non attractive) compartment and their behavior (*i.e.* their attempts to cross the fence) was recorded using infrared cameras. The putative arrival compartment was enriched with a little pond, mosses and sand. Behind the arrival compartment, another compartment hosted two males and speakers playing sounds of *Epidalea calamita* & *Phelophylax sp*. in order to motivate amphibians to cross the fence.

We show that Natterjack toad did not overpass a concrete fence 14cm high (corresponding to their body length legs extended). Furthermore, we found a positive relationship of both mass and adult toad size (Snout-Vent Length) and the highest height they can cross, adults overpassing twice their SVL (least significant Spearman p-value=0.003). The juvenile Agile frogs were able to climb up to 17cm and juvenile Smooth newts up to 21cm. Accordingly, the 40cm high concrete fence commonly used along the roads appears to be appropriate to prevent all tested amphibians to cross. We also show that a 9cm wide overhang on top of the barrier prevents all amphibians from overpassing the fence at lower (11cm) heights.

Bases on our results, we recommend urban planners to build 40cm high concrete fences along the roads to stop amphibians and guide them toward the closest wildlife underpasses.

KEYWORDS: Fragmentation, Roadkill, LTI, Road ecology, Crossing structures

#6 Canopy bridges: Innovative mitigation solutions for arboreal mammals

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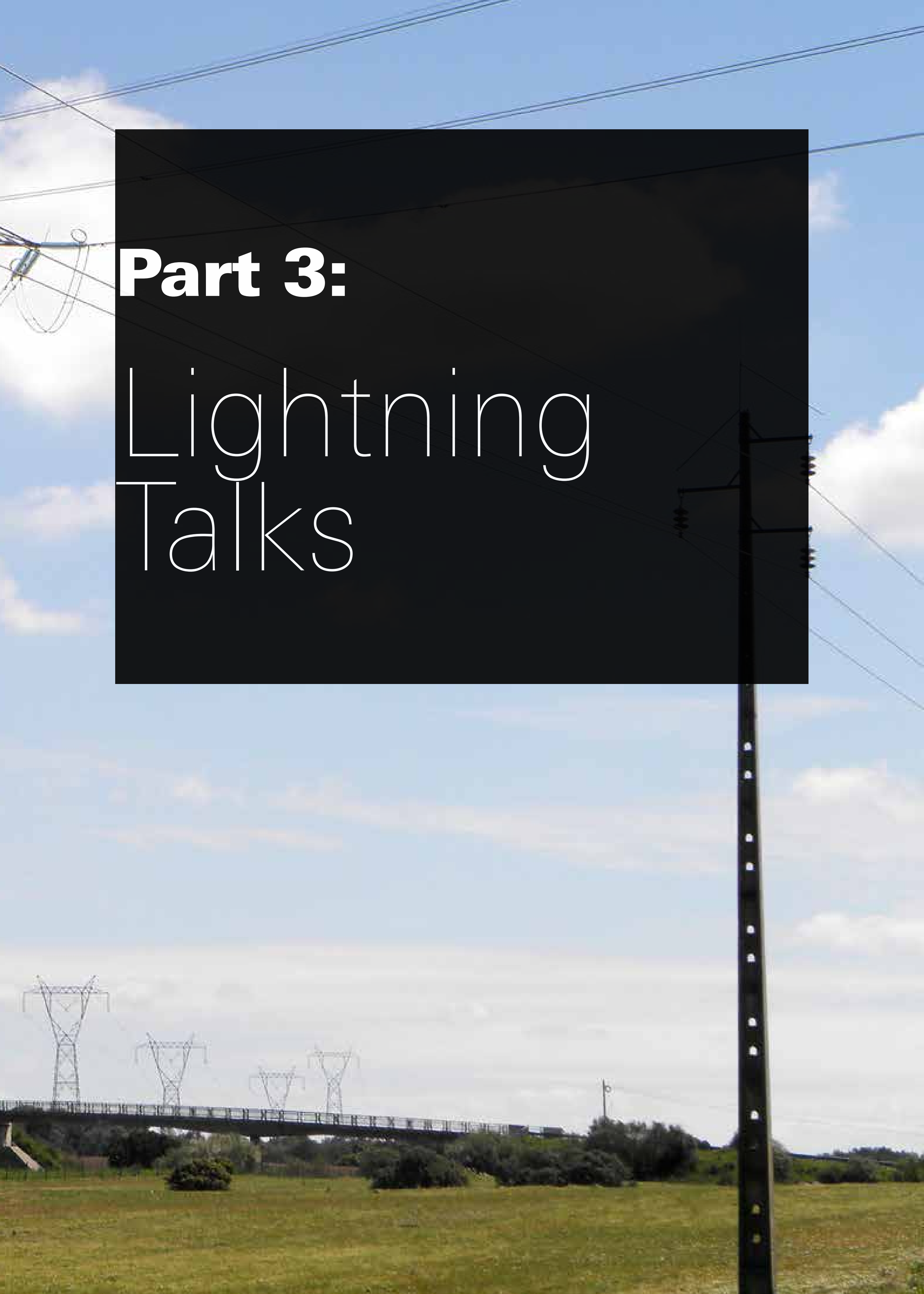
Roads, pipelines, railways, and transmission lines fragment habitats for all forms of wildlife, but they can be particularly obstructive for strictly arboreal species, including some primates, rodents, marsupials, procyonids, and other groups. Because arboreal species are ill-adapted to movement on the ground across open clearings, these types of infrastructure can be permanent and absolute barriers. Dividing populations of arboreal species can result in decreased access to resources, limitations on dispersal opportunities, and ultimately, genetic isolation and localized extinction. This is a topic of increased concern in tropical areas and, in particular, the Neotropics where the high historical occurrence of closed canopy forests has contributed to the evolution of substantial radiations of highly or even strictly arboreal mammal species. However, canopy bridges, both natural and artificial, provide innovative solutions to maintaining habitat connectivity and gene flow between populations divided by linear infrastructure. We present results from a study of natural canopy bridges (NCB) over a hydrocarbon pipeline right-of-way (RoW) in the Peruvian Amazon, and we describe an upcoming project in which we are testing artificial canopy bridge (ACB) designs over a two-lane highway, BR174, in Amazon state, Brazil. For the NCB study, connecting branches were deliberately left in-tact during the construction of the RoW, forming 13 bridges. We installed camera traps in the bridges and on the ground to monitor RoW crossings over the course of one year. In a control area, no connections were left, and cameras were placed only on the ground. We found the bridges to be used shortly after their exposure, with 25 species from 12 families using them at a crossing rate 200 times higher than on the ground. Only six of the species found in the canopy were also recorded on the ground, and there was little difference in crossing rate on the ground between the control and test areas, suggesting that the absence of bridges does not translate into a higher crossing rate.The ACB study will test two designs: one unidimensional and composed of a single large rope and the other a two-dimensional rope lattice. Both bridges will be attached directly to trees on the sides of the road. The ACBs will be installed at 10 locations along the highway. Each location will have two ACBs, one of each design, for a total of 20. For 16 months, each ACB will be monitored by two camera traps, one facing the bridge and the other facing the forest, allowing for the calculation of an acceptance ratio (animals that approach the bridges vs those that actually cross) by arboreal mammals for each structure between the two designs. With this proposed research we aim to test differential use of two low-cost canopy bridge designs by arboreal species with differing locomotor strategies. Data from both studies will inform

impact reduction best practices that can be incorporated into legislation in Peru, Brazil, and other countries with large proportions of strictly arboreal mammals.

KEYWORDS: Natural canopy bridge, Artificial canopy bridge, Arboreal mammals, Peru, Brazil

Part 3:
Lightning Talks



SESSION 1.3.4A. MANAGING INFRASTRUCTURE MARGINAL HABITATS FOR BIODIVERSITY

#1 Developing road verges' hosting capacity for wild bees: why and how

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For the last two decades, the decline of pollinating insects has raised concerns and questions in the scientific community and with public authorities. Among them, wild bees contribute significantly to the pollination of numerous crops and wild plants. Like many insects, they are victims of various pressures due to intensification of land use by farming, urbanization and to the development of transport networks. Consequences on wild bee populations in Europe are such that today many species are recognized as threatened.

Road infrastructures notably, through natural habitat destruction and fragmentation they cause, carry their share of responsibility among pressures afflicting wild bee populations. However, into environmental contexts degraded by an intensive use of territory, the right management of verges of pre-existing roads could locally bring remedies to lessen the pressures affecting these insects. Indeed, in such places, road verges can be the last sites available for natural local flora and the associated entomofauna. At the national scale, the total surface of road verges cover thousands of hectares. Adjacent to the road network, they are connected to a great variety of natural environments, parts of the green framework, from the local to the national scale.

A guidebook freely available to everyone aims to explain to road managers why and how they can take action for protecting wild bees thanks to the space offered by road verges. First, the general importance of insect pollination and what are the various pollinating insects are presented to them, along with the specific relevance in acting for wild bees in road verges, the fundamental principles of action and the positive effects for various other insects (among Lepidoptera, Diptera and Coleoptera notably). Operational recommendations are made in order to provide food resources and nesting sites necessary for the various wild bee species: indication of entomophilous species to develop among herbaceous plants, shrubs and trees; of maintenance techniques to increase floral diversity; of means to allow bee nesting in the ground, in hollow stems of some plants and in wood. Finally, the way to ensure the consistency of the different actions over time in the road verge space is presented. This must be done in connection with the surrounding landscape resources in order, first to take advantage of preexisting functional relationships, and then to develop them as elements of the green framework. Opportunities of actions are illustrated (photos) and commented by means of a series of actual situations observed on road verges.

KEYWORDS: Wild bees, Local flora, Nesting, Road verges, Management

#2 Moving on the verge: effects of traffic intensity and quality of the road verge on the movement of pollinating insects

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Despite the increasing evidence documenting the severe negative effects of roads on biodiversity, roads are estimated to span a total of 64 million kilometers on earth's surface with an additional 25 million kilometers to be added to the already existing network by 2050. Air, light and noise pollution, wildlife mortality due to collisions with traffic, loss and degradation of habitat, and isolation of animal populations are some of the phenomena that can be directly linked to roads. On the other hand, road verges, which are managed grasslands usually coupled to roads, can serve as habitat or corridors for a number of taxa. In addition, road verges that have a high number of plant species (high quality road verges) have been shown to be an important resource for pollinators, especially in landscapes with a low amount of semi-natural habitats. However, it is unknown how the quality of the road verge and the interaction with the adjacent traffic can affect the movements of pollinating insects and thus the viability of their populations. To assess the potential dual role of roads as barriers to movement and road verges as movement corridors for pollinating insects, we established a study design with 10 pairs of sites differing in the number of plant species in the road verge (species poor vs. species rich) which also had a gradient in traffic intensity (number of cars per day) on the road. On the road verges of each of these 20 sites we placed 16 pots of a highly attractive flowering species, *Scabiosa columbaria*. Then, using fluorescent dye particles, we tracked the movements of pollinating insects by estimating the rates of movements along the road verge, across the road and into the adjacent habitat. The results of this study will show if the positive effect of road verges as movement corridors outweighs the negative effect of roads as movement barriers, and how this trade-off is mediated by traffic intensity and road verge quality. This will in turn inform about which types of road verges that are optimal for biodiversity-targeted management.

KEYWORDS: Traffic, Road verges, Semi-natural grasslands, Pollinator movement

#3 Both roads and power line corridors contribute to landscape scale biodiversity of plants and insects

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Traditionally managed semi-natural grasslands, and the biodiversity associated with them is declining all over Europe. Linear infrastructure rights-of-way, such as road verges and power line corridors contain vast areas of grassland habitat managed in a way that is resembling that of traditional semi-natural grasslands, and hence they have a great potential for conservation of especially species associated with grasslands. We first conducted a review of the value of linear infrastructure habitats (LIH) for biodiversity. Similar to grasslands or heathlands, LIH often harbor high numbers of species including rare plants and animals. There is, however, a risk that LIH act as ecological traps, by attracting organisms that fail to survive or reproduce there. Second, we selected 32 forest-dominated landscapes with contrasting amounts of LIH and semi-natural grasslands. In each of these 32 landscapes we surveyed plants, butterflies and bumblebees in five different habitats: semi-natural grasslands, power line corridors surrounded by forest, road verges of big and small roads and uncultivated field margins. Then, we investigated how the amount of LIH in the landscape affected the evenness, phylogenetic diversity and species richness of the three different organism groups within the five before mentioned habitats.

Landscapes with presence of power line corridors had higher species richness of plants than landscapes without power lines, but there was no such effect for butterflies or bumblebees. At the local scale, power-line corridors had as high diversity of plants and butterflies as did grazed semi-natural grasslands. Road verges along larger roads tended to have lower diversity of all taxa than road verges along small roads. The overlap in species composition between habitats was relatively large, but with relatively distinct, sets of plant species in field margins and power line corridors compared to the other habitats. The similarity in species composition between habitats in the same landscape was higher in landscape with presence of power line corridors. For bumblebees, this was especially the case when the density of roads was high. In contrast, a high road density tended to result in less similarity in species composition. In conclusion, linear infrastructure habitats have a high diversity of plants and pollinating insects, and provide additional habitat for a large proportion of the grassland species in the landscape. Especially power line corridors contribute to higher landscape scale biodiversity and appear to provide connectivity resulting in more similar composition of communities in different grassland habitats in the landscape. Roads have less clear effects, possibly due to the dual role of road verges as habitat and roads themselves as barriers to dispersal. Future studies that assess the population level mechanisms behind the observed patterns are needed before any clear recommendations for biodiversity conservation can be given.

KEYWORDS: Biodiversity, Beta-diversity, Pollinators, Plants

#4 Feasibility of local partnerships for a more biodiversity-friendly management of linear infrastructure right-of-ways

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Nowadays, managers of linear transport infrastructures (LTI) express their will to apply, within right-of-ways (ROW), some practices more favourable to conservation (species, habitats) and the connectivity with natural surrounding environments. Besides, LTIs cross territories in which different types of local actors are already involved in the management and maintenance of (semi-)natural environments. Considering their skills and motivation, these actors could be relevant partners for LTI managers, in the aim to maintain ROWs with better practices on the ecological point of view. Punctually some initiatives may exist (or have existed) aiming at conservation, agro-ecology, ecosystem services, nature recreation... But the overall situation suffers a great lack of experience feedback to allow lessons, improvements and dissemination of good practices.

The purpose of a 1-year exploratory study carried out in France was to assess the actual possibilities offered by such partnerships, considering the legal framework, actors' own interests and the various difficulties encountered on the field.

First, a national survey was conducted among LTI major operators by means of questionnaires and grey literature review, in order to gather a large sample of case studies. From them (15), four were selected for their informative and complementary nature in order to conduct detailed analysis of partnerships' determining factors. They cover towpaths and canal freeboards, banks of a navigable watercourse and a power line right-of-way. The maintenance is achieved by sheep or cattle grazing, or through the creation of a forest orchard and local partners are associations or breeders. Each case analysis covered legal texts (laws and regulations), formal contractual rules passed between stakeholders (agreements between LTI operators, landowners and management partners), on site interviews with stakeholders and observations of site characteristics.

In addition to the legal determining factors arising from the purpose of LTIs and the regulatory responsibilities of operators, factors of social, economic, ecological and technical nature have been identified, whether they are explicitly taken into account in the studied agreements, whether they emerge from lacks experienced by actors in practice, or from more general difficulties linked to the today general context for developing efficient and sustainable partnerships.

Proposals are expressed to address some of these issues and to contribute to an increased effectiveness of future management partnerships regarding the observed practices. They concern the negotiation and formalization of specific points between actors during the drafting of partnership agreements.

They also concern clauses that can be included in all partnership agreements, without being limited to just the practices encountered in this project. Finally, they concern

measures that would contribute, on the one hand, to creating a more favourable general framework for the development of grazing along canals, and, on the other hand, to a better recognition of the ecological interest of certain alternative maintenance methods for ROWs.

These are thus modular elements that can be taken into account (or not) by the actors depending on the local context and the concerned LTI. Given some similarities between ROWs of different LTIs, some elements could apply to other types of LTI and/or to other management objectives.

KEYWORDS: Right-of-way, Management, Partnership, Local actors, Feasibility

#5 Enhancing biodiversity on Great Britain's railway network

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Britain's rail network is one of the oldest and safest in the world. In recent times it has transported 4.8 million people and around 200,000 tonnes of freight every day, making a vital contribution to the country's economic prosperity. But it also provides a rich mosaic of habitats, including woodlands and grasslands, for a wide variety of plants and animals.

Network Rail is Great Britain's public body responsible for the safe and efficient running of this busy and extensive transport infrastructure. Managing the habitats alongside the 32,000 km of track is vital for the safety of the passengers, train crew, employees and contractors. It's a balancing act to maintain and improve the railway to keep it running safely and smoothly, while being mindful of the land that surrounds it, the natural capital Network Rail are responsible for, the public benefits it offers, and the wildlife that lives on it. This network, including cuttings and embankments, dating back almost 200 years, can play a vitally important role in connecting fragmented wildlife habitats across the countryside, creating visual amenity benefits for commuters, reducing disturbance for neighbours and much needed carbon capture through the network's stock of over 6 million trees.

In partnership with the UK Centre of Ecology & Hydrology (UKCEH), Network Rail has developed a new and ambitious strategy for enhancing biodiversity and wildlife on the railway lineside. The Biodiversity Action Plan is the first step in achieving a vision of a lineside managed sustainably for safety, performance, the environment, and Network Rail's customers and neighbours. In this presentation, we outline ambitions for biodiversity and habitats, and how the organisation intends to protect, maintain and enhance their condition to 2035. This will require Network Rail to develop new skills and competencies in ecology and vegetation management, and apply these to decision-making at all levels of the organisation. It will also involve forming and maintaining partnerships with stakeholders and neighbours to maximise the benefits a well-managed transport infrastructure can bring for biodiversity. The Biodiversity Action Plan supports Network Rail's commitment to the key goal of no net loss in biodiversity on the lineside estate by 2024, moving to biodiversity net gain by 2035. Where it is not safe or practical to mitigate biodiversity loss associated with management actions, Network Rail may need to create appropriate habitats elsewhere on, or beyond, the estate to offset any impacts.

A first step to embedding biodiversity into railway asset management decision making will be to conduct a comprehensive assessment of the type and condition of biodiversity 'assets' across the rail network – including species and habitats. This is fundamental to producing detailed habitat management plans, defining outcomes and measuring progress towards them. UKCEH is supporting Network Rail to complete this assessment using novel modelling techniques and remote-sensing satellite imagery to map the type and extent of habitats across the rail network. Ground truthing of these data will use traditional survey methodologies alongside a wealth of citizen science species records.

KEYWORDS: Railway ecology, Sustainable transport, Biodiversity

SESSION 1.3.4B. MANAGING AND MONITORING ECOLOGICAL IMPACTS OF LINEAR INFRASTRUCTURES

#1 Environmental monitoring of reptiles across a wildlife overpass

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Our objective is to evaluate the functional connectivity for reptiles after establishment of a wildlife passage. We evaluated the distribution of reptiles across a major highway and ecoduct located 20 km south of Gothenburg, Sweden.

We used Artificial Cover Objects (ACOs) for inventory and monitoring of reptile diversity. The ACOs were comprised of plywood coverboards placed in a system of positions along transects parallel with the highway. We monitored the ACOs 6 times during spring and 5 times during autumn between the years 2018 and 2019. We positioned 14 ACOs on or at the base of the ecoduct, whereas 66 ACOs were placed along transects between 50 and 250 m away from the highway. Monitoring of reptile counts underneath ACOs were combined with data on vegetation cover and shadiness and of ambient temperature from the Swedish Meteorological and Hydrological Institute. Our study design generated 308 ACO monitoring events within the ecoduct area, 792 monitoring events within the reference area west of the highway, and 660 monitoring events within the reference area east of the highway.

We used Generalized Linear Mixed Effects Models (GLMM) to analyze reptile counts in relation to the ecoduct while controlling for percent vegetation cover, shadiness and ambient air temperature. We used the ACOs as independent unit and, thus, included ACO identity as a random effect. Our data is dominated by zero counts of reptiles and the variance is lower than the mean. Therefore, we applied a negative binomial Poisson distribution.

"Barrier effect hypothesis" – the reptile distribution is different around the ecoduct area compared to the surrounding landscape, while controlling for vegetation cover, shadiness and ambient air temperature.

"Connectivity hypothesis" – the reptile distribution is the same between the ecoduct area and the surrounding landscape, while controlling for vegetation cover, shadiness and ambient air temperature.

We constructed three *a priori* candidate GLMMs, reflecting our two hypotheses; "Barrier effect" and "Connectivity" and an intercept (null model) in order to analyze overall performance of our models. Model selection was based on Akaike's Information Criteria (ΔAIC_c and AIC_c weights).

On 163 occurrences did we detect reptiles of six species; 10 grass snakes (*Natrix natrix*), 17 smooth snakes (*Coronella austriaca*), 2 sand lizards (*Lacerta agilis*), 7 viviparous lizards (*Zootoca vivipara*), 126 slowworms (*Anguis fragilis*) and 1 adder (*Vipera berus*).

The most parsimonious of our models supported the "Connectivity hypothesis", i.e. variation in reptile counts was best explained without discriminating between ecoduct and surrounding reference areas, while controlling for vegetation cover, shadiness, and ambient temperature (ΔAICc = 0.00 and AICc weights = 63%). Reptile counts was higher at AOCs with lower degree shadiness (β=-0.012 ±0.006 (SE), z=-2.1, P=0.039) and increasing ambient temperature (β = 0.073 ±0 .0346 (SE), z = 2.1, P = 0.036). The highly endangered sand lizard (*Lacerta agilis*) was identified under ACO on the ecoduct only one year after its establishment. Our results stress that management of suitable habitats is crucial across wildlife passages, in order to function for reptiles.

The monitoring program is financed by the Swedish Transport Administration.

KEYWORDS: Ecoduct, Reptiles, Connectivity, Infrastructure barriers, Habitat

#2 Risk of bird electrocution in powerlines: a framework for prioritizing species and areas for conservation and impact mitigation

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Despite the benefits for humans, powerline networks are known to pose serious threats for birds, including mortality due to electrocution. While this mortality source can have significant impacts on bird populations, bird electrocutions also cause power outages, resulting in serious economic and social losses for powerline companies and their customers. It is therefore important to identify the more susceptible species and key geographical areas, both for biodiversity conservation purposes and for outage mitigation. This requires detailed data on bird mortality, often non-existing over large extents. Here we suggest a framework of large-scale assessments in which we estimate the risk of bird electrocution as the interaction between the species-specific exposure to electricity poles and susceptibility to electrocution in Brazil. We used medium voltage pole density within a species distribution area as a proxy of exposure and the species morphological (wing length) and behavioral traits (perching and nesting on both poles and wires) to assess susceptibility. Using Brazil as a focal region, we built different maps aimed to answer: How is the distribution of overall bird exposure to electrocution? How is the distribution of overall bird susceptibility to electrocution? Which species are priorities for conservation measures? How is the distribution of overall bird risk of electrocution? We found that the Atlantic forest (coastal and nearby highlands rainforests) is the biome with higher exposure to powerlines, whereas Pantanal (the largest tropical wetland in the world) concentrates the higher number of susceptible species to electrocution, and therefore the routing of new powerlines therein must be carefully planned, preferentially avoiding this region. We also identified a set of 38 species with High Risk of electrocution, classified as the priority species that should be targeted for grid mitigation practices, and which should receive special attention during environmental assessments of new powerline projects. We identified the Atlantic forest as hotspot where the risk of bird electrocution is higher due to the simultaneous presence of high pole density and high number of susceptible species. In this region, we suggest the adoption of mitigation measures in strategic sites to reduce the risk of electrocution. Our approach is useful for a first assessment, so environmental and regulatory agencies can coordinate with electric companies to focus more intensive and systematic assessments, looking for example, for high-risk poles overlapping local occurrences of priority species.

KEYWORDS: Bird conservation, Risk assessment, Power lines poles, Priority areas

#3 The Afsluitdijk, an important ecological connection

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A The Afsluitdijk is a dike which was constructed in 1932 and forms the separation between the Lake IJsselmeer and the Wadden Sea. The functions of the Afsluitdijk are to provide for water safety from the Wadden Sea and water discharge from the IJsselmeer to the Wadden Sea. For birds and mammals, including bats, the Afsluitdijk is an important connecting element between the coasts of Friesland and Noord-Holland. The long, ribbon-shaped character of the Afsluitdijk is a clear landmark and an important migration route for birds and bats, especially *Nathusius pipistrelle* and Pond bat. The Afsluitdijk also forms a connecting structure for small carnivores such as stone marten.

Intervention project Afsluitdijk

In the period 2018-2022, the Afsluitdijk will be reinforced, the dike will become higher and wider, the covering will be replaced and the discharge of water to the Wadden Sea will be increased by using pumps and new discharge sluices. Part of the Afsluitdijk project is keeping the important ecological function of the dike as habitat and migration route of plants and animals. The following 2 examples of the ecological function are being explained:

Restoring the unique flora on the new covering,

Installing adapted lighting for bats

Restoring the flora on the new covering

The new covering will consist of big concrete blocks on the lower slopes (Levvel blocs) and small concrete blocks on the higher slopes (Quattroblocks). The Levvel blocs get a roughened top layer on which algae and snails of the intertidal zone can attach. The Quattroblocks have room between them for plants to grow. One of the components of the ecological dike is a rapid return of typical seashore plant and animal species. Salt tolerant species of rocky coasts, such as Sea kale, Wild cabbage, Wild carrot, Sea pea, Rock samphire and Sea beet, find a fine habitat on the Afsluitdijk. The seeds of these species on the Afsluitdijk have been collected and dried by volunteers. Currently, the best way to plant the seeds is being tested in a section of the dike near the Frisian coast that already has the new covering. Interestingly, some species have already established themselves spontaneously.

Placing adapted lighting for bats

The Afsluitdijk is an important migration route for the *Nathusius pipistrelle*. In the spring they travel along the Wadden Sea and Baltic Coast to Eastern Europe and in the autumn they travel back to Southern and Western Europe. Other species that regularly occur at the Afsluitdijk are Common pipistrelle, Serotine bat, Noctule bat, Pond bat and Daubenton's bat, as well as the rare Soprano pipistrelle and Parti-coloured bat. To prevent disturbance of the bats by light during the project Afsluitdijk, caps are placed on the sides of the lamps to prevent light scattering. To maintain the migration route along the Afsluitdijk after reinforcing the dike, only lights with a maximum of 3000 K (warm white) are allowed. It is known that bats experience less disturbance from this light colour.

KEYWORDS: Afsluitdijk, Ecological connection, Migration route, Typical seashore vegetation, Bats

#4 How well fences work?

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The effective implementation of mitigation measures against ungulate-vehicle collisions (UVC) requires the identification of locations where such incidents are most frequent. Localities with higher risks may be associated with linear landscape features that funnel animals towards roads, as well as with artificial infrastructures. Locations where UVC occur more frequently may vary annually due to natural or human-related factors, including the installation of wildlife fencing.

We assessed the effect of wildlife fencing on UVC in Lithuania in 2002-2017, performing temporal analysis of changes in annual UVC (including in fenced road sections) in relation to changes in the total length of the fences on main, national and regional roads.

The main roads (motorways) are characterised by high speed and high traffic intensity - annual average daily traffic (AADT) of 3000-20000 cars/day. On these roads, the annual increase in UVC was 11 %, while the increase in total length of fences was 14 %. On the national roads, characterised by medium speed and medium traffic intensity (AADT: 500-3000 cars / day), the annual UVC increased by 12 % and the total length of the fences by 23 %. On regional roads, characterised by medium/low speed and low traffic (AADT: up to 500 cars / days), the annual UVC increase was 15 %, while the increase in total length of fences was 19 %. In 2017, the average length of individual fence sections was 1.3km, 0.18 km and 0.06 km on main, national and regional roads respectively.

Thus, the number of UVC increased on all categories of roads. At the beginning of the period, both UVC and fenced road sections were most common on roads characterised by higher traffic intensity. However, later in the period, while main roads had the most fenced sections, the majority of UVC occurred on national roads.

Over the period, the total length of newly-built fences per year slightly increased on regional roads, but decreased on national and main roads. Similarly, the total number of newly-built fences per year increased most on regional roads, while a smaller increase was noted on national roads and a decrease on main roads. The average length of newly-built fences per year decreased on all types of roads, with the highest rates of decrease on main roads and the lowest on regional roads. Over the period, annual UVC totals increased at the greatest rates on regional roads, with lower rates of increase on national and main roads. From this, it can be seen that UVC rates increased the most on roads with lower speed and lower traffic intensity.

We conclude that wildlife fencing on roads characterised by higher speed and higher traffic intensity may, while it can decrease UVC in the short term, shift UVC occurrence towards roads characterised by lower speed and lower traffic intensity, this potentially due to altered wildlife movements shifting animals to roads with insufficient or no mitigation measures. At the same time, with dispersion limited, the importance of adjacent habitat patches for wildlife can be reduced, while importance of more distant patches amplified.

KEYWORDS: Accident prevention, Fencing, Temporal statistical analysis, Traffic intensity, Wildlife-vehicle collisions

#5 Green and blue infrastructure: How trees can accompany our rivers and canals Conflicts - Solutions - Implementation

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The straightening and deepening of rivers and streams led to a great loss of habitats for a wide variety of species. In order to compensate for part of the loss of natural habitats, the thousands of kilometres of dams and dikes along the rivers should be used as green infrastructure and make an important contribution to the protection of plant and animal species as well as lichens and fungi. From the point of view of climate protection, it is also important to improve the green infrastructure and take every opportunity to plant and conserve trees and shrubs. In addition, avenues and tree rows along waterways are also important links between biotopes, especially in the cleared agricultural landscape we find in many places in Europe.

Yet, the demand currently manifested in standards states that woody plants (trees, shrubs and hedges) on dykes and dams are fundamentally unacceptable because they apparently impair stability and maintenance. These standards hinder not only planting of trees and shrubs along new construction, but also when it comes to tolerating and planting trees on dams and dykes during renovation measures.

For many decades, representatives of nature conservation and landscape management, associations and local citizens have been calling for environmentally compatible solutions to be implemented. Landscape architects and hydraulic engineers are also increasingly questioning these regulations. Engineering biology has very good answers to the question of how plants can be used as living building materials to secure dams and dikes.

Using the example of the rehabilitation of the dams along the Stoerkanal in the Lewitz in north-eastern Germany the presentation will demonstrate that a rehabilitation of a dam with preservation of the tree population is possible and even meaningful. Only extensive protests by local residents and environmental associations led to trees being preserved and the necessary work on the dams having to be discussed with a tree expert. Here technical solutions were found, which made the reconstruction of the dams with preservation of an especially beautiful oak avenue on the dam possible.

KEYWORDS: Dam, Dike, Canal, Tree, Reconstruction

SESSION 2.3.3A. NEW TOOLS TO MITIGATE AND MONITOR ECOLOGICAL IMPACTS OF ROADS

#1 Making the road more permeable to wildlife using existing infrastructure

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Roads are built to increase permeability between places that often have a social and/or an economic interest for humans in a most economical and time efficient manner. While increasing connectivity for humans, roads reduce permeability between habitats for wildlife. Mortalities caused by AVC often directly affect population characteristics such as abundance, density, and sex structure of these animals. One way to encounter this problem is to have effective animal passages to increase the permeability between habitats. Installing a whole new set of infrastructures for this purpose could be costly and therefore, the chances of that happening are very thin, especially in developing countries. Therefore, the aim of this research is to make suggestions to improve the existing mitigation measures to create a system of effective animal passages making use of the existing infrastructures.

The study road is in the North Central Province of Sri Lanka (8° 3′49.43″N, 80°46′27.31″E). It falls under the AA-grade road category. Roads in the AA-grade category connect main cities in Sri Lanka and many of them experience a high traffic volume. The selected road connects the city of Dambulla to Polonnaruwa (AA011). Due to its central location, Dambulla acts as the main vegetable distribution center within Sri Lanka and hence is considered one of the major commercial capitals within the country. Further, both cities are tourism hubs that attract thousands of visitors to their specific tourist attractions therefore experiencing a greater influx of vehicles due to tourism.

The only animal passages type available at the study road are culverts. Culverts are known to have varying degree of success for different taxa. However, a pilot study conducted at the study road revealed that the existing system of culverts does not affect the number of roadkills. However, since it is the only type of animal passage available at the study site, to make use of the existing infrastructures to make the road more permeable for wildlife, it is expected to experimentally determine whether constructing fences that direct animals toward the existing drainage culvert system could reduce the number/pattern of road kills by using 16 selected culverts along the study road.

Starting from July 2019, during the first year of the study all 16 culverts will be monitored for their usage by wildlife. For this sand traps and camera traps will be used. Sand traps will record animal tracks and signs giving an indirect measure regarding the usage of selected culverts. Then, during the second year of the study for eight of the selected culverts, an array of guide fences will be set up in order to guide the animals towards them. The remaining eight culverts will be left as they are to use as the controls in the analysis. Then, all 16 culverts will be monitored using the same methods for their usage by wildlife. The goal of this study therefore, is to find whether the guide fences built at existing culverts could make a difference in the number of roadkills at the study road.

KEYWORDS: Existing infrastructure, Culverts, Permeable habitats

#2 New real-time mitigation measures based on animal-vehicle collision spatio-temporal models

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Road ecologists have proposed a wide range of mitigation measures in order to reduce the number of animal-vehicle collisions (AVC). Some measures aim to modify driver behaviour (road signs, speed limitation, etc.), others to modify animal behaviour (fences, wildlife passes, swareflex, mirrors, etc.), and others both. The costs and effectiveness vary enormously. In general, driver-oriented measures as road signs are widely implemented because of their low cost, but they are also much less effective. This lack of effectiveness is related to driver habituation. Improving sign designs to increase driver response may reduce AVC. To do this, it is possible to take advantage of the fact that AVC are concentrated in time and space. The aim is to alert the driver only when a certain risk threshold is exceeded. With this purpose spatio-temporal AVC models can be used to focus the warning signal on the periods of maximum probability of an accident. The models have to be fed in real time with data about traffic, weather, hunting, road conditions, etc. The results can be displayed on different devices: app, navigators, road signs, etc. For example, we are developing a prototype of variable road sign based on these spatio-temporal AVC models. This prototype will probably show considerable advantages over the measures currently being implemented to minimize AVC. In economic terms, it is much cheaper than other structural measures, and, by focusing only on those moments of real risk, it avoids driver habituation. It is expected that this warning will cause drivers to slow down, so the number of AVC is expected to decrease.The main challenge is to define appropriate alert thresholds in relation to the risk of AVC. A very low threshold would favor driver habituation. A very high threshold would mean that in moments of high risk no alarm would be emitted with the consequent loss of efficiency. The idea could also be applied to endangered species also affected by road traffic (carnivores, amphibians, etc.).

KEYWORDS: Mitigation measure, Road sign, Spatio-temporal models, App, Animal-vehicle collision

#3 Daily, Annual and interannual variations of wildlife underpasses use by small and medium-sized mammals: a study case in the agricultural plain of the Bas-Rhin, France

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The development of road networks contributes to the fragmentation of natural habitats. To reduce landscape fragmentation induced by roads and railways, wildlife underpasses (WU) are built. The effectiveness of these structures is evaluated through studies monitoring their use by wildlife. However, monitoring studies can be too short to accurately assess the WU use, and long ones represent a high investment. In order to optimize WU monitoring studies, we quantified the daily, the annual and the interannual use of WU by small and medium-sized mammals.

Seven WU were continuously monitored with two camera traps per underpass during four years (May 2012 to May 2016) in the agricultural plain of the Bas-Rhin (France). All WU were located under the A35 motorway and surrounded by crops. The use of a WU was quantified as the number of specific detected individuals per time unit (hour, month and year). The significance of temporal variations of the use was assessed by boosted regression trees models for each species and for the species richness. The variation of the cumulated species richness per WU was quantified to find the minimal number of days needed to accurately quantify the WU use with camera trap.

During the 1,451 days of the study, we recorded 1,375,333 photos and 24 mammals species, including rare ones. All species showed daily variations of the use, corresponding to their nyctohemeral rhythm. Most of them showed annual variation of the use, corresponding to their breeding, dispersion and birth periods. For a few species, differences between their known biology and our results were observed. High interannual differences of the use were observed, with a synchronicity between preys and predators. Our results showed that two years are needed to observe most of species frequently using WU but that even after four years, new species were still detected but with a very small use of WU.

KEYWORDS: Preys, Predators, Synchronicity, Phenology, Wildlife crossings

#4 A comparison of camera trap and permanent recording video camera efficiency in wildlife underpasses

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In the current context of biodiversity loss through habitat fragmentation, the effectiveness of wildlife crossings, installed at great expense as compensatory measures, is of vital importance for ecological and socio-economic actors. The evaluation of these structures is directly impacted by the efficiency of monitoring tools (camera traps…), which are used to assess the use of these crossings by observing the animals. The aim of this study was to quantify the efficiency of camera traps in a wildlife crossing evaluation.

Six permanent recording video systems sharing the same field of view as six Reconyx HC600 camera traps were installed in three wildlife underpasses entrance. Each device was attached to a ceiling sliding rail two meters from the entrance (allowing them to entirely cover the entrance), and was suspended 19.5 to 44.5 cm above floor level. Cameras were oriented about 10 degrees downwards to view the first meter of the underpass and outside. They were used to assess the exact proportion of missed events (*event* being the presence of an animal within the field of view), and the error rate concerning underpass crossing behaviour (defined as either *Entry* or *Refusal*). A sequence of photographs was triggered by either animals (*true trigger*) or artefacts (*false trigger*). We quantified the number of false triggers that had actually been caused by animals that were not visible on the images ("false" false triggers).

Camera traps failed to record 43.6% of small mammal events (voles, mice, shrews…) and 17% of medium-sized mammal events. The type of crossing behaviour (*Entry* or *Refusal*) was incorrectly assessed in 40.1% of events, with a higher error rate for entries than for refusals. This error rate did not depend on animal size. Among the 3.8% of false triggers observed, 85% of them were "false" false triggers. This study indicates a global underestimation of the use of wildlife crossings for small mammals. Means to improve the efficiency are discussed such as the use of sequential camera traps, lures, or the simultaneous use of several camera traps.

KEYWORDS: Wildlife crossings, Camera-trapping, Monitoring study, Triggered cameras, Small mammals

#5 Bat Overpasses as a Solution to Increase Habitat Connectivity Depending on the Context

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Roads have a multitude of negative effects on wildlife, including their prominent role in habitat fragmentation. Habitat fragmentation particularly affects bats during their nightly movements between roosts and foraging areas. Bat overpasses are among the proposed improvements intended to reduce the fragmentation impact of roads, but they have rarely been tested. We studied four bat overpasses in France and developed two innovative methods: (i) Acoustic Flight Path Reconstruction (AFPR) for characterize bat crossings using acoustic recorders and (ii) Bat Tracking Toolbox (BTT) for characterize bat flight height using a thermal camera. Among the four bat overpasses, we performed a Before-After Control-Impact (BACI) analysis for one site located in west of France during three years and located in a narrow bat commuting route (i.e. a hedge). We obtained 888 bat crossings of five taxa and our results suggest that this bat overpass increase significantly bat habitat connectivity. Indeed, bat crossings were three times higher after the installation of bat overpass comparing to the control without bat overpass. Moreover, this bat overpass reduce significantly the risk of collision with vehicles. Results demonstrate that bat fly height was 6.1 meters before bat overpass and 9.3 meters after its installation. Moreover, 19% of bats crossing before bat overpass were under 5 meters above the road and under 1% of bat crossing were at risk collision after the installation. For the three others bat overpasses, they were already installed during our sampling. Thus, we don't have a BACI design. Nevertheless, we obtained 284 bat crossings of six taxa for all sites and our results suggest that bat crossings are more numerous if a bat overpass is located on a pre-existing bat commuting route before the road construction identified in an Environmental Impact study. However, we found that the proportion of bat crossings along the commuting route was the same with or without an overpass; thus highlighting that bat overpasses do not fully restore habitat connectivity. In synthesis of the results for these four bat overpasses, we concluded that bat overpasses can increase habitat connectivity only if they are placed on a narrow commuting route and can reduce the collision risk for bats after their installation. Moreover, our studies demonstrate that AFPR combining to the BTT are a useful approach to evaluate mitigation measures. Finally, we emphasize the importance of field testing the effectiveness of mitigation measures with appropriate sampling design for other sites in different context.

KEYWORDS: Mitigation measures, Bats, Acoustic surveys, Thermal camera, Highways

SESSION 2.3.3B. INFRASTRUCTURE ECOLOGICAL MITIGATION AND RESTORATION – 2

#1 From dumpsite to nature sanctuary

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In the course of building a new high-performance railway line from Vienna to Salzburg, a tunnel system beneath the Vienna Woods (total length: 13.3km) was constructed. Excavation material from the tunnel was deposited in an old landfill site on Taglesberg in the Vienna Woods. Descending from the 1980ies, this site required a 'clean-up' before it could be utilised since it did not correspond to the state of the art anymore, concerning actual legal requirements and was already threatening the ground water.

The site was therefore registered as an area of suspected contamination. The entire clean-up, restoration and landfill activities took place over a seven-year period (between November 2001 and December 2008). From January to August 2007, 1.1 Mio tonnes of excavation material was deposited at that site. The major part of the material was transported in a very environmentally friendly way, with a conveyor band. All the deposited material was shaped in order to fit into the typical landscape of the Vienna Woods, which is an important recreation area for the inhabitants of Vienna. In 2005 the region of the Vienna Woods, expanding from the western districts of Vienna to the surrounding districts of the federal state of Lower Austria, was declared a UNESCO Biosphere Reserve. Due to the zoning of the Biosphere Reserve, the dumpsite has become part of the management zone of the Biosphere Reserve-area! Hence, the huge landscape pit of the former waste dump was transformed into a smooth terrain, ready to become part of the forest again. During the short period of tunnelling works up to 6000m^3 of tunnel–excavation material was processed per day. The original native soil was put on top of the excavation material and the whole area has been replanted with plants such as red clover and bur clover that grow the roots deep into the ground. Thousands of typical trees and bushes have been replanted as well. The reforestation partly took place in cooperation with local elementary schools, in order to keep children in touch with nature and to make them familiar with the transport infrastructure project. The reforestation was planned and coordinated by the Austrian Federal Forests, who are the owner of the area. Whilst the official, mandatory verdict of the forest authority demanded a complete reforestation of the dumpsite (8ha), biological monitoring in the following years revealed that some subareas of the landfill site, especially where forest development did not meet the expectations, showed highly valuable transition biotopes, boosting with rare species of plants (e.g. *Ononis arvensis)*, insects (e.g. *Conocephalus fuscus)*, reptiles (e.g. *Zamenis longissimus)*, amphibians

(e.g. *Bombina variegata)* and birds (e.g. *Lanius collurio)*. Therefore ÖBB-Infra AG as the holder of the verdict, together with the Austrian Federal Forests, decided to ask the forest authority for a clearing permission, in order to maintain those valuable biotopes. Fostering biodiversity is also in accordance with the goals of the biosphere reserve. The biosphere reserve management will take care of the maintenance programme and organise volunteers for vegetation management activities.

KEYWORDS: Railway tunnel, Waste dump site, Reforestation, Biosphere reserve, Biodiversity

#2 A guidance system for amphibians made of recycled guardrails in Kirchberg on the Raab (County Styria / Austria) – a successful alternative

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Along the state road L 245 in Kirchberg on the Raab (County Styria/Austria) a new bicycle lane has been installed. In the course of construction works, the road itself has also been renewed, which made it also possible to install the long aspired guidance system for amphibians over a segment of 1,100 metres. The installation of amphibian guidance systems increases the costs for about 30 %.

The aim was to build a cost-saving and, to the least, equally effective alternative to conventional guidance systems for amphibians. Discarded guardrails were installed as guiding elements in an amphibian guidance system. The efficiency of the system was investigated using a standardized monitoring of their acceptancy.

The amphibian migration route in this area is one that displays one of the highest numbers of species, including five particularly protected species, alongside one of the highest number of individuals within the county of Styria. The amphibians migrating seasonally between their land habitat and their spawning grounds on an annual basis. The habitat of the amphibians is cut through by the L245. Over the last 15 years a mobile, provisional fence for the protection of the amphibians had been installed on the arriving side every spring. When migrating back, adult and juvenile individuals were unprotected.

Prior to the installation of the system, two pre-examinations on the migration of the amphibians were carried out in order to define, among other things, where the key points of the migration of the single species lie and to thus specify the number of passage ways and their localisations. It was also analysed if the system with its passages (60x100 cm tunnels) was profitable for all species, for the protected species of the common spadefoot toad (*Pelobates fuscus*) in particular. In 2018, the first monitoring of acceptancy was carried out.

The realisation brought some challenges along, as it turned out that, for instance, it took more effort than initially thought to provide the necessary material. Old guardrails were collected from all over Styria. Specific mounting systems were developed for the installation. For bolting the single elements, an ideal solution had to be found in practice.

The result paid for all expenses. This surely is one of the most robust permanently installed guidance systems for amphibians throughout the entire country. The road banks can also be used by heavy agricultural machines without doing any damage to the system at all. This resilience towards damage of all kinds, as e.g. through mowing works, means a remarkable reduction in costs when the maintenance of the system is concerned. The total costs ranged at about a third of the costs for a comparable system.

The monitoring of acceptancy confirmed that the acceptance of the system was above 90 % among the arriving adult amphibians. Guidance systems for amphibians are considered successful on a long term basis if 75 % of the migrating adult amphibians pass through the system. The guidance system was also well accepted by sensitive species.

KEYWORDS: Amphibians, Recycled guardrails, Migration, Conservation, *Pelobates fuscus*, Common spadefoot toad, Styria

#3 Condition of amphibian road mitigation constructions in Sweden

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In efforts to reduce barrier effects and road mortality of amphibians, the Swedish Transport Administration has installed tunnels and/or guiding fences at 35 different road sections identified as high-risk sites for amphibians. These constructions were built between 2000 and 2017. Until now, an overview of the different designs and materials used has not been readily available and, more importantly, the technical condition of the constructions has been largely unknown. To remedy this, we visited all 35 objects during the summer of 2018 and evaluated them using a standardized protocol. We used existing guidelines for construction and maintenance as well as previous registrations of possible problems as a foundation for the evaluation. We developed a protocol with focus on quantitative measurements of flaws in the structure or materials. For example, we measured the gap size between different segments of the fences, the amount of material blocking the tunnels and the height of vegetation growing near the fences. Additionally, we assessed the permeability of fences qualitatively. Four objects were in very poor condition. We judged the remaining objects to be largely functional although few were in perfect condition. We conclude that there are three main types of flaws, based on a combination of frequency and severity: 1) Large gaps between fence and tunnels. 2) Damage to the top of the fence. 3) Vegetation near the fence. The problems we identified with the condition of mitigation constructions for amphibians were varied and seemed to occur with all types of materials and irrespective of the age of the structure. Many of the more severe structural flaws seemed to be the result of site-specific events, such as flooding or ground movement. Overgrowth or otherwise poorly maintained vegetation and damage caused by machinery was, on the other hand, common. For some of these problems there may be underlying causes, such as flaws in the construction that could have been detected already in the building phase. We conclude that thorough inspection during building and regular and proper maintenance is vital for ensuring long term functionality. Although this may appear obvious, our study reveals that it is not always put into practise.

KEYWORDS: Amphibian, Road mitigation, Technical inspection, Maintenance

#4 Design and test of a semi-automated system based on time-lapse camera trapping for the monitoring of wildlife overpass use by amphibians

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Camera trapping is an increasingly used technique for wildlife crossings monitoring and evaluation of road mitigation efficacy, especially for medium and large mammals. However, its use for small animal detection and counting like amphibians is more challenging. Indeed, the detection of small ectothermic animal with camera traps put the efficiency of the passive infrared sensors to the test. To deal with this, time-lapse camera traps have recently been used as an alternative tool. This method appeared to be effective and promising for amphibian crossings monitoring. In this context, we tested the use of a camera trap (Reconyx® Hyperfire PC900) with time-lapse image recording for the monitoring of an amphibian tunnel in North Eastern France. First, a sample of the thousands of images obtained from March to April 2018was visually analysed to count crossing amphibians, which were mostly common toads (*Bufo bufo*). Then, the obtained number of common toads was compared with the number of live trapped individuals by volunteers (routine monitoring of different amphibian tunnels). Analyses showed a good correlation between the number of toads count by time-lapse image method and the one obtained with live trapping. This result shows the potential of time-lapse image recording to estimate the number of crossing amphibians. Moreover, although the use of camera trap with time-lapse image recording could reduce the time passed on the field, the task of visually analysing the large image collection is time-consuming. To reduce this time of analysis, we experimented a computer vision algorithm elaborated to detect moving objects on images series. Recognised animals were automatically marked with a bounding box, which facilitate the counting of amphibians by an operator. The perspectives of this preliminary study are now to improve this semi-automated monitoring system in particular by automatically counting individuals and determining the direction of their movements. The developed algorithm could be also implemented in an open-source tool designed to help scientists and managers in studying and monitoring wildlife overpass use by amphibians and other small animals.

KEYWORDS: Amphibian, Road tunnel, Time-lapse camera trap, Semi-automated monitoring system, *Bufo bufo*

#5 Species-rich Energy production

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Society and the transport sector are facing major challenges: "Biodiversity is deteriorating at a rate that is already a global and generational threat to human well-being". 75% of the terrestrial environment, 40% of the marine environment and 50% of streams manifest severe impacts of degradation and the number of invasive alien species has doubled over the last 50 years (IPBES 2019). Globally greenhouse gas emissions need to decrease at a rapid rate in order to reach zero emissions by the middle of the century, after which it has to become negative.

The transport sector is one of the major drivers of the current devastating development and road traffic contributes to 21 percent of EUs total emissions of carbon dioxide. All actors within the transport sector therefore have a duty to contribute to the 2030 Agenda for sustainable development, set by the UN member states. This includes reaching the climate target, improve biodiversity and protect and safeguard the world's natural heritage. It is crucial that wealthy countries take a lead in the transition to a sustainable society.

The Swedish Transport Administration will therefore conduct a study on *species-rich energy production.* In 2020 a pilot will be implemented in which road verges with grassy vegetation will be harvested. Grassy vegetation and alien invasive species will be collected and transported to a biogas plant in order to increase biodiversity and produce biogas upgraded to vehicle fuel. Species-rich energy production thus contributes to climate mitigation, improved biodiversity, prevents further dispersion of invasive alien species and helps preserving Swedish natural heritage. The project is a continuation of an earlier pre-study and will investigate the frameworks and opportunities for species-rich energy production from vegetation harvested in existing infrastructure.

By combining these objectives a new business model is created, in which the contractor in addition to existing pay for road maintenance gets a bonus from the Swedish Transport Administration for contributing to species-rich energy production. The contractor will also get payed by the biogas plant for delivering biomass. A project design will be presented along with cost calculations for harvest and investments for species-rich energy production compared to costs for current road side management.

KEYWORDS: Biodiversity, Invasive species, Natural heritage, Energy harvesting, Biogas

#6 A dynamic restoration index to monitor and assess fragmentation reduction along a trans-Andean pipeline

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The southern Peruvian Andes are part of the globally recognized Tropical Andes biodiversity hotspot. This region is a transition zone from humid montane forests in the east to dry deserts in the Pacific coast that harbours many rare and endemic species. The construction of a buried 408 km natural gas pipeline through this area between 2009-2010 fragmented the landscape and affected species, communities and ecosystems in different ways and in varying magnitudes. To maximize the recovery of biodiversity and the reestablishment of ecological processes, measures and activities were implemented before and right after construction ended. These included soil rehabilitation and revegetation methodologies in landscapes dominated by cacti, grasslands, wetlands, scrublands and forests during two stages. The aim of the first stage was to recover vegetation cover, and the aim of the second (present) stage is to recover the species richness and composition of native plant and animal communities that ensure adequate ecosystem function. For the past ten years, we have been performing yearly monitoring activities to assess the recovery status of the Right-of-Way (RoW). Using spatially intensive field survey methods that record vegetation characteristics every 500 m along RoW, we have focused on the first 280 km of the RoW, which contains large expanses of high Andean grasslands and wetlands critical to local human communities. We did not use a static biological pre-construction baseline against which to compare changes in habitat recovery. Instead, we surveyed adjacent habitats outside and parallel to each 500 m RoW section representative of the dominant native vegetation to control for natural or anthropogenic factors that could be influencing local or landscape level changes not related to the pipeline construction or operation. To date, we have gathered data from nearly 10,000 surveys that we used to develop a dynamic index to assess and visualize the recovery of the vegetation and the reduction in habitats fragmented by the RoW. For this, we calculate the average vegetation cover for each 500 m RoW section and for each survey year, together with asymmetric confidence intervals, and compare it to the historic vegetation cover average obtained with the adjacent control surveys. The data show clear overall recovery trends in vegetation cover along the RoW, with a consequent reduction in habitat fragmentation. This finding is supported by additional plot-based surveys in selected locations that show positive changes in species richness and vegetation composition that increasingly resemble adjacent vegetation over time. After ten years, most RoW sections have recovered more than 90% of the vegetation cover when compared to control habitats. The detailed taxonomic, temporal and spatial surveys allow the aggregation of data by dominant or native plant species, major vegetation types or landscapes to allow for analyses that consider the complex characteristics of this Andes-to-coast cross-section. The concept of a dynamic index and the analytical routines we discuss are readily transferable to similar linear infrastructure projects, making this information available to adaptive management decisions.

KEYWORDS: Tropical Andes, Fragmentation restoration, Vegetation monitoring methods

SESSION 4.3.4A. ROADKILLS IMPACT ASSESSMENT, MITIGATION AND MONITORING

#1 Assessing the relative effect of road- and carcass-related factors on searcher efficiency: implications for future roadkill monitoring programmes

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Carcass counts along roads can notably underestimate the number of wildlife casualties due to several sources of bias, including observers' inability to detect carcasses during the surveys. A wide range of road-type and carcass-related factors can affect the detection efficiency by the observers, particularly when looking for small-sized species, such as amphibians, small mammals and reptiles. To assess the relative importance of factors such as road type (in terms of width and traffic volume), observer, carcass type and its condition as well as the location of the carcass, we carried out searcher-efficiency trials on two paved two-lane roads located in central Portugal, namely on a*(i)* national road, with wide lanes and shoulders (daytime traffic: ~22.8 vehicles/hour); and on a*(ii)*secondary road, with narrow lanes and without shoulders (daytime traffic: ~2.7 vehicles/hour).

Each road was divided into 12sectionscomprising 500m in length (spaced at least 250m apart) along which carcasses of passerines were randomly placed (7-10 carcasses per section). In addition, bat carcasses were also randomly placed along the National road (3-5 carcasses per section).The trials were then completed by four independent, similar experienced observers driving a vehicle at 30-40km/hour that recorded the trial carcasses detected. All observers were accompanied (on the passenger seat) by the researcher who previously placed the carcasses, to check for their presence, current status (e.g. intact, flattened, only feathers) and position on the road (e.g. left lane, center line, right shoulder, verge).

Our preliminary results show that bat carcasses are far more difficult to detect (detection rate: 0.28; 95% CI: 0.18 - 0.41) than passerines (detection rate: 0.69; 95% CI: 0.62 - 0.76). Carcass position and status seems to significantly affect the detection rates of passerines at the National road, but not in the Secondary road (except if carcasses fall on road verges). In both types of roads, the observers seem to detect carcasses of passerines equally well. The same did not happen with bat carcasses, with different observers showing considerably different detection rates. On average, almost half of the carcasses (43.6%) were removed before the arrival of the first observer (i.e., ~3 hours after its placement on the asphalt). Carcass disappearance resulting from traffic or scavengers can, therefore, negatively impact the robustness of the searcher-efficiency trials and, ultimately, the accuracy of the carcass detection rates obtained. We provide suggestions to minimize this issue as well as to improve the design of carcass detection trials in future roadkill monitoring programmes.

KEYWORDS: Mortality bias, Detection rates, Experimental design, Bats, Passerines

#2 Evaluation of the impact of road infrastructure on vertebrate mortality and possible measures for ecological connectivity in the landscape in the Aburra Valley, Colombia

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Since the 1970s the negative impacts of the roads on wildlife and possible mitigation measures to reconnect fragmented ecosystems along the roads has been studied. Countries like United States, France, Canada and Spain have led these initiatives with positive results. In Colombia, there are not enough investigations related to Road Ecology; however, some research articles report the presence of roadkill phenomenon, the number of bodies found and the most affected species, without focusing on the identification of variables or the proposal of mitigation or preventive measures. Additionally, there is not a standardized diagnostic methodology for roadkill diagnostic surveys applied for the Colombian context, so it is not possible to compare the results obtained by the researchers. For this reason, the objective of this work is to generate a standardized methodology to carry out a diagnosis of wildlife mortality on highways. The proposed methodology seeks to unify different techniques used by national and international researchers that have been described in previous works, establishing a suggested methodology to diagnose the effects of the roads over wildlife populations. This methodology consists of: An initial selection of the roads to survey, a characterization of the road and carcass count by car survey with 3 observers and 1 driver, a geostatistical analysis of the collected reports and the proposal of mitigating measures to wildlife roadkill according to the most affected species. To evaluate the proposed methodology, 51 diagnostic surveys were carried out on a 148 km long road (7,548 km in total) in the department of Antioquia, Colombia. 499 records of wildlife roadkill were collected, these reports had a distribution of 64 species, the most affected from each class were: *Rhinella marina* (n=74) for Amphibians, *Turdus ignobilis* (n=24) for Birds, *Didelphis marsupialis* (n=90) for Mammals, and *Clelia Clelia* (n=23) for Reptiles. From these findings, we identified the spatial patterns, hotspots and variables associated with wildlife roadkill. Climatic season, the type of landscape adjacent to the road and the slope of the road segment were identified as significantly related to wildlife roadkill by Fisher exact test applied in R software. Finally, we estimated road mortality statistics using Siriema software, this estimation had into account the detection probability of the carcass and the estimated time of removal of each class, it resulted on an estimated of 575,284 vertebrate animals killed every year in the sampled roads, distributed as follows: Birds: 19,204 per year, Amphibians: 551,078 per year, Reptiles: 1,228 per year, Mammals: 3,774 per year. Due to the high mortality rate, mitigation measures are proposed to diminish the roadkill of vertebrates in the census circuit, such mitigation measures seek to reduce the number of accidents, as well as reconnect ecosystems fragmented by road infrastructure.

KEYWORDS: Roadkill, Mortality estimates, Diagnostic methodology, Siriema, R

#3 The most roadkilled mammal species in Brazil, considering sampling effort, detectability and removal rates

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Brazil is a large tropical country with a high species richness of mammals and an increasing linear infrastructure network that causes a significant mortality rate by vehicle collision for many mammal species. It is incorrect to order the most roadkilled mammal species without considering detectability and removal rates. This work aims to list the roadkilled mammal species in Brazil and evaluate the top 10 medium and large mammal species with higher roadkill rates considering sampling effort, detectability and removal rates on the Brazilian highways. Peer-reviewed publications on roadkill monitoring performed in Brazil were searched and analysed. The roadkill rate, considering sampling effort, detectability and removal rates of medium and large mammals was estimated using the "Estimated mortality rate" tool of Siriema v.2 software. Based on the literature, we considered detectability rate of 0.73 and removal rate of 4.93 days. A total of 63 studies on wildlife roadkill monitoring conducted from November 2000 to October 2016 in Brazil were analysed. The records include 11,881 roadkilled mammals from 140 species, being 34 species (24.3% of species) from the order Chiroptera, 31 (22, 1%) Rodentia, 25 (17.9%) Carnivora, 15 (10.7%) Didelphimorphia, 10 (7.1%) Primates, 7 (5.0%) Cetartiodactyla, 7 (5.0%) Cingulata, 7 (5.0%) Pilosa, 3 (2.1%) Lagomorpha and 1 (0.7%) Perissodactyla. Records of roadkilled species correspond to 20.1% of native terrestrial mammal species in Brazil. The 10 species with the highest mortality rates per 100 km (roadkill/day/100km) caused by vehicle collisions, considering sampling effort, detectability and removal rates, were: 1) *Conepatus chinga* with 0.552 roadkill / day / 100km, 2) *Lycalopex gymnocercus* with 0.293, 3) *Cerdocyon thous* with 0.203, 4) *Euphractus sexcinctus* with 0.180, 5) *Dasypus hybridus* with 0.116, 6) *Tayassu pecari* with 0.091, 7) *Tamandua tetradactyla* with 0.087, 8) *Mazama gouazoubira* with 0.081, 9) *Myrmecophaga tridactyla* with 0.067 and 10) *Procyon cancrivorus* with 0.063 roadkill / day / 100km. Among the species with the highest roadkill rates, two are considered threatened (IUCN Red List 2019-1 (Global) category VU): *Myrmecophaga tridactyla* and *Tayassu pecari*. *Cerdocyon thous* usually is considered the most roadkilled mammal in Brazil, however when sampling effort, detectability and removal rates are considered medium-sized mammal species showed higher in the ranking, such as *Conepatus chinga* and *Lycalopex gymnocercus*. It is important to notice that if one consider only the amount of roadkilled animals recorded, it seems to represent huge numbers, but when including the sampling effort, detectability rate and removal rate in roadkill estimates it will show a more precise and correct data that will result in better decisions on

mitigation measures. Besides that, some mammal species considered threatened by IUCN became relevant, such as *Myrmecophaga tridactyla* and *Tayassu pecari*, which is alarming for conservation purposes. We strongly recommend that sampling effort, detectability and removal rates should be considered when evaluating vertebrate species most affected by roadkill, particularly in the tropics where biodiversity conservation is a relevant issue and is related to road ecology.

KEYWORDS: Threatened species, Detectability rate, Removal rate, Roadkill, Tropics

#4 Are movement corridors coincident with areas of high road-kill likelihood? A study for felids in Brazil

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Increasing habitat loss, fragmentation, and road density has led to increasing road mortality for many species worldwide and are pressing concerns for conservation. Transportation planners usually seek to understand the main drivers of such impacts on wildlife to plan mitigation. Recently, some studies provided evidence that habitat corridors (areas of higher connectivity) coincide with areas of high road mortality, while other studies showed that potential corridors and locations of high road-kill likelihood often do not overlap. The main goal of this study is to compare potential movement corridors and road mortality likelihood for felids in Brazil to test if potential movement corridors may coincide to higher probability of road mortality.

We used data of tiger cats *Leopardus tigrinus* and *L. guttulus,* ocelot *Leopardus pardalis,* jaguarundi *Herpailurus yagouaroundi* and puma *Puma concolor*. We applied circuit theory to identify potential movement corridors crossed by roads using occurrence data for each felid species. We applied maximum entropy to determine mortality likelihood of road segments using road-kill occurrences. We then spatially compared the locations of potential movement corridors and high road mortality likelihood and assessed if current values had any effect (linear or otherwise) on the relative change in road mortality likelihood. Our results suggest that potential movement corridors and high road mortality likelihood most often do not occur in the same locations and that current and road mortality likelihood are not related. We suggest that differences in the behavioral state of the animals in the species occurrence and road-kill data may explain these results. We recommend further studies to disentangle the role of different data types to identify potential movement corridors crossed by roads. Until then, the complementary use of both methods at landscape scale may be useful to guide managers to target road segmentsfor local-scale analysis for road mitigation.

KEYWORDS: Wildlife corridors, Road mortality, Road mitigation, Circuit theory

#5 A Transport Ecology Workshop towards developing sustainable transportation in national and international level in Myanmar

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Southeast Asia is facing rapid and extensive infrastructure development in the coming years with development of road networks and high-speed railway. While there is an inevitable need for transport network improvement in the region to overcome current difficulties, at the same time this also poses a serious threat to wildlife. Myanmar is a large country of the Greater Mekong Region aiming to respond to the challenges of the sustainable development goals. As the country is hosting important biodiversity areas with new species being found in still unexplored forests which sustain the largest populations of tiger and elephant in Southeast Asia like the mountainous Tenasserim Region close to the south Myanmar – Thailand border zone.

In 2015, responded at WWF Myanmar call, Infrastructure and Ecology Network Europe - IENE implemented a special mission in Myanmar and Thailand aiming on assisting in finding environmentally friendly solutions to problems that will result from the Bangkok - Dawei road development crossing the Tenasserimarea and meeting with relevant authorities and conducting fieldwork along the proposed route in Thailand. In 2019 in cooperation of WWF Myanmar and Ministry of Construction of The Republic of the Union of Myanmar, a second call lead to the organization of a Transport Ecology Workshop in NaiPyiDaw during November 2019. The attendance of the workshop consisted of a target group of 38 members of high level staff of the Ministry of Construction, the Ministry of Transport and Communication, Ministry of Natural Resources and Environmental Conservation and the Yangon Technological University/School of Civil Engineering with responsibility on planning and implementing (design, construction and use) of large scale transport infrastructure plans and projects.

The four day workshop included basic chapters of sustainable development of transport infrastructure like: (i) a general introduction on transport, (ii) the global concerns on biodiversity loss in combination with the demands of large scale infrastructure development, (iii) the appropriate proactive policies on strategic planning on development of transport projects engaging all the important stakeholders, (iv)the overall range of technical solutions against fragmentation and securing the ecological permeability of roads and railways to integrate them in the local landscapes,(v) the environmental supervising of the transport projects in a long life-cycle perspective from the initial planning until the operation and maintenance of the transport infrastructure.

The workshop was scheduled in an interactive process giving an active platform for exchange of knowledge, know-how and ideas and responding to questions on both general concerns and practical solutions for concrete problems in transport projects. Additionally a field trip was included in the overall workshop schedule to visit local road networks with special needs for integration of ecological connectivity in their updating

process. The programme of the workshop will be presented following by the results and the conclusions and the feedback of the overall interactive process.

KEYWORDS: Sustainable Transport Infrastructure, Ecological Connectivity, Mitigation Hierarchy, Mitigation Measures, Strategic Planning, Exchange of Knowledge

SESSION 4.3.4B. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 3

#1 Birdprotection on railways

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ÖBB-Infrastruktur is operating a railway network of almost 5000 km in Austria. Approximately3560 km of that network are electrified with 15 kV and a frequence of 16,7 Hz.

The electrified network suffers from roughly 4000 short circuits on average each year. These short circuits are caused by trees, bushes, facility break downs and also by birds and small mammals. Each short circuit leads to a very high mechanical and electrical stress for the infrastructure. The damage can be so severe that parts of the facility have to be replaced.

Such maintainance works can also be the reason for train delays and increased financial costs and demands on personnel.

In almost all cases, a short circuit caused by a bird or small mammal results in a fatality for the animal.

Therefore ÖBB Infrastruktur AG decided to take measures to reduce the number of short circuits. Two of these measures are the application of a guard-device in front of the isolator and a bird protection cap on top of the pillar, where the catenary system is running from one pillar to the other. These two devices effectively protect animals from electrocution.

The guard-device keeps animals from getting into the section between the grounded and live power part of the facility, which would cause a short circuit.

The bird-protection cap is isolating the live power parts on top of the pillar and provides a safe resting place for large birds. From a species protection point of view, this is of particular importance, because mainly large birds of prey, storks, herons and other rare and protected species are prone to electrocution. Therefore the protection caps help to safe these key-stone species.

Due to economic reasons it´s not feasible to equip the whole electrified network with the two devices mentioned above.

The roll out is carried in areas where our electrified railway infrastructure is touching bird protection sites or areas where rare and protected bird species can be found. As a basis for this prioritisation, ÖBB-Infrastruktur AG assigned the bird protection NGO bird life with the creation of a nationwide map of these priority zones. The GIS layer was then integrated into the GIS of the railway infrastructure.

In the case of facility re-investments, electrification of already existing lines or new construction of railway lines, both guard-device and bird-protection cap are attached anyway. ÖBB-Infrastruktur has started to use the bird protection cap in 2016 and has fixed about 19.000 of them so far (status: June 2019).

The positive effect of these measures is currently being measured with onsite experiences and data submitted from daily operations. For a statistical proof, the number of samples (development of the short circuits over the years) is still too low.

KEYWORDS: Bird protection, Catenary System, Availability of traction energy supply

#2 The need to consider searcher efficiency and carcass persistence in railway wildlife fatality studies

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The lack of reliable estimates of wildlife fatalities result in a misperception that wildlife-train collisions are of minor conservation concern. To improve the road-kill mitigation planning on railways, it is crucial to assess the number of fatalities resulting from this type of infrastructure more accurately. Correcting errors from the sampling process to estimate animal fatalities on infrastructures is already a practice in road and wind farm studies; however, this type of correction is rarely applied to railways. We aim to illustrate for railways the relevance of considering the two main errors from the sampling process: searcher efficiency (probability of an observer to detect an available carcass in the search area) and the carcass persistence (probability of a carcass remaining in the search area for a given time). We corrected the estimation of medium and large-sized mammal fatalities on a 750-km railway located in the Brazilian Savanna accounting for these errors. We used a dataset of observed fatalities collected by two observers in a rail inspection vehicle. We estimated searcher efficiency as the proportion of the carcasses observed on foot that were found by the team in the vehicle. Surveys on foot were performed by two observers in 15-km segments. We estimated carcass persistence based on trials with a subset of carcasses that had their persistence verified along three consecutive days. After nine surveys covering the railway by vehicle in two years (2015-2016), 1,950 carcasses were recorded. Searcher efficiency was 28%. Carcass persistence for three days was 99% and the mean persistence time estimated was 298 days. By correcting for these sampling errors we estimated that 4,542 mammals died on this railway in two years. After correcting for searcher efficiency and carcass persistence we estimated that more than twice of the observed number of medium and large-sized mammals have died on this railway over two years. Our results clearly demonstrate the need to improve sampling design to consider these errors and to enable more accurate estimation of fatalities on railways. This is especially important to better inform mitigation planning and monitoring. However, our results also indicate that dealing with these errors in railway ecology is still a challenge, since our approach resulted in a fatality estimate with low precision.

KEYWORDS: Linear infrastructure, Railway fatalities, Sampling errors, Wildlife-train collisions, Detectability

#3 Routing power lines in Brazil: towards an environmental and engineering friendly framework for reducing conflicts in the planning phase

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Building new energy infrastructures, including power transmission lines (TLs) is fundamental to supply the growing energy demand worldwide. Lessons learned from past projects drive the current planning processes to consider early assessments in order to avoid environmental impacts. Thus, designing TLs routes that avoid negative environmental effects and comply with mitigation hierarchy steps becomes an essential step. In many countries, the environmental perspective still poorly considered, and it is usually incorporated too late into the project, causing conflicts in the evaluation due to divergent opinions. These limitations have legal implications and risk decisions that cause delays in Environmental Impact Assessments and, consequently, in project implementation. As for the TL allocation projects, the identification of conflicting areas early in the planning process is important to avoid adding cost and delay to the project. Moreover, late adjustments normally result in a narrow range of feasible alternatives. To overcome these limitations, we proposed a decision workflow of route design in which we used the hypothetical planning of a TL located in southern Brazil as a case study. Our workflow includes: i) the proposal of alternative routes using Geographic Information System and Least Cost Path Analysis based on two sets of fuzzy criteria – engineering and environmental; ii) an experimental approach with gradual variation among five scenarios that integrate engineering and environmental perspectives (varying the environmental map influence from 10 to 25, 50, 75 and 90%), based on Spatial Multi-criteria Analysis and Analytic Hierarchy Process and, later, compared by eight evaluation metrics; and iii) identification of route segments with a consensus between engineering and environmental considerations using a Moving Window Analysis over the five scenarios overlapped. Our findings show that the scenarios with the greatest influence of environmental criteria achieved better performances in all environmental metrics. The spatial convergence among segments of all five modeled alternatives demonstrates the existence of three stretches that meet all the criteria (35% of the pixels had intermediate and high route coincidence values). The high coincidence of TL routes segments represents less conflict between environmental and engineering criteria in these sites and means that decisions may concentrate on minimization of residual impacts through the construction phase or in the next levels of the mitigation hierarchy. Fifty-five percent of the pixels presented low values for route coincidence, corresponding to higher conflict between engineering and environmental criteria in these stretches and, thus, more complex decision-making. Besides dealing with geographic intelligence to enhance the quality of the TL design, our study also presents an innovative approach to select the alternative TL segments among different scenarios based on the adherence of the result. Improvements in this approach will depend on the quality and spatial availability of the impact criteria: the more refined and better represented in the initial planning phase, the greater the power for optimization in reducing environmental impacts. We

recommend that measures taken to prevent impacts may occur at different scales in time and space. Thus, planning TLs could be an iterative process of applying the mitigation hierarchy.

KEYWORDS: Energy, Multi-criteria analysis, Decision support system, Mitigation hierarchy, Win-win situation

#4 Level and spatial scale of impact from different linear development types

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Linear infrastructure (LI) development and improvement take place at all possible scales all around the world. Among many different LI types, the one in the greatest demand is transport infrastructure. Other types of LI are the utility easements and industrial linear corridors, such as powerlines, pipelines and seismic exploration lines. Like roads and railways, they too are often used to provide access and energy, supporting a regions' economic growth. Power lines and pipelines usually occur at low densities compared to roads. However, they could be as wide as roads and are usually kept clear of trees and woody shrubs, often covering long distances across a wide range of habitats.

There is a clear bias in LI related research interests. It is seen regarding both infrastructure type as well as in the impacts being studied. Roads are the most extensively studied LI type and among many different impacts from LI, road mortality is the most extensively studied. However, all LIs, despite their use for humans, are affecting the wildlife at varying degrees and scales. Also, most of the scientific work conducted on LI development has been conducted in temperate ecosystems. Nevertheless, the impact is as serious or even worse for the Tropics. Therefore, this present project aims to compare the level and scale of impact from roads, railways, and powerlines on wildlife at the community level in a tropical ecosystem.

The study site is in the Polonnaruwa District of North Central Province in Sri Lanka. The site has all three LI of interest (i.e., roads, railway, and powerline) crossing with each other within the same habitat type. The forest patches that are being crisscrossed by these LI are nationally protected and have been experiencing the effects from these infrastructure types for more than 20 years. The survey intends to investigate the change in bird species richness and community composition as a response to distance from each type of linear development and then to investigate the degree of impact from roads, railways, and powerlines on bird species richness and community composition. Bird surveys are being conducted in both dry and wet seasons at 70 points located at varying distances from the selected LI. Ten additional plots will be surveyed as control plots to find the impact at each category in relation to the complete natural scenario. A control plot will have the same habitat as the sampling plots and will be more than 1km away from any given linear development. Dry-season sampling session just completed in this past July and the wet-season sampling will begin in January 2020. Model selection (AICc) will be used to select the most parsimonious model relating bird species richness, diversity (Shannon-Wiener diversity index H') and abundance to distance from each infrastructure type. Findings of this section will enable me to identify the level and scale of impact from roads, railway and powerline on wildlife at the study site. Hence, it will enable me to make well-informed estimations regarding the level of impact on similar habitats from similar developments.

KEYWORDS: Roads, Railway, Powerline, Community composition

#5 Shedding a Light on Sensory Pollution in Road and Railway Ecology

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A growing topic of investigation in road and rail ecology is the impact of light, noise and vibrations (i.e. sensory pollution) on wildlife. I will present the results from a systematic review of the current literature on the impacts of sensory pollution from roads and railways on wildlife.

I searched SCOPUS for articles pertaining to the impacts of light, noise and vibration from roads and railways on vertebrates. I limited my search to empirical, peer-reviewed journal articles, written in English. To be included, articles must have been on the ecology, behaviour or physiology of wildlife, so I removed any articles on humans, plants, and invertebrates. Finally, I excluded articles that suggested sensory pollution was a potential mechanism of the trends described, without directly investigating said sensory pollution (for example, studies that described a decrease of abundance of a species with proximity to a road and suggested such impact was due to a traffic noise, but did not measure noise levels). My search was limited to all of the available literature published by the end of 2019. I read through abstracts, and removed any article that did not meet the above criteria. In the end, I collected 161 articles. 2 articles were removed, since I could not get the full-text for those articles. So a total of 159 articles were used in this systematic review.

From each article, I extracted: the sensory pollution and transportation corridor investigated; the year, location and study taxa; the style of study (observational or experimental), whether or not the authors investigated the impact directly or if they tested a mitigation strategy, and also a summary of the main findings.

Preliminary analysis of the 159 articles shows 153 studies were at roads, and only 4 were at railways. 2 articles investigated both road and railway impacts. Furthermore, a majority of articles were on the impact of noise from roads. 95 articles were on noise impacts (90 at roads, 3 at railways, and 2 at both), 56 on light impacts (all at roads), and 7 articles on both, light and noise (6 at roads and 1 at railways). Only 1 article was on the impact of vibrations from roads on wildlife.

Finally, the majority of articles were on birds (n = 69; 52 on noise from roads, 11 on light from roads, 4 on light and noise from roads, and 2 on noise from railways), mammals (n = 60 articles, 34 on bats; 37 on light from roads, 22 on noise from roads, and 1 on noise and light from railways), and amphibians (n = 21, 16 on noise from roads, 4 of light from roads, and 1 from light and noise from roads). Thus, there is a clear bias in the literature towards the sensory impact of roads on wildlife, particularly noise from roads on birds, light from roads on bats, and noise from roads on amphibians.

Results from this study can be used to inspire future direction in linear road and railway ecology research.

KEYWORDS: Sensory Pollution, Barrier Effect, Avoidance

SESSION 5.3.4A. NEW TOOLS AND TECHNOLOGIES TO PREVENT AND MONITOR LINEAR INFRASTRUCTURE IMPACTS – 2

#1 Is field technician's work under threat? Video-recoding *vs.* traditional observation for monitoring flight behaviour of birds across a high-speed railway

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Bird collision in high speed railways (HSRs) is a highly topical subject in recent years due to the expansion of this infrastructure. Understanding how birds interact with railway networks could improve mitigation actions. Therefore, it is urgent to develop cost-effective systems to monitor bird behaviour in HSRs. For this purpose, we compared *in-situ* flight behaviour of birds across a HSR with *ex-situ* observations extracted from videos. During three seasons, three HD video-cameras were used to record the flight and crossing behaviour of birds in a HSR in Central Spain, where an anti-bird collision screen had been installed. In each season two HSR sections of 360m each were sampled: i) one along the anti-bird screen, and ii) one control section. The section covered by each camera was 120m approx. Simultaneously, direct observation censuses were done with binoculars (10x42), covering the same area as cameras. The time and direction of passing trains in the study area were also recorded, and used as synchronization points between videos and direct observations. An independent observer visualized 18 videos per season of 10' (lapses hereafter). For each day of recording, three lapses were randomly selected, albeit ensuring that at least one of the lapses contained a behaviour event. For each event observed in the HSR, during field observation or extracted from videos, the following parameters were noted: time, type of behaviour (crossing, flying or resting), bird species and size of the flock. Concordance between videos and direct observations were tested using the t-Student test for paired samples, comparing the number of individuals and the number of events per lapse. Pearson's Chi-squared tests for contingency tables were used to compare differences in the total number of individuals and events detected in function of the bird size (large, medium and small) and the flight behaviour. Bird size was used instead of bird species due to very low species detection was found in videos (42.99% of unidentified observations). Within the 540' of visualized lapses, 170 events and 321 individuals were detected in videos, whereas 201 events and 827 individuals were counted at field-work in the same lapses. We found discordance between methods in the number of individuals and events detected per lapse. In 20.37% of lapses, bird behaviours were detected only by direct observations, whereas behaviours detected only through video recordings represented

only 3.70% of lapses. Results showed that the number of individuals detected by the different procedure differs and that the detection ratios vary among sizes and types of behaviour. However, the number of events detected was similar between methods and sizes, although differences were found in function of the flight behaviour. Video recordings may be useful to monitor bird crossing events, but their efficiency is conditioned by the flight behaviour of birds and thus are less reliable method to identify species or their abundance, relevant information for conservation or mitigation actions. Therefore, video recordings might be an economical method for general monitoring but direct observations and technicians are still necessary in order to obtain reliable field data.

KEYWORDS: Camera, Management, Avian mortality, Railway ecology, Mitigation

#2 An analysis of Vulture mortalities on powerlines in South Africa from 1996 – 2018

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Vulture mortalities recorded by the Eskom / Endangered Wildlife Trust (Eskom/EWT) Strategic Partnership since its inception during 1996 – 2019 are presented here. Data were analysed to determine species most affected, the type of powerline structures responsible for the mortalities, and the key factors that contributed to the mortalities. The number of sites mitigated, as well as the average response time of mitigation measures were examined. Eskom's policy and standards for re-active mitigation as well as the recently adopted Pro-Active Bird Mitigation Strategy are explained. Challenges such as limited funding and the lack of technical solutions to reduce vulture mortalities on powerlines in South Africa are discussed.

KEYWORDS: Powerlines, Partnership, Vultures, Impacts, Business

#3 Hotspots in the Grid: The Spatial Distribution of Bird-Energy Interactions in Europe and North Africa

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Wind farms and power lines are responsible for a significant number of bird deaths in Europe and North Africa, primarily due to injuries arising from collision or electrocution. This will become increasingly important as countries in Europe and North Africa move to reduce their dependency on fossil fuels and transition to a zero carbon economy; wind energy capacity in the region is set to triple by 2030 and the capacity of the current 10 million km of overhead power lines, which make up a significant component of the electricity network within Europe, is forecast to quadruple before 2050. In areas where there are high densities of this infrastructure it can supress populations of vulnerable species and for the White Stork *Ciconia ciconia* it is the single largest anthropogenic cause of mortality in Iberia. Species most at risk include large, diurnally-migrating birds such as raptors and storks. These birds tend to fly at heights where they are vulnerable to collision or electrocution.

Here we use GPS tracking data of resident and migratory birds to determine regions with a high frequency of interactions between birds and energy infrastructure. We collated quantitative data on the movements of birds in Europe and North Africa (routes, flight heights and speeds) and publically available information of the location and type of energy infrastructure to identify collision and electrocution hotspots. GPS tracking data from 60 tracking studies including 27 bird species and 1320 individual birds was used to identify areas where there is a high degree of overlap between the flights of tagged birds at danger height and power infrastructure.

We show the potential cumulative effect of collisions and electrocutions for birds (in particular migratory species) which pass through multiple areas where wind turbines and powerline infrastructure is present. There is significant clustering of flights at danger height in certain regions, hence our map shows the location areas that have the highest potential risk of collision/electrocution, these are concentrated around migratory bottlenecks during the spring and autumn migratory periods. Next steps include validation of the risk maps using mortality data, obtained from tagged individuals and/or carcass search studies. This study provides a quantitative method for regulators and developers to target pre- and post-construction surveys and to develop cost-effective mitigation required to reduce the impact of energy infrastructure.

KEYWORDS: Collision, Electrocution, Wind, Transmission, Mitigation

#4 Using drones to track nest occupancy

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During construction and operating phase, Transport Infrastructure generates a habitat loss and disturbance of birds' species. Therefore Ornithological inventories are carried out before the work is undertaken to assess impacts of the infrastructure on the existing populations. After construction and during operations, regular monitoring is generally conducted to evaluate the real impact of the infrastructure and the impact of the measures recommended to reduce its effects.

Ornithological inventories generally include watch points, listening points, identification of nests and their occupancy. Monitoring of nets occupancy requires mobilization of important human resources because of their high elevation into the trees. For example, in the case of a well-developed oak tree, the time spent to examine a nest may take one hour. Half of this time is taken to install the equipment and ensure security. Moreover, risks associated with an activity at this height involve a special training requiring a specific license for ecologists to avoid the risks of a fall.

As part of an on-going project, an experimental measure has been proposed along with compensation of Transport Infrastructure impacts on the Hobby Falcon (*Falco subbuteo*), which is a protected species. This measure consisted in installing ten artificial nests. For every nest, the monitoring consists in verifying the presence of clues proving attendance in the nest (feather, droppings, remains of eggshell …).

To improve efficiency of nest monitoring both in terms of time and personnel security, the use of drones, also called Unmanned Aerial Vehicles (UAVs), has been tested and proven as part of a project. A first experience has been conducted to test the capacity of UAVs to hover at different distances of the nest.

Several parameters have been measured: distance to the nest, image resolution, noise level (DB) and sound frequency.

The optimal distance to reduce the disturbance linked to the noise and frequency emitted by UAVs and obtain a sufficient image resolution to interpret the different clues indicated above of an activity have been defined: it has been shown that the optimal distance was around 8 meters. The UAV maneuverability allows to survey nest occupancy at this quite long distance, even with a dense foliage.

Secondly, a monitoring campaign has been carried out to survey nest occupancy. For the first campaign, the drone pilot was accompanied by the ecologist to localize the nests. The survey duration was very efficient: 1 hour for preparation and 1 hour UAV flight for ten nests as opposed to 1 hour per nest with the traditional method. The closer the nests, the higher the interest in using the UAV approach.

It is to be noted, georeferenced pictures allow facilitating the survey report as well as the condition of the artificial nest.

As a conclusion, using drone presented an interest to save time in terms of safety.

KEYWORDS: Ecological monitoring by drone, Birds, Nest monitoring

#5 Artificial Intelligence-Based Detection of (no-)Animals in Camera Trap Images

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Camera traps are a critical tool in wildlife and transportation ecology, used to measure occupancy, movement, activity, and basic demographic characteristics. The scale of image processing led us to develop methods for identifying images with animal presence/absence and for identifying common species. We integrated several tools to flag images for animal presence/absence and for automated identification of deer. We provide these services in two online contexts, an image analyzing web-service (REC ImageID, https://roadecology.ucdavis.edu/imageid) and one that integrates with our camera trap management system (Cam-WON, https://wildlifeobserver.net).

We describe a workflow for detecting images in a dataset of camera trap imagery that may or may not contain an animal. We used a variety of training and test image types, ranging in background complexity, time of day (or night), and with multiple animals present. We tested 4 tools for identifying animals and for deer in particular: 1) A convolutional neural network (CNN) animal identifier (MLWIC). When tested with our camera trap imagery, MLWIC only achieved a 30.5% accuracy rate (top 2 guesses) in identifying mule deer. We found that MLWIC was not reliable for identifying images with and without animals, or for identifying the species of animal; 2) Microsoft's MegaDetector, based on a CNN and the TensorFlow Object Detection API. With MegaDetector, we achieved high (>90%)true negative rate (images classified as empty, and which did not contain an animal) and true positive rate (images classified as containing animals which actually did contain animals) for images with and without animals. We were also able to automate counting of animals in images; 3) We created a novel instance of a Keras library (utilizing TensorFlow API) that we trained with 51,392 images, 30,060 of which contained deer. We found that the tool had higher accuracy (>93%) identifying deer in images from the same camera positions as used to train the tool than from camera positions on which the tool was not trained (a measurement of external validity, 67%); and 4) "SEEK", a neural-network based app available from iNaturalist that can identify organisms to the genus or species level. We found that SEEK could not identify species that were moving or far away from the camera trap, but still identifiable by a wildlife technician. Furthermore, SEEK did not differentiate between "no animal" and "unable to identify animal".

Users uploaded batches of images in zipped directories to REC Image ID (for analysis only) or Cam-WON (to incorporate analyses into the project). The outputs returned to users include 1) a csv file describing the results of analysis, 2) a zip file of animal images (no animal images removed) and 3) incorporation of the images into Cam-WON tagging area with the records updated based on the analysis results.

We conclude that our integrated tool can identify the majority of images that contain no animal, but is weak in terms of identifying the animal species. While these tools can save time, further research is needed to perfect species identification, even for common species.

KEYWORDS: Artificial intelligence, Machine-learning, Wildlife, Camera traps

SESSION 5.3.4B. CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY – 2

#1 Validity of road-based data collected by volunteers for wildlife population monitoring

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A multitude of smart phone and more traditional tools are used with increasing frequency by volunteers on roads for long-term monitoring of wildlife. Data collected by volunteers on roads has recently indicated large-scale declines of some widespread amphibians in Western Europe. However, it is unclear how representative such data are or not in relation to the actual species distribution. Spatial biases could skew results towards more urbanised areas and consequently produce incorrect or partial trend estimations at regional or national scales. Our objective was to compare and verify potential spatial biases of road based data using distribution datasets of different origins. As a case study, we used the common toad (*Bufo bufo*), a fast-declining species and the main amphibian targeted by conservation action on roads in Europe. We calculated ecological niche models with the built used Maxent models to compare road survey data obtained from the UK flagship, 35 year-long "Toads on Roads" project, containing almost 2 million amphibian records, in Great Britain with models using national-scale toad distribution records in Great Britain as well as with models using randomly generated points on roads. Road based distribution models that used data collected by volunteers on roads produced similar results to those obtained from overall species distribution, indicating the lack of selection bias and a high spatial coverage of volunteer-collected data on roads. Toads were present in most parts of the country but were generally absent from mountainous areas and, despite the high availability of potential recorders, showed nearly complete absence in large urban areas. To our knowledge, this is the first study that comparatively evaluates species distribution models created using datasets of different origin in order to verify the influence of potential spatial bias of data collected by volunteers on roads. We show that for countries with high road density road network coverage, such as Great Britain, road based data collected by volunteers represent a robust dataset in terms of coverage and a critical citizen science contribution to conservation.

KEYWORDS: Amphibian, Citizen science, Roads, Trend estimations, MAXENT

#2 Identifying risk areas for hedgehog road collisions using citizen science data

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Vehicle road collisions are likely to be an important contributory factor in the decline of the European hedgehog (*Erinaceus europaeus)* in Britain. Here, a collaborative roadkill dataset collected from citizen science projects was used to assess when, where and why hedgehog roadkill are more likely to occur. Seasonal trends were assessed using a Generalized Additive Model (GAM). There were low numbers of casualties in winter — the hibernation season for hedgehogs — with a gradual increase from February that reached a peak in July before declining thereafter.

A multi-level hierarchical Habitat Suitability Modelling (HSM) framework was then used to identify areas showing a high probability of hedgehog roadkill throughout the entire British road network (~ 400,000 km) based on environmental determinants. Using hedgehog roadkill presence data and landscape variables, the HSM predicted that grassland and urban habitat coverage were important in predicting the probability of roadkill at a national scale. Roadkill probabilities peaked at roughly 50% urban cover at a 1 km scale and increased linearly with grassland cover (improved and rough grassland). Areas predicted to experience high probabilities of hedgehog roadkills were where a mix of urban and grassland habitats occur. These areas covered 9% of the total area within the national British road network. Used alongside evidence on the persistence with which hedgehog roadkill are recorded in a given location over time, the HSM framework can help to identify priority areas for mitigation measures.

Hedgehogs are charismatic, and there are more records for this species than for any other mammal in Britain. Conversely, many other species are highly under-recorded. This presents a challenge when using citizen science data, and limits the kinds of analyses that can be performed. The British Mammal Society has therefore developed a new free app 'Mammal Mapper' for use on mobile phones. This facilitates the recording transect surveys (as well as incidental records) and means that future analysis of road casualty data will be able to account for the amount of survey effort.

KEYWORDS: Hedgehogs, Roadkill, Citizen science, Habitat suitability modelling

#3 A vision of a sustainable infrastructure by 2050 in different countries

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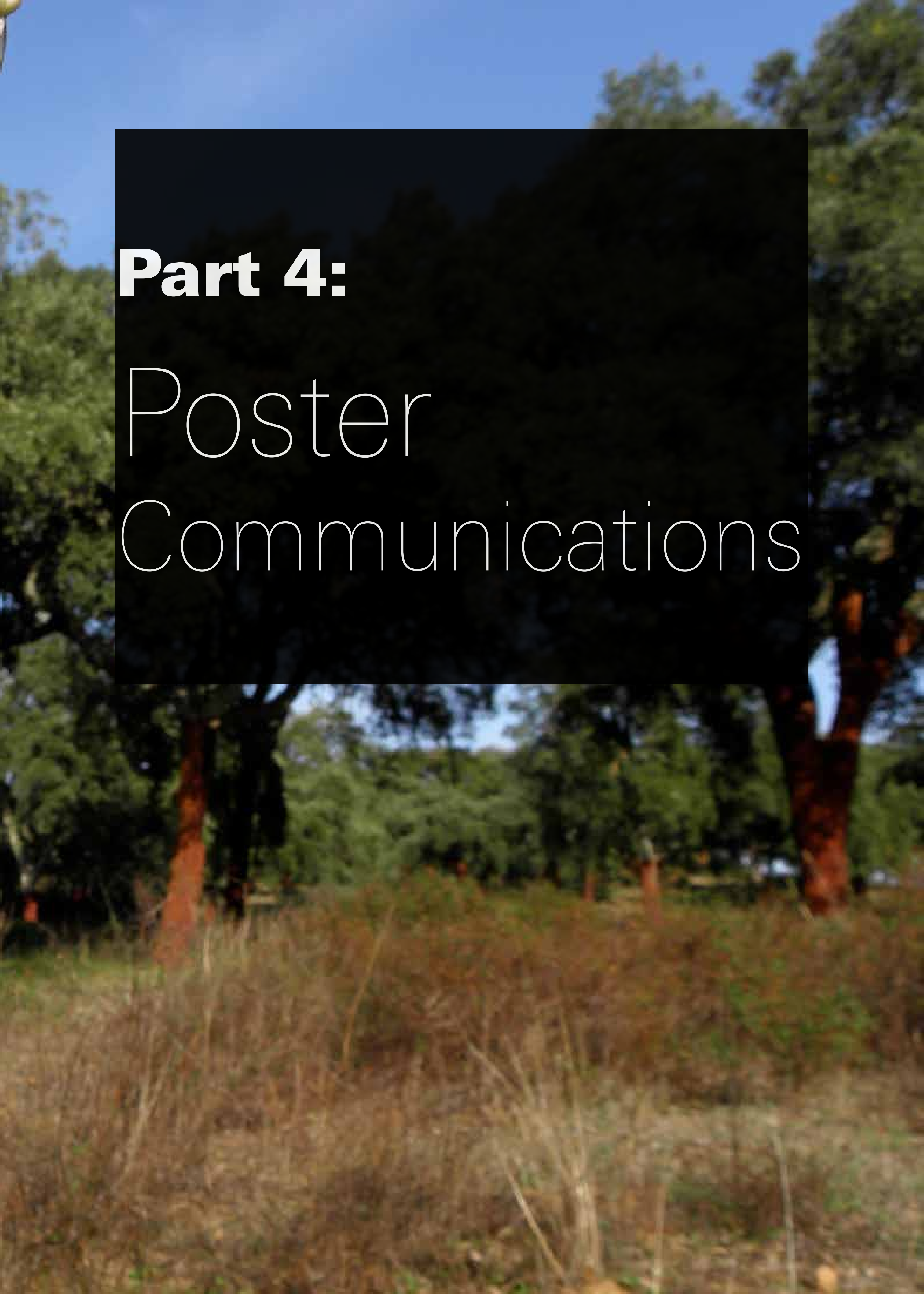
The growing infrastructure, the global conditions and problems it creates from a social, economic and ecological perspective affect all countries and its inhabitants, including students who learn about sustainable development from an early age. Following the school curriculum about sustainable development that extends across many topics and central content, this project is a continuing school work, from 2018, comprising 50 students in Åkerö skola in Leksand, Sweden. The aim of the project is to teach students at the age of sixteen about sustainable development using infrastructure as an instrument to get a more concrete discussion on the subject. In the 2018 project, the focus was on working thematically on the subjects of technology and biology. To develop the project, we worked thematically on the subjects of geography, social studies, technology and biology to give the students a broader knowledge of different countries´ ecological, social and economic conditions for creating a globally sustainable transport system. The project was a collaboration with the traffic agency in Sweden and the company "Road and Environment" in Sweden. The students individually choose a country to immerse themselves in. They started the project by writing a background introducing the country, using characteristics as population, economic conditions, natural resources, imports and exports, important business sectors and infrastructure. They received lectures, searched for information independently and contacted experts in different areas within the framework of the project. They also got visits from the traffic agency and the company of "Road and Environment" to learn how to plan and design different constructions to foster sustainability and biodiversity, which was reflected on how the different countries work today to achieve the global goals. They got the opportunity to become aware of how to create sustainability in the future while meeting needs, within the environmental absolute conditions and thereby got the introductions to their final assignment, how to cooperate with nature while building, for example roads and railways, to create their own vision of how the society in different countries can improve the transport system by 2050.

In the vision they had to consider what type of vehicle that should dominate, discuss in what ways the stress on the ecosystems reduces, in what ways their vision would benefit biodiversity and the underlying causes as consumption, transport needs etc. As a conclusion, they wrote arguments and explained why their vision of the transport system 2050 is more sustainable than today´s. It is very important for students to learn about this area of infrastructure and sustainable development as it is they who are our future and them who will plan this in the future. They gain an insight into a global problem that must be solved jointly in all countries and they get the chance, both to be creative and ambitious while learning about sustainable development.

KEYWORDS: Sustainable transport system, Vision by 2050, Students, School project

Part 4:

Poster Communications



SESSION 1.1.3. POSTER SESSION

INNOVATIVE SOLUTIONS FOR LINEAR INFRASTRUCTURE IMPACT ASSESSMENT, MITIGATION AND MONITORING

#1 Wildlife crossing structures aid bats with a high-risk collision to cross the road safely

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Roads have a multitude of negative effects on wildlife, including their prominent role in road kills. Most bat species rely on life history traits characterised by high adult survival (associated with long lived species) and low reproduction rates (hence slow growth rates), hence road kills are expected to negatively affect local abundance and bat population dynamics. Wildlife crossings are among the proposed improvements intended to reduce collisions. Among these structures are mainly monitoring for large mammals but they have rarely been tested for bats. In this study, we monitored during three consecutive years, two wildlife overpasses located in woodland habitats, in France, and used two new innovative methods: the first was the Acoustic Flight Path Reconstruction (AFPR) to assess bat crossings using acoustic recorders and the second was Bat Tracking Toolbox (BTT) for characterize bat flight behaviour using a thermal camera. Among the two wildlife crossings structures, we performed a Control-Treatment as sampling plan. The treatment corresponding to the location of the wildlife overpass while the control was placed 50 meters from it along the highway in the same woodland. We obtained over 160,000 bat passes. Among these bat passes, we obtained over 700 bat crossings: 70% of bat crossings were located at the treatment site and 30% were located at the control site. Moreover, species with a very or a high risk of collision with vehicles, crossed the road only at the location of wildlife structure. Concerning the flight behaviour, we found that bats used mainly the wildlife overpass for crossings the road. Very few of bats used the wildlife crossing structure for foraging: 9% of bats trajectories. Moreover, in complementary results, we demonstrate that bats do not used the wooden palisade for foraging and commuting: 98% of flight behaviour observed. Our study also demonstrates that AFPR combining to the BTT are a useful approach to evaluate mitigation measures. Finally, we emphasize the importance of field testing the effectiveness of mitigation measures with another appropriate sampling design: Before-After / Control-Impact in order to know if these structures can increase habitat connectivity.

KEYWORDS: Acoustic surveys, Bats, Thermal camera, Highways, Wildlife crossing

#2 Geographically Weighted Regression for modelling amphibian road-kills: comparison with other modelling methods

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Road networks are the main source of mortality for many species. Amphibians, which are in global declining, are the most road-killed fauna group, due to their activity patterns and preferred habitats. Many different methodologies have been applied in modelling road-kills, such as logistic regression and ecological niche modelling. Here, we compared the performance of five regression techniques in addressing the relationship between amphibians' road-kills/mortality hotspots and environmental variables. For this, we surveyed four country roads in northern Portugal in search of road-killed amphibians and identified clustered locations (hotspots). To explain the presence of road-kills and hotspots, we selected a set of variables that are important for the presence of amphibians (surrounding habitat) and occurrence of road-kills (road characteristics). We compared the performances of five modelling techniques: i) Generalized Linear Models (GLM), ii) Generalized Additive Models (GAM), iii) Random Forest, iv) Boosted Regression Trees, v) Geographically Weighted Regression (GWR). The best results were obtained with the GWR model for both analyses on roadkill frequencies and roadkill hotspots. The results suggest that GWR is a useful tool for roadkill modelling, as well as to better visualize and map the spatial variability of the models.

KEYWORDS: Road ecology, Logistic regression, Wildlife-vehicle collision, Ecological modelling

#3 Are roads and railroads barriers for the moor frog?

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Roads and railroads have been repeatedly identified as potential barriers for amphibian movements. Both the physical features of (rail)roads and traffic-induced mortality of animals that attempt to cross are believed to result in populations that are partly or fully isolated from each other. For many amphibian species, however, potential barrier effects of (rail)roads have not been empirically assessed. Our objective is to explore whether (rail)roads are a barrier to moor frog (*Rana arvalis*) movements and result in genetic differences between moor frog populations. Our study site is the nature preserves Naardermeer and Ankeveense Plassen in the central parts of The Netherlands. A two-track railroad that connects Amsterdam with the cities in the east of the country – constructed in 1874 – bisects the wetlands of the Naardermeer over a length of about 4 kilometres. Traffic intensity is relatively high, with about 400 trains/24h. Furthermore, a two-lane provincial highway (~20.000 vehicles/24h) – constructed in 1937 – is present between the two preserves. In spring and summer of 2019 we collected DNA samples of 145 moor frogs across both preserves. In addition we collected 43 DNA-samples in reference populations, both in areas immediately adjacent to the study site and in areas in other parts of the country. DNA was collected through collecting eggs as well as by toe clipping juvenile and (sub-)adult frogs. All samples were genotyped using eight microsatellite markers to analyse population structure and determine whether differences occur in genetic diversity and heterozygosity north and south of the railroad. We found a genetic structure in which the populations north and south of the railroad did not significantly differ. Genetic differentiation, however, was found for the populations north and south of the highway. These differences will allow for using genetics as a mean to evaluate the effectiveness of constructed wildlife underpasses in restoring habitat connectivity. Our study highlights the value of applying genetic techniques in the assessment of barrier effects, provides baseline information for future evaluations of planned crossing structures and eventually help to improve decision-making on mitigating barrier effects of (rail)roads for amphibians.

KEYWORDS: Railroad, Barrier effect, Genetics, Moor frog, Mitigation

#4 Evaluating the effectiveness of a wildlife overpass in restoring gene flow in a slow worm population

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In the Netherlands many slow worm (*Anguis fragilis*) populations have been fragmented by roads. Currently, wildlife crossing structures are being built across the country intending to reduce the barrier effects of roads and facilitate animal movements and gene flow across the landscape. However, little is known about the degree to which these structures reduce the barrier effects and enhance the exchange of individuals and genes between populations on opposite sides of a road. Our objective is to evaluate the effectiveness of a wildlife overpass in restoring gene flow in a slow worm population in the Gooi region, Netherlands. The overpass, constructed in 2013, bridges a motorway and two-track railroad, and is 50 m wide and 170 m long. The railroad was built in 1874, the motorway in 1974. It is positioned within a nature preservation area with mixed forests, heathlands and fens. In 2014-2015 slow worms were caught at the overpass and in the surrounding preserve over a distance of about two kilometres from the overpass. Life expectancy of slow worms is 10-15 years. Each year adult females may give birth to 6-15 young. We genotyped 153 individuals at nine microsatellite markers to analyse population structure and determine the origin of migrants found on the overpass or its ramps. We identified three genetic clusters with a distinct spatial pattern. We found that the motorway has been a genetic barrier; individuals from the western and eastern road verges belong to different genetic clusters. Individuals that were found on the western ramp and top of the overpass seem to originate from the genetic cluster on the western side of the transport barriers. Genetic diversity and heterozygosity was found to be extremely low in the western cluster which indicates genetic impoverishment and inbreeding. Our study shows that transport infrastructure may result in a genetic barrier for slow worms. The genetic differences between the populations on opposite sides of the transport barriers will allow for evaluating gene flow after the vegetation on the overpass has been fully developed and slow worms have had sufficient time to reach and accept the structure. Therefore the genetic sampling will be repeated in 2020. Our study highlights the value of applying genetic techniques in road ecology and emphasizes the importance of studies that go beyond the monitoring of the use of crossing structures by wildlife.

KEYWORDS: Road mitigation, Wildlife overpass, Gene flow, Slow worm

#5 Use of wildlife overpasses by roe deer: What are the effects of human co-use?

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In the Netherlands over 70 wildlife overpasses have been built across the country intending to reduce the barrier effects of (rail)roads and facilitate animal movements across the landscape. At some of these overpasses, human co-use is facilitated through the installation of cycling, hiking and/or horseback riding trails. Currently, little is known about the effects of such human co-use on the functioning of the overpass as corridor for wildlife. Our objective is to study the effects of human co-use on the use by roe deer (*Capreolus capreolus*) of a recently constructed wildlife overpass in the Gooi region. The overpass is open for cyclists, hikers and horseback riders. At the overpass we surveyed crossing rates, crossing times and behaviour of roe deer with the help of camera traps. Simultaneously we registered the amount of human use of the overpass. We found no effect of human use on deer crossing rates. However, we did find a correlation between the intensity of human use and the time of crossing by deer. On crowded days (>250 humans) the deer passed on average three hours later than on quiet days (<100 humans). Our study may help to improve decision-making on opening wildlife overpasses for human co-use and provide guidelines for the design of such multi-functional crossing structures.

KEYWORDS: Road mitigation, Wildlife overpass, Human co-use, Crossing rates, Roe deer

#6 Comparative study between environmental DNA method and electrical fishing method

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Impacts of linear infrastructure on biodiversity are widely documented for roads and railways but pipelines have rarely been studied. Among impacts on biodiversity by pipelines, especially on rivers, impacts of wastewater must be assessed.

In two areas in France, on six rivers, we tested two methods in order to assess the effectiveness of each method: (i) electrical fishing method completed in 2012 and 2017 and (ii) environmental DNA method (i.e. collection of surface water send to a research lab for DNA extraction) completed in summer 2018. We also compared results for electrical fishing method between two years: 2012 and 2017

Concerning the electrical fishing method, we found 9 to 10 species with 2 samples while we found 14 species with the environmental DNA method with one sample. Thus, the environmental DNA method permits to find a greater number of species than to the electrical fishing method.

Many reasons can explain this difference. First one, electrical fishing could induce disturbance due to the human activity on the river. In second, all micro-habitats cannot be sampling due to their accessibility or due of the water depth for example. Also, the low conductivity of water, or low water in summer can explain a low number of species by environmental DNA method.

Environmental DNA appears as a better method for four reasons: (i) a non-invasive method, (ii) a non-lethal method, (iii) a low skilled technician and (iv) more safety (i.e. absence of electrical equipment).

The environmental DNA method seems to be a good alternative compare to the traditional method on economical, efficiency and security aspects in order to lead complete inventory of fish fauna.

KEYWORDS: Environmental DNA, Electrical fishing, Pipeline, Sampling technique

#7 gDefrag: a graph-based tool to prioritize linear infrastructure defragmentation

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Habitat fragmentation due to anthropogenic action is a major biodiversity threat. In particular, linear infrastructures, such as roads, railways or powerlines, constrain the movement of individuals and are a relevant cause of non-natural mortality. Roadkill data have been used to define priority areas for road effect mitigation, but data availability and reliability are an issue, particularly on wide spatial scales. Datasets covering wide spatial scales are scarce, and those available are frequently flawed by irregular sampling effort. Additionally, the absence of roadkill information in a given location may not imply a lack of impact, as it may be a region in which the population was already severely depleted by the linear infrastructure-related mortality. And finally, mitigating the whole infrastructure network is unfeasible. As such, expedite methods are thus required to address such challenges.

We developed the gDefrag package, a graph-based approach that builds on habitat value and accessibility after simplifying the landscape as a graph. Its advantages include: not requiring roadkill or movement data, and providing effective methods to deliver reliable information, allowing landscape managers to address landscape fragmentation overall. gDefrag prioritizes roads which should be targeted first to defragment the landscape. It includes a user-friendly manual and currently implements four prioritization criteria: habitat quality, maximum number of inter-habitat paths, overall landscape connectivity, and simultaneously larger and higher-quality habitats.

This approach, prioritizes roads for mitigation based on spatial graphs, using a different perspective to evaluate the landscape fragmentation, where the land polygons (delimited by roads and by territory limits) are the nodes, and the roads themselves are the links. We aim to identify the links (roads) that connect the nodes with greater quantity and quality of habitat and/or are key areas for overall connectivity.

We applied this approach to prioritize the defragmentation of the major road network of the Iberian Peninsula, targeting all mammalian carnivores inhabiting this region, and using two complementary metrics: Area Weighted Metric (AWM) and Integral Index of Connectivity (IIC).The prioritization process highlighted several roads bisecting regions with high biodiversity potential in northern Spain and along the Portugal-Spain border. Four roads were scored as high-priority by both AWM and IIC, suggesting that they may have particular impact both in the amount of quality habitat and in overall landscape functional connectivity. When comparing the systematic prioritization with the random prioritization of roads, there were significant differences between the two approaches, the former showing clearly poorer performance, particularly for AWM.

This new and simplified approach helps decision makers to prioritize areas for road mitigation increasing landscape resilience and allowing biodiversity to recover from road-related impacts. It is also completely scalable, allowing a fast assessment of large territories, such as the Iberian Peninsula, or even at Continental scales. Hence, it is well suited for a first evaluation of where to focus the management resources.

KEYWORDS: Spatial graphs, Roadkill hotspots, Landscape connectivity, R package

#8 Development of a Video Image Analysis System for Reducing Operation on Surveys of Wildlife Behavior

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To design passages, crossings or other traffic infrastructure for wildlife to avoid wildlife-vehicle collisions, automatically and continuously recorded video images of wildlife behavior have been used to analyze their road crossing behaviors. Such analysis is also used for measuring the effectiveness of those facilities to prevent wildlife-vehicle accidents. The automatic recording system has enabled to obtain wildlife behavior records over a longtime. On the other hand, the system needs continuous electric power supply to record images that require tremendous time and human labor to be analyzed because of their huge volume.

To overcome such drawbacks, the authors developed a system that automatically detects only images that record wildlife when it appears on the road. The accuracy of the system was also verified.

The system is configured with an infrared-sensor-equipped CCD camera, a video recorder and a tablet terminal (Windows 8). A specially developed wildlife detection software program is installed on the system. The system's accuracy of wildlife image detection was verified by comparing its outputs to the visual observation results.

A video consists of multiple static images that change in quick succession. Humans recognize these successive images as moving pictures. The newly developed system catches the changes among a series of static images and extracts those of wildlife. The objects other than wildlife such as cars can be eliminated from the extracting objects by masking the specific area of the image. This reduces unnecessary image detections.

The accuracy of the automatic image detection system was also tested. In the test, the rate of the visual target detection was compared to that of the system's automatic detection. As a result, the system's detection rate of sika deer images was nearly the same as that for visual observation and the time to detect the sika deer images came to be halved compared with that taken by the previous system without the automatic detection function. The detection rate of birds images for the system was low, about one-third that of visual observation. And, it rarely detected animals that were not detected by visual observation.

We have been continuing to improve the wildlife behavior recording system, because its software modification is expected to improve the wildlife image detection accuracy and thus to contribute to savings in the labor needed to analyze the recordings and eventually to improve the efficiency and effectiveness of road infrastructure to prevent wildlife from collisions against vehicles.

KEYWORDS: Monitoring, Video survey, Video image analysis

#9 Effectiveness of road and railway bridges for reindeer and wildlife movements – an ongoing project

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Large roads and railways act as barriers for ungulates, with potential impact on individual fitness, population demography, and genetic diversity. Such barriers to movements are particularly problematic in areas where ungulates conduct seasonal migrations, such as in northern Scandinavia. For semi-domestic reindeer, as for wild migratory ungulates, fenced roads and railways may effectively block animals from reaching crucial seasonal areas and resources. For the reindeer husbandry, roads and railways with fences or high traffic volumes tend to create severe obstacles during driving of large herds, require extra efforts to retrieve animals from the "wrong" side, and result in loss of odd individual animals to neighbor districts or unknown fates. In order to minimize the barrier effects, the Swedish Transport Administration (STA) aims at providing safe passages for reindeer and other large mammals where major transport infrastructures intersect with important animal migration routes and movement corridors – i.e., at conflict points between grey and green infrastructure. However, it remains unknown how such passages should be designed to fulfill the ecological and practical requirements in the most cost-efficient way. Therefore, we have started a project to monitor how reindeer and wildlife use existing bridges over and under roads and railways. The bridges monitored vary in dimensions and design; some are constructed specifically for reindeer while others are bridges for roads or streams. The data collection includes camera trapping within and around the bridges, and camera images are analysed for number, behavior and categories of animals. The project includes the development of effectiveness criteria towards which the use of individual bridges can be evaluated. The project is planned to run 2018-2020, and to work in close cooperation between university, STA and five reindeer husbandry districts ranging from mountain to forest and lowland (concession) districts, within Norrbotten county, Sweden. Some preliminary results will be presented.

KEYWORDS: Bridges, Effectiveness, Migrations, Reindeer, Ungulates

#10 Optimising the ring road of Europe's capital: integrating enhancements in mobility, ecology and public involvement

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At the heart of Europe, heavy traffic jams are daily business. The Brussels ring road (called The Ring), designed and build in times when car mobility was heavily promoted and possible social and ecological side effects were considered subordinate, is not any longer adapted to today's needs. Neither is it accommodated to the surrounding landscape, creating strong barrier effects for both people and wildlife and causing important habitat fragmentation in the Sonian Forest, one of Europe's most reknown Natura 2000 beech forest habitats and a UNESCO World Heritage Site.

The Flemish government started an ambitious program to adapt this transport infrastructure to 21th century needs, called 'Work on the Brussels Ring Road: working together on a more fluent and liveable future'. The program involves improvements in public transport, cycling infrastructure, ring road infrastructure and liveability, including large-scale reconnection of green areas.

Habitat defragmentation, preservation of valuable road side vegetations and the improvement of wildlife connections are important goals on the ecological level. It is important that these ecological goals and needs are defined and integrated at the designing process of the road infrastructure, in order to promote the process of permissions as well as to create stronger ecological awareness of the participants and the designers and to avoid additional costs.

For the Sonian Forest, the proposed measurements include the adjustment of the road to restore important landscape structures above as well as underneath the Ring, a change in the lighting regime of the Ring and connected road infrastructure; and an improvement of ring road water run-off treatment. Apart from the enhancements in ring road infrastructure it is equally important that all measures taken cause no additional ecological side effects (e.g. fragmentation or disturbance from cycling infrastructure). On the contrary, the enhancements seek to improve the ecology.

The project involves many mitigation measures, two of which will be realised in the short term: a wooded valley that is now blocked by highway infrastructure will be restored, creating a broad ecological passage underneath the Ring. A large bat hibernation structure is part of the design and will be integrated in the ecological passageway. Additionally, a small ecoduct will be realised next to one of the main visitor's centers of the Sonian Forest, which also aims at possibilities for nature education and sensibilisation for ecological defragmentation.

These measures will be proposed in detail in the poster.

KEYWORDS: Barrier effect, Defragmentation, Ring road, Brussels, Sonian forest

#11 Quantifying the individual impact of artificial barriers in freshwater: operationnal technology transfer of a standardized and absolute index of genetic connectivity to regulatory studies

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Fragmentation by artificial barriers is an important threat to freshwater biodiversity. Mitigating the negative aftermaths of fragmentation is of crude importance, and it is now essential for environmental managers to benefit from a precise estimate of the individual impact of weirs and dams on river connectivity. Although the indirect monitoring of connectivity using molecular data constitutes a promising approach, it is still plagued with several constraints preventing a standardized and individual quantification of barrier effects. Indeed, observed levels of genetic differentiation depend on both the age of the obstacle and the effective size of the populations it separates, making difficult comparisons among obstacles. Here, we developed a standardized index of genetic connectivity (CINDEX), allowing an absolute and independent assessment of the individual effects of obstacles on connectivity. The CINDEX is the standardized ratio (expressed as a percentage) between the observed genetic differentiation between pairs of populations located on either side of an obstacle and the genetic differentiation expected if this obstacle completely prevented gene flow. The expected genetic differentiation is calculated from simulations taking into account both the age of the barrier and the effective size of the targeted populations. Using both simulated and published empirical datasets, we explored and discussed the validity and the limits of the CINDEX. We demonstrated that it allows quantifying genetic effects of fragmentation only a few generations after barrier creation and provides valid comparisons among populations (or species) of different effective populations sizes and obstacles of different ages. The computation of the CINDEX requires a minimum amount of fieldwork and genotypic data, and solves some of the difficulties inherent to the study of artificial fragmentation in rivers and potentially in other ecosystems. This makes the CINDEX a promising and objective tool for managers aiming at restoring connectivity and at evaluating the efficiency of restoration programs that we now deploy in operational studies.

KEYWORDS: Connectivity, Freshwater, Landscape genetics, Mitigation, Standardized index

#12 Standardisation of camera-trap monitoring of wildlife crossings

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Ecoducts and underpasses are commonly used to mitigate effects of linear infrastructure on wildlife. Given the high costs and large differences between situations and designs, there is a need for adequate wildlife monitoring to assess and compare effectiveness between designs and situations. This requires standardisation of data collection.

Camera traps (CT) are often used to monitor the use of ecoducts and underpasses. The captured information could in theory easily be standardised and shared. However the use of CT-results in an international multisite research approach requires overcoming several obstacles.

Here, we identify six key challenges in wildlife monitoring at ecoducts, and provide solutions:

1. Sharing – Comparison of monitoring studies across studies is hindered because many researchers store CT images and data in stand-alone data applications or datasheets. A solution is to run monitoring projects in one of the platforms (e.g. Trapper, Lepus, Agouti) that were developed to store, organise and annotate CT- pictures.

2. Human error – Many mistakes are made when researchers read and manually insert date and time of pictures in a datasheet. However, this information and other metadata are automatically stored by the CT into an EXIF-file attached to each image. Platforms such as Agouti retrieve this information automatically and avoid human errors.

3. Data structure - CT-monitoring results in thousands of images. The species and the number of individuals have to be specified for each observation. The use of sequences of images, rather than individual images reduces the required effort by a factor of 3 or even 10 (depending on camera settings) without losing any information. On the contrary, the automated creation of sequences based on the timestamp of the image does not require any limitation in the number of pictures taken in a photoburst. Agouti and other CT-platforms use therefore sequences.

4. Image annotation – Nevertheless hundreds of sequences still have to be annotated. Agouti therefore supports the export of sequences to the Zooniverse citizen science platform, allowing citizens to play a major role in identifying and counting animals in the generated sequences.

5. Data standards – Standardising the export formats of these data platforms is a challenge because they were developed independently from each other. The Camera Trap Metadata Standard (CTMS) developed by Forester et al. (2016) is used as an export format by many of these platforms which facilitate the aggregation of data from different sources. Therefore, we will use the CTMS standard to generate automatic export files. Finally species observations will be translated into Darwin Core and uploaded to GBIF while pictures will be archived in Zenodo.

6. Monitoring design – A last – and probably the most difficult challenge is to establish a more uniform camera set-up in the field. Given the possible impact of camera height and position, the option to use bait and camera settings, there is an urgent need to better understand the impact of these factors and how they impede an integrated analysis of CT-data of different monitoring projects related to ecoducts or underpasses in Europe.

KEYWORDS: Camera trapping, Mitigation, Standardisation, Data, Wildlife crossings, Ecoduct, Underpass

#13 Biodiversity information tool to supporting Environmental impact assessment

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The assessment of the effects over wildlife, flora and natural habitats is a complex aspect in the procedure of environmental impact assessment. The reasons might be by the complexity of the natural systems; the lack of information about the distribution and status of the species implied, or the difficulty of carrying out the monitoring of wildlife. In other cases, not all the actions included in a project are considered in the assessment.

The species of fauna and flora, and habitats that require special attention in this assessment, they are those with some degree of threat included in catalogues or lists, as well as the species and habitats that are included in the European Directives 92/43/CEE and 2009/147/CE. Under these Directives, the repercussions of plans and projects that can bring on Natura 2000 sites have to be assessed. The deterioration of the habitats as well as the perturbations that affect the birds also have to be avoided.

The Ministry of Territory and Sustainability (Government of Catalonia) ordered the Forest Sciences Centre of Catalonia the development of a tool called *Information to support the Environmental Impact Assessment* (IAIA in catalan). The access is restricted to all the technicians of this Ministry, both Central Office and Territorial ones (over 40 people). The process of tool building up connected the Catalan administration officers in charge to perform this process of future projects and the biodiversity information stored by the unit responsible of natural heritage conservation.

The tool is a user-friendly online server which facilitates biodiversity information after the user defines a query specifying project type (roads, electric lines, mountain lifts…) and location. The tool integrates information about sites location and habitats and species distribution which can be overlapped with future project's location using a GIS scheme. This spatial information let the technicians in charge of environmental Impact Assessment to clearly identify which species, habitats and sites are potentially impacted within a project's area.

Moreover, the tool translates scientific information to qualitatively estimate the likely effect on species and habitats occurring within the area impacted by a project. To do so, the tool links the threats and pressures associated to every project type with the susceptibility of the species and habitats spatially overlapped This information let users to improve the assessment using scientific based information to identify which project elements could impact on biodiversity. The tools' outputs are ready-to-use, downloadable and easy to interpret.

KEYWORDS: Biodiversity, Environmental Impact Assessment, GIS

#14 Predicting wildlife collisions hotspots based on machine learning and GIS: A case study in a tropical dry forest area in Colombia

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The Roadkill of wild fauna is a problem that has had a proportional increase in the growth of constructed roads. Animals and Vehicles Collisions (WVC) can lead to human injuries, costs associated with vehicle repairs and loss of life of humans and animals alike, affecting the biodiversity of the most biodiverse regions of the planet. It is estimated that approximately 2 million collisions between vehicles and large mammals occur in the United States each year, resulting in 29,000 people injured, 200 or more human deaths and at least 1 million animals killed each year. Sadly, Colombia does not have enough information to mitigate the impacts of the roads. Due to the magnitude of this problem and the lack of information of WVC hotspots, it is necessary to propose predictive techniques to prevent it from the moment of road infrastructure planning. Artificial intelligence and machine learning techniques have proven useful at predicting spatial phenomena such as forest fires, flash floods and traffic accidents, however, these algorithms have not been sufficiently explored in Road Ecology. For this reason, the objective of this work is to evaluate the performance of machine-learning techniques in predicting the places most likely to be considered as roadkill hot spots on roads between the municipality of La Pintada, and Bolombolo, Colombia. For this purpose, roadkill surveys were performed, collecting roadkill data (n=157) through citizen science and security inspections of the road between the municipalities of La Pintada and Bolombolo, Colombia. Significant hot spots of wildlife roadkill were identified through a geostatistical approach, resulting in a database of hot and cold spots segments with spatial descriptors associated. Algorithms such as K Nearest Neighbors (KNN) and Support Vector Machines (SVM) were trained with a training ratio of 0.5 spatial descriptors such as: % of forest cover, distance to rivers, altitude and Normalized Difference Vegetation Index (NDVI) was used during training and validation phases. Validation tests were performed on the dataset, KNN model had an accuracy and specificity of 88%, while for the SVM had an accuracy of 85.5% and a specificity of 98.84%, considered as successful results in the prediction of hotspots of fauna roadkill from spatial variables. The use of these algorithms opens the opportunity to carry out transfer-learning experiments, predicting the hot spots of fauna roadkill in areas that do not have data or the possibility of carrying out a survey. These tools should be considered by decision-makers during the planning of linear infrastructures, implementing measures to reconnect fragmented landscapes along the way. This serves as a successful precedent towards the prediction of WVC in a tropical ecosystem from spatial descriptors.

KEYWORDS: Artificial intelligence, Spatial Analysis, Prediction, Hotspots, Roadkill

#15 Ecologically friendly erosion control

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A possible mitigation measure to reduce the impact of linear transportation infrastructures on wildlife, is to install ecologically friendly verges and riverbanks. If so, these structures can function as important longitudinal, green corridors.

Verges and riverbanks are quite often subject to multiple forms of erosion caused by rain, wind and water. Most of the time the development of spontaneous vegetation is not enough to stabilize the banks. Often, environmentally unfriendly geotextiles are used as an extra protection.

This poster provides a clear overview of internationally applicable biodegradable erosion control solutions. The innovative aspect of the presented overview is the collection of solutions covering each possible slope angle. All proposed materials are technical textiles exclusively made from natural fibers. They provide temporary erosion control until the vegetation root network is strong enough to take over.

In this way an environmentally friendly alternative is given to common used erosion control textiles, often containing synthetical fibers, grids, nets and/or foils. These synthetical materials remain in the soil as waste and might be harmful for many fauna species.

This overview was made in the context of aneco-technical material care system/certification (NTMB-zorgsysteem) which aims to gain and spread knowledge about ecologically friendly building materials and to help improve the quality of the applications in which this kind of materials are used.

This practical overview is the result of co-operation between the Flemish government, engineering offices, developers and suppliers of ecologically friendly solutions. It is based on their studies and field experiences and is meant as a practical tool for decision makers.

KEYWORDS: Ecologically friendly, Erosion control, Verges and riverbanks, Technical textiles, Biodegradable

#16 The NOTEE VA method

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The NOTEE VA method is an ecological impact assessment instrument used on highway operations. « Ecological Impact » means the difference between previous and subsequent biodiversity statues due to works on a highway development operation. All the area which are impacted by Project Owners' actions are included (except environmental compensation measures).

Thus, the fields covered by the NOTEE VA method are exclusively those related to the quantification and qualification of the biodiversity status in the area at a given time.

The method relies on a state of the art analysis, in France and overseas.

4 themes were chosen to help define the ex-ante and ex-post biodiversity status:

- ecological status of the natural habitats in the area;
- cultural heritage of these habitats: i.e. social construction assessing what is rare;
- connectivity – continuity: to quantify the way for species to make vital movements to complete their life cycle;
- protected nature: biotope or species getting regulatory protection status which respond to the Project Owner concerns and to the sustainability reporting.

The chosen indicators to report these themes are measured by expert assessments before and after the works. They meet 3 main objectives: being proportionate and "feasible" for a project owner (inexpensive and quick to set up), returning a quantified data, being simple and renewable. Thus, each indicator takes a value between 0 and 1 reflecting changes in the state of biodiversity before and after the works.

The two aspects of the procedure for returning the ecological impact are:

- quantitative representation in the form of a diagram showing the intensity of the differential, also summarized by a rating showing the loss (-1), the maintenance (0) or the gain (+1) per indicator;
- cartographic atlases to obtain a qualitative view of the results.

NOTEE VA is intended to enable project owners to measure and synthesize losses and gains related to the natural environment in the works area of an operation. At the same time, it provides a tool allowing to assess the level of achievement of avoidance and reduction measures. It helps to inform project owners on the typology of the data that must be acquired from the initial states of the project to achieve such an evaluation. Finally, the geographical reading of the ecological impact provides a basis for the development of dependency management plans for the operator.

The application of the NOTEE VA method to the A63 2X3 road lanes operation highlights the ability of project owners to limit its ecological impact on some segments. This result is linked to a strong environmental management ambition for an operation.

It is planned to continue the research along the following lines:

- integration of environmental compensatory measures in the results to carry out a complete and factual assessment;
- leading to the detailed and exhaustive definition of input data for the deployment of indicators and the profile of the necessary expertise;
- Carrying out detailed maps highlighting nuanced color gradients of the different levels of ecological impact by theme.

KEYWORDS: Assessment, Tool, Highway, Biodiversity

#17 Long-Term Monitoring of ecological Impacts from a Road Project in Denmark 2012-2020

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In 2010, the Danish Road Directorate prepared an Environmental Impact Assessment (EIA) for a new northern orbital road at Naestved (Zealand, Denmark). The orbital road is about 7 km long and will pass a Special Protection Area (SPA) in the Danish Natura 2000 Network (Susåen, SPA H194). In the vicinity of the construction site there are several areas with protected habitat types (Habitat Directive Annex I), as well as species such as sand lizard (*Lacerta agilis*),brook lamprey (*Lampetra planeri*), spined loach (*Corbitis taenia*) and various species of bats listed on the Habitat Directive Annex II and Annex IV. According to the EIA Report of 2010, ground water level will not be affected during or after the construction work. This assumption is crucial to the assessment of the expected impact of the project, as many water-dependent protected habitat types are located close to the project area.

At the final approval of the project in 2010, a programme for nature monitoring was initiated. The purpose of the monitoring programme was to compare the actual impacts with the expectations as described in the EIA report. The monitoring programme comprised investigations during three periods: Prior to construction (baseline), during construction and after construction. The period of investigation was established from 2012 to 2020. The duration of the construction project was 2014-2017.

The monitoring programme focused on (a) Annex-II/IV protected species, (b) terrestrial protected habitats, and (c) stream-water quality. The selected parameters for the investigations were:

- (a) Presence and distribution of sand lizard (*Lacerta agilis*) in pristine and restored locations.
- (a) Presence and distribution of various species of bats.
- (b) Occurrence and quality of alkaline fens on adjacent areas within the SPA (Annex I, habitat type 7230).
- (c) Occurrence of protected habitats in watercourses (Annex I, habitat types 3260 and 6430).
- (a+c) Occurrence of particular species of fish in watercourses: spined loach (*Corbitis taenia*) and brook lamprey (*Lampetra planeri*).

- (c) Monitoring of macroinvertebrates as biological quality element (BQE) for stream water quality assessment. This parameter was monitored with conventional taxonomic expertise and compared to DNA metabarcoding (See Kuntke *et al.* 2020, *Ecol. Indicators* 111: 105982).

The monitoring was mainly based on methods being used in the national environmental monitoring in Denmark. The last part of the monitoring is scheduled for 2020. At this point in time the new road has been in operation for about 3 years.

Towards the end of the monitoring period modern DNA technology was included in the program. DNA metabarcoding of stream-water invertebrates was compared to conventional water quality assessment according to the Danish Stream Fauna Index (DSFI). The DNA metabarcoding of invertebrates provided a unique fingerprint of the studied communities of invertebrates and was successful in describing stream water quality. This novel approach creates new opportunities to continue or repeat future monitoring programs facilitated by modern DNA technology.

The preliminary results generally do not suggest any significant change in either stream water quality (c) or the distribution of the protected species (a).The terrestrial protected habitats (b) showed a weak positive development which may partly be explained by optimized habitat management. When presenting the results, data until 2019 will be included.

KEYWORDS: Habitat Directive, Long Term Monitoring, Impact Assessment, DNA methods

#18 Mitigation measures for wet grasslands, wader birds and amphibians along rail and road infrastructure in south west Sweden

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The Swedish Transport Administration constructed a new double track railway and a four-lane road between Gothenburg and Trollhättan during 2004-2012. This affected the nearby wet grasslands and wild animal populations. The administration has therefore a commitment to secure and improve the maintenance of these unique environments and their biodiversity. This longstanding project of ecological compensation covers 172 hectares of grazed grassland in four separate areas along Götaälvriver during a period of 25 years.

The mitigation is carried out by promoting more cattle grazing, special mowing activities, better fencing and construction of wetlands. Yearly inventories are conducted since 2014 and 2015 to monitor the development of vegetation, and the populations of birds and amphibians. The goal is to decrease the amount of reed, increase areas of grass-low-sedge vegetation, and to have well grazed high-sedge areas. The grassland habitats as well as targeted animal species should be kept in a favourable conservational status. The vegetation is studied in transects. Birds are surveyed during the breeding season by measuring breeding populations using territory mapping. Amphibians are surveyed during mating season by calculating egg clusters and playing frog males. Smooth newts are caught in traps.

The results show that the goals, with some exceptions, generally are being fulfilled now. The majority of areas with reed have substantially decreased and "a blue zone" has developed between reeds along the shoreline and the grazed wet meadows. Areas with grass-low-sedge have increased in some places, which is positive because it is a species rich vegetation, favourably for wading birds. The results of the bird inventories give us no clear evidence if the goals are fulfilled. In general the results show that the same species of birds are still being seen in the areas where the rail and road constructions have been completed. Some populations of waders, like the northern lapwing and common redshank, have been decreasing here and in the whole country since the 1970's due to less grazing and mowing in wet grasslands. Some species of passerines in wet grasslands however show a stable or even a small increase in numbers. The results from the inventory of amphibians show that all constructed ponds are being well used for reproduction, especially of Common frog. Smooth newt is distributed in all areas, although it is not observed every year nor in every pond. A negative trend in frog numbers is noticed during 2018 and 2019, which might only be temporary, or an indication that the ponds need further renewal.

This project is a unique possibility to manage nature conservation in wet grassland areas in an adaptive manner. It links the practical management with the development of habitats and species by frequent monitoring of them.

KEYWORDS: Mitigation measures, Ecological compensation, Wet grasslands, Wader birds, Amphibians

#19 Prevention of Deer-train collisions by a deterrent sound

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Deer-train collisions 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 against 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 1100 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 the 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). The reduction in deer sighting frequency therefore seems to be due to deer leaving the railway tracks on hearing the deterrent sound being emitted from trains. The distance between the train and the deer when they were sighted was estimated using the images recorded from the train. In cases where the train was playing back the deterrent sound, the distance was found to be 106 m (average of 22 samples). In cases where the train was not playing back the deterrent sound, the distance was found to be 45 m (average of 38 samples). This demonstrates that the distance between the deer and the train was greater when the train was playing back the deterrent sound, than in the control experiments when it was not.

As Nippon deer (*Cervus nippon*) is the most popular and habituate in Japan other than Hokkaido (where Ezo deer habituate). Field observation against Nippon deer have done in southern part of Japan. During 6 weeks of train runs with sound being emitted, deer were observed 60 times. Out of 60 cases, 58 deer (97%) were in a state of alert and 29 deer (48%) were leaving away from tracks. Only 2 deer (3%) were not alerted. 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 alert, 21 deer (17%) were leaving away from tracks, and 45 deer (37%) were not alerted. The deterrent sound playback changed the behavior of deer and there was no collision happened if deer were leaving away from tracks. So, the deterrent sound playback from the train will be an effective countermeasure for the collisions.

KEYWORDS: Railway, Deer collision, Deterrent sound, Mitigation

#20 Green Urban Areas: critical patches for biodiversity & ecosystem connectivity

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Green Urban Areas (GUA) have been recently recognized as dynamic refuges of biodiversity and landscape connectivity in the city. Considering the unprecedented expansion of urbanization worldwide, GUA become critical patches of nature conservation. Many GUA could be characterized as biologically significant sites mostly due to their role in metapopulation mechanisms, but also in providing breeding and seeding habitats affecting species richness. Nevertheless GUA confront many threats concerning their preservation as well as their shrinkage and isolation.

In this paper we make an attempt to investigate the potential role of GUA in protecting biodiversity from artificial light and noise pollution. We studied 4 GUA inside the centre of Athens. Field measurements were conducted in order to record noise and light pollution as well as other environmental characteristics in GUA. We implemented an integrated approach of combining traditional methodologies of landscape and acoustic ecology with view to dealing with a new concept urban ecosystems' biodiversity by means of highlighting the importance of GUA.

Special attention should be drawn to planning and designing GUA in such a way so that human pressures could not penetrate. Urban biodiversity demonstrates various patterns among different cities. Only by recognizing and interpreting the major drivers of variation in each case study, GUA could become an effective management tool towards conserving biodiversity at global scale. The landscape mosaic observed in GUA is accompanied, by various trends in soundscape and other environmental characteristics, emerging difficulties in assessing and thus preserving biodiversity.

Under this concept soundscape in combination with artificial lighting and environmental status of a site clarify the edge effect of ecosystems leading to an alternative multi-dimensional management approach.

KEYWORDS: Green Infrastructure, Urban biodiversity, Noise pollution, Light pollution

#21 A clustering analysis should precede the identification of local factors: evidence based on the Czech WVC data

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Identifying the factors influencing the presence of these locations is a natural step in the safety assessment process, following the localization of high-risk locations along roads where wildlife-vehicle collisions (WVCs) occur. Previous research mostly examined factors explaining the locations of individual WVCs. It has been demonstrated, however, that WVCs form clusters (hotspots) influenced by factors which can be divided into two groups: spatially random and non-random. The latter group consists of local factors acting at specific places, while globally acting factors belong to the former group.

Our database of WVCs contained 27,142 records (roe deer and wild boar) which occurred on the Czech road network between 2012 and 2016. First, statistically significant clusters of WVCs were identified by the use of the KDE+ method. Subsequently, selected local factors were gathered for the most important clusters as cases and for locations of single WVCs outside clusters as controls. The Bayesian inference, odds ratios and logistic regression were applied to evaluate the effect of each local factor on clustering of WVCs. Second, a simulation study was performed. WVCs were randomly distributed into case and control groups to highlight the importance of the clustering approach prior to any regression modelling.

Statistically significant clusters with roe deer and wild boar contained 34% and 27% of the records in our database. These hotspots covered only 0.98% (0.18%) of the road network in question. The results obtained from the simulation study suggest that the most pronounced signal determining statistically significant local factors was achieved when WVCs were divided according to the results of the cluster analysis. In conclusion, the application of a clustering approach should precede regression modelling in order to reliably identify local factors influencing the spatially non-random occurrence of WVCs along a road network. Additionally, further research on effectiveness of mitigation measures reducing risk of WVCs should focus on clusters of WVCs, not on the individual WVCs.

KEYWORDS: KDE+, Clustering, Regression model, Environmental factors, Spatio-temporal analysis

#22 Use of drainage pipes as underpasses by wild mammals in Southeast Brazil

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The wildlife roadkill threatens the persistence of natural populations and ecosystems integrity in the world, especially in extensive road networks such as in Brazil. However, the growth of traffic flow is not matched by mitigating measures that simultaneously promote road permeability and driver safety. Therefore, it is essential to develop studies monitoring fauna passages to enable the implementation of roadkill measures control with lower cost/ effectiveness. With this purpose, we inspected culverts and water drainage pipes usage as passages for small, medium and large mammals in the MG-428 highway, Minas Gerais state, southeast Brazil. We also monitored roadkill in the adjacent kilometers to verify if the animal species that use the passages differ from the ones that are run over. We installed six camera traps in four drainage pipes with different structure and vegetation characteristics, two culverts (60cm / 34.2m and 80cm / 45.8m in diameter/extension, respectively) and two bridges (7.9 / 6.6 / 20m and 9.8 / 7.4 / 30m in width/height/extension, respectively). From March/2017 to February / 2018 we fortnightly visited the area to monitor the cameras, driving (40 to 60 km / h with two observers) 6km around the passages and checking the presence of animal carcasses. We performed analysis of variance (ANOVA) to compare the use of culverts and bridges as passages in terms of type and season (drought x rainy). Thirteen species of mammals were spotted using pipes and bridges in 1672 photographic records. From the total of records, there are 171 complete and 30 incomplete crossings, with the presence of *Leopardus pardalis* and *Myrmecophaga tridactyla*, endangered species in Brazil. Monitoring the road near the passages (n = 576Km) we didn't find carcasses of the species that use the pipes on the highway. However, there were roadkill registers of six-banded armadillo (*Euphractus sexcinctus*) and hoary fox (*Lycalopex vetulus*; 0.52 mammal's roadkill / 100km / year). The pipes were used more frequently as passages during dry season ($p<0.001$) and although there were differences between culverts and bridges ($p<0.05$), they did not occur seasonally ($p > 0.05$). It should be related more to the characteristics of the passage, such as dimensions, presence of vegetation and water resources than to the local climate. The passages in Km 45 and 84, located in dense vegetation areas, were the most used, with seven/nine species, totalling 71 and 78 complete crossings respectively. The presence of vegetation corridors, the width of the passage, low anthropic use and dry environments must have favoured their utilization such as the case of Km 84 viaduct, which has gallery forest, a vegetation corridor that connects both sides of the highway and the occurrence of animal trails beside a stream partly protected by vegetation. Thereby, the data indicates that drainage pipes can effectively contribute to the permeability of the highway to mammal species and assist in the conservation of local fauna. We suggest that tunnels should be adapted (installation of dry lateral platforms for usage by small and medium mammals) and coupled fences of adequate size installed around the passages to direct the animals to their entrance. Such adjustments can help make these passages accessible to more vertebrate species, promote effective connectivity, reduce vehicle-animal collisions and provide greater safety for highway users.

KEYWORDS: Roadkill, Mitigation, Low Cost Solution, Hot Spot, Cerrado

CHALLENGES AND OPPORTUNITIES FOR HABITATS RELATED TO LINEAR INFRASTRUCTURES

#1 New approach to mitigate bird-window collisions

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Glass is abundant among linear infrastructure (train stations, wind and noise barriers, balconies, facades) and causes high non-natural mortality of many bird species worldwide. In Europe an estimated 250.000 birds die every day due to collisions with glass surfaces (BUND NRW 2015). Current methods to mitigate bird-window collisions are not aesthetically pleasing and some even do not work. In contrast to the widespread assumption, a single hawk silhouette placed on a glass pane does not significantly avoid bird strikes. Any shape of decal can be effective if it uniformly covers the glass according to the hand rule (10cm x 5cm) (Klem 2015). There is a great need to increase infrastructure sustainability by joining and sharing experiences of those involved in linear infrastructures planning and management. Therefore, the Austrian Federal Railway (ÖBB) has acknowledged the issue of bird-window collisions and mitigates it where possible. Since 2013 new constructions are provided with a vertical stripe pattern in order to avoid bird-window collisions, on glass elements where a high collision risk can be assumed. However, older constructions are not equipped with appropriate patterns and for some new glass constructions visible window markings do not comply with the original architectural glass design. The Austrian Startup BirdShades develops an invisible high-tech window film to prevent deadly collisions with glass surfaces to enable architectural freedom. The technology is based on the fact that most bird species are able to see UV-light (Cuthill 2000). The Austrian Federal Railway is one of the first pilot customers to test the Beta-Version window film which is produced for field trials. A location was chosen where bird-window collisions frequently occur. With the beginning of fall 2019 factors such as effectiveness, general performance, customer reviews, acceptance and appearance will be measured via data loggers and questionnaires. The gained data will directly be implemented into the ongoing product development of the BirdShades window film. This project shows strong collaboration in the development process of an innovative solution for linear infrastructure and is vital for innovative solutions to grow and to achieve market readiness.

KEYWORDS: Bird-window collisions, Glass, Biodiversity, Bird strikes

#2 Enabling wildlife to cross linear transport infrastructures - Examples of infrastructure requalifications - Collection of 12 sheets

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This document aims at support project owners and contractors to restore sustainably the ecological transparency of their Linear Transport Infrastructures (LTI). It presents feedbacks with different examples of achievements on the territory. It concerns various issues, technical processes, project owners (State, local authority, motorway operating companies, railway network, waterways...) and target species (aquatic species, small wildlife, large wildlife, ...). All these projects illustrate the need to study accurately this issue in order to apply an optimal and concerted solution with a budget often constrained.

This feedback is composed of an introduction explaining the context of the approach and the specificities of environmental infrastructures requalifications, as well as 12 feedback sheets (from 4 to 8 pages) about: Hamster pipelines near Strasbourg, a batrachoduc near Der-Chantecoq lake, a restoring of ecological continuities for small wildlife under motorways, a management and reconstruction of bridges for semi-aquatic fauna, a fish pass, construction of monkey bridges in French Guyana forest, fence movement for ecological corridor function applied to green dependencies, overpass and underpass constructions and requalifications on highways.The monitoring carried out showed the effectiveness of the measures applied.

Each sheet presents a summary of the operation. It exposes, the important points of the methodology applied from the preliminary studies, a description of the developments carried out, a global analysis of the operation.

This work currently is being set up and will be free downloadable on Cerema's website at the beginning of the year 2020.

KEYWORDS: Re-qualification of infrastructures, Ecological engineering, Wildlife corridors

#3 Evidence of the positive impact vegetation management of power lines corridors on habitats and species: feed-back of LIFE Elia-RTE in Belgium

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Integrated Vegetation Management (IVM) is a practice of Transmission System Operators (TSOs) to proactively manage the corridor forest openings underneath high voltage power lines. The purpose of this is to enhance the land's ecological value and regional habitat connectivity, to bring down maintenance costs and to build relationships with landowners. These Green Infrastructures, together with those associated with pipelines, motorways, railways or rivers, contribute to a European Green Network.

Traditionally, TSOs have used vegetation slashing as the main way to remove trees that naturally re-grow in power line corridors.

To move away from this traditional vegetation management, between 2011 and 2017, as part of a LIFE+ Biodiversity project, the TSOs RTE (France) and Elia (Belgium) tested a range of new IVM methods and natural habitat restoration practices. The "LIFE Elia-RTE" project resulted in habitat restoration and in the improvement of the management of vegetation over 429 ha in Belgium, among which 200 ha of meadows and grasslands are now managed with a goal of biodiversity enhancement. Other field actions resulted in re-developing forest ecotones, digging ponds, implement extensive grazing, remove or reduce the presence of invasive plant species and plant local varieties of wild fruit trees.

Elia conducted a biological monitoring of the restored sites during the next 2 years after the end of the LIFE project. 51 sites were selected in Belgium for about 130 ha where the vegetation was described and a selection of animal taxa was sampled.

Habitats and species belonging to the European "NATURA 2000" directives proved to react very well to the modification of management practices. The benefit for biodiversity was found as good on 69% of the sites and very good on 21%.

We found 8 species of dragonflies and 16 species of butterflies belonging the Regional Red List (from not threatened to critical threat or extinct). Bats were studied by recording their ultra-sounds to identify the species composition and their behaviour. A least 16 species were identified, in which 3 belong to the second annex of the 'Habitat Directive'. These results provide evidences that bats are active in hunting and traveling along the power-lines green infrastructures.

Moreover, the management of the sites became easier and much cheaper since the management plans conducted to local partnerships with landowners, farmers, hunters and the forest administration, to manage adequately the habitats.

The contribution of power lines to the connectivity between biodiversity sanctuaries (protected areas, NATURA 2000, ...) is insufficiently documented to date. Our results provide evidence that an IVM of the power-lines infrastructures create biodiversity hotspots with developing populations of key species.

We conclude that energy transmission operators may improve the resilience of forest ecosystems by adopting a new strategy of Integrated Vegetation Management throughout Europe and farther.

KEYWORDS: Power-lines, Integrated Vegetation Management, Connectivity, Biodiversity hotspots, Biological monitoring

#4 Enhancing biodiversity on Great Britain's railway network

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Britain's rail network is one of the oldest and safest in the world. In recent times it has transported 4.8 million people and around 200,000 tonnes of freight every day, making a vital contribution to the country's economic prosperity. But it also provides a rich mosaic of habitats, including woodlands and grasslands, for a wide variety of plants and animals.

Network Rail is Great Britain's public body responsible for the safe and efficient running of this busy and extensive transport infrastructure. Managing the habitats alongside the 32,000 km of track is vital for the safety of the passengers, train crew, employees and contractors. It's a balancing act to maintain and improve the railway to keep it running safely and smoothly, while being mindful of the land that surrounds it, the natural capital Network Rail are responsible for, the public benefits it offers, and the wildlife that lives on it. This network, including cuttings and embankments, dating back almost 200 years, can play a vitally important role in connecting fragmented wildlife habitats across the countryside, creating visual amenity benefits for commuters, reducing disturbance for neighbours and much needed carbon capture through the network's stock of over 6 million trees.

In partnership with the UK Centre of Ecology & Hydrology (UKCEH), Network Rail has developed a new and ambitious strategy for enhancing biodiversity and wildlife on the railway lineside. The Biodiversity Action Plan is the first step in achieving a vision of a lineside managed sustainably for safety, performance, the environment, and Network Rail's customers and neighbours. In this presentation, we outline ambitions for biodiversity and habitats, and how the organisation intends to protect, maintain and enhance their condition to 2035. This will require Network Rail to develop new skills and competencies in ecology and vegetation management, and apply these to decision-making at all levels of the organisation. It will also involve forming and maintaining partnerships with stakeholders and neighbours to maximise the benefits a well-managed transport infrastructure can bring for biodiversity. The Biodiversity Action Plan supports Network Rail's commitment to the key goal of no net loss in biodiversity on the lineside estate by 2024, moving to biodiversity net gain by 2035. Where it is not safe or practical to mitigate biodiversity loss associated with management actions, Network Rail may need to create appropriate habitats elsewhere on, or beyond, the estate to offset any impacts.

A first step to embedding biodiversity into railway asset management decision making will be to conduct a comprehensive assessment of the type and condition of biodiversity 'assets' across the rail network – including species and habitats. This is fundamental to producing detailed habitat management plans, defining outcomes and measuring progress towards them. UKCEH is supporting Network Rail to complete this assessment using novel modelling techniques and remote-sensing satellite imagery to map the type and extent of habitats across the rail network. Ground truthing of these data will use traditional survey methodologies alongside a wealth of citizen science species records.

KEYWORDS: Railway ecology, Sustainable transport, Biodiversity

#5 High occurrence of pollinating insects on new ecoduct in western Sweden

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Ecoduct Sandsjöbacka was constructed in year 2018 to secure safe passages for wildlife across the highway E6 in western Sweden. The ecoduct is 64 meters long (crossing four lanes) and 32 meters wide. Most previous infrastructure passages for wildlife has been focusing on large mammals such as moose, deer and roe deer. The ecoduct of Sandsjöbacka was designed to also create suitable conditions for pollinating insects of butterflies and bumble bees with the aim to increase their environment and to facilitate dispersal. Over 100 trees of six different species has been planted on the ecoduct and an area of 8000 m^2 has been seeding to create a flowery meadow of local occurring plant species. Survey of pollinating insects was made using scientific standardized methods based on line transects on the area of the ecoduct as well as on three reference areas nearby the ecoduct (European dry heaths, mixed forest and seminatural grassland consisting of fennoscandian lowland species-rich dry to mesic grasslands (now on called fennoscandian lowland grassland)). The survey was performed with one visit per month during May to August 2019. The result shows that the ecoduct is widely used by pollinating insects and hold equally or more species compared to nearby suitable habitats. Compared to the habitats of European dry heaths and mixed forest, the ecoduct holds more species and more individuals of butterflies (ecoduct - 13 species, 79 individuals; European dry heaths – 10 species, 28 individuals; mixed forest – 6 species, 7 individuals) and of bumble bees (ecoduct - 5 species, 20 individuals; European dry heaths – 2 species, 5 individuals; mixed forest – 2 species, 3 individuals). Moreover, the ecoduct holds approximately the same number of species and individuals of butterflies (13 species and 79 individuals) as the fennoscandian lowland grassland (16 species and 79 individuals). Surprising, as the fennoscandian lowland grassland was empty on bumble bees, five species were recorded on the ecoduct.

These results show that functional environment for pollinating insects can be integrated in infrastructure wildlife passages for large mammals. The result also show that pollinating insects is attracted to the new created environment after just one year and hence reconstruction of suitable living areas for these organisms can be an effective measure for upholding pollinators richness.

KEYWORDS: Ecoduct, Pollinating insects, Infrastructure barriers, Butterfly, Bumble bee

#6 Power line rights-of-way and pollinators: A partnership to develop!

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Pollinator habitats invariably consist of feeding areas (including water supply), nesting areas and wintering areas. These components are present in various ecosystems, including brushlands. Indeed, such habitats, which are often rich in plants and flowers, are excellent feeding grounds for these insects. What's more, some 30% of pollinators nest by burrowing into the pith of the stems or branches of common brushland shrubs like staghorn sumac, raspberry bushes and mulberry trees.

Brushlands can develop on farmland, vacant commercial or industrial lots and power line rights-of-way. Both for safety reasons and to ensure a reliable electricity supply, vegetation growing in power line rights-of-way must be maintained at a height of 2.5 metres or less to prevent flash-over. Vegetation control activities thus keep terrestrial ecosystems in natural environments at the brushland stage. Ongoing maintenance promotes early successional plant species, many of which produce flowers, while creating a heterogeneous structure favourable to pollinators. Depending on their surrounding environment, habitats in power line rights-of-way promote the development of different plant and animal species, including pollinators. Additionally, with their linear configuration, rights-of-way serve as corridors for pollinator movement by creating a network of interconnected open environments, particularly in urban settings. Such corridors help pollinators reach a variety of natural and semi-natural habitats.

As a result, for over a year now Hydro-Québec has been conducting studies on the biodiversity in rights-of-way. Among other things, the studies have yielded guidelines that, aimed at property owners whose lands border or overlap power line rights-of-way, suggest ways of enhancing pollinator habitats. Simple modifications can make ideal habitat for pollinators. For examples, increase flower diversity, provide access to soil surface for nesting, retain some branches or logs for nesting resources. Diagnostic tools are also being developed to quickly identify the improvements needed. Some tools and guidelines became available on the company's website in spring 2019.

Lastly, a pollinator inventory is underway in two power line rights-of-way, one in Laval and the other in Montréal. This marks a first in Hydro-Québec's biodiversity studies: no such inventory has yet been carried out in an urban setting. Pollinator populations using the rights-of-way will be documented over three seasons—spring (May), summer (July) and fall (September)—and a direct link will be established with nectar-rich plants. Very little research to date has documented both the pollinators present in these habitats and the plant species on which they feed. In addition, the inventory was carried out in three types of right-of-way: more abundant vegetation in right-of-way, equivalent and lower vegetation. Finally, we will compare our inventory results to the exhaustive inventory work carried out by the University of Montreal on the territory, considered to be the benchmark.

The fall inventory took place in 2018 and the spring and summer inventories, in 2019. Preliminary findings show that rights-of-way host an abundance of the plant species favoured by pollinators, including Canadian goldenrod, New England aster and raspberry.

Pollinator species captured included the green sweat bee, common eastern bumble bee, honeybee and a native bee. The inventory will be completed in fall 2019 and the results available at the conference. Early results from the spring inventory show high diversity in the rights-of-way in terms of both nectar-rich plants (close to 50 species) and pollinators (27 species). Of the latter, the honeybee was the most numerous, followed by the common eastern bumble bee.

Hydro-Québec believes these findings are clear evidence of the importance to pollinators of power line rights-of-way.

KEYWORDS: Connectivity, Pollinators, Wild bees, Biodiversity

#1 Temporal patterns of humans and ungulates at bridges - Co-existence or disturbance?

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The effectiveness of fauna passages depends on a number of factors, one of which being human disturbances in and around passages. There is an increasing demand to allow humans to use fauna passages, and even to construct passages with a combined function for fauna, recreational use and local traffic. Yet the impact of human co-use on fauna use of crossing structures is not well understood. We are studying temporal patterns of humans and ungulates at six road or railway bridges in Sweden; four constructed mainly for fauna and two for other purposes (road or stream), but all accessible to people and traffic. We have collected data over 6 consecutive months, using trail cameras to record the activity of humans, wild ungulates (moose and roe deer) and semi-domestic free-ranging reindeer at the passages. Human activity at individual bridges ranged from approximately 0.07 to 2.8 events per day, while ungulate use ranged from approximately0.2 to 1.3 events per day. Overall, human activities were primarily snowmobiles, secondarily cars and pedestrians. Human activity events occurred mainly in daytime or evening, leaving most of night and dawn without human interference. Moose and roe deer used the bridges mainly at night, which coincides with the period they are assumed to be most active. Reindeer, on the other hand, used the bridges mainly in daytime. At three bridges, humans were more active on weekends than weekdays, but at one bridge the trend was opposite. Ungulate use of bridges tended to be higher on weekdays than weekends, though these results were inconsistent. Human activity increased throughout the winter, which is likely associated with the gradual increase in daylight and improved conditions for snowmobiling. Ungulate use was higher in early winter, possibly due to natural seasonal migrations. The time elapsed between a human event and the subsequent moose event was generally longer than the time elapsed between two moose events, indicating a disturbance effect of human activity on moose use. There was no similar effect on reindeer, while that aspect could not be analyzed for roe deer. We conclude that i) human activity at bridges varied over time (in general lower at night and dawn, at weekends and in early winter), and accordingly that time-sharing between humans and wild ungulates occurred to a degree, and ii) there were some indications of human disturbance effects, but yet no consistent reverse temporal patterns between human and ungulate use of the bridges. These conclusions are however preliminary; the study is ongoing (including all year and additional bridges) and we hope to better understand the nuances of these relationship and the implication of the results to fauna passage construction.

KEYWORDS: Bridges, Disturbance, Temporal patterns, Ungulates

#2 Bird species more frequently recorded in roadkill studies in Europe: A review using a trait-based approach

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Urbanization is characterized by the concentration and expansion of human settlements, with a road network developed to connect these centres. The road networks are significantly altering the landscapes, increasing the ecosystem fragmentation. Amongst the most significant issues related to the expansion of these pervasive features of the landscape, we can highlight their ecological effects on vertebrate wildlife, which have been well documented. The primary ecological effects on wildlife are related to a) habitat loss, b) direct disturbance by noise and artificial light, and especially by d) artificial barrier to animal movements and mortality by collisions with traffic. Then, wildlife is considered key topic in the management of road fragmentation. However, even considering the importance of the effects on wildlife and impact of vehicle incidents on conservation of biodiversity and human safety, there is little information available on the relative involvement of road-killed bird taxa and the frequency of road-kills at a large geographical scale.

In this study, using a large dataset collected from several European studies, we explored the frequency of occurrence of bird casualties, species by species, focusing on the percentage of roadkills in the complete set of European studies. Then, we tested the potential phylogenetic relatedness on roadkill frequency. We modelled the inter-specific variation in roadkills frequency across the avian phylogeny, obtaining the phylogenetic relationships from 'www.birdtree.org'. We used the following R packages: 'ape', 'phangorn' and 'Rphylip' to work with the phylogenetic trees. To test the phylogenetic signal we used Blomberg's K and K* statistics, using the R package 'phylosignal'. Finally, we explored the association between roadkill frequency and some avian traits (e.g. body mass, type of diet, day-activity period). We tested the potential association among variables using generalized linear models.

We recorded data from 91 different articles in 9 European countries, collecting data on roadkill's about 258 bird species. Overall, the avian species most frequently recorded in roadkill studies in Europe were: *Turdus merula* (71%), *Passer domesticus* (64%), *Erithacus rubecula* (59%), *Tyto alba* (59%) and *Pica pica* (58%). However, the relative frequency of roadkills for the species within each study was different, with the following species showing the higher values of incidence: *Passer domesticus* (21%), *Passer italiae* (24%), *Cygnus olor* (18%) and *Columba palumbus* (11%).

The percentage of roadkills of avian species was unrelated phylogenetically ($K = 0.142$, $p = 0.213$ and $K^* = 0.176$, $p = 0.187$), indicating that the incidence of avian causalities is independent from the phylogenetic position of species. The exploration of behavioural and morphological traits of avian species showed that birds more frequently recorded in roadkill studies in Europe were mainly characterized by nocturnal activities, but such

differences were not statistically significant. Additionally, we didn't find statistically significant associations between the body mass, main type of diet and distribution range of species, and their frequency of occurrence in roadkill's studies ($p > 0.05$ in all selected models).

KEYWORDS: Avian species, Bird traits, Conservation, Literature review, Roadkill

#3 Effects of noise from transport infrastructure on bats

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Increasing levels of noise from transport are creating new anthropogenic soundscapes that may affect wildlife globally. Bats — which form about a third of all mammal species — are sensitive bioindicators, and may be particularly vulnerable because of their dependency on echolocation. There is concern that roads and railways may fragment the landscape for bats, but attention has focused on vehicle collision risk,

Here we present the first controlled field experiment with free-living bats to examine the impacts of road traffic noise on activity and foraging behaviour. Using a Before-After-Control-Impact study, we disentangle the impacts of traffic noise from other co-varying exposures such as habitat quality, and demonstrate a profound effect on bat activity.

Each of the five ecologically-different functional groups examined responded negatively to noise, suggesting that the results are very general. This effect is mainly because of responses to the audible (sonic) spectrum, which elicited aversive responses in all bat species tested; whereas responses to ultrasonic noise were restricted to a single species.

We will also present the results of new work which assesses the impact of railway traffic on bat activity.

Given that sonic components of traffic noise propagate through the air over large distances, impacts well beyond the immediate footprint of the transport network are likely. Our work, which has identified a key mechanism by which transport infrastructure affects free living bats, shows that Ecological Impact Assessments should be considered wherever there is significant increase in traffic flow, and not just when new schemes are built.

KEYWORDS: Noise, bats, phantom road, playback experiment, railways

#4 Modelling roadkill hazard zones for ten different vertebrate species in Austria using remote sensing data, expert knowledge and previous studies

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Roadkills or road accidents involving huntable or non-huntable wildlife are a risk for humans and biodiversity. The number of road kilometers is increasing worldwide; in Austria alone an increase from 106.855 km to 138.696 km between 2007 and 2017 is documented. Consequently the potential number of roadkills will also increase. Considering huntable wildlife only, around 74,000 animal-vehicle collisions were counted in Austria in the season of 2017/18. In 2018 the number of wildlife accidents leading to injuries increased by >30% compared to 2017, leading to 418 injured people and four casualties as a result of animal vehicle collisions in Austria. In addition to the impact on human health, economy and society, recent research indicates, that road traffic and related animal vehicle collisions have a major negative influence on animal biodiversity, particularly in vertebrates. However, worldwide only very few systematic studies on a national level investigating road-killed animals exist. It is important to get an overview of locations where roadkills are clustered to verify prediction models and to effectively implement mitigation measures such as wildlife crossing structures, fences, roadside reflectors or speed limits to halt the loss of biodiversity and increase human and animal safety. Monitoring road-killed animals on national level bears several challenges including large geographic areas and low persistence rates especially of small carcasses, resulting in time and personnel intensive monitoring approaches. The aim of the project presented with the poster is to derive hazard zones for AVCs in the vicinity of roads using remote sensing data, expert knowledge and results from previous studies. Therefore, possible impact factors (land cover, terrain, phenological influences, environmental factors, socio-ecological factors, etc.) were defined based on the behaviour of wild animals in order to subsequently transfer this information to potential data stocks like Copernicus data or Open Street Map (OSM) data. From this knowledge-based approach, risk areas for motorists and various animal species were derived. The validation of detected impact areas was done with available vehicle accident data (including data from citizen scientists and hunters). In a next step the hazard zones derived from remote sensing and geoinformation will be offered as a cloud based service that returns the risk of an AVC in a particular area (e.g. on a scale from one (lowest accident risk) to five (major accident risk)). The vision of the project is that different users (car drivers, insurance companies, navigation services, public authorities, etc.) draw corresponding conclusions (e.g. when building a new road).

KEYWORDS: Public participation in science, Animal vehicle collision, Prediction models

#5 Roads as a driver of changes in the bird community and disruptors of Ecosystem Services provision

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The Mediterranean oak woodlands are a vital ecosystem due to their economic value and importance for biodiversity. However, this ecosystem has shown a decline in recent years, due to a high occurrence of insect pests in cork oak areas. The road network is a well-known problem to wildlife, particularly to the bird population, that act as biological pest control agents and prevent possible outbreaks. Although the relationship between roads and birds, as well as the predation of pests by birds has been widely examined, little is known about how roads influence the efficiency of pest control provided by birds and how this ecosystem service can be maintained or even improved to compensate for roads' negative effects. Accordingly, we aimed to assess if road proximity affects the assembly and structure of the predator-prey relationship of Mediterranean oak woodlands. Bird surveys during winter were performed at twenty-five sampling sites, each one with three sampling points at increasing distances to the road, to assess the relationships between abundance of birds, abundance of cork oak pests and their variation with road proximity. Due to logistic constrains of COVID-19 pandemic (lockdown), there was a reduction in sampling period, and consequently a reduction of the number of sampling site and distance between sampling points. Pest and bird surveys during spring were performed at eleven sites of the twenty-five sites previously sampled, each one with two sampling points at increasing distances to the road. Furthermore, in the same sampling points we collected data regarding the degree of infection of two species of buprestids, Coroebus florentinus and Coroebus undatus, because these species are considered significant pests due to the damage they cause to the tree. As result, bird abundance and richness decreased with proximity to roads. Two bird species assessed showed significant lower presence near the roads, whereas only one displayed lower presence as the distance to the road increased. The opposite pattern was found for pests, pest abundance increased with proximity to the road, with four species of cork oak pest showing a higher abundance in trees close to roads. Both Coroebus florentinus and Coroebus undatus showed a decrease in the degrees of infection as the distance to the road increase.

The results showed bird abundance decreases with road proximity, whereas the abundance of cork oak pest increase, suggesting a cause-effect relation between the two groups, mediated by road effects. These results provide the first evidence that roads may affect the provision of ecosystem services, particularly by disrupting the pest control by birds in cork-oak systems. We anticipate that such impact may translate into important losses to cork economy.

KEYWORDS: Road ecology, Biological pest control, Prey-predator relations, Conservation

#6 Potential ecological impacts and their mitigation of Central Asia-South Asia (CASA-1000) transmission line: Afghanistan part

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The Kyrgyz Republic, Tajikistan, Afghanistan and Pakistan are pursuing the development of electricity trading arrangements and the establishment of a Central Asia - South Asia Regional Electricity Market (CASAREM). Its objective is development of a cross-border electrical interconnection linking all four countries to facilitate the transfer of surplus power from the Kyrgyz Republic and Tajikistan, southwards to Afghanistan and Pakistan. The first phase of CASAREM is to establish the necessary transmission and trading infrastructure and systems to enable a trade of 1000 to 1300 MW of electricity between Central Asia and South Asia, and referred to as "CASA-1000".

- A 450 km 500 kV HVAC transmission link between Kyrgyz Republic (430 km) and Tajikistan (20 km) to supply Kyrgyz electricity to South Asia via Tajikistan.
- A 750 km 500 kV High Voltage Direct Current (HV DC) transmission system between Tajikistan (117 km) through Afghanistan (562 km) to Pakistan (71 km). The proposed ROW has difficult terrain for approximately 160 km with a maximum altitude of 3750 masl.
- In Afghanistan, the proposed T/L will pass through seven provinces with different physical and biological features.

METHODS

Different feasibility studies and environmental assessments of CASA-1000 project (Afghanistan part) were reviewed and in addition, information about water, soils, flora, fauna and birds of the project area was collated and reviewed to assess the ecological impacts of the project.

KEY FINDINGS

- Approximately 75% of the COI traverses mountainous terrain with various types of exposed rocks and no soil cover. The geology of the area is suitable for transmission line construction.
- The COI is very dry and poorly vegetated with low biological diversity due to the limited rainfall, poor soil and decades of over exploitation. Biodiversity in Afghanistan is generally low because of water shortages, minimal rainfall and poor soil. Vegetation is also sparse due to excessive exploitation in the vicinity of the COI.
- CASA-1000 transmission line route is located in two global migratory bird- flyways; the Central Asian Flyway (CAF) and the East Asian-East African Flyway

(EAEAF). During the migratory season, thousands of migratory birds pass through CASA-1000 region.

- Due to four decades of war and armed conflict, the ecological resources of Afghanistan have been severely damaged with small efforts to conserve these resources.

- CASA-1000 project if implemented successfully will have positive impacts on the socio-economic conditions of Afghanistan particularly on the local communities along the project corridor.

- Some short term and isolated negative environmental impacts are envisaged during construction phase of the project especially on water, soil, vegetation, fauna and agriculture along the route of the transmission line but these can be mitigated by adequate management measures.

KEYWORDS: CASA-1000, Electricity transmission line, Afghanistan, Ecological implications

#7 Evaluation of selected methods to control invasive species along transportation linear infrastructures: a preliminary approach

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Roads and railways are linear infrastructures, massively widespread throughout the territory, with negative effects on biodiversity. These transport routes are a privileged channel for invasive flora species introduction and spread. As such, it is necessary to establish management actions for invasive species control around these infrastructures and understand the impacts of each method.

In Portugal, some of the most widely distributed invasive species along linear infrastructures are *Acacia dealbata*, *Acacia melanoxylon*, *Ailanthus altissima*, and *Arundo donax*. This work aimed to evaluate the effectiveness of control methods for these species, and their impacts on the surrounding native species community, in two roads (EN4 and EN114) and one disabled railway (Évora ecotrail) in southern Portugal. The distribution of each invasive target species was initially mapped along these linear infrastructures in 2017, and thereafter the most appropriate control methods were applied in selected plots between 2018 and 2019, following an innovative approach, where the control methods were used individually or jointly. The effect of control methods over invasive species and the surrounding native species community was evaluated through the assessment of flora species abundance before and after the interventions. The population structure of each target invasive species and their vigour, as well as the structure, specific richness and diversity of the different layers of the native community vegetation, were also evaluated.

The control of *A. donax* produced an immediate reduction in the cover of this species, followed by a progressive appearance of new shoots and consequent increase of cover. When the control was carried out through rhizomes removal, the initial reduction was more evident, and the resumption of the species cover was slower. The control methods applied to the different acacia species have shown different effects and effectiveness. Adults cut resulted in an immediate reduction of the species cover, but this action promoted the exponential appearance of new shoots, due to a reduction of the allelopathic effect of cut individuals. Drill and herbicide injection, or peeling have the advantage of not promoting the appearance of new shoots, though the drying effect was slowly. Nevertheless, peeling showed the fastest results, especially in smaller individuals. Results showed that control actions should be carried out continuously and targeting particularly shoots. The control of invasive species also had impact on the cover, richness and diversity of native species, especially herbaceous. The cut of acacia species has shown to be disadvantageous, since it enhances the development of new shoots, with a competitive advantage over native species. On the other hand, the methods applied to control *A. donax* seemed to benefit the native community, especially rhizomes removal. Obtained results have a preliminary character, being essential to continue data collection under the planned monitoring, in order to strengthen the evaluation of the methods. This study has practical applications in vegetation manage-

ment along linear infrastructures, also contributing to elaborate standardized guidelines for invasive species control. This work was financed by the LIFE LINES project (LIFE14 NAT/PT/001081), from the European Union LIFE programme, under the coordination of António Mira.

KEYWORDS: Invasive species, Control, Restoration, Vegetation structure, Native vegetation

#8 A chronicle of brown bear-vehicle collisions in Greece

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Transportation infrastructure is recognized as one of the most important drivers of landscape fragmentation and biodiversity loss. Other road impacts include edge and barrier effects, contagious development and land use change, as well as, wildlife - vehicle collisions. The needs of large carnivores for broad, relatively undisturbed areas and their low reproductive rates render them vulnerable to transportation infrastructure development and especially to road-related mortality.

Brown bear (*Ursus arctos*) is a strictly protected large carnivore species in most European countries and is listed in Annex II and IV of the EU Habitats Directive (92/43/EEC). In Greece, the species is protected under both national and international legislation, which has significantly contributed to the species' recovery; yet, threats and pressures remain, and specific measures must be adopted to guarantee the species' long-term survival. Wildlife-vehicle collisions jeopardize both wildlife and road traffic safety and thus, the need to develop comprehensive cost-effective strategies and adopt suitable mitigation measures is acute.

In Greece, more than 100 brown bears i.e. approximately 25% of the current population (ca. 475 - 500 individuals), have been involved in collisions with vehicles over the last 20 years. The majority has been fatal for the animals, but luckily, no people have been seriously injured. It is worth noting that there are several unrecorded cases of bear - vehicle collisions which have not been reported to the authorities, usually because property damage was minor, and the injured animal fled. Such incidents are made known only via coincidental personal communication with people involved and thus, are rarely recorded. We used data from 2004 to 2019 and applied the Point Clustering Method with the SANET (Spatial Analysis on a Network) program to identify collision clusters along the transportation network. We identified 6 bear - vehicle collision clusters in northwestern Greece: 1) national road network from Kastoria to Edessa (n=4); 2) national road network from Amyndaio to Vevi, (n= 14); 3) A2 and national road network from Kozani to Siatista (n=6); 4) A2 from Siatista to Grevena (n=5); 5) A29 from Siatista to Kastoria (n=23) and 6) road network around lake Orestiada (n=13).

During the past few years, a 130km bear-proof fence (2.2 m high, 0.8 m overhang with a negative angle, 1.5 m horizontal mesh) has been installed on both sides of A29 and along the south-western segment of A2. The fence in combination with the retention of safe passages for the animals (e.g. tunnels, overpasses and underpasses) has substantially decreased collisions on highways. Nevertheless, there are still ongoing efforts to further mitigate wildlife - vehicle collision hotspots. LIFE projects are used to put pressure on authorities and road agencies, and also fund mitigation tools and monitoring actions (i.e. LIFE15 NAT/GR/001108 and LIFE17NAT/IT/000464). However, change in driver culture and behaviour is still crucial for tackling wildlife - vehicle collisions.

KEYWORDS: Brown bear, *Ursus arctos*, Roadkill, Wildlife-vehicle collisions

#9 Mitigation measures on Alqueva Irrigation Project canals

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Alqueva Irrigation Project is the largest in Portugal comprising 47 dams linked by 358 km of surface and underground canals and provide water for 120 000 ha of agricultural fields. This project is managed by a public limited company with an exclusively public share capital that belongs to the state corporate sector (EDIA, S.A.).

Irrigation is essential to support agricultural production in arid and semiarid regions, but the benefits from irrigation have environmental costs, particularly to wildlife. Canals are linear infrastructures identified as barriers, disrupting animal movements and as a trap, causing drowning occurrences.

Compared to older projects, canals from Alqueva Irrigation project have mitigation measures in order to reduce mortality and fragmentation, such as fences along the canal, under and overpasses, fauna passages and pipes in sensitive areas.

Canals represent 22% of the total length of water transportation infrastructures comprising 179 underpasses (2 underpasses / km) and 83 overpasses (1 overpass / km). Multiuse Underpasses or drainage culverts were constructed to maintain landscape hydraulic function and can be circular (pipe) or box shaped (0,8 – 1,8m diameter; 1,2 – 5 m width and 1,2 – 2 m high; 19 – 42 m long). Overpasses or bridges can be used for local traffic, linking in most cases rural roads and are also used for cattle movements (10 - 22 m long and 4 - 6,5m width) and working vehicles. Faunal over-passes (only in one segment) are exclusive for cattle and wild fauna (19 or 37m long and 1,5 or 2 m width), with no vehicles usage.

All the extension of the canals are double fenced, with a progressive mesh size for cattle, of 1,5 m high with one or two rows of spin wire on the top and overlapped a second fence 50 cm high and 50 cm underground with 5x2cm mesh size.

These infrastructures were constructed between 2007 and 2015, crossing agricultural landscapes with low population density. Human disturbance near the canals is very low, increasing with the proximity of roads and human settlements.

In order to assess mitigation measures results, EDIA implemented a monitoring program to answer some basic questions, progressively since 2007. The infrastructures were assessed seasonally for 5 days with different methodologies.

Mortality was assessed along the total length of the canals at a low speed with stop points to assess specific structures that could retain animals. Tracks were registered inside the fenced area.

To asses if over and underpasses were being used to cross the infrastructure, video record were made with infrared video cameras, along with tracks.

These linear infrastructures are underrepresented in science and technical reports related to mitigation measures evaluation are essential to understand different responses from several biological groups.

KEYWORDS: Canals, Irrigation, Mitigation measures, Barrier effect

#10 Measures to favour the pollinators in environmental restoration

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Effects on alteration and fragmentation of the habitats caused by road infrastructures are well known but at the same time can also be an opportunity to improve the conservation of the pollinators in certain conditions.

Open land –usually with wide flowering ranges- have been reduced and fragmented for the advance of the forestland, generally less suitable for the pollinators.

A suitable revegetation practices on road verges can be a useful tool to increase the habitat availability for pollinators. Moreover, road verges can also work as connectors for pollinator populations among different open land fragments.

The Ministry of Territory and Sustainability and CREAF have created a guide to favour pollinators and the creation of nest building substrata for the wild bees in the banks of the road infrastructures, with the following contents:

a.1) A list of appropriate species for every one of the 12 groups of habitats (plant formation), to attract the maximum diversity of pollinator species.

a.2) A layer GIS available for consultation for all public

a.3) A set of practices to ensure the availability of nest building substrata for wild bees.

The species included in these listings keep to the following selection criteria: own autochthonous taxa for each vegetal formation; high contents in nectar and/or pollen; generalist behave; a combination of flowering periods in order to guarantee an uninterruptible food source during the period of the pollinator activity, and a diversity of taxonomic plant families in order to attract an optimum diversity of pollinators.

Complementarily, a geodatabase that allows to obtain a list of plants with the categories "Optimum" or "Advisable". This consultation is both possible by habitat or group of habitats (plant formation). This GIS tool is public and available for consultation for the practitioners with the objective to be incorporated in the revegetation design of new projects.

To favour the substrata of nest building, the guide details measures to favour the nest building of bees: conditioning zones of naked ground slightly compacted, installation structures with wood pieces with holes of different sizes and a brief list of plants that provide stems of soft marrow that serve as substratum of nest building.

Looking ahead

This guide has generated two new work lines which are in progress. On the one hand, a pilot test consistent in the modification of the clearing maintenance patterns in the roads verges. The goal of the pilot test is to determine how the pollinator communities reply in front of the modification of the clearing schedule works in the road verges. This test will be done in a selection of forestry landscape areas.

A second line of work is a comparative study among the diversity of pollinators in road verges where the measures of guide have been implemented and control zones with absence of them. The study is carried out with the objective of monitoring the functionality of the tool and exploring future improvements.

To favour the substrata of nest building, the guide details measures to favour the nest building of bees: conditioning zones of naked ground slightly compacted, installation structures with wood pieces with holes of different sizes and a brief list of plants that provide stems of soft marrow that serve as substratum of nest building.

KEYWORDS: Verge management, Pollinators, GIS tools

#11 Monitoring fauna in the road environment

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In order to help road managers carrying out environmental assessments, monitoring techniques considered as particularly adapted and recommended for the road environment were gathered. This work was first done for two taxa: amphibians and mammals (except for chiropteras), as part of a study aimed at developing a handbook for road managers. This handbook will be designed in order to facilitate and validate the choices of monitoring techniques when assessing two main problematics: (i) is the infrastructure crossed by fauna, and/or (ii) how is the road right-of-way used as a habitat by fauna? These questions are the ones adressed by regulatory reviews preceding any road construction or rehabilitation. According to our searches, this work seems to be a pioneer one.

The techniques were gathered from litterature and interviews with environmental technical experts, and their advantages and drawbacks were discussed regarding the road context and problematics adressed (is the technique usable for a particular study?), as well as the road manager's constraints (costs, regulations, etc.).

The parameters considered for measuring the practicability of a technique were: length of the transect, time of day, ways of locomotion for the observaters, speed, number of observaters, persistence of roadkills on the road (scavengers and vehicles) and detection of roadkills. All these parameters are detailed in order to explicit how they are best suited depending on the situation and the goal of the study.

The parameters considered for taking the manager's constraints into account when using a technique were: financial investment, time investment on site, time investment in data processing, [French] authorizations and legal requirements (capture/marking), technique's intrusiveness for the individuals and practicability in a road right-of-way context.

Among the techniques gathered, two are considered as inherent to road environment and thus unavoidable when monitoring the presence of mammals or amphibians on roads: roadkill surveys and "krospection".

"Krospection" comes from the abbreviation of two words: "kronenbourg" and "prospection" and was mostly cited during interviews. This technique involves picking up every can and bottle found in the road environment in order to examine its content. Indeed, these items thrown away by road users are an ecological trap for a lot of small mammals. They think they just have found the perfect shelter and they end up being stuck in it. To examine a can's or a bottle's content allows to identify the bones of dead small mammals.

Besides these two techniques, others are considered as very adapted and recommended on the road and its green verges: pitfalls, thermal cameras, fluorescent powder, infrared beam and camera traps. Indeed, their implementation on the field comply with the parameters associated to the road (the linearity of the road, constant presence of vehicles, noise, vibration, etc.), making it a whole new environment to study aside of the classics ones.

KEYWORDS: Amphibians, Mammals, Monitoring, Road, Surveys

#12 Temporal patterns in animal-vehicle collisions based on neural networks and temporal density functions

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Animal-vehicle collisions (AVC) show relevant temporal variations linked to wildlife activity patterns: throughout the year, during the day, or even the phases of the moon. Thus, for example in Spain AVC with wild boar and deer are concentrated in the autumn, coinciding with the period of rutting and hunting. AVC with roe deer occurs especially in the spring and summer months, also coinciding with the bark and the dispersion of juveniles. In terms of daily patterns, most AVC tend to be concentrated at dusk and during the early hours of the night. Full moon is also an important factor. The study of these temporal patterns may be interesting to develop real-time warning systems on the risk of collision. The idea is to reduce the driver's habituation by focusing the warning only for those periods of time when a certain risk threshold is exceeded. We used neural networks (self-organizing maps) and temporal density functions to characterize the temporal patterns in the AVC occurrence in the hotspots of the Castile and Leon road network (northwest Spain). AVC reports from 2001 to 2018 were used in the study. 219 hotspots were analysed and ranked using KDE+ software. Different temporal patterns were identified depending on the species involved and the characteristics of the road. In most of the hotspots, more than 50% of the AVC were concentrated in 10% of the hours. The analysis of temporal concentration makes it possible to rank hotspots according to the relationship between the reduction of AVC and the hours that a variable road signs should be active in order to achieve such a reduction.

KEYWORDS: Temporal patterns, Animal-vehicle collision, Neural networks, Temporal density functions

CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY

#1 A comparison of state-wide databases related to bird roadkill in Czechia

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Collisions with motor vehicles rank among the leading sources of bird mortality influenced by human activity. Such collisions are only seldom traffic safety issues and therefore available roadkill data on this phenomenon are often opportunistic, sparse or biased. We compared four different data sources of avian road mortality which are currently available in Czechia: AVIF database, used primarily by bird-watchers; data provided by Czech Ringing Stations; data from animal rescue shelters and data from Srazenazver.cz – an application used predominantly by gamekeepers and police (traffic crashes with animals)

All data sources indicate similar temporal roadkill distribution, but they are considerably different in terms of species composition. Moreover, species composition varies compared to previous studies from Central European region. Sparrows (*Passer sp.*), which are reported to constitute more than 40% of all killed birds on roads in the Central European region, make up less than 8 % of reported birds in any of examined databases.

Some differences can be attributed to state-wide scale of examined databases (opposed to local scales of previously published papers), but we are of the opinion that the primary factor are different background and interest of respective database users. For example, the common pheasant (*Phasianus colchicus*) makes up 23% of bird species in Srazenazver.cz database, but only 2% in AVIF database, used mainly by bird-watchers. Owls and raptors, on the other hand, constitute 40% of birds reported to animal shelters (mostly by public), 13% of records in AVIF database (bird-watchers) and 8% of records in Srazenazver.cz database (gamekeepers/police).

Opportunistic biological data collected by public can be valuable source of information, but as demonstrated here, can also be non-representative or skewed due to varied interests and background of data collectors. Systematic monitoring of avian road mortality should be encouraged, however. We plan, in the further work, to use this primary data sources for estimation of the overall, and species-specific, bird mortality on Czech roads.

KEYWORDS: Birds, Road mortality, Citizen science, Database

#1 Risk-based Conservation Plan of fauna passages

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The region South Holland of the Dutch Road Agency has 100 big and small fauna passages, under and above the highways, which are constructed between 1996 and now. Each fauna passage consist of different fauna facilities like tunnels, walking boards, fences, stumps, etc

Besides a sustainable construction is a good maintenance essential for functionality of the fauna passages. So we developed a Risk-based Conservation Plan that describes the risk-based maintenance, which forms the input for our financial programming basis for the next 20 years.

In this conservation plan the annual and long term maintenance measures are defined in order to guarantee the functionality of all elements of a fauna passage, as well as the process that fits within the financial planning of our Road Agency.

The risk-based conservation plan has different components: a descriptive report, an object risk analyses table (ORA), a decomposition software (Ultimo) and a geographic information system software (SIG).

The Report describes the fauna passages, it's ecological functions, the objects in the surroundings which may affect the maintenance, the decomposition of the fauna passages in elements and in building components (fauna facilities like fences), overview of earlier annual inspections, desired management/ maintenance and costs estimation.

The Object Risk Analyses (ORA) allows us to optimize management and maintenance concerning the quality, costs and risks. The ORA's are Excel tables per object (with the associated elements and building components) and contains the following sub sessions: initial risk analysis, maintenance strategy/tasks, current risk and desired risk.

"Ultimo" software is based on the ORA's information. "Ultimo" is our maintenance management system for all assets (asphalt, lampposts, bridges, fauna passages, etc) of the Dutch highways. All activities in the area, such as inspections, measurements and repairs are record and managed in "Ultimo". The users of this software are simultaneously the road agency and the contractors.

The SIG software contains all geographic information from all the building components of the fauna passage, besides information of the highways.

In de coming years is the Dutch Ministry of Infrastructures investing more in sustainable and efficient maintenance. The development of this conservation plan is seen as a pilot for the rest of the Dutch regions that soon also will implement it. In these way is the exchange from individuals within populations assured in the future.

KEYWORDS: Risk-based Conservation Plan of fauna passages

#2 The Impact on Bats of Traffic Infrastructure: Eurobats Guidance

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Bats are relatively long-lived animals but with low fecundity thus populations cannot quickly recover from losses. They are vulnerable to disturbance, damage and loss of roosting sites and habitat, and intentional or incidental killing. Hence they have protected status in all European countries.

The EUROBATS Agreement was set up under The Convention on the Conservation of Migratory Species of Wild Animals, 1979. It aims to protect all European bat species through legislation, education, conservation measures and international co-operation. An EUROBATS Intersessional Working Group (IWG) on the Impact of Roads and other Traffic Infrastructures on Bats was established recognising the potential for transport projects to impact on bat populations. The IWG was requested to publish guidance highlighting the effects on bats and on minimising its impact. Resolution 7.9 (2014) urges Parties (signatories to the Agreement) and non-party Range States to:

Take bats into account during the planning, construction and operation of roads and other infrastructure projects;

Ensure that pre-construction strategic and environmental impacts assessment procedures and post-construction monitoring are undertaken and recommend that the data collected are made available for independent scientific analysis;

Promote further research into the impact of new and existing roads and other infrastructure on bats and into the effectiveness of mitigation measures;

Develop appropriate national or supranational guidelines, drawing on the general guidance to be published by the Advisory Committee.

Members and Range States were asked if guidance had been produced in their country, what research had been conducted and which practices were followed to take bats into account in the planning, construction and operation of transport infrastructure projects.

Most bat species resident in the Eurobats area were recorded as casualties from at least one form of operational transport (road, rail and air). Short-range echolocating bat species were more likely to be affected than mid- or long-range echolocators by road and rail traffic collisions, though noctules were the main casualties in some studies. The guidance also considers the impact of habitat loss and fragmentation on bats, and the challenge of minimising mortality whilst maintaining or enhancing landscape-scale permeability.

It is essential when planning infrastructure projects to understand the bat species present in the area in order to design the scheme to avoid wherever possible, mitigate or compensate for impacts on species with different ecological requirements.

Appropriate survey and monitoring of mitigation measures must be considered in the early planning stages and should complement each other by providing robust data assessing impacts. The guidance distinguishes between "use" and "effectiveness" of mitigation and recommends setting targets for effectiveness, e.g. for 90% of bats crossing safely (not in the collision risk zone). The guidance recommends the use of green bridges, open-span bridges, viaducts, tunnels and culverts as effective mitigation. Other measures may be effective in some circumstances, or in combination, though wire gantries (bat bridges) are not recommended. Effective mitigation is appropriate to the species at risk, located along known flight lines and connects to other bat habitat.

KEYWORDS: Bats, Transport infrastructure, Barrier effect, Collision, Mitigation measures

Part 5:

Workshops

SESSION 2.1.1

A Review of Wildlife-Vehicle Conflict Observation Systems

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Globally, wildlife-vehicle conflict (WVC) damages vehicles and can prove fatal to drivers, fragments wildlife populations (due to road/traffic-aversion), kills and injures individual animals, can cause wildlife population declines, and may eventually contribute to local or total extinction of certain species. Preventing WVC begins with recording locations of conflict, such as vehicle crashes, animal carcasses (roadkill), or animal behavior around roads, such as avoidance of roads or crossing-behavior. These data are ideally used to inform transportation policy and planning and to retrofit roadways and their structures to reduce WVC. We collectively manage eight regional and/or national systems for reporting WVC in collaboration with volunteers. In this review, we survey systems for recording WVC by volunteers and agency staff on different geographical levels, based on existing literature and our personal experience. We report the range of data collection methods, data management systems and data visualizations employed as well as discuss the groups and type of volunteers and agencies involved. We use our expertise and the global survey to provide methodological specifications based on current best-practice for collecting and using WVC data to inform transportation and conservation decisions. We conclude with a vision of next steps toward a global network of WVC reporting systems.

Whether this session presents a novel introduction to practices you seek to apply in your field or allows for an expansion of your established niche within transportation ecology, practitioners of all levels of expertise can benefit from this session. Instructors will cover a range of topics, providing case studies from their respective countries and a summary of data collection practices and processes. Spanning these areas, the presenters will emphasize the partnering and engagement with relevant stakeholders, which can help with the development of both the science and successful practice.

The aim of this workshop is to provide an overview of current practices and approaches in WVC data collection and reporting in the context of both assessing impacts of roads on animals and people for conflict mitigation, and as a method for tracking wildlife population dynamics and distribution We use this review of global systems and practices as the basis for recommended specifications for volunteer and agency data collection and reporting of WVC data. We present several of the largest and longest running WVC data collection programs in the world and from that position, offer perspectives on the current and future directions of opportunities for WVC data collection development.

Each of the listed authors will give a brief presentation of WVC data methodology collection from their respective countries, outlining successes as well as challenges.

Based on these principles, we have developed a series of recommendations that can be used to design a WVC reporting system at a regional or national scale. We do not attempt to anticipate all the nuances that a reporting system will face during development, but we believe that the practices recommended will facilitate deployment of a successful system. We also recognize that WVC reporting is only a fragment of the total picture of understanding this type of conflict.

We anticipate that the rapid changes in the fields of environmental observations, web-informatics and the increasing use of artificial intelligence in biology may date aspects of our study. However, there has been little change to the basic rules in the last decade, and we expect the majority of our general observations and recommendations to remain relevant for the foreseeable future.

The outcomes of this session are intended to provide a suite of practical measures and tools for both new and current experts in the linear infrastructure field that participants can apply in their local systems.

KEYWORDS: Citizen science, Data collection, Volunteer, Wildlife-vehicle conflict, Wildlife vehicle collision

SESSION 2.1.2

Mitigating Railway impacts on wildlife

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Railways will play a key role in future transport systems. Many countries have and will continue to invest in expanding the railway network and upgrading existing infrastructure to cope with the growing demands in speed and efficacy, in order to provide a mode of transport that is competitive with air, sea and road travel. Although railway systems provide many environmental and economic benefits (i.e. fewer carbon emissions, lower cost for operations etc.), they can entail a variety of impacts on the physical environment, ecosystems and biodiversity. These impacts are not yet well understood, rarely considered during planning and operation, let alone mitigated.

It is assumed that knowledge from road infrastructure can be applied to railway systems as well, but this may only be partly true, especially in the case of high-speed rails. Thus, we crave solutions that address the specific challenges of railway systems. For example, similar to roads, railways make a physical imprint on the landscape, and modify its hydrological and topographical properties. Where fenced, railways, especially high-speed lines, impose significant movement barriers for wildlife. On the other hand, unfenced railways can be highly lethal for wildlife as the relative long intervals between trains can be deceiving, especially when trains approach quickly and quietly. Animal mortality on railways due to collisions with trains and electrocution appears to be strongly underestimated and may easily exceed road mortality per kilometre infrastructure. Collisions with larger wildlife are less hazardous to passengers than collisions on roads, but can cause costly material damages and significant delays in railway traffic. Unlike roads, vibrations and noise from passing trains are very intensive and sudden, with less chance for habitation but also less chronic effect. Finally, many of existing conventional railway infrastructure with its side-areas can provide valuable and relatively undisturbed habitat for small fauna and flora. Thus, although many of the impacts are thought to be shared between roads and railways, we require new or adjusted ways of mitigation in order to achieve ecologically adapted railway systems.

Most of the research and development needed for this endeavour will benefit from cross-country and inter-corporal collaboration. To foster this, we propose a new railway workshop to be held during the IENE 2020 conference. With this workshop, we seek to establish a working platform for cooperation and exchange between stakeholders and experts in questions related to railways, wildlife and biodiversity. Special focus will be given to High Speed Railways and to results from mitigation and monitoring projects conducted in different countries. We intend to identify several points of interest where collaboration can be initiated across countries.

The workshop especially addresses stakeholders from railway agencies, governmental bodies and companies dealing with railway systems, as well as experts in wildlife ecology with experience or interest in railway impacts and solutions.

The workshop will be organized as follows:

1. Lightning talks (8-10 talks, 3 min each) by invited participants from e.g., ADIF Spain, RURALIS Norway, SLU Sweden, ÖBB Austria, EWT South Africa, WII India, UFRGS Brazil. The participants are asked to present their respective challenges, experiences and activities.

2. Group discussions (30 min) on selected topics including mortality, habitat, mitigation and monitoring, with proposals for future collaboration in research and development.

3. Round table discussion (ca 30 min) on how to proceed jointly towards concrete collaboration projects.

With this workshop, we intend to provide output such as:

- List of urgent questions / challenges that require new research

- Proposal of topics that can be addressed in multinational joint projects

- First steps towards a road-map for the IENE WG on Railway Ecology

KEYWORDS: Rail ecology, Train-animal collisions, Rail habitat, Railway mitigation, High speed railway

SESSION 2.1.3

Advancing the Role of NGOs to Promote Wildlife-friendly Infrastructure

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Linear transport infrastructure - roads, railways, and canals - is a major cause of fragmentation and biodiversity loss around the world. A growing number of individuals and institutions have been collaborating informally, albeit not always in a coordinated manner, to provide solutions that can reverse this trend. Non-governmental organizations (NGOs) in particular, can play a significant role in addressing the social, economic, cultural, and environmental effects of transport infrastructure. Acknowledging ongoing efforts, such as the nascent International Strategy for Sustainable Transport and Other Linear Infrastructure, both within and outside of IENE, a coalition of NGOs can reinforce and complement these initiatives.

NGOs play a crucial role that governments, academia and the private sector often cannot. Using their expertise in grassroots organizing, fundraising, advocacy, media engagement, and other outreach approaches, NGOs can inform decision-making, advocate for change, and push for transparency and accountability. Building on these strengths, this workshop provides a platform for NGOs and other stakeholders to align their efforts. Discussions will focus on how collaboration can enhance and accelerate efforts to advance proactive policies, appropriate legal frameworks, better planning, and innovative science-based solutions to reduce the adverse impacts of infrastructure on ecosystems and society.

This workshop will include presentations from various NGOs on their work to address infrastructure impacts to date followed by a panel discussion where NGOs, government representatives and members of the audience will discuss the challenges and opportunities for strengthening the role of NGOs in advocating for wildlife-friendly infrastructure initiatives, policies and practices. Co-facilitators and presenters will lead a conversation that elaborates on the need for a more coordinated NGO community. Government and academic partners will also provide their perspectives on the roles that NGOs can play. Workshop participants will discuss opportunities for engagement, priorities for action, and desired outcomes that can inspire the creation of a global network of NGOs for smart green infrastructure.

Anticipated workshop agenda (90 minutes total):

NGO Presentations: 30 minutes

- Kate Newman & Nilanga Jayasinghe (World Wildlife Fund-US)

- Wendy Collinson (Endangered Wildlife Trust; South Africa)
- Rob Ament (Center for Large Landscape Conservation; Montana, USA)

Speaker Panel and Audience Q&A: 30 minutes

- *NGOs*: Kate Newman, Nilanga Jayasinghe, Wendy Collinson, and Rob Ament
- *Government*: Yannick Autret (French Ministry of Environnment, Sustainable Development and Energy)
- Ján Kadlečík (State Nature Conservancy of the Slovak Republic)
- One representative from an academic institution: TBD

Facilitated Breakout Group Discussion: 15 minutes

Full Group Discussion: opportunities for engagement, priorities for action: 15 minutes

KEYWORDS: Network, Collaboration, Partnership, Non-governmental organizations

SESSION 2.2.1

Development of an Indicative European Defragmentation Map (IEDeM) as a contribution to preserving existing national and internationally important Green Infrastructure while transport infrastructure improvements are delivered within Europe

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Biodiversity, as a fundamental basis for life and human well-being, remains under serious threat across Europe and worldwide. Main reasons for this pressure on animal and plant species are the destruction, isolation and fragmentation of their habitats. Climate change has added a new dimension to this threat as functional habitat networks are essential for adaptation to secure enhanced habitat dynamics. So increased landscape connectivity for populating and re-populating habitats is an urgent requirement for genetic exchange between populations.

Many member states of the European Union have already put in place national schemes for ecological networks to (re-)connect fragmented habitats.

In combining these concepts, a central European network emerges as an important part of the European Green Infrastructure (GI) programme. With the Pan European Ecological Network (PEEN), efforts had already been made to visualise ecological coherence for biodiversity conservation throughout Europe, even if these PEEN-Maps (2002/2006) were not detailed enough to estimate the impacts which can be expected of such as linear infrastructure plans at EU level in Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA).

A new attempt to compile the existing and planned networks of the different European countries started in 2015, initiated from the German Federal Nature Conservation Agency (BfN), scientifically prepared and so far supported by the University of Kassel and with contributions from IENE. By now, these initiative have led to three working phases, in which an initial draft of an Indicative European Defragmentation Map (IEDeM) has been created. At the IENE international conference in Eindhoven in 2018, the current status of the work was presented.

Until now, the map provides an overview of a considerable part of Europe's Green Infrastructure: The ecological core areas and the connecting ecological corridors within and among 15 member states. These national and transnational important parts represent a substantial core component of the Europe-wide GI network. Every concept is unique, based on different ecological data. Nonetheless the concepts represent an important framework of biodiversity conservation at national level and even further afield.

In the past, member states made big efforts to avoid fragmentation and habitat destruction caused by linear infrastructure projects.

For example, many countries implemented preventative mitigation and compensatory measures including passages above and under motorways and railways. Wildlife crossings, as man-made measures, are an additional component of Green Infrastructure and are shown on the map as far as data were available. Moreover, several transnational cooperation and projects combine national initiatives to maintain valuable nature throughout Europe.

The intention of the workshop is to improve and supplement the Indicative European Defragmentation Map further. We'd like to increase the extent of integrated national networks, analyze the information available and identify – with the support and expertise of the workshop participants –critical/endangered areas and parts that need to be developed.

By compiling the networks and proposals for defragmentation measures in the new developed map, a rough assessment of fragmentation due to the existing and planned Trans-European Transport Network (TEN-T) is possible where detailed country-specific concepts are available.

An important step for the IEDeM was the recognition by the European Environmental Agency of the potential Green Infrastructure (Estreguil et al. 2019) as a dynamic and resilient network capable of delivering ecosystem services core habitats and corridors within the EU territory.

The IEDeM as a further step and extension could be used, because these map integrate existing and potential national networks as a summary of different types of ecosystems (woodlands, wetlands, dry and open habitat) interlinked by corridors. Although the approaches differ, the country-specific networks cover a wide range of ecosystems and thus comprehensive biodiversity conservation activities.

The newly commissioned staff working document "Guidance on a strategic framework for further supporting the deployment of EU-level green and blue infrastructure", published by The European Commission (2019), underlines the importance of EU-level green and blue infrastructure and encourages the scaling-up of funding at EU-level to assure that it reaches its full potential.

The targets of the proposed workshop are:

1. Find more partners and contributors with relevant information and interest for the IEDeM,

2. Develop new ideas to strengthen transnational links and identify bottlenecks between the habitat networks of neighbouring countries,

3. Discuss possibilities and obstacles of mitigating impacts of linear infrastructure development within Europe,

4. Both provide and obtain references to point out national and international critical points for defragmentation/mitigation measures,

5. Collect and share ideas for international cooperation with regard to projects at EU level.

The workshop (90 min) will be structured and timed as followed:

A. Presentation Part (beamer projected) – 15-20 min

- Current state of the Indicative European Defragmentation Map (IEDeM)
- Participating/involved countries
- Map Contents (national data characteristics)
- Data Analyses (bottlenecks, transnational links and gaps, endangered parts of the networks e.g. intersections with TEN-T)
- Potentials and Perspectives (map subjects, need of action, cooperation opportunities)

B. Discussion part (round table) – 65-70 min

The discussion part will be organized as a round table meeting. Main discussion points are the contents of a questionnaire, which will be distributed to the expected participants in the run-up to the conference. As such, all existing and future supporting partners and supporters should be invited.

The focus of this meeting should be on:

- Hints and advice to the map contents from country representatives (e. g. National GI characteristics, re-linking programmes and measures)
- Potentials and future use of the map with regard to relinking measures
- Identification of priority areas for relinking habitat corridors at national and European level
- State and perspectives of international cooperation (research, options and restrictions of international measure consultations, supranational funding and financing options in research, planning and implementation of measures)

The results of this workshop will be integrated in an elaborate report (English), which is already in process of compilation by Kassel University. Moreover, an article publication is planned.

KEYWORDS: Habitat Networks, Green Infrastructure, Impact Mitigation, The Trans-European Transport Network expansion, Indicative European Defragmentation Map

SESSION 2.2.2

Helping tigers, rhinos, and elephants cross the road: wildlife friendly infrastructure measures in Asia

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According to projections, 75% of the infrastructure in 2050 is yet to be built. Ambitious infrastructure plans in place to connect countries and markets pose enormous threats to the places and species we need to protect. This is especially the case in Asia, where tigers, elephants, snow leopards and numerous other species and landscapes are at increased risk from existing and planned linear infrastructure. As countries develop and expand their infrastructure networks, there is a critical need for ecology to be a central part of the planning and design in order to ensure that while we connect countries, cities and towns, we keep landscapes connected and protected to support the movement of wildlife and functioning ecosystems. More countries in Asia are starting to incorporate biodiversity into infrastructure planning and putting in place mitigation measures to accommodate wildlife. There are now examples of these measures from India, Bhutan, Nepal, Taiwan, China, Thailand, Malaysia and beyond. However, there is a need to increase knowledge sharing in the region and beyond and to ensure that planning and design accommodate species and landscapes unique to Asia.

A number of countries in Asia are starting to implement measures to reduce infrastructure-related wildlife mortality, improve connectivity, and further wildlife friendly, sustainable infrastructure planning. Until now, there has been limited dissemination of Asian experiences within and outside the continent, and the goal of this workshop is to enable presentation of examples and lessons learned from Asian countries.

The workshop will be structured around presentations by representatives from Thailand, Nepal, Myanmar, India, and Mongolia that will encompass case studies relevant to their countries, where various mitigation measures have been implemented and monitoring is now beginning to demonstrate the results and effectiveness of these efforts.

The following presentations/topics are planned:

The presenter from Thailand's Department of Highways will speak about the viaduct and overpass along highway 304 in Thailand that bisects Dong Phayayen-Khao Yai forest complex, a UNESCO World Natural Heritage Site since 2005, and of which sections were opened only in 2018. To offset the potentially negative ecological impacts of the road expansion, it was designed with a mix of underpasses and two flyovers. Incorporating wildlife crossings has been a central feature of the design and the objective has been to re-establish connectivity - this road has been a barrier to wildlife crossing for some time as, for instance, analyses have confirmed less genetic diversity in bear populations.

The presenter from WWF-Nepal will provide an overview of the wildlife crossings along the Narayanghat-Mugling Road Section in the Barandabhar Forest Corridor in southern Nepal, which connects Chitwan National Park in the south to Annapurna Conservation Area in the north. To reduce the vehicle accidents involving wildlife, and to ensure the safety of both humans and wildlife, the Nepal Department of Roads has introduced Nepal’s first underpasses along BCF. WWF has supported the government and carried out the first monitoring studies of these crossings and these results along with ideas for how to improve effectiveness

Presenters from Mongolia will elaborate a number of efforts being implemented to enable the safe and uninterrupted migration of ungulates unique to the Mongolian steppes. In order to prevent and reduce the potential impacts on the migrations from infrastructure, the Ministry of Environment and Green Development and the Ministry of Road and Transportation established a joint working group to improve the legal framework, standards, and guidelines to mitigate impacts from the road sector to the wildlife habitat and migration. Following development and advocacy, standards for enabling connectivity for ungulates as it relates to rail and highways in the steppe and Gobi region of Mongolia and standards for Wildlife Crossings in Roads and Roadway Facilities in Mountainous Areas were approved in Mongolia The ultimate goal of the wildlife crossing standard is to protect endangered and rare species such as the Mongolian saiga, wild ass, black-tailed gazelle, Mongolian gazelle, Argali sheep, Siberian ibex, and snow leopard from habitat fragmentation and extinction through building 3 types of wildlife passages. In order to promote enforcement of standards, key stakeholders such as WWF have begun monitoring key crossing areas and conducting remote sensing surveys of wildlife movements and migrations at the regional level to form the basis for building adequate wildlife crossings.

In India, WWF India worked with the Assam Forest Department and the National Highways Authority of India (NHAI) in 2011 to propose mitigation structures along National Highway 54E (NH54E), passing through Lumding Elephant Reserve in Kaziranga Karbi Anglong complex that are part of the larger Brahmaputra Landscape. The presenters will provide an overview of the detailed mitigation report that was prepared by civil engineers engaged by WWF India, with inputs from NHAI. Suggested mitigation structures were included by NHAI at a later date, and the expanded highway became fully functional towards early 2019, along with the mitigation structures. WWF India began monitoring the highway and use of the mitigation structures by large mammals like elephants. Studies showed that elephants are using both the accessible areas along the highway and the animal underpasses built as mitigation structures. Presenters will elaborate on the functionality of the crossings and discuss the process for having them implemented along the road.

The presenter from Myanmar’s Ministry of Construction and presenter from Thailand’s NEDA will co-present on the Dawei road in Myanmar, which cuts across an important ecological corridor connecting forests in Myanmar and Thailand that is home to tigers, elephants, and other key wildlife species. This road is currently being planned and designed and a number of wildlife crossings – the first in Myanmar – are being planned.

This may be a best practice project that can help inspire and make infrastructure development more ecologically sustainable in Myanmar and beyond.

Following these presentations, each allotted for 10-15 minutes, a moderator will facilitate a panel discussion on the future of sustainable infrastructure development in Asia, including opportunities and challenges. The discussion will also explore what more is needed for these countries to push for inclusion of biodiversity considerations into infrastructure development plans. The moderated panel session will include a question and answer session for broader participants, with an opportunity for feedback, suggestions, and guidance from lessons learned in wildlife friendly infrastructure from Europe, etc.

Findings and outcomes from the session will be captured in a brief document and shared with workshop participants and used to inform more events that will support further networking and knowledge sharing across Asia.

The target group for this workshop will be attendees from across Europe and North America, who may have interest in learning about wildlife friendly infrastructure efforts in Asia and engaging in discussions that would further provoke thought and provide recommendations to the group.

Presentation format:

PRESENTER	COUNTRY	PRESENTATION TOPICS / TENTATIVE TITLE OF TALK	DURATION
Kate Newman – WWF	USA	Introduction by the session moderator	5 mins
Speaker from the Thai Department of Highways	Thailand	Mitigation measures along sections of Highway 304 that bisect Dong Phayayen-Khao Yai Forest Complex in Thailand	10 mins
Speakers from Nepal Department of Roads/WWF-Nepal	Nepal	Overview of wildlife crossings along the Narayanghat-Mugling Road in the Barandabhar Forest Corridor in southern Nepal, which connects Chitwan National Park in the south to Annapurna Conservation Area in the north	10 mins
Speaker from Mongolia's Ministry of Road and Transportation	Mongolia	Efforts to enable safe migration of ungulates in the Mongolian Steppes	10 mins

PRESENTER	COUNTRY	PRESENTATION TOPICS / TENTATIVE TITLE OF TALK	DURATION
Speaker from WWF-India	India	Mitigation measures along National Highway 54E passing through Lumding Elephant Reserve in Kaziranga Karbi Anglong complex that are part of the larger Brahmaputra Landscape	10 mins
Speakers from Myanmar's Ministry of Construction and presenter from Thailand's NEDA	Myanmar/ Thailand	Presentation on the Dawei road in Myanmar, which cuts across an important ecological corridor connecting forests in Myanmar and Thailand that is home to tigers, elephants, and other key wildlife specie	10 mins
Moderated by Kate Newman, WWF	Various	Panel session with presenters, including questions and answers from presentations - discussion on the future of sustainable infrastructure development in Asia, including opportunities and challenges. The discussion will also explore what more is needed for these countries to push for inclusion of biodiversity considerations into infrastructure development plans	25 mins
Moderated by Kate Newman, WWF	Various	Wrap up and next steps	10 mins

KEYWORDS: Road ecology, Sustainable infrastructure, Asia, Tiger, Elephant

Wildlife and Traffic Handbook Update: towards European standards for fauna passages and fencing

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Evidence-based guidelines for measures to reduce the impacts of transportation on wildlife are crucial to enhance the application of effective mitigation. Standards are required by practitioners involved in infrastructure development and maintenance, and other stakeholders dealing with ecology and transportation to ensure the quality and suitability of the mitigation measures that are implemented. Fauna passages and fencing are one of the most widely used measures to prevent animal-vehicle collisions and reduce habitat fragmentation due to transportation infrastructure. The first standards on these topics were established in 2003 in 'Wildlife and Traffic. A European handbook for identifying conflicts and designing solutions'. This was the main output of the COST341 Action promoted by IENE (Infrastructure and Ecology Network Europe) that involved experts from around twenty participating countries. The standards were the result of consensus and expert criteria based on compiling and analysing all published literature and unpublished reports, previously checked for quality. The handbook was translated into many languages and has been adapted by various countries. It has supported the implementation of mitigation measures in European transportation networks.

At present, the handbook is being updated by an IENE working team in cooperation with the Conference of the European Directors of Roads (CEDR) to include the extensive knowledge generated by monitoring and evaluation projects and new research providing useful information to design mitigation measures. Guidelines are now presented in an online handbook that provides easy access to the document and opens up opportunities for user cooperation in further improvement of the standards.

The section on mitigation measures, particularly fauna passages and fencing, is the first topic to be updated. A task force including teams working on new handbooks and standards in France and Switzerland and at European level (by CEDR) is contributing knowledge to the development of the new handbooks. The working group has compiled and compared standards provided in national and regional handbooks together with evidence from the scientific and technical literature, and innovative technologies.

The 'Handbook of Road Ecology' has been a complementary reference in the review. Some of the topics of interest are:

- Fauna passages: typologies (11 basic categories), dimensions, landscape of the structure, integration into the surrounding landscape, distances between structures, etc.

- Fencing: dimensions and shape of meshes, materials, reinforcement of existing fences, etc.

Standards need to be adapted to habitats and landscape context and to target species. The Wildlife & Traffic handbook focused on the diversity of life forms, providing indications on wildlife passages for more than 20 taxa from invertebrates to large carnivores. Moreover, new information is being added about features to increase the effectiveness for target species, based on knowledge gathered in recent years. It is challenging to agree on a basis for European standards for fauna passages and fencing, considering the diverse nature of European biodiversity. Nevertheless, an improvement in efficiency in terms of reducing costs and uncertainties about the measures' effectiveness is encouraging international cooperative action.

Within this framework, the workshop aims to present the results of compiling and evaluating the information and proposals for new updated standards on fauna passages and fencing to be included in the online 'Wildlife and Traffic Handbook'. The objective is also to obtain information and expert opinions and criteria from the audience, to enhance the proposal.

The workshop is aimed at researchers and practitioners from transportation and biodiversity administrations, researchers, and engineering and consultant companies interested in the production or application of standards for wildlife mitigation measures. Professionals dealing with wildlife crossings and fencing topics are a particular target of the workshop. Co-authors and other professionals involved in the working team for the 'Wildlife and Traffic' update will also be invited to participate.

The workshop will be divided into three parts:

1.) General presentation about the goals and the organisation of the meeting. Short talks will be given on each standard to be discussed: standards provided in the original 'Wildlife and Traffic' handbook, a comparison with other published standards and proposals for the update. Duration:20 minutes

2.) The audience will be divided into thematic groups to discuss the proposals and identify new information or topics to be addressed. Duration: 40 minutes

3.) Leaders of the thematic groups will present the results to the audiencethen a discussion will be held and final recommendations will be made. Duration: 30 minutes

The output of the workshop will contribute to updating the standards, identifying new sources of information and testing the degree of consensus between experts regarding the proposed standards. Gaps and conflict points will be identified. Participation in the workshop is expected to enhance the audience's future cooperation in the handbook update and particularly in the review of any new standards that are produced.

The work is supported by Swedish Transport Administration, CEDR's 2013 Transnational Research on "Road and Wildlife", Federal Road Office (Switzerland) and Ministry for an Ecological and Solidary Transition (France).

KEYWORDS: Road ecology, Guidelines, Mitigation measures, Fauna passages, Fencing

SESSION 2.3.2

Infrastructure, Biodiversity and Health

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Man-made infrastructure, and more specifically transportation infrastructure, especially roads, is undergoing unprecedented development with high environmental impacts. By 2040, the G20 estimates that nearly $79 to $95 trillion will be invested in roads and that by 2050, the road network will create more than 25 million km of new networks, mostly in virgin or low-density areas of developing countries.

This development increases the risk of new human disease emergence (not to mention wild animal to domestic animal transmission). Many factors contribute to this: demographic (for example, population growth, especially in urban areas), economic, such as, increased and accelerated national and international trade, and political factors, which are themselves reinforced by the effects of climate change. Infrastructure plays a major role via:

1. The dissemination of these zoonosis via the movement of reservoir hosts, intermediate hosts or human populations (e.g. human-to-human transmission), and their transformation into epidemics or pandemics via the movement of humans, domestic animals (included domestic pets and livestock), or the movement of alien and invasive species that are reservoirs of zoonotic agents (e.g. rodents, wild meat, and illegal wildlife trade).

2. Bringing human populations into contact with zoonotic reservoirs. Generally, infrastructure will lead to further degradation of ecosystems (see work of Laurance et al.). Disturbed trophic interactions disrupted by landscape fragmentation, reduced functional connectivity and other changes to the ecosystems make them less resilient to diseases and more likely to transmit pathogens to humans.

3. The incursion of new human groups (e.g. members from sectors such as of mining andagricultural, as well as legal and illegal hunting and trade, nature-based tourism etc.) are likely to be the cause of interspecies transmission, or create the spread of new diseases to local populations.

The more connected a region is, in terms of the amount of infrastructure and the number of movements, either over long- , such as air or sea, and short-distances, such as roads or waterways, the more likely it is to play a role in the spread of emerging pathogens with epidemic or pandemic potential and itself be the target of an outbreak.

Furthermore, infrastructure may facilitate dispersal, and/or displacement of particularly generalist species (i.e. zoonotic reservoirs), to habitats proximal to human populations. In short, positive relationship of increased zoonoses and species abundance (i.e. mammal), are often more adapted to human landscapes. Increased understanding of spread, improvement or establishment of transport networks can play a recognised facilitating and accelerating role for an integrated risk framework for transportation.

RESEARCH NEEDS:

1) The Environmental Impact Assessment Process

Although the process of zoonotic disease spreading and its human and economic consequences have been more studied in the wake of the COVID-19 , research on prevention is very deficient and, therefore, justifies the importance of developing more widely the socio-eco-epidemiological approaches (a OneHEalth approach) (Benchimol and Silva 2008, His CienSaude-Manguinhos).

Human health and its relationship with new infrastructure development, is often absent during the design and planning stage, resulting in inadequate Environmental Impact Assessments (EIA). A quick analysis of the publications of the International Association for Environmental Assessment (IAIA) and of the World Bank documents shows how much this field remains almost unexplored.

2) Disease regulation and adaptation challenges of transport sector

Analysis of local challenges and risks related to infectious diseases and their spread, demonstrate the unfeasibility of risk-reduction in areas where it is impossible to control intra-and inter disease transmission. For example, in the Democratic Republic of Congo, the spread of Ebola accelerated from one week in 2008 to eight hours in 2019. It is therefore necessary to think beyond a state-centered approach and integrate the paradigm of an increasingly rapidly interconnected world, with the socio-political consequences that this entails.

Multiplication of emerging infrastructure, and their cumulative effects, poses a real and immediate risk with one example being the Belt and Road Initative. It requires the integration of a dynamic approach to health risks for the environment, through not only their reduction, but the development of a global strategic analysis outlining responsible and sustainable infrastructure, that consider environmental, and thus, human health. This process should include the entire chain of actors, as defined at the COP 14 (Convention on Biological Diversity, 2020), whose reflections will continue at the next International Union for Conservation of Nature Congress and COP 15 in 2021 [?]. It requires the coordination of other transport actors that are often not considered within biodiversity and health fora, such as roads, railway or air Transport.

The present workshop will have a duration of 90 minutes. It will start with a 10-min introduction by Fraser Shilling (University of California, USA), two or three guests' interventions (15 min each) and a final discussion and workshop summary by Wendy Collinson (Endangered Wildlife Trust, South Africa) and Fraser Shilling.

KEYWORDS: Zoonosis, Disease spread, Health risk, Human health, Zoonoses

SESSION 2.3.4

Corridors and Crossings: "Guidance for Connectivity Conservation Impacted by Linear Transportation"

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Linear infrastructure is increasingly a threat to ecological connectivity and biodiversity conservation. It is projected that an additional 25 million kilometres (km) of road lanes and over 300,000 km of railway track will be built by 2050; with 90% to be constructed in developing countries. Over the last 30 years, many countries have experimented with, and studied various measures designed to minimize the impacts to ecological connectivity and wildlife mortality caused by linear transportation infrastructure—roads, railways, and canals. With the rapid expansion of transport systems across the globe, the Transport Working Group was formed under the auspices of the International Union for the Conservation of Nature (IUCN), specifically under its World Commission of Protected Areas (WCPA's) Connectivity Conservation Specialist Group. The Transport Working Group has been developing a WCPA technical report titled, *Guidance for Connectivity Conservation Impacted by Linear Transportation*.

This *Guidance* has been written by practitioners around the world and provides an introductory level document that is applicable in all social, economic, cultural, and environmental contexts, and particularly seeks to be helpful for those regions experiencing rapid infrastructure development. The Transport Working Group will lead a presentation of the *Guidance* and how it contributes to increasing awareness on existing solutions that reduce habitat fragmentation and wildlife mortality and enhance the interconnectedness of protected areas. This workshop will present an overview of the 12 chapters of the *Guidance* and discuss practical applications, with the aim of increasing awareness and providing tools for biodiversity sensitive planning, construction, operation, and maintenance of linear transportation infrastructure.

Experts from NGOs, academic institutions, and government will discuss a multi-pronged approach that incorporates policy, research, technology, and public involvement resulting in more sustainable linear transportation projects. The workshop is directed toward inspiring decisions that implement best-practices when planning, constructing and maintaining linear transportation infrastructure. The workshop's focus will be on demonstrating solutions that are available to: a) increase the number, quality, and rate of ecologically-friendly transport projects; b) decrease the deleterious impacts to wildlife movement and mortality; and 3) increase transportation safety by establishing principles for mitigating animal-vehicle collisions.

Participants will hear first-hand from core authors and partners about the process of creating the guidelines from conception to publication. They will be introduced to the numerous examples of linear infrastructure impacts and mitigation worldwide and learn how to apply the guidelines toward specific challenges in their own countries and jurisdictions. They will also receive a briefing about new and upcoming opportunities to increase the quality and rate of exchange of information, and build greater capacity from local to international levels.

As the world embarks on the United Nations' Decade for Ecosystem Restoration and creates the post-2020 Global Biodiversity Framework, addressing the impacts of linear infrastructure development on ecological connectivity will play a vital role to boost the achievement of conservation targets. The session will highlight the use of the *Guidance* as an important tool in efforts to arrest the fragmentation of nature. Overall, it will demonstrate how wildlife-friendly transportation infrastructure, as a critical element of connectivity conservation, serves to increase resiliency and contributes to the Post-2020 Global Biodiversity Framework.

The design and format of the workshop is as follows (90 min total):

1. Welcome and introductions: Threats and solutions - Linear transportation infrastructure and ecological connectivity (Rob Ament, CLLC) 7 minutes

2. Presentation: A tour of the IUCN's "Guidance for Connectivity Conservation Impacted by Linear Transportation" (Rodney van der Ree, EII) 7 minutes

3. Presentation: Case studies- The elements of wildlife-friendly transportation projects in developing countries (Kate Newman, WWF-US) 7 minutes

4. Presentation: Species and regional efforts to advance wildlife-friendly transportation (Tony Clevenger, Latin American and Caribbean Transport Working Group [or other partner] and Nilanga Jayasinghe, Asian Elephant Transport Working Group) 15 minutes

5. Panel discussion and moderated question and answer session: Applying the guidance to coordinate urgent action in policy, research, technology, and public involvement (All speakers) 15 minutes

6. Breakout Discussions: feedback on the Guidance and its application to local contexts (Audience participation) 25 minutes

7. Summary of breakout discussions; invitations to collaborate (All) 10 minutes

KEYWORDS: Guidelines, Best Practices, Research

SESSION 3.1.1

The Potential of Smart technologies for ecological planning and landscape measures

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A. Main Thesis:

In ecological planning smart technologies are used more and more for detection of plants, vegetation and animals. Methods like the use of drones for analysing vegetation structure or size, genetic tracing (environmental DNA) especially for qualitative and quantitative analysing of water organisms like frogs and fishes, species detection with ultrasound for bats, infrared and radar for the detection of bird movement at night, helium balloons for bat movement at high altitudes. Furthermore, landscape measures itself became more technical orientated (e.g. by the use of light management in tunnels or construction sites, multi-functional mobile walls at construction sites, bubble curtains to reduce noise under water, especially for the protection of fishes and water mammals).

On the other hand, infrastructure engineering uses increasingly smart technologies for planning (e.g. Building Information Modeling (BIM) or artificial intelligence for programming) and organisation of traffic (e.g. solar collectors beside the roads and induction loops in the asphalt producing electricity for parallel railways, automatic wildlife warning systems to avoid accidents with animals).

These two specialist areas coexist with too little communication beside each other. The thesis is to get new ideas and innovative solutions by connecting engineering and environmental smart technologies, especially in terms of green infrastructure, but also for mitigation and compensation measures far from the infrastructure, somewhere in the countryside. All available smart knowledge of road systems, but also of other infrastructure systems (especially railways, waterways, energy lines), should be included in this process.

The workshop is intended for better networking and to give a better understanding and cooperation between landscapers and engineers to discuss best practice examples of solutions.

B. Presentation (10 minutes):

The content and the strategy for the workshop will be presented using 6 examples (some of these were developed during a workshop at IENE 2018 in Eindhoven)

Detecting systems

- Helium balloons for detecting bats
- Environmental DNA

Technical landscape measures

- Light management for bats in pedestrian tunnels in Switzerland (IENE 2018)
- Big bubble curtains to reduce underwater noise

Measures for intelligent roads

- Wildlife warning system
- Induction loops for power generation

Key Message: Networking between intelligent infrastructure and landscape technologies can lead to better innovative technical solutions on both sides.

The relevance of good technical solutions in species detecting systems, technical road and landscape measures will be presented in case studies.

C. Interaction between participants (50 minutes)

The discussion will be structured as follows (The organiser voices suggestions and presents PowerPoint slides to initiate discussions about the main questions by using the examples listed above):

- The participants are expected to comment on the smart solutions presented. (10 minutes)
- Discussion:
- What do we need to optimise the networking between smart technologies? (20 minutes)
- Achievement of a better knowledge and understanding of landscapers for technical solutions.
  How can landscape planners benefit from knowledge of intelligent infrastructure?
  Can we achieve better landscape measures by a better understanding of intelligent technical processes on and beside the infrastructure lines? Do we really use all possibilities of technical potential to get the best result? Are there technical solutions for a better protection of insects? Can technical engineers benefit from landscape knowledge, especially innovative detecting systems?
- Activation of technical know-how of engineers (e.g. ideas competition)

- Standardization of technical measures vs. individual solutions (saving costs of planning and construction)

- The participants should briefly present other cases of smart / intelligent technologies examples of their own country or experience. (10 minutes)

- The participants should be motivated to create posters for the best practice collection of the Road and Transportation Research Association (FGSV), see below. (10 minutes)

D. Communication of the workshop findings:

Additional information on the best practice collection can be found on the website of the "Forschungsgesellschaft für Straßen- und Verkehrswesen" (FGSV, Cologne: https://www.fgsv.de/wisseHYPERLINK "https://www.fgsv.de/wissenstransfer/poster.html"nHYPERLINK "https://www.fgsv.de/wissenstransfer/poster.html"stransfer/poster.html).

The organiser of the workshops will create posters of the workshop results and upload them to the FGSV platform. Posters and other input papers of the participants will be uploaded as well. As output of the workshop at the IENE conference 2018 in Eindhoven 10 posters in English language were added to the digital poster session on the FGSV website.

The collection so far comprises around 150 posters. The poster sessions are already internationally organised (German and English language is used). In addition to various German examples, the following countries are involved so far:

Austria, Belgium, Switzerland, Luxemburg, Poland, Japan, Australia.

The website is operated professionally and will be updated on a regular basis. A long term documentation of the findings is therefore ensured.

E. Use of the outcome of the workshop

The poster sessions have been used in a research project of the "Federal Highway Research Institute (BASt)". Based on the research project, some guidelines of German infrastructure planning (concerning risk management and mitigation in particular) have been developed or updated.

Actually published in 2019 is the "Information on risk management and monitoring for landscape conservation measures in road construction (HRM)".

An applicated research project of the road construction authority in Mecklenburg Western Pomerania, started in 2019, is partly based on the poster session. The results of the IENE workshop will be part of updates or intended guidelines of the FGSV and will be published in national ("Straße und Autobahn", "Straßenverkehrstechnik") and international journals.

In cooperation with the Technical University of Dresden the organiser will present the workshop results for intelligent infrastructure applications in scientific publications and in trainings for students.

Organisation of an international conference “Networking between infrastructure and landscape smart technical solutions“.

KEYWORDS: Smart technologies, Intelligent infrastructures, Ecological detection, Landscape measures, Creation of posters

SESSION 3.2.1

An International Strategy and Action Plan for Stakeholders' Engagement on Sustainable Transport and other Linear Infrastructure

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A Transport and other Linear Infrastructure (TLI), which includes, roads, railways, navigable channels, power lines, and pipelines, extend across large swaths of the globe and are essential for an interconnected world allowing the expansion of human societies and improved livelihoods. Accordingly, global demand for TLI has progressed rapidly in the last decade providing access to remote areas as well as generating an improved understanding of both the positive and negative impacts on natural systems both spatially and over time. Nevertheless, beside intensive agricultural land-use and urban expansion, TLI is a major cause of fragmentation of natural ecosystems and biodiversity decline worldwide. Further impacts resulting from edge effects can extend for many km on either side of the structures affecting ecosystems for many years to come. These less obvious impacts often create barrier effects for migrating wildlife as well as consequences for human safety due to animal vehicle collisions (AVC). The demand for improving humans and wildlife safety, and resilient TLI, under the climate change scenario, requires the development of a strategy that involves all stakeholders.

Other Linear Infrastructure, such as power lines, are also major causes of human-induced mortality for birds worldwide due to collision and electrocution, especially when towers and poles become attractive perches and roost sites. Both voltage distribution and transmission lines present a near-invisible flight barrier and collisions between birds and conductors and shield wires are well-documented.

Since 2015, a growing number of professionals and organisations, from all over the world, have joined forces. Comprising the four TLI continental conferences (ACLIE, ANET, ICOET, IENE) as well as international organisations (IUCN, WWF), this collaborative team have developed 'International Guidance for Ecologically Friendly Linear Infrastructure' (IGELI). IGELI aims to ensure that the TLI built today are safe for both humans and wildlife, and ecologically sustainable. With this in mind the mainstreaming of biodiversity in TLI sectors, has been introduced as part of the Convention for Biological Diversity framework (CBD) and the achievement of Aichi Global targets in CBD 2018 COP 14 in Egypt, resulting in our coalition developing an International Strategy and Action Plan on Sustainable TLI Stakeholders' Engagement (Strategy).

The Strategy aims to support the CBD 2020 COP 15 in China, through the development of an international roadmap. This roadmap seeks to engage different stakeholders, as key players, on mainstreaming biodiversity for the sustainable development of TLI by integrating environmental, social and economic components. The Strategy has a number of tiers: firstly, identifying relevant TLI stakeholders and their crucial roles in launching proactive policies and establishing appropriate legal frameworks; and secondly, supporting the relevant TLI stakeholders with guidance towards better planning, construction and maintenance of resilient TLI, ultimately promoting multi-sector cooperation and encouraging innovative science-based solutions.

The Workshop will include three phases:

> The first phase will include a 20 min presentation of the main elements of the Strategy which include: a) The aims, principles and overall framework of involving the key stakeholder groups for safe and sustainable TLI globally; and, b) An outline for an Action Plan that includes a framework for the Strategy with concrete outputs and a specified timeframe (2020-2030).
>
> The second phase will include a discussion about the next steps towards supporting CBD 2020 COP 15 in China and further developing of international cooperation on sustainable transport and other linear infrastructure. The duration of this phase will be 60 min.
>
> The third phase of the last 10 min will include the conclusions of the workshop.

KEYWORDS: Sustainable Linear Infrastructure, Ecological Corridors, Ecological Connectivity, Mitigation Hierarchy, Strategic Planning

SESSION 3.2.2

Planting and preservation of trees on dams and dykes as a part of green infrastructure: Conflicts - Solutions - Implementation

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With the straightening and deepening of rivers and streams in the last 250 years, transport has become faster and possible for larger ships. At the same time, many natural habitats such as floodplain forests with their winding arms of water disappeared and made way for open, bare agricultural land. Straightening and containment led to a decline in the biodiversity of countless species. In the course of river straightening, accompanying trees and shrubs were and are often removed. Due to the lack of vegetation on the dams and dikes, the waters heat up and dirt and fertilizer are not retained. As a result, the canalised rivers and streams lack the organisms in the waters and the time for sufficient self-purification. In addition, the loss of trees and shrubs along the waterway means that important habitats for many species continue to disappear.

In order to compensate a part of the loss of natural habitats, the thousands of kilometres of dams and dikes along the rivers should be used as green infrastructure and make an important contribution to the conservation of plant and animal species as well as lichens and fungi. From the point of view of climate protection, it is also important to improve the green infrastructure and use every opportunity to plant and preserve trees and shrubs. In addition, avenues and tree rows along waterways are also important connecting paths between biotopes, especially in the cleared agricultural landscape that we find in many places in Europe.

Yet, the demand currently manifested in standards states that woody plants (trees, shrubs and hedges) on dykes and dams are fundamentally unacceptable because they apparently impair stability and maintenance. These standards hinder not only planting of trees and shrubs along new construction, but also when it comes to tolerating and planting trees on dams and dykes during renovation measures.

For many decades, representatives of nature conservation and landscape management, associations and local citizens have been calling for environmentally compatible solutions to be implemented. Landscape architects and hydraulic engineers are also increasingly questioning these regulations.

Engineering biology has very good answers to the question of how plants can be used as living building materials to secure dams and dikes. The workshop will demonstrate that a dam or dike rehabilitation with preservation of the tree population is possible and even meaningful.

As an example of best practice, the rehabilitation of the dams along the Stoerkanal in der Lewitz in north-eastern Germany is to be used. Here technical solutions were found, which made the reconstruction of the dams with preservation of an especially beautiful oak avenue on the dam possible.

Target group

Landscape architects, hydraulic engineers, biologists, representatives of nature conservation and landscape management and associations.

Structure of the workshop (60 min)

15 minutes - Introduction: The workshop facilitators will highlight the importance of trees along waterways as part of the green infrastructure. They will identify conflicts and solutions based on the results of the rehabilitation of the Störkanal.

35 minutes - Discussion: The workshop facilitators will ask the participants to answer the following questions:

- In your opinion, what are the advantages and disadvantages of planting woody plants on dams and dikes?
- What is the legislation in your country on this topic?
- Are there examples where trees and shrubs could be preserved during restoration works on dams and dikes or even shrubs and trees were planted?

10 minutes - Formulating a result

How will we present the workshop findings afterwards and how will we use the outcome of the workshop

The results of the reconstruction along the Störkanalare documented in a brochure.

This brochure will be made available to the workshop participants in English.

The brochure is not yet finished. Together with our Polish project partner we are working on the update. Examples from Poland will be added as best practices. Our aim is to use the workshop to identify further positive examples from other countries, so that a brochure can be published on "best practice" for the conservation and use of woody plants on dams and dikes along waterways in Europe. This brochure will be completed in 2020 and made available to the IENE Committee. In addition, all workshop participants will be informed about the publication of the brochure, which will be available on our website.

KEYWORDS: Dam, Dike, Canal, Tree, Reconstruction

SESSION 3.3.1

GLOBAL CONGRESS: Linear Infrastructure and Environment (GCLIE): A Platform to Enhance Cooperation and Coordinated Action between the Existing Continental Conferences on Ecology and Infrastructure

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The proposed session will introduce the Global Congress of Linear Infrastructure and the Environment (GCLIE) to the world. There are already 5 "continental conferences" globally, focusing primarily on their home continents: the African Conference for Linear Infrastructure and Ecology (ACLIE), the Australasian Network for Ecology and Transportation (ANET), Congresso Iberoamericano de Biodiversidade e Infraestrutura Viária (CIBIV), Infrastructure & Ecology Network Europe (IENE), and the International Conference on Ecology and Transportation (ICOET). The Global Congress is intended to complement the continental conferences, periodically bringing together parties interested in linear infrastructure and the environment at the global scale. We have two aims with this session: 1) Develop the idea of a Global Congress, demonstrating its potential, strategic value to global stakeholders in linear infrastructure and the environment; and, 2) Propose a structure and approach to carry out the conference with continental partners-hosts.

Our vision for the Congress is for a global gathering that includes the intellectual content of a scientific conference and the international reach of the United Nations. We will facilitate truly global conversations and debates about issues such as new infrastructure in un-developed areas, mitigating and adapting to climate change, global funding mechanisms that can either enable or threaten environmental and social restoration, and equitable distribution of the costs and benefits of infrastructure.

It has become very apparent that the existing conferences are expanding to include all forms of linear infrastructure (LI; namely roads, rail, power lines, pipelines, canals, fences) because these infrastructure modes usually co-exist and have multiple and potentially synergistic, negative impacts on biodiversity. Examples of how themes are similar across infrastructure types include the loss of wildlife due to traffic and electrocution on power lines.

LI is recognised as a global business and biodiversity issue. There are numerous international programs with the intent to expand existing networks, which suggests we need a truly global network and forum with opportunities to convene regularly to address these threats on a global scale. The existing international networks (e.g. ICOET / IENE / ANET / ACLIE / CIBIV) are well-attended and respected world-wide, but despite efforts to be 'international', the audience and content is usually dominated by continental issues and organizations, which presents new challenges to genuinely participate. A regular, repeated, organised and coordinated Global Congress is needed to address global issues in a systematic way, that goes beyond primarily addressing more continental challenges. A dedicated global meeting would enable exchange and networking at the truly global scale. For example, the Global Congress would be the ideal space to provide a workshop to address a global framework for a specific cause.

The session will introduce the Global Congress, describe our goals and objectives, and be an excellent opportunity to get feedback from and foster discussion among IENE participants. Because the Global Congress is a new effort, it is important to gather input from as many people as possible on needs it can meet and ways it can be successful.

Workshop Purpose: To discuss the Global Congress which is intended to complement the continental conferences, periodically bringing together parties interested in linear infrastructure and the environment at the global scale. We have two aims with this concept:

- Develop the idea of a Global Congress, demonstrating its potential, strategic value to global stakeholders in linear infrastructure and the environment; and,

- Propose a structure and approach to carry out the conference with continental partners-hosts.

The detail of how the Global Congress will run long-term needs to be determined. For example, if ICOET hosts it in 2021, it will presumably be virtual. ANET have subsequently volunteered to host it in 2022 (and if the COVID-19 pandemic is over, then it will likely be a hybrid of congress of in-person and virtual. However, this still needs discussion, particularly regarding the organisation. For example, our current discussion will guide the ICOET in 2021, building momentum for 2022 and beyond.

What do want from participants?

We want to give every potential participant a voice in the development of the Congress to ensure its success and growth. We will: 1) explain concept and why and need and how it works and 2) collect participants' thoughts on the goals, structure, and potential needs the Congress could address.

KEYWORDS: Global collaboration, Linear infrastructure, Environmental impact

Road sides as ecological traps – Challenges and solutions: Changed biotic interactions due to non-native seed mixtures and invasive alien plants

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Roadsides offer habitats for many species, and they act as a habitat network in numerous landscapes. Therefore, in many countries, efforts are made to improve roadside quality for biodiversity. However, there is widespread evidence that these habitats may attract animals and allow establishment of plant populations that end up having lower fitness. This is caused by slower growth, higher mortality and reduced reproduction in plants and animals. In the most extreme cases sink populations develop that depend on constant colonisation by individuals from adjacent source populations. In those cases, roadsides act as so-called ecological traps with overall negative effects. One key question for the work with roadside biodiversity, is to evaluate under which conditions roadside habitats act as ecological traps for plant and animal populations, and when they actually improve their conservation status.

The intensity of the trap effect on plants and animals depends on the quality of the roadside in relation to the surrounding habitats, and on the degree of stress and disturbance caused by traffic. Some of these effects are moderated by the width of the roadside, and negative effects can be mitigated by improved planting and adapted management schemes. A less well understood effect is the quality of the plant material used. In some regions non-native (and sometimes invasive) plants are still planted along roadsides, and often species-poor commercial seed mixtures that disrupt trophic interactions with native pollinators and herbivores are sown. These problems are exacerbated if invasive alien plants colonise roadside habitats, because they outcompete native plant species and require hard management.

Most likely, the unwanted trap effects depend on the size and the traffic volume of the road, as well as on roadside maintenance and adjacent land use. However, they may increase under climate change due to low reproduction and increased mortality of species adapted to current conditions. Moreover, phenological mismatches might occur between primary producers, consumers and decomposers. This can cause reduced pollination and increased herbivory, which would jeopardise the ecosystem services roadsides provide.

It is still debated whether or not roadside design should encourage establishment of certain plant and animal species, and we largely lack methods for evaluating risks of trap effects for different species groups. Also methods for mitigating such effects are scarce, although, more recently, some solutions have been developed to address these problems. One measure is to use local plant material and to ban the use of cultivars or (potentially) invasive plant species. Seed mixtures, seeding methods and maintenance strategies that reduce the establishment of unwanted species and benefit biodiversity of associated animals are available.

The suggested workshop will address these topics with an interdisciplinary perspective. We have assembled a group of plant and animal ecologists, vegetation scientists, restoration ecologists, conservation experts and roadside ecologists that have agreed to support the workshop. Some of these scientists have already reviewed the literature on the workshop topic. The expert knowledge shared and discussed in this workshop should later be exchanged with roadside engineers, construction experts, landscape planners and roadside authorities to identify potential solutions to the challenges described above. The results of the workshop will be incorporated in a manuscript that is under preparation and should be submitted in summer 2020. The practical implications will be communicated to road authorities.

The workshop will have the following structure and content:

1) Welcome and introduction – J. Kollmann (Munich), 15 min

2) Keynote 1 "Roadsides as ecological traps" – J.C. Habel (Salzburg), 20+5 min

3) Keynote 2 "Significance of local adaptation for biotic interactions" – A. Bucharova (Münster), 20+5 min

4) Keynote 3 "Engineering biotic resistance of plant communities against unwanted species" – F.A. Yannelli (Berlin), 20+5 min

5) Coffee break

6) Small discussion groups on trap effects, regional plant material, invasive alien plants and adaptation to climate change, 50 min

7) Plenary discussion (H.M. Hanslin), 25 min

8) Conclusions and practical implications (S. Kroeger), 15 min

The time frame for the workshop is expected to be 3 hours; the workshop would be suitable for 40–60 participants.

KEYWORDS: Biotic interactions, Ecological trap, Invasive alien plant, Roadside, Seed mixture

Part 6: Side Events

LIFE LINES Final Seminar

Most of the Linear Infrastructures networks worldwide were built prior to the dissemination and mandatory implementation of Environmental Impact Assessment policies. Therefore, many of these infrastructures are not prepared to couple with biodiversity conservation issues and need to be adapted. Very often simple and inexpensive solutions can be used to increase environmental performance of old infrastructures. We will discuss successes and failures of actions/ adaptations often implemented to reduce the ecological impacts of Linear Infrastructures and strategies to promote a widespread dissemination of solutions which proved to be successful. We will use the experience of the LIFE LINES project (LIFE14 NAT/PT/001081) to contribute to this discussion. The project aims to essay, evaluate and disseminate practices directed at mitigation of negative effects from transport/energy infrastructures on biodiversity. Simultaneously, it contributes to the creation of a demonstrative Green Infrastructure based in habitat corridors and stepping-stones that increase connectivity and improve conservation of local/ regional biodiversity. Its target area is one of the main transport/ energy corridors linking Portugal to Spain. Through this seminar, we will also gather inputs from shared experiences and networking to use in the Post-LIFE Communication and Conservation Plan.

SESSION 1.2.1. LIFE LINES FINAL SEMINAR – 1

#1 Linear Infrastructure Networks with Ecological Solutions

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The LIFE LINES project (LIFE14 NAT/PT/001081), located in the Alentejo region, Portugal, aims to essay, evaluate and disseminate practices directed at mitigation of negative effects from transport/energy infrastructures in biodiversity and promote the creation, along them, of a demonstrative Green Infrastructure, based in corridors and stepping stones that can increment connectivity and improve conservation of local/regional biodiversity. In its 5-year duration, the project has contributed, among others, to the decrease in roadkilled fauna, control of invasive flora species, increase in flora / fauna richness and abundance, and contributed to decision support data for balancing linear infrastructures and biodiversity.

KEYWORDS: Roads, Power lines, Roadkill mitigation, Green Infrastructure, Biodiversity

#2 IP's participation in LIFE LINES: Reducing fauna roadkills and defragmenting habitats

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Infraestruturas de Portugal (IP) is the Portuguese public company holding a long term concession contract of the national road and rail infrastructures in Portugal. IP manages around 14,000 km of roads and over 2,500 km of railways, providing a public service in areas such as funding, maintenance, operation and development of the Road and Rail Networks. Environmental sustainability is one important goal of IP and is incorporated in IP's procedures.

IP, being one of the partners of LIFE LINES Project, is responsible for the implementation of several actions concerning the mitigation of fauna roadkills and the promotion of connectivity and landscape permeability. Several solutions were implemented and are now being tested, such as dry ledges inside strategically located culverts, nets to avoid rabbits on the slopes, barriers to elevate owls' flight, wildlife warning reflectors, barriers to lead amphibians to culverts and a new road sign specific to amphibians.

It was also created, with the support of the University of Évora, a national database of wildlife mortality (on roads) and a mobile application to record animal roadkills, available to everybody. The data, after being validated by the LIFE LINES project team, will integrate the fauna roadkill database and will be used for scientific purposes, such as modelling data to implement mitigation measures and promote the establishment of a Green Infrastructure to support biodiversity conservation.

Other actions of the Project concern the road verges management and the control of invasive vegetation, which will also contribute to the establishment of the Green Infrastructure. In association with these actions, it were developed efforts to involve IP's collaborators and relatives in volunteer activities, promoting environmental awareness and active participation.

LIFE LINES was an extraordinary opportunity to find new solutions and improve some known less-efficient/less-viable solutions. The results will indicate ways to better apply these new or improved solutions in overall terms, assuring a more sustainable relationship between infrastructures and biodiversity.

KEYWORDS: Habitat defragmentation, Fauna roadkills, Public awareness

#3 Bustards and power lines in Portugal: an overview of research done so far and its implications on impact assessment, mitigation and planning

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A Collision of birds with power lines is an important source of non-natural mortality, however bird vulnerability to collision with overhead obstacles is a species-specific issue. Bustards are among the most prone species to collide with power lines due to their heavy loads, limited flight manoeuvrability, flocking behaviour and importantly their limited ability to sense obstacles ahead when flying. Furthermore, current mitigation measures are not efficient in reducing mortality. Adding to their susceptibility to collisions, in Portugal they are also highly threatened species with ongoing declining trends. Here we will review the research carried out so far regarding interactions of little bustards *Tetrax tetrax* and great bustards *Otis tarda* with power lines, focusing mostly on assessment of impacts, mitigation and planning.

Altogether, over the last 10 years, seven papers were published in international peer reviewed journals. Our work has contributed significantly to understanding what power line designs and environmental factors are more likely to pose collision risk, where accidents are more likely to occur, how power lines affect the spatial distribution of bustards in different seasons of the year and the overall population collision rate.

We mapped collision risk of little bustards with distribution power lines using a theoretical approach, were risk was modelled per season as a function of proportion of flights at collision heights, regional bird density and flight length. To assess the main environmental drivers of collision risk for both bustard species with transmission power lines we compiled information from monitoring studies on birds' collisions in the country (2003-2015). Little bustard survey data was used to test weather transmission power lines displaced breeding males and if the density of these utility structures relates to population decline. Lastly, we looked at movement data from tagged little bustards with GPS tracking devices to assess if they were affected spatially by the presence of these infrastructures and estimate the yearly mortality rate caused by collisions with power lines.

Our main results show an astonishing high (and probably unsustainable) yearly collision rate of the little bustard Iberian populations estimated between 3.5 and 4.5%, likely to be contributing significantly to the species decline. In fact, when looking at the features relating to the dramatic trend of the species over the last 10 years (50% decline), areas with higher density of power lines coincided with greater decline rates. Transmission power lines were found causing an avoidance effect, with lower breeding densities in the vicinity of the infrastructure, somewhat similar with distribution power lines that were also avoided at stopovers during migration. We also found that bustards showed a greater collision risk during the post-breeding season which is when they fly for greater extents at collision risk height.

In view of the overwhelming evidence on how power lines may impact bustards and the lack of efficient mitigation solutions, existing and new powerlines require careful planning and a conservative approach when mitigating impacts, including dismantling or re-routing lines away from bustard sites and the implementation of compensation schemes.

KEYWORDS: Bustards, Overhead power lines, Impact, Mitigation, Research review

#4 Predicting wildlife-vehicle collisions using movement simulation models with the novel software SiMRiv

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Biologists, managers and conservationists are increasingly called to predict how animals respond to human infrastructure, such as roads, e.g. estimating the location of road mortalities and evaluating the effectiveness of mitigation measures. Computer based simulation models are widely used to do so. Most of such models, however, assume animal omniscience of the landscape, thus yielding unrealistic movements, and focus more on genetic connectivity than actual movement paths, or are case-specific and mathematically / computationally challenging to apply. *SiMRiv* is a novel, open source software (R package) for simulating spatially-explicit, individual multistate (Markovian) movements incorporating landscape bias. It was specifically conceived to deal with animals that move in linear habitats (e.g. river networks), but programmed in a powerful and flexible way so that it can be used to model any species in any habitat. Here, we illustrate *SiMRiv*'s potential in the subject of road ecology, namely using it to reproduce wildlife movement patterns and predict high-risk areas for road-kill, using Eurasian otters (*Lutra lutra*) as a model species. We used a subsample of an otter tracking dataset collected within the framework of an extensive project on otter ecology and behavior from2007 to 2010 in Alentejo (Southern Portugal). In particular, we used 234 nocturnal, continuous tracking sessions data (radiolocations taken every 15 min, which lasted on average 562 min) from 14 otters, resulting in a total sample of 8055 locations. Otters moved mostly within watercourses, but often visited dams and ponds, sometimes crossing the landscape matrix to reach these lentic habitats. We compared the number of road crossings in real otter movements (from the radiotracking data) and null models (simulated, multistate movements) incorporating the effect of the landscape structure (here, water dependence).The number of road crossings in real and simulated movements was remarkably similar, and limited real otter road-kill data supported *SiMRiv*'s road-kill risk predictions. Other emergent movement properties were also very similar in real and simulated movements. Overall, results show that *SiMRiv* has potential for reconstructing wildlife movement patterns, as well as for predicting road-kill risk areas. Specifically for this study, based on the results, we anticipate that road-kill monitoring in our study area may miss key road sections with elevated otter mortality. Likewise, we identified sections of road where road-kill observations were predictably low. This suggests that *SiMRiv* could be used to design stratified samples to guide efficient monitoring of road-related mortality for rare or cryptic species. *SiMRiv* constitutes a flexible, powerful, and intuitive tool to help biologists and managers to test mechanistic hypotheses on wildlife landscape, spatial and movement ecology, including those related to wildlife-vehicle interactions, holding potential for applications also in animal behaviour, disease and invasive species spread, and population dynamics.

KEYWORDS: Landscape connectivity, Individual-based mechanistic movement simulation models, Movement ecology, Road ecology, Road-kill hotspots

#5 LIFE, Biodiversity and Infrastructures

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The **LIFE programme** is, since 1992, the European Union's funding instrument for environment and climate action. The current funding period 2014-20 has a budget of € 3.4 billion. It is divided into two sub-programmes: environment and climate action.

The environment sub-programme funds nature conservation projects concerning biodiversity, habitats and species. It provides action grants for best practice, pilot and demonstration projects that contribute to the implementation of the EU's directives and strategies.

Member States have **national contact points** (NCP) to help candidates with their application. These NCP organise information and networking events, proposal writing workshops and they can point you in the direction of local partners. Agência Portuguesa do Ambiente (APA) is the Portuguese one.

Since the start of LIFE and until 2018, a total of **174 projects** have been funded in **Portugal**: 80 focus on Environmental Innovation, **86 on Nature Conservation**, three on Information and Communication, three on Climate Change Adaptation, a Preparatory project for the European Solidarity Corps and a National Capacity Building project.

These projects represent an investment of € 199 million, of which approximately € 113 million were funded by the EU.

With the help of LIFE, **European infrastructures** are in an ongoing process to be increasingly environmentally friendly.

Highways, train ways and powerlines (e.g.) no long have to be an obstacle to nature conservation. With projects like LIFE LINES, Imperial and Estepárias we see that territories with infrastructures can and should be an opportunity: with the right design and management, native species and infrastructures can happily coexist together.

APA had a **Capacity Bulding project** (CAP; 2016-18) with the main objective to improve the Portuguese capacity for participation and use of the LIFE, by increasing the number of winning projects. A set of complimentary goals were stablished and mainly achieved:

- increasing the capacity of public administrations involved with the Programme;
- improving networking and best practice dissemination mechanisms;
- facilitating access to other co-financing sources;

- promoting a better interaction between beneficiaries and the national administrations dealing with LIFE;

- increasing the dissemination of the Programme and projects.

In the **after-LIFE (CAP) period**, APA continues to support applicants, both in the proposal preparation and in the implementation phase. Different project teams often approach APA to clarify questions about, e.g., expenses eligibility, tendering procedures and issues with partners.

APA also supports the potential applicants through regionalized public sessions and workshops; electronic support; networking events with different stakeholders; newsletter and LIFE database and LIFE PT website.

APA continues the contacts with the Environmental Fund to extend the national counterpart of LIFE projects and continues to assess the possibility of applying for funds to give some robustness to some actions of networking. Whenever possible, APA participates in the monitoring visits to ongoing projects.

CAP was a very enriching process: public entities that support LIFE were reinforce in their structure; beneficiaries saw their project disseminated and got the chance of networking with their pairs; potential stakeholders got the chance of know more about the Programme… **and we will keep on doing it!**

KEYWORDS: LIFE, Environment, Nature, Climate action

#6 Implementation of volunteer environmental programs

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The volunteer program aims to involve local communities and organizational groups in nature conservation works that do not require skilled labor, in this case the building of a green infrastructure. It is intended to bring together different audiences and to enhance their active and direct involvement, increasingly and continuously, in conservation actions, contributing to the sustainability of their maintenance and subsequent replication.

Voluntary actions involve: a theoretical introduction; practical training; execution of the assigned tasks and assessment through an anonymous survey distributed to participants, which allows to evaluate the success of these voluntary actions allowing to detect problems and needs for adjustments / corrections.

This Communication presents the developed methodologies and their success, targeting nature conservation objectives and participant's satisfaction and motivation, enhancing the change of attitudes and behaviors towards nature conservation, contributing to the durability of impacts, results and subsequent replication in other context. This volunteering program has involved more than **2025 citizens and 24 entities**, over these 4 years of project.

In order to support green infrastructure development, volunteering actions have involved: control of plant IAS, the operation of a plant nursery focused on native species (collecting seeds, sowing, transplanting, weeding) and planting actions / habitat restoration.

The volunteering actions performed in the plant nursery involved the production of **6021** plants and the collection of **4398** grams of native seeds. The produced plants have been used on project conservation actions, executed by project partners, in the micro-reserves, or in the controlled invasive areas in the Ecotrails, national and municipal roads and under the electricity pylons.

IAS control activities were made in Montemor-o-Novo and Évora Ecotrail's, disable railway lines, with significant present of plant IAS on its verges. So far, due to safety measures, a smaller area than previously predicted, **0,288 ha** was controlled by volunteers. Some of the areas are located in high slope verges with the risk of landslide. In the same way areas located at the roadside also demand special safety measures, even in low traffic roads.

The coordination of this volunteering program has highlight the value and effectiveness of voluntary work in nature conservation, with a particular focus on green infrastructure development or support. This type of nature conservation works involves repetitive tasks, some of them requiring low voluntary skills, or easy to develop necessary skills.

Nonetheless, effective volunteering program design, regarding nature conservation goals, has to take in consideration conservation works demands towards group dimension, age range and safety. Adapting tasks to volunteers is crucial to ensure effectiveness & sustainability of voluntary work, and to gain visibility since the volunteers will be disseminating the knowledge and good practices acquired during voluntary work.

KEYWORDS: Citizen awareness, Invasive species, Plant nursery, Plantation, Ecotrail

#1 Assessing behaviour states in a forest carnivore in a road-dominated landscape with hidden Markov models

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Anthropogenic infrastructures and land-use changes are major threats to the successful movement of animals across heterogeneous landscapes. The barrier effect posed by roads has been reported as having several negative effects (e.g. long-term population viability, connectivity, behavioural) on high vagility species. Yet, the behavioural consequences of such constraints remains poorly understood. Despite the evident role of behaviour on animal movement, movement analyses considering behaviour effects are still uncommon and remain a fundamental challenge in ecology. Here, we studied the relationship between common genet (*Genetta genetta*) behaviour and road proximity within a dominant mixed forest-agricultural landscape in southern Portugal and included on highly fragmented area by roads. Specifically, we aimed to (i) identify and characterize behavioural states displayed by genets and related movement patterns; and (ii) understand how behavioural states are affected by proximity to main paved roads and landscape features. We used a multivariate hidden Markov model (HMM) to model the fine-scale movement (10-min fixes GPS) of 7 genets tracked between 2016 and 2019, using distance to main paved roads and landscape descriptors as covariates. The best HMM model revealed that genet's movement patterns were composed by three behavioural states, categorized as "*resting*" (short step-lengths [mean = 10.5 m] and highly tortuous), "*foraging*" (intermediate step-lengths [mean = 46.1 m] and a wide range in turning angle) and "*transiting*" (larger step-lengths [mean = 113.7 m] and mainly linear movements). Within genet main activity-period (17h-08h), the movement model predicts that genets spent 36.7% transiting, 35.3% foraging and 27.9% of the time resting. The probability of genets displaying the transiting state was highest in areas far away from roads (> 500 meters), whereas genets had highest probability of being in foraging and resting states in areas relatively close to roads (up to 500 meters), steadily decreasing as distance to roads increased. When genets moved beyond 500 m from roads, they were in the transiting state 48.0% of the time, being the dominant behavioural state. In contrast, when moving within 500 m from roads, genets were in the foraging state 42.4% of the time, being this the dominant state. Landscape characteristics also had a pronounced effect on behaviour state-occupancy. Given that, transiting had highest probability to occur in areas with lower forest edge density, lower vegetative productivity, and close to riparian habitats, while foraging was most likely to occur in areas with higher amount of forest edge density, more productive and far away from riparian habitats vicinities. Our results support evidence that the proximity of roads, along with more heterogeneous and fragmented areas, might favour foraging opportunities for genets. Our study also shows that the HMM approach is useful to disentangle the movement behaviours and to understand how animals respond to landscapes with increasing road densities and habitat fragmentation. This information may help road-engaged stakeholders on management of landscape elements surrounding roads (e.g. vegetation) and evaluation of genet habitat suitability in order to mitigate the negative effects of roads.

KEYWORDS: Movement model, Genet, Behaviour, Hidden Markov Models, Roads

#2 Effectiveness of amphibian mitigation measures to reduce roadkills in low traffic roads

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Linear infrastructures, such as roads, railways and powerlines, are a major threat to biodiversity, a problem that has been widely documented in the scientific community. Although some positive effects have been reported, such as the use of road verges as refuge or corridors, linear infrastructures have mainly negative effects on biodiversity. The continuous growth of these web infrastructures leads to habitat loss and fragmentation, reduced landscape connectivity, direct mortality and avoidance behaviour, which can severely affect the persistence of populations in road dominated environments. This is especially true for amphibians since they perform annual migrations to and from reproduction sites, when they often meet roads that need to cross. Moreover, they are slow moving organisms that often do not react to the presence of approaching vehicles which makes them one of the most roadkilled groups even in low traffic roads. Since their reproductive cycles are highly dependent on humidity and rain, high mortality numbers are often aggregated in time, being particularly high, in Mediterranean regions. The Mediterranean basin is a biodiversity hotspot, where 2 out of 3 amphibian species are endemic. Thus, amphibian represents key-taxa, which are globally declining. Roadkilled rates are abnormally high and contribute to their threaten status worldwide. In our study, more than 10 years of roadkill data allowed us to identify roadkilled hotspots and areas with higher amphibian connectivity, and use this information to outline measures to mitigate road mortality and barrier effect. In the framework of the LIFE LINES - Project LIFE14 NAT/PT/001081 (co-financed by the European Union), we were able to install specific measures for amphibians, in order to reduce mortality in two municipal roads (M529 and M535) in southern Portugal. To our knowledge, these measures were the first-ever taken place in Portugal. They consist in several amphibian tunnels (ACO models), water draining tunnels, specifically designed concrete guiding fences, and canvas guiding fences. The extension of mitigation measures in the two roads is around 3km, and control areas, with no measures, with approximately the same extension and located in similar landscape contexts were also monitored to evaluate mitigation measures efficiency. Monitoring is still ongoing and the results are preliminary; however, since the installation of these measures (Spring 2018) amphibian mortality was reduced by approximately 40% in intervened sections of both roads. In control areas, the results show the opposite tendency: more roadkills in 2018, after the installation of the amphibian mitigation measures. The year 2018 was atypical in Southern Portugal, with heavy rain during late spring which increased the survival rate of tadpoles. Thus, in Autumn a higher number of animals was migrating, when compared with the previous years. However, despite the higher amphibian activity recorded after the installation of the measures, the results show that areas with guiding fences had much less amphibian mortality. We believe these results show the immediate effects of these simple measures in reducing amphibian mortality in low traffic roads. Nevertheless, more sampling seasons are still needed in order to account for a full evaluation of measures efficiency.

KEYWORDS: Amphibians, Roadkill, Mitigation measures, Roads

#3 Road effects on Tawny owls (*Strix aluco*): patterns in road-kills, abundance, population trend, and movements

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Owls can be strongly affected by roads, namely due to collision with vehicles and disturbance. The Tawny owl (*Strix aluco*) is a common European raptor species and a frequent victim of road-killing. We studied road mortality and abundance of Tawny owl in southern Portugal from 2005 to 2019 (from 2015 onwards within the project LIFELINES - Linear Infrastructure Networks with Ecological Solutions LIFE14/NAT/PT/001081). We analysed two road types with varying traffic load: main roads and secondary roads. Mortality was checked daily or weekly along 37 km of roads. Owl abundance was studied using point counts with call-playbacks. We measured the behavioural response to conspecific intrusions during capturing attempts. We tagged five Tawny owl living near roads with data-loggers to analyse their movement behaviour regarding these linear infrastructures (individuals were tracked between 6 and 64 days; 436 – 5262 fixes). Road mortality of Tawny owl showed a decreasing trend along the study period. Mortality was greater during the post-fledging dispersal period (June-October). Mortality hotspots seem to be influenced by overall roadkill patterns and landscape connectivity. Tawny owl abundance was negatively affected by main roads. Abundance near secondary roads and far from roads is similar. The tawny owl population shows a negative trend in the study area, despite its apparently stable trend in Portugal. The local population trend was stable far from roads, and negative near main and secondary roads. Roads seemed to affect territorial occupancy between years, with territories near main roads showing greater turnover. Sites near secondary roads showed greater variation in the number of territories. Secondary roads also showed greater intra-year variation in occupancy, losing more potential territories along the breeding season. Areas near main roads apparently have low quality for Tawny owl, as suggested by lower territory occupancy and lower aggressive response to intrusions by the territory holders. The home range size of tracked owls varied between 0.36 km^2 and 2.34 km^2. The road extension within the home range varied between 0 and 1486 m, with a road crossing rate of 0.19 to 4.47 crossings per day. Roads coincided mostly with home range boundaries, however some individuals crossed the road very regularly or used verges as hunting areas. Our results indicate that mortality hotspots should be looked for not only on main roads but also secondary roads. Accordingly, mitigation measures may need to be applied as well in secondary roads. Tracking results suggest that landscape features that attract owls across roads (perches, feeding areas, movement pathways) increase mortality risk, and thus are priority sites to application of mitigation measures.

KEYWORDS: Disturbance, Movement behaviour, Owls, Population trend, Road-killing

#4 Minimization of electrocution risk in priority areas for the Iberian Imperial Eagle (*Aquila adalberti*)

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Electrocution is a significant factor of adult and juvenile mortality for Iberian Imperial Eagle (*Aquila adalberti*), and is considered one of the most important factors of non-natural mortality. Despite the small numbers of this species in Portugal, with only 17 pairs in 2018, between 2003 and 2018 there were 13 confirmed accidents. Collision is not a threat to the species and it rarely occurs.

To reduce this impact, it is set to apply protection methods in the electrical supports identified as dangerous in terms of risk of electrocution for the Imperial Eagle. Thus, the aim was to monitor and evaluate the effectiveness of different methods to reduce birds' electrocution and to determine the most effective method to reduce avifauna electrocution.

The study area included Castro Verde, Vale do Guadiana and Mourão/Moura/Barrancos SPA. The monitoring was held for a year and consisted of a monthly prospection of the pylons by foot looking for dead birds within a radius of 10 meters around each support. The mortality rate was expressed as number of dead birds per number of supports per month.

To evaluate the effectiveness of different methods of electrocution reduction, three models were monitored: 1) "Strapping"; 2) "Sleeve"; and 3) "Black tweezers". This evaluation was complemented with the assessment of unprotected control lines. The sample amounted to an approximate total line length of 40 km, corresponding to 10 km per each type of correction.

To determine the effect of applying the most effective electrocution reduction method, a total extension of about 27km of power lines identified as priority for the Imperial Eagle was monitored during a year before and a year after the protection devices were applied.

The results of the evaluation of the effectiveness of the different models revealed, as expected, the greater tendency for the occurrence of electrocution in the electrical lines without protective measures. However, only the "Sleeve" model did not report any case of mortality or any type of anomaly of this equipment. However, in order to reduce technical problems in terms of energy distribution and to increase the effectiveness of protection against electrocution, it has been defined as the most effective method to apply a "Combination of the sleeve-type over-strapping" model with a clamping reinforcement.

The results revealed the occurrence of high mortality during a complete annual cycle, with a total of 36 birds electrocuted in all the electrical lines before the application of the protection method. Mortality affected mainly Carrion crow (*Corvus corone*), Raven (*Corvus corax*) and Spotless Starling (*Sturnus unicolor*). However, 12 birds of prey including some with high conservation status, such as Bonellis's Eagle (*Aquila fasciata*), Red Kite (*Milvus milvus*), Griffon Vulture (*Gyps fulvus*) and Snake-eagle (*Circaetus gallicus*).

After the application of the "Combined" method, for a total of 27 km with 175 supports and 6 disconnectors intervened, there was no mortality during the following year after the intervention. There were only slight anomalies in the application of the clamping, with these having been loosened in some supports, thus representing a 3,75% rate of anomalies in all the applied clamping and which are already being replaced.

KEYWORDS: Iberian imperial eagle, *Aquila adalberti*, Conductor protection cover, Electric line support, Electrocution

#5 Protocols Avifauna – Joint efforts to mitigate bird mortality in powerlines

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Avifauna Protocols have been running In Portugal since 2003 and Avifauna 7 (2016-2018) and 8 (2019-2021) are the ultimate projects, showing already a solid knowledge base and new developments in the mitigation of powerline impacts on birds. These innovative approaches have arisen from the initiative and long-time cooperation between the private electrical energy distribution company - EDP Distribuição, the national authority for nature protection - ICNF and 3 NGO's - LPN, SPEA and Quercus.

Avifauna 7 and Avifauna 8, both deal with the continuation of previous actions and presenting new initiatives, such as:

- Electrocution risk maps for threatened species, namely Imperial Eagle, Bonelli's Eagle, Cinereous Vulture, Osprey, Golden Eagle
- Mortality prospection for electrocution risk maps to assess the real mortality of the riskiest powerlines;
- Assessment of the effectiveness of new devices for electrocution prevention, which are being employed by EDP Distribuição in medium tension lines;
- Construction and validation of collision risk maps for great bustard;
- Assess the effectiveness of anti-collision devices in the medium-long term.
- Uniformization and unification of databases regarding bird mortality, powerline retrofitting and powerline prospection for bird mortality;
- Assessing the collision risk in estuarine areas;
- Evaluating the risk factors that increase the risk of wildfires, ignited by birds electrocuted in powerlines.

Bird mortality in powerlines is a conservation problem and, in some cases, a safety problem for the line and for the environment. We emphasize the benefits of working together with all relevant stakeholders to reach acceptable solutions for a common problem and the advantages of long-term cooperation within CTALEA – Technical Commission for the Surveillance of Powerlines and Birds.

Among the several different approaches that have been taken to mitigate bird mortality in EDP Distribuição medium-tension to high tension lines, mortality risk maps for conservation priority species have been most useful in tackling problems in advance. Therefore the project extended these studies to other threatened species and the more sensitive powerlines are selected for retrofitting in the yearly list.

Joint georeferenced databases available to all partners GIS system is being developed, providing better knowledge for decision-making procedures concerning retrofitting priorities.

KEYWORDS: Powerlines, Bird mortality, Electrocution, Collision, Portugal

#6 Can power lines poles bases be used as habitat promotion?

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Linear infrastructures are spread across a great variety of environments causing landscape fragmentation and hampering populations' long-term persistence by diminishing their connectivity. Power lines are a very common linear infrastructure in the landscape and causes negative effects, especially for birds. However, its wide distribution in agricultural and semi-natural landscapes, together with a negligible agricultural or livestock use of the pole bases, makes these areas perfect to promote habitat patches in the landscape, providing refuge for both plants and animals and functioning also as a feeding habitat for fauna. In this work, we aimed to analyse the potential of power line poles bases to become suitable habitat patches by assessing the effect in flora structure and diversity of the application of three management types (without intervention, fenced, and fenced and sown).

The 15 analysed power line poles bases (plots)are spatially distributed around Évora (South of Portugal; Mediterranean climate) and located in areas with different land cover, including open areas and *montado*, that are grazed by cows. Of these plots, 5 were used as reference (without intervention), 5 were fenced (to prevent livestock grazing), and 5 were fenced and sown with a diversified species mixture. The plots were intervened in the autumn 2017. The effect of these management types was evaluated through the assessment of flora species abundance and diversity, and vegetation structure, before and after the intervention (spring 2017, and springs 2018 and 2019, respectively).

Intervened plots showed differences regarding the vegetation community structure. The plots fenced and sown showed an increase of flora richness, species height, vegetation overlap degree, and cover. The plots fenced presented vegetation cover and height increase, but a decrease of flora richness, vegetation overlap degree, and diversity. The reference plots showed higher diversity, but lower vegetation cover and height due to livestock pressure.

Over time, the behaviour of vegetation communities in fenced plots (sown and not sown) tends to become similar because, without grazing disturbing effect, biotic interactions between plant species favour the dominance of competitive species and this may imply loss of habitat suitability, namely for pollinators. Also, the poles with a high density of stork nests had less flora richness and diversity: regardless of the management type, only two flora species could prosper.

These preliminary results suggest that the management of poles with fence and sowing is the most beneficial solution, since simultaneously increases the floristic richness and the habitat and refuge for fauna. In densely wooded areas (*montado* areas) there is evidence that the vegetation structure and the promotion of biodiversity don't benefit from intervention.

This work was financed by the LIFE LINES project (LIFE14 NAT/PT/001081), from the European Union LIFE programme, under the coordination of António Mira. Special thanks are due to Francisco Moreira for facilitation with REN.

KEYWORDS: Biodiversity, Connectivity, Restoration, Vegetation structure

LIFE SAFE CROSSING Workshop: Innovative techniques to mitigate transportation infrastructure impact on large carnivores

The LIFE SAFE CROSSING project aims at implementing actions to reduce the impact of transportation infrastructure on priority large carnivore species (Brown bear, Wolf and Iberian lynx) in Greece, Italy, Romania and Spain. To mitigate the effects of road mortality and barrier effect threatening large carnivore populations the project will rely on experience gained in a previous LIFE project during which an innovative Animal-Vehicle Collisions Prevention System was successfully developed. Methods to identify locations where mitigation measures will result more cost effective, increasing road permeability by adapting crossings to be used by wildlife and techniques to aware driver's makes also part of the project. In this framework, the goal of the seminar is to share information and exchange knowledge with organisations working on the topic of large carnivores and transportation. Main output expected is to produce recommendations to increase effectiveness of the actions planned in the project and to create a networking platform allowing to replicate the actions in other study areas where long-term conservation of large carnivore populations should be guaranteed.

SESSION 3.1.2. LIFE SAFE CROSSING WORKSHOP: INTRODUCTION TO THE WORKSHOP AND TOPICS CONCERNING LARGE CARNIVORES AND TRANSPORT

#1 LIFE SAFE-CROSSING: the project overview

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The aim of the LIFE SAFE-CROSSING project (life.safe-crossing.eu) is to implement actions to reduce the impact of transportation infrastructure on priority large carnivore species (Brown bear, Wolf and Iberian lynx) in Greece, Italy, Romania and Spain. This is achieved through 1) installation of devices to prevent the direct mortality of animals on roads, 2) adaptation of crossing structures to reduce habitat fragmentation and 3) raising the general public's awareness of the importance of correct driving behaviour.

The aim of the project is also to disseminate the results to other potentially interested stakeholders and decision-makers, and to exchange expertise and experiences with other researchers and practitioners. Moreover, since innovative activities are carried out (e.g. installation of innovative AVC prevention tools, use of a neuromarketing method for the development of awareness-raising panels) we aim to promote the use of these tools in other countries or in relation to other wildlife species.

The SAFE-CROSSING side event that will take place during the IENE2020 conference is organized to bring together organisations dealing with large carnivores and transportation infrastructures, to inform them about the project activities and to receive their input to improve the development of the project.

The technical workshop is structured as follows: a first session of presentations starts with a review by Prof. Djuro Huber of the Veterinary Faculty of Zagreb about the impact of road infrastructures on large carnivore populations. This will be followed by presentations from project partners about the four main components of the LIFE SAFE-CROSSING project: monitoring AVC, methods to prevent accidents, adaptation of existing crossing structures and communication and awareness activities.

Talks will be followed by a participatory session in which the participants will be invited to contribute with their expertise on the presented topics. The participants will be split into four groups for each presented topic and will spend some time in each thematic workshop. The whole process will be led by a facilitator.

The results of the workshop will be summarized in a specific report. The involvement and suggestions of the participants will be important to increase the effectiveness of actions planned in the project and to create a networking platform that will allow the actions to be replicated in other study areas.

KEYWORDS: LIFE SAFE-CROSSING, Side-event, Dissemination, Stakeholders, Transferability

#2 Large carnivores and transportation infrastructure: a review

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Transportation infrastructure has two negative effects on large carnivores: it can kill them and/or fragment their populations. Carnivores do get killed in collisions with vehicles. When the population is low, such losses can lead to extinction. Moreover, there is always damage to vehicles, and passenger safety is an issue. Frequent traffic incidents also place large carnivores in a negative light in public attitude. But even more important is the habitat fragmentation that obstructs movements of individual animals, resulting in genetic isolation of new and remaining metapopulations. Fragmented habitat is the main reason why much of western and central Europe does not have viable large carnivore populations anymore. Unfortunately, the most common measure to prevent traffic kills directly contributes to fragmentation of habitat. This is fencing of highways and of railways for modern fast trains. The better the fence, the more severe is the habitat fragmentation. Luckily, there is a compromise, and it is becoming routinely used. These are wildlife crossing structures that can be effective both to reduce mortality and to secure connectivity. They are expensive, especially if large enough, properly designed and placed where needed. The best solution is to plan them with the construction of a new transportation route, but equally important is to add them to infrastructures that were built in times before this problem was recognised. For proper solutions, the criteria must be clearly defined, typically in the "guidelines for producing the environmental impact study" to secure the permeability of traffic routes. Such guidelines exist in many countries and the challenge is to use them consistently or to adopt them where they do not exist. The list of measures available for permeability mitigation are numerous, although for large carnivores, small structures are of little or no use. Here we discuss large overpasses called green bridges or ecoducts, large and high underpasses, and tunnels. Many bridges, viaducts and tunnels that are included in routes mainly for topographic reasons serve perfectly as animal crossings. Some adaptations in design may enhance efficiency considerably. In Croatia, we developed the criteria that passages for large carnivores must be a minimum of 80 meters wide and underpasses (viaducts or bridges) must be at least 8 meters high in most of the span, in addition to the width. When a passage has been constructed and placed, we should monitor how animals use it. The standardised way shows trends of use (seasonal, diurnal) and indicates whether there is a need for improvements. In any case, human disturbance has to be eliminated or minimised. Lastly, when crossing structures are secured, fencing a transport route is acceptable and desirable. Fencing should be good enough to prevent animals from digging underneath it (it must be fixed to the ground) or climbing over it (e.g. by adding extra electric wires).

KEYWORDS: Habitat fragmentation, Carnivore, Road, Fencing, Croatia

#3 Planning measures to avoid Animal-Vehicle Collisions: the approach of the LIFE SAFE-CROSSING Project targeting the Apennine brown bear

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The interaction between wildlife and human activity is constantly increasing due to the spread of anthropic activities, leading to an overlap with wildlife, which is also increasing in some areas. One artificial element that influences human-animal interactions is the road network. Animal-vehicle collisions (AVCs) illustrate the impact of infrastructure on the ecosystem and they cause damage to humans and wildlife.

To reduce AVC risks and the barrier effect of roads, arrange of mitigation approaches are used worldwide. Construction of underpasses and overpasses is a common measure, and their effectiveness has been assessed frequently.

Measures to be implemented in the Life Safe-Crossing Project are the adaptation of existing crossing structures, the use of road signs and road information panels and the use of a virtual fence, a barrier that consists of electronic deterrents installed at regular intervals on the roads and activated by the headlights of approaching vehicles in a radius of 300m.Furthermore, the AVC Prevention System device tested during the Life Strade Project will be installed. The added value of this system is that it is only activated in cases of actual AVC risk, when the presence of an animal on the roadside coincides with a vehicle approaching at high speed. A risk map has been created to rank the most important factors that affect AVC events and thus identify high-AVC-risk road stretches where mitigation measures should be concentrated to optimize the cost-benefit ratio of installing devices.

The same risk evaluation approach has been adopted to plan all other mitigation measures foreseen in the project. Road-kill data, barrier effects, and the presence of crossing structures have been evaluated to identify the most relevant factors in determining collision risk, and to delineate high-risk areas, thus favouring the implementation of effective interventions in terms of the type and location of a given mitigation measure.

Life safe-crossing results will contribute to developing better know-how about AVCs mitigation measures planning, thus helping to reduce road mortality and human-wildlife conflicts.

Topics to be discussed are *i*) how to use opportunistically collected data in risk evaluation analysis; *ii)* the best methods for finding the ideal spot to install AVC-PS; *iii*) evaluation of the extent to which electronic devices can actually compensate for a lack of existing crossing structures; *iv)* the role of maintenance activities to guarantee the long-term effectiveness of all the mitigation measures.

KEYWORDS: Mitigation measures, AVC, Road mortality, Life Project, Apennine brown bear

#4 Adapting underpasses to be used as wildlife crossings: An action of the LIFE SAFE-CROSSING project to reduce large carnivore habitat fragmentation

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The LIFE Safe-Crossing project includes defragmentation actions to adapt existing underpasses for use as crossings for large carnivore target species: Brown bear (*Ursus arctos*), Marsican brown bear (*Ursus arctos marsicanus*), Iberian lynx (*Lynx pardinus*) and Wolf (*Canis lupus*) in selected roads of Greece, Italy, Romania and Spain. The primary functions of underpasses are to provide drainage or crossings for pedestrian paths and forestry roads. They can also play an important role in improving road permeability to large carnivores and reducing mortality risks. Some structures are already used by target species, but others need to be modified to allow or increase large carnivore crossing. To select the most suitable structures to be adapted for improving large carnivore road permeability, an inventory of existing structures has been undertaken in each study area inroad sections identified as animal-vehicle collision hot spots or those frequently crossed by target species. Field surveys to inventory and characterise transversal structures and the features of the surroundings were undertaken applying standardised methods. Guidelines have been provided on identifying and modifying features so that their use by large carnivores can increase. Some of the actions to adapt underpasses for use by the target species include improving fencing, restoring vegetation so that animals are funnelled to the entrances of the structure, or removing elements that block or hinder the pass. Monitoring of the structures by camera trapping is planned or conducted to obtain information about Before and After use of the structures by target species. A total of 358 transversal structures were inventoried along 16 roads surveyed in the study areas: 132 in Greece (Kastoria/Florina provinces), 101 in Italy (Abruzzo Lazio and Molise National Park and Majella National Park) and 123 in Romania (south eastern Carpathians). Viaducts, underpasses and culverts are the main types of transversal structures considered for adaptation. Adaptation of roads' transversal structures and complementary defragmentation actions have already been undertaken in the Iberian Lynx distribution area in Andalucía (southern Spain)as part of the IBERLINCE project. Fencing was installed along 15 km of 8 roads (A-481, A-421, A-483, A-301, A-49, A-4, N-420 and N-4429) together with fences funnelling the animals to transversal structures adapted as wildlife crossings. Twenty transversal structures were conditioned for use by Iberian lynx. Other measures were addressed to reduce the speed of vehicles by installing rumble strips and signs. In addition, two new fauna passages were constructed.

Topics to be discussed at the workshop thematic tables are: i) Which stakeholders should be involved in adapting underpasses as wildlife crossings? ii) The criteria for selecting the best transversal structures for adaptation iii) Uses compatible with large carnivore crossings iv) The role of maintenance activities to guarantee the long-term use of the structures.

KEYWORDS: Large carnivore, Fauna passages, Fencing, Mitigation, LIFE Safe-Crossing

#5 LIFE SAFE-CROSSING in Greece: Analysis and mapping of crossing structures on the A29 and activities to enhance connectivity through interventions on underpasses and road sides

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The brown bear (*Ursus arctos*) in Greece is a strictly protected species under national and international legislation. It is a priority species listed in Annex II and IV of the EU Habitats Directive (92/43/EEC), which implies that Member States should avoid the deterioration and disturbance of bear habitats. Transportation infrastructure, however, alters ecological processes and threatens biological diversity. Road networks act as barriers that restrict gene flow, isolate populations and reduce overall landscape connectivity.

In northwestern Greece, motorway A29 has penetrated brown bear habitat since 2009. This motorway is equipped with ca. 140 underpasses of varying size (width range: 1-125m, height range: 2-40m, depth range: 10-400m) distributed along a 55km road segment. From 2009 to 2013, more than 20 bear-vehicle collisions occurred on the A29, while in 2014 a bear-proof fence was installed to discourage animals from stepping onto the motorway. Bear-vehicle collisions were drastically decreased, but the lack of monitoring actions resulted in concerns about the barrier effects of the newly-installed fence on the resident bear sub-population.

The implementation of the LIFE SAFE-CROSSING project in 2018 provided the support needed to evaluate and enhance the motorway's permeability. The first step was to record all potential wildlife passages, inspect and register their condition and relevant features (i.e. shape, surrounding landscape, evidence of use by wildlife) and identify obstacles to animal movement. Subsequently, after a thorough evaluation, we selected 45 structures to be monitored (spring 2019 to spring 2020) via solar-panel/battery powered cellular (4G) cameras. The monitoring system is supported by back-end infrastructure capable of passage visualization on the map along with associated information, automated camera snapshot/videostorage, snapshot depiction and statistics per passage, etc. via a user-friendly graphic environment.

According to field inspections and monitoring, interventions will be proposed to safeguard the use and increase the attractiveness of underpasses. These actions will mainly consist of shrubby vegetation plantations and removal of ground material that has downsized/blocked the passage due to mud deposits. The best period for these interventions, considering bear disturbance during sensitive periods for biological processes, would be fall and spring. These seasons are favorable for newly planted shrubs to grow. Following these interventions, we expect increased use of wildlife passages.

Thus, there will be a second monitoring period of passages for re-evaluation of their use.

These actions will hopefully have a positive impact on brown bears and other species resident in the area and guarantee long-term permeability of the A29. The efforts provide a precedent for future road development projects in Greece, setting an example of safe and permeable transportation networks. Topics to be discussed at the workshop thematic tables are: i) How do we handle the mass of data input cost-effectively? ii) How do we overcome the lack of network coverage in underpasses? iii) How do we avoid vandalism/theft? iv) What about privacy rights of people using structures for commuting? v) What would be an appropriate plan for monitoring 140 underpasses using-45cameras? vi) Is monitoring necessary both before and after adaptations?

KEYWORDS: Mitigation measures, Underpasses, Monitoring, Brown bear, *Ursus arctos*

#6 Increasing awareness to encourage the adoption of driving behaviour to reduce AVC risk: new approach applied at LIFE SAFE-CROSSING

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The prevention of animal vehicle collisions (hereafter AVC) is a major challenge, which is most often faced through systems and technologies to avoid wildlife crossing permanently or it may result in a risky situation. One aspect that is often underestimated is drivers' perceptions of the risk of wildlife collisions and how more responsible driving behaviour can be encouraged. As part of the LIFE STRADE project (www.lifestrade.it) a public survey was carried out in central Italy (n = 1000) to assess the level of awareness about AVCs, their impact on biodiversity and their causes. Most respondents (49%) stated that the main cause of AVC is the abundance of wildlife next to the road, while only a small percentage (12%) considered that reducing speed could decrease the risk of collisions. We recorded a general trend of associating wildlife collisions with animal behaviour, without considering the impact of driving behaviour. As reported by various studies, the traditional wildlife warning sign is ineffective because drivers quickly get used to it and do not react in a significant way. The LIFE STRADE project also included the monitoring of drivers' reactions to a warning sign with flashing lights triggered by sensors or a thermal camera, when animals are detected near the roads. In this case, only 23% of vehicles reduced their speed when the flashing lights were active. During the entire project duration, we recorded that around 90% of vehicles did not respect the speed limits.

Based on these results, the aim of the LIFE SAFE-CROSSING (life.safe-crossing.eu) project is to increase drivers' awareness of the danger of AVCs, and to implement specific actions to encourage more responsible driving behaviour. This is achieved through developing and testing the effectiveness of new road information panels. However, on the roads, complex texts and images cannot be used because drivers have to receive messages quickly and clearly. We therefore used a neuroscience technique to study how road panels could be improved: a sample of 30 participants was exposed to different stimuli (four road panels) inside a lab. Their brain reactions were evaluated using specific techniques. The panel selected for installation on the road will have the highest visibility comprehension and memorability. The effectiveness of the panels will then be assessed by measuring the speed of vehicles that pass by them to evaluate whether they reduce speed. The project also includes a set of communication activities for young and future drivers. A video game and specific educational activities will be developed with local driving schools. We believe it is vital to act on driving behaviour to reduce AVC, and this study could be a first step in this direction.

Topics to be discussed at the workshop thematic tables are: i) How can we increase driver's awareness when they are in areas with high AVC risks? ii) Could residents of rural areas and visitors react in a different way to wildlife awareness signs? iii) What are the best messages to adapt drivers' behaviour? Which are the most effective communication techniques?

KEYWORDS: Driving behaviour, Awareness, Communication, Neuroscience, Road signs

Part 7:
Training Session

MONITORING WILDLIFE CROSSINGS AND ROADKILLS

This course is suitable for students, young researchers and practitioners involved in projects targeting the identification of roadkill hotspots and evaluation of the effectiveness of measures aiming to mitigate road-barrier effect and mortality. It includes sessions focused on the importance of monitoring road mortality and the effectiveness of wildlife crossings and fencing. Information provided will help the definition of monitoring aims and targets, and the selection of the best protocols and techniques to respond to each project specific goals. Participants will also receive basic training on data analyses and associated software. Participants will be invited to discuss, in situ, monitoring results considering the methodological protocol that has been used and the landscape context. The field trip initially planned for the second day was cancelled and the training course is now scheduled for a full-day online Theoretical-practical session.

Instructors:

Carme Rosell (Minuartia, LIFE Safe Crossing, Spain); António Mira, Sara Santos (University of Évora, LIFE LINES, Portugal); Michal Bíl (CDV – Transport Research Centre, Czech Republic); Marina Torrellas (Minuartia, LIFE Safe Crossing, Spain); Nuno Pedroso, Luis G. Sousa (University of Évora, LIFE LINES, Portugal)


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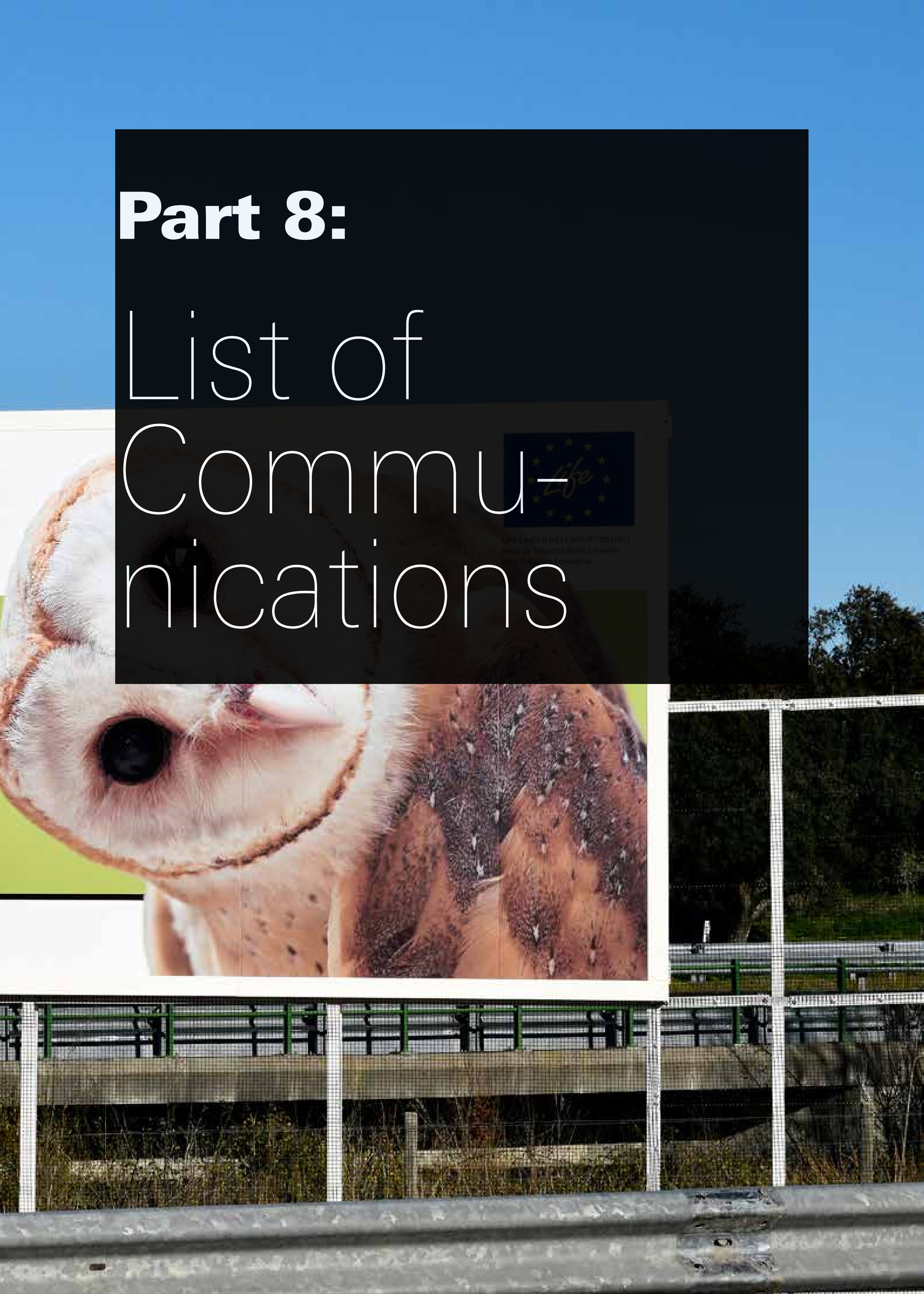
Part 8:

List of Communications



Full Presentations

SESSION 1.1.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 1

#1 Managing knowledge after 15 years of defragmentation - Adam Hofland, Camiel Meijneken

#2 "Breaking down" global defragmentation concepts to a macro-region – the example of the Danube River Basin - Anneliese Fuchs, Michael Jungmeier

#3 Risks and opportunities for wildlife living in road dominated environments. What pieces are missing to complete the puzzle? - António Mira, Ana Galantinho, Denis Medinas, Helena Sabino-Marques, Carmo Silva, Sara Santos

#4 Developing mitigation strategies to reduce the impact of land transport infrastructures on Amphibian populations: the example of Denmark, Sweden, Poland, Lithuania and Estonia - Lars Briggs, Alix Aliaga

#5 Use of snow-tracking to evaluate the impact of Linear Transportation Infrastructures on wolf and ungulates - Sandro Bertolino, Aurelio Perrone, Giulia Mutinelli, Massimo Rosso, Elisa Ramassa, Elisa Avanzinelli

#6 The barrier effect of railways and other linear grey and green infrastructure on the small fauna - Heinrich Reck, Henning Nissen

SESSION 1.1.2. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 2

#1 Do roadkill of different species respond in the same way to habitat and matrix? The case of four Brazilian mammals - Douglas W. Cirino, Artur Lupinetti, Simone R. Freitas

#2 Do culverts contribute to reduce the number of roadkills? A study on roadkills along the Habarana-Polonnaruwa road, Sri Lanka - Dishane Hewavithana, Devaka Weerakoon, Mayuri Wijesinghe, Christopher Searcy

#3 Risk analysis of high-voltage power lines in Belgium to map bird collision-prone spans - Dominique Verbelen, Kristijn Swinnen, Antoine Derouaux, Jean-Yves Paquet, Johan Mortier

#4 Maturity-index assessment: ecology adaptation within road authorities doesn't come easy - Camiel Meijneken, Adam Hofland

#5 Developing an ecological defragmentation programme in Flanders: a challenge! - Katja Claus, Marleen Moelants, René Meeuwis, Joris Everaert

SESSION 1.3.1. INFRASTRUCTURE MITIGATION AND DEFRAGMENTATION

#1 The Corridor Map-a-Thon: crowdsourcing baseline spatial data and building capacity to assess wildlife corridor disruption by infrastructure - Grant Connette, Katie LaJeunesse Connette, Eunkyung Kwong, Sai Than Lwin, Hanna Helsingen, Paing Soe, Nirmal Bhagabati

#2 Eskom/Endangered Wildlife Trust partnership 1996 – 2020, 24 years of partnering together to reduce impacts on business and on biodiversity - Kishaylin Chetty, Lourens Leeuwner, Constant Hoogstad

#3 Building an electrocution risk map with overhead power lines for a critically endangered raptor in Portugal - Ana Teresa Marques, João Paulo Silva, Carlos Carrapato , Rita Ramos, Francisco Moreira, Jorge Palmeirim

#4 Effectiveness of an anti-bird strike tubular screen in a high-speed railway - J. Herranz, L. Falcao, I. Hervás, C. Mata, A. E. Santamaría, E. García de la Morena, J. E. Malo

#5 Experimental evaluation of crossing structures used by amphibians along a high-speed railway line - Guillaume Testud, Dorothée Labarraque, Claude Miaud

#6 Acoustic Animal Deterring Device as a mitigation measure to limit collisions of rail vehicles with wild animals - Joanna Żyłkowska, Marek Stolarski, Dorota Bartoszek-Majewska

SESSION 1.3.2. NEW TOOLS AND TECHNOLOGIES TO PREVENT AND MONITOR LINEAR INFRASTRUCTURE IMPACTS – 1

#1 The conflict points between green and transport infrastructure–methodology for the multicriterial assessment - Ivo Dostál, Marek Havlíček

#2 Automatic acoustic monitoring of wildlife - Julien Ricard

#3 Using evidence-based approaches and evidence customization to improve mitigation practice - Silviu Petrovan

#4 BioBIM – Biodiversity, BIM & Infrastructures - Sylvain Moulherat, Denis Leroux, Martin Barbier, Christophe Delran

#5 The TRANSGREEN Project – Integrated Transport and Green Infrastructure Planning in the Danube-Carpathian Region for the Benefit of People and Nature – a cross-sectoral contribution to the improvement of permeability of linear infrastructure in the Carpathians - Lazaros Georgiadis, Hildegard Meyer, Miroslav Kutal, Vaclav Hlavac, Martin Strnad, Ivo Dostál, Jan Kubeček, Gabriella Nagy, Csaba Domokos, Tibor Sos, Radu Mot, Cristian-Remus Papp, Diana Cosmoiu, Catalina Murariu, Katarina Galiková, Jan Kadlečik, Tereza Thompson, Maros Finka, Vladimir Ondrejička, Milan Husar, Elke Hahn

#6 ICF Ecosystem Connectivity Planning Tool: A Web-based Tool Identifying Opportunities for Improved Ecosystem Connectivity - Shannon Crossen, Jon Walker, Matthew Townley, Martin Fisher

SESSION 1.3.3. ROADS AND MAMMALS: ECOLOGICAL IMPACTS AND SOLUTIONS

#1 Effectiveness of wildlife fences in reducing Key deer road mortality on the Florida Keys, USA; the importance of implementing mitigation measures at the appropriate spatial scale - Marcel P. Huijser, James S. Begley

#2 Dry pathways and flowing water within culverts jointly promote crossings by carnivore mammals - João Craveiro, Joana Bernardino, António Mira, Pedro G. Vaz

#3 Why, When and How Giant Anteaters Cross Roads? Understanding Impacts and Effects of Roads on Giant Anteater Populations - Arnaud Desbiez, Fernando Ascensão, Danilo Kluber, Débora Yogui, Mariana Catapani, Mário Alves

#4 New approaches to avoiding and mitigating the effects of streetlighting on bats - Fiona Mathews, Domhnall Finch, Paul Jerem

#5 Effects of roads on European badger occurrence in intensively used Mediterranean farmland - Ricardo Pita, Rui Morgado, Francisco Moreira , António Mira, Pedro Beja

SESSION 4.1.1. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 1

#1 Infrastructures, human activities and biodiversity in co-evolution: the examples of Upper-Rhine, Danube and Inn - Andreas Huber, Sebastian Weber, Jean-Nicolas Beisel, Cybill Staenzel, Carine Granier, and Manon Pons

#2 Biological control of invasive Tree of Heaven (Ailanthus altissima) along linear infrastructures using Ailantex® - Erhard Halmschlager, Oliver Maschek, Thomas Kirisits

#3 Citizen participation improves the quality of green infrastructure at road verges in Poland - Piotr Tyszko-Chmielowiec

#4 Factors driving the distribution of an amphibian community in stormwater ponds: a study case in the agricultural plain of the Bas-Rhin, France - Jonathan Jumeau, Julien Lopez, Alain Morand, Lana Petrod, Françoise Burel, Yves Handrich

#5 Maintenance of ecological asset on transport infrastructure: new chapter in the online 'Wildlife and Traffic' handbook - Carme Rosell, Vincent O'Malley, Elke Hahn, Adam Hofland, Tony Sangwine, Anders Sjölund, Marina Torrellas, Joana Colomer, Michal Bíl, Heinrich Reck

#6 Introducing 'www.TransportEcology.info': An online, open access resource to globally share information, knowledge and experience in ecologically-friendly linear infrastructure - Rodney van der Ree, Clara Grilo, Wendy Collinson-Jonker

SESSION 4.1.2. NEW TOOLS TO MONITOR ECOLOGICAL IMPACTS OF LINEAR INFRASTRUCTURES

#1 Evaluating the impacts of highway mitigation measures for fish connectivity using radio-telemetry and RFID PIT-tagging technologies in France - Yann Abdallah, Cédric Heurtebise, Arnaud Caudron

#2 Monitoring the expansion of alien species along roads with remote sensing - Neftalí Sillero, Patrícia Lourenço, Ana Cláudia Teodoro, José Alberto Gonçalve, João Honrado, Mário Cunha

#3 Mobile mapping system (MMS2) for detecting Roadkills - Hélder Ribeiro, Neftalí Sillero, Diana Guedes

#4 Improving Wildlife Fencing for Herpetofauna to Ensure Effective Implementation: An Analysis of Global Mitigation Case Studies - Steve Bega

#5 A simulation of WVC underreporting to hotspot spatial stability - Michal Bíl, Richard Andrášik

SESSION 4.2.1. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 1

#1 Monitoring a mature ecoduct: Intensive camera surveillance confirms significant increase in crossing rates and diversity after 13 years - Darryl A Jones, Ben Mackenzie, Kat Mackenzie

#2 Mitigating barn owl traffic victims using innovative design and citizen science data - Jasja Dekker, Johan De Jong, Nico Jonker, Karen Zwerver

#3 Development and Challenge of Green Highway Construction in China - Chen Xueping, Jian Li, Yang Yangang, Yao Jialin, Gao Shuohan, Wu Qiong, Wang Mengmeng

#4 Protecting the protected through assessing driver behaviour in protected areas of South Africa - Wendy Collinson, Courtney Marneweck, Harriet Davies-Mostert

#5 Estimating roadkill risk when there is no roadkill data - Eloy Revilla, Andrea Barón, Marcello D'Amico, Juan Carlos Rivilla, Carlos Rodríguez, Jacinto Román

#6 Roadkill as a Threat to Global Mammal Conservation - Clara Grilo, Luis Borda-de-Água, Pedro Beja, Eric Goolsby, Kylie Soanes, Aliza le Roux, Elena Koroleva, Flávio Z. Ferreira, Sara A. Gagné, Yun Wang, Manuela González-Suaréz

SESSION 4.2.2. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 2

#1 Factors affecting usage rates of wildlife crossing structures – a systematic review and meta-analysis - Dror Denneboom, Avi Bar-Massada, Assaf Shwartz

#2 Roadkills in Europe: areas of high risk of collision and critical for populations persistence - Clara Grilo, Elena Koroleva, Richard Andrášik, Michal Bíl, Manuela González-Suárez

#3 A national program to monitor fauna roadkills in Portugal - Graça Garcia

#4 Wildlife-vehicle accident maps – a new support tool for mitigation planning and communication in Sweden - Andreas Seiler, Mattias Olsson, Sofia Willebrand, Ulrika Lundin, Anders Sjölund

#5 Scary sounds as a tool to prevent moose – train collisions in Norway and Sweden - Svein Morten Eilertsen, Petter Almås, Næstad Frode, Aina Winsvold, Karen Marie Mathisen

#6. Roads as overlooked drivers of change in bird communities - Fernando Ascensão, Eloy Revilla, Henrique M. Pereira

SESSION 4.3.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 3

#1 The use of culverts in road networks as roost sites to maintain landscape connectivity for a trawling bat: a case study of the large-footed myotis (Myotis macropus) in Australia - Vanessa Gorecki, Ramona Maggini, Boyd Tarlinton, Caroline Hauxwell, Stuart Parsons

#2 Road effect zones of major prey species in roaded landscapes in India - Akanksha Saxena, Asha Rajvanshi, Bilal Habib

#3 Speed thrills but kills: Roadkill scenario in National Highway 715 (new) passing through the Kaziranga National Park, Assam, India - Somoyita Sur, Jaydev Mandal, Prasanta Kumar Saikia

#4 Graph-based multi-attribute decision making: Impact of barriers on ecological network - Andrius Kučas, Linas Balčiauskas

#5 Multi-level landscape analysis of wildlife vehicle collision sites in Estonia - Jaanus Remm, Piret Remm, Kaile Eschbaum, Kertu Jaik

SESSION 4.3.2. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 3

#1 A green light for blue wildlife reflectors? - Edgar A. van der Grift, Fabrice G. W. A. Ottburg, Dennis R. Lammertsma, Frans P .J. van Bommel

#2 Evaluation of an Animal Detection System (ADS) as an alternative for large defragmentation infrastructures - Marleen Moelants, Bollen Stan, Winters Guido, Katja Claus

#3 Hit the road Jane! Roads decrease the relatedness for females lesser horseshoe bats - Denis Medinas, João Tiago Marques, Vera Ribeiro, Hugo Rebelo, Soraia Barbosa, Joana Paupério, Francesco Valerio, Sara Santos, António Mira

#4 Mapping and monitoring large mammal underpasses on motorway A29 - Maria Psaralexi, George Lyberopoulos, Elina Theodoropoulou, Yiannis Tsaknakis, Athanasios Tragos, Yiorgos Lazaros, Niki Voumvoulaki, Carme Rosell, Marina Torrellas, Spyros Psaroudas, Yiorgos Mertzanis

#5 The value of a non-scientific approach for road agencies - Victor Loehr, Japp Mulder

#6 LIFE SAFE-CROSSING: A new international project for preventing large carnivore road mortality in Europe - Annette Mertens, Simone Ricci, Fabio Papini, Mihai Fedorca, Spyros Psaroudas, Inigo Fajardo, Carme Rosell, Antonio Antonucci, Andrea Gennai

SESSION 4.3.3. CHALLENGES AND OPPORTUNITIES FOR BIODIVERSITY CONSERVATION IN LINEAR INFRASTRUCTURES

#1 How do roads affect the ecological processes and biodiversity? – summing up a systematic literature review for the decade 2008-2018 - Hans Martin Hanslin, Johannes Kollmann, Svenja Kroeger, Larissa Uhe, Sabrina Behrendt, Jörgen Wissman, Tommy Lennartsson, Jan Christian Habel, Marcello D'Amico, Knut Anders Hovstad

#2 The Brazilian Network of Transport Ecology Specialists (REET Brasil) - Simone Freitas, Clarissa Rosa, Helio Secco, Mariane Biz, Fernanda Teixeira, Marcelo Gordo

#3 Creating high voltage power lines green corridors: how to demonstrate a win-win strategy? - Lisa Garnier, Bruno Salvi, Agnès Baccelli, Amélie Lafragette, Christophe Martinez, Damien D-Eaubonne, Gérald Sambardier, Sandrine Willer, Fabien Merpillat, Delphine Bonnifay, Juliette Auger, Emma-Pacome Vejux, Alexis Roset, Luc Estachy, Grégoire Martin, Kevin Rossi, Etienne Dupuy, Gérard Jadoul, Jean-François Godeau, Céline Davril-Bavois, Nicolas Bock, Jean-François Lesigne

#4 Protection of birds on power lines in the Czech Republic – from monitoring to practical measures - Václav Hlaváč

#5 Assessing Biodiversity in Railway Dry Grassland Patches - Magnus Stenmark

#6 Determination of the bird protection effectiveness of animal deflectors on railway overhead lines - Jana Görlich, Stefan Kornhuber, Hans-Peter Pampel, Christoph Jöckle, Marion Leiblein-Wild

SESSION 5.1.1. INFRASTRUCTURE ECOLOGICAL MITIGATION AND RESTORATION – 1

#1 Make amphibian defragmentation infrastructures great (again?) - Kristijn Swinnen, Ilf Jacobs, Griet Nijs, Simon Feys, Karin Gielen, Dominique Verbelen, Jorg Lambrecht, Katja Claus

#2 AMPHIbianCONservation and habitat restoration (LIFE AMPHICON) - Katja Poboljšaj

#3 Assessing the ability of modern metapopulation models to mimic real life using genetic data - Sylvain Moulherat, Jonathan Remon, Jérôme G. Prunier, Gaël Bardon, Aurélie Coulon

#4 Road proximity affects reproductive investment in lizards: a two-years translocation experiment - Rodrigo Megía-Palma, Rafael Barrientos

#5 ControlInRoad: Controlling invasive alien plant species along roads - Friederike Trognitz, Swen Follak, Alexander Fürdös, Norbert Sedlacek, Herbert Seelmann, Maximilian Koch, Angela Sessitsch

SESSION 5.1.2. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 2

#1 Risky wandering close to the railway: flight behavior of birds across the platform and viaducts in a high-speed railway - J. E. Malo, I. Hervás, C. Mata, A. E. Santamaría, J. Herranz

#2 Linking habitat composition, local population densities and traffic characteristics to spatial patterns of ungulate-train collisions - Karolina D. Jasińska, Michał Żmihorski, Dagny Krauze-Gryz, Dorota Kotowska, Joanna Werka, Tomas Pärt

#3 Are railways really detrimental to bird populations? The case of the new Bothnia Line Railway in northern Sweden - Adriaan de Jong

#4 Bird mortality by collision with transmission power lines: analysis of 15 years of impact assessment in Portugal - Ricardo C. Martins, Teresa Marques, João P. Silva, Francisco Moreira

#5 Effects of linear infrastructures on the composition of local vertebrate scavenger guilds and bird carcass removal patterns in two Mediterranean agricultural landscapes - Joana Bernardino, Regina Bispo, Ricardo C. Martins, S. Santos, Francisco Moreira

#6 UIC Ecological Effects of Railways on Wildlife project (rEvERsE) - Pinar Yilmazer, Thomas Schuh, Lucie Anderton

SESSION 5.2.1. GREEN INFRASTRUCTURE NETWORKS: POLICY AND STRATEGIC PLANNING

#1 German's federal waterways – A linear infrastructure network for nature and transport - Volker Steege, Dirk Dr. Engelbart, Nicole Hädicke, Kai Schäfer, Jennifer Dr. Wey

#2 Developing projects for harmonization of Green and Grey Infrastructure (the HARMON project experience in the Danube Region) - Radu Mot, Florina Ciubuc, Lazaros Georgiadis, Miroslav Kutal, Emma Gileva, Roland Grillmayer, Niki Voumvoulaki, Roxana Stoian, Elke Hahn, Anders Sjölund, Hildegard Meyer, Cristian-Remus Papp

#3 From technology to strategy: developments and perspectives of research in infrastructure and ecosystems - Yannick Autret, Judith Raoul-Duval, Bruno Villalba, Sylvie Van Peene, Héloise Benard

#4 The SaveGREEN Project – Safeguarding the functionality of transnationally important ecological corridors in the Danube basin - Hildegard Meyer, Roland Grillmayer, Emma Gileva, Petko Tsvetkov, Miroslav Kutal , Ivo Dostál, Jan Kubeček, Gabriella Nagy, Árpád Ferincz, Krisztina Filepné Kovács, Laszlo Kollanyi, András Weiperth, Radu Mot, Alexandra Doba, Marius Nistorescu, Cristian-Remus Papp, Diana Cosmoiu, Barbara Immerova, Milan Janak, Maros Finka, Milan Husar, Vladimir Ondrejička, Elke Hahn, Lazaros Georgiadis

#5 Mapping ecological corridors to educate policymakers and the public - Jan Mampaey, Thomas Impens

SESSION 5.2.2. CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY – 1

#1 Are largescale citizen science data precise enough to determine road-kill patterns? - Pablo Quiles, Fernando Ascensão, Marcello D'Amico, Eloy Revilla, Rafael Barrientos

#2 Using citizen science to survey roadkill at wide spatio-temporal scales - Wendy Collinson

#3 Using citizen science to uncover temporal patterns of wildlife roadkill in the UK - Amy L. W. Schwartz, Robert J. Thomas, Elizabeth Chadwick, Sarah E. Perkins

#4 Integration of sensory qualities in landscape modelling and its effect on infrastructural resilience - Lucía Jalón Oyarzun, Dieter Dietz, Aurélie Dupuis, Julien Lafontaine Carboni

SESSION 5.3.1. MANAGING BIODIVERSITY ALONG ROAD VERGES

#1 Integrating the ecological quality of highway verges in the road assets: a new evaluation tool - Marguerite Trocmé

#2 Testing wild plants seed mixtures along grey infrastructures - Mariana P. Fernandes, Paula Matono, Carla Pinto-Cruz, Anabela Belo

#3 Using remote-sensing to map suitable road verges for a rare small mammal, the Cabrera vole (Microtus cabrerae) - Francesco Valerio, Eduardo Ferreira, Sérgio Godinho, Ricardo Pita, António Mira, Nelson Fernandes, Sara M. Santos

#4 How roadside belts can be managed for a sustainable environment? - Noreen Khalid, Naila Hadayat, Sumreen Anjum

#5 Road Ecology, Challenges and Mitigation: A case study from Abohar Wildlife Sanctuary, Fazilka, Punjab, India - Khursid A. Khan, A. K. Bhardwaj, S. P. Goyal, A. Rajvanshi, K. Ramesh

#6 Results of the management on biodiversity along species rich roadsides in Sweden - Mats Lindqvist, Johanna Lindberg

SESSION 5.3.2. INFRASTRUCTURE ECOLOGICAL MITIGATION AND DEFRAGMENTATION – 4

#1 Ecological efficiency of an eco-bridge: Lessons from the Adrets-de-L'Esterel eco-bridge on the A8 Highway (Southeast of France) - Jean-Louis Malfère, Hippolyte Pouchelle, Christian Xhardez, Dorothée Labarraque

#2 Importance of roadside habitats for biodiversity: what do we know? - Svenja B. Kroeger, Marcello D'Amico, Hans M. Hanslin, Knut A. Hovstad, Johannes Kollmann; Tommy Lennartson

#3 Monitoring of green bridges in Austria - Brigitte Sladek, Elisabeth Ransmayr

#4 The SLOSS dilemma of road ecology – Single Large Or Several Small fauna passages? - Jan Olof Helldin

#5 Towards next level in Road Ecology: from counting road-kills to assessing population impacts - Rafael Barrientos, Fernando Ascensão, Marcello D'Amico, Clara Grilo, Henrique M. Pereira

#6 Is Connectivity Conservation via Wildlife Corridors/Linkages Sufficient? - Fraser Shilling

SESSION 5.3.3. ROAD ECOLOGY: IMPACT ASSESSMENT, MITIGATION AND MONITORING – 4

#1 Wildlife hotspots prediction with artificial intelligence algorithms, geographic information systems and multispectral image processing - Juan Carlos González-Vélez, Juan Carlos Jaramillo-Fayad, Juan Pablo Murillo-Escobar, Maria Constanza Torres-Madroñero

#2 A simple analytical model for predicting the fence-end effect and the minimum length for wildlife fencing to be effective - Jochen A. G. Jaeger, Stefano Re

#3 Prioritizing road sections for wildlife fencing: Including the fence-end effect - Stefano Re, Jochen A.G. Jaeger

#4 Standardized WVC Data Collection at Large Extents - Fraser Shilling

#5 Road mortality mitigation measures: concrete fence for amphibians - Antonin Conan, Meven Le Brishoual, Lorène Garnier, Nicolas Durr, Nathan Dehaut, Jonathan Jumeau, Jean-Yves Georges, Yves Handrich

#6 Canopy bridges: Innovative mitigation solutions for arboreal mammals - Tremaine Gregory, Fernanda Abra, Farah Carrasco Rueda, Jessica Deichmann, Joseph Kolowski, Alfonso Alonso

Lightning Talks

SESSION 1.3.4A. MANAGING INFRASTRUCTURE MARGINAL HABITATS FOR BIODIVERSITY

#1 Developing road verges' hosting capacity for wild bees: why and how - Denis François, Violette Le Féon

#2 Moving on the verge: effects of traffic intensity and quality of the road verge on the movement of pollinating insects - Juliana Dániel Ferreira, Jörgen Wissman, Åsa Berggren, Erik Öckinger

#3 Both roads and power line corridors contribute to landscape scale biodiversity of plants and insects - Erik Öckinger, Juliana Dániel-Ferreira

#4 Feasibility of local partnerships for a more biodiversity-friendly management of linear infrastructure right-of-ways - Denis François, Claire Etrillard, Pascal Gastineau

#5 Enhancing biodiversity on Great Britain's railway network - Richard Pywell, Neil Strong, Rory O'Connor

SESSION 1.3.4B. MANAGING AND MONITORING ECOLOGICAL IMPACTS OF LINEAR INFRASTRUCTURES

#1 Environmental monitoring of reptiles across a wildlife overpass - Marcus Elfström, Mats Lindqvist

#2 Avian electrocution risk: a framework for prioritizing the conservation of species and areas across large spatial scales - L. D. Biasotto, F. Moreira, G. A. Bencke, M. D'Amico, A. Kindel, F. Ascensão

#3 The Afsluitdijk, an important ecological connection - Dennis Wansink, Sophie Lauwaars

#4 How well fences work? - Andrius Kučas, Linas Balčiauskas

#5 Green and blue infrastructure: How trees can accompany our rivers and canals Conflicts - Solutions – Implementation - Katharina Dujesiefken

SESSION 2.3.3A. NEW TOOLS TO MITIGATE AND MONITOR ECOLOGICAL IMPACTS OF ROADS

#1 Making the road more permeable to wildlife using existing infrastructure - Dishane Hewavithana, Devaka Weerakoon, Christopher Searcy

#2 New real-time mitigation measures based on animal-vehicle collision spatio-temporal models - Victor Javier Colino-Rabanal, Roberto Rodríguez-Diaz, Maria Jose Blanco-Villegas, Miguel Lizana Avia

#3 Daily, Annual and interannual variations of wildlife underpasses use by small and medium-sized mammals: a study case in the agricultural plain of the Bas-Rhin, France - Jonathan Jumeau, Robert Matthieu, Oriane Marquot, Françoise Burel, Yves Handrich

#4 A comparison of camera trap and permanent recording video camera efficiency in wildlife underpasses - Jonathan Jumeau, Lana Petrod, Yves Handrich

#5 Bat Overpasses as a Solution to Increase Habitat Connectivity Depending on the Context - Fabien Claireau, Yves Bas, Jean-François Julien, Nathalie Machon, Cédric Heurtebise, Philippe Chavaren, Benjamin Allegrini, Sébastien J. Puechmaille, Christian Kerbiriou

SESSION 2.3.3B. INFRASTRUCTURE ECOLOGICAL MITIGATION AND RESTORATION – 2

#1 From dumpsite to nature sanctuary - Thomas Schuh, Alexandra Wieshaider, Joahanna Scheiblhofer

#2 A guidance system for amphibians made of recycled guardrails in Kirchberg on the Raab (County Styria / Austria) – a successful alternative - Frank Weihmann, Wolfgang Lanner

#3 Condition of amphibian road mitigation constructions in Sweden - Emma Håkansson1 Jan Olof Helldin

#4 Design and test of a semi-automated system based on time-lapse camera trapping for the monitoring of wildlife overpass use by amphibians - Julian Pichenot, Céline Muller, Stéphanie Aravecchia, Cédric Pradalier, Gérald Tekielak, Alain Morand

#5 Species-rich Energy production - Anders Sjölund, Eva Ditlevsen, Julia Litborn, Håkan Johansson

#6 A dynamic restoration index to monitor and assess fragmentation reduction along a trans-Andean pipeline - Reynaldo Linares-Palomino, Héctor Chuquillanqui Soto, Bruno Vildoso-Giesecke, Godofredo Mamani, Alfonso Alonso

SESSION 4.3.4A. ROADKILLS IMPACT ASSESSMENT, MITIGATION AND MONITORING

#1 Assessing the relative effect of road- and carcass-related factors on searcher efficiency: implications for future roadkill monitoring programmes - Joana Bernardino, Regina Bispo, Francisco Moreira, Sara Santos

#2 Evaluation of the impact of road infrastructure on vertebrate mortality and possible measures for ecological connectivity in the landscape in the Aburra Valley, Colombia - Juan Carlos Jaramillo-Fayad, Maria Mercedes Velásquez-López, Juan Carlos González-Vélez, Jose Luis González-Manosalva

#3 The most roadkilled mammal species in Brazil, considering sampling effort, detectability and removal rates - Simone Freitas, Fernando Pinto, Douglas W. Cirino, Rubem Dornas, Fernanda Teixeira

#4 Are movement corridors coincident with areas of high road-kill likelihood? A study for felids in Brazil - Rafaela Cobuci Cerqueira, Paul Leonard, Lucas Gonçalves da Silva, Alex Bager, A. P. Clevenger, Jochen A. G. Jaeger, Clara Grilo

#5 A Transport Ecology Workshop towards developing sustainable transportation in national and international level in Myanmar - Hans Bekker, Lazaros Georgiadis, Elke Hahn, Sai Than Lwin, Hanna Helsingen

SESSION 4.3.4B. WILDLIFE AND LINEAR INFRASTRUCTURE INTERACTIONS: FIELD MONITORING AND ECOLOGICAL SOLUTIONS – 3

#1 Birdprotection on railways - Julian Heger, Gerold Punz, Thomas Schuh

#2 The need to consider searcher efficiency and carcass persistence in railway wildlife fatality studies - Bibiana Terra Dasoler, Andreas Kindel, Júlia Beduschi, Larissa D. Biasotto, Rubem A. P. Dornas, Larrissa Oliveira Gonçalves, Pryscilla Moura Lombardi Talita Menger, Gabriela Schuck de Oliveira, Fernanda Teixeira

#3 Routing power lines in Brazil: towards an environmental and engineering friendly framework for reducing conflicts in the planning phase - L. D. Biasotto, F. G. Becker, A. A. R. Nobrega, A. Kindel

#4 Level and spatial scale of impact from different linear development types - Dishane Hewavithana, Devaka Weerakoon, Mayuri Wijesinghe, Christopher Searcy

#5 Shedding a Light on Sensory Pollution in Road and Railway Ecology - Manisha Bhardwaj

SESSION 5.3.4A. NEW TOOLS AND TECHNOLOGIES TO PREVENT AND MONITOR LINEAR INFRASTRUCTURE IMPACTS – 2

#1 Is field technician's work under threat? Video-recoding vs. traditional observation for monitoring flight behaviour of birds across a high-speed railway - A. E. Santamaría, G. Fabbri, J. E. Malo, I., Hervás, C. Mata, J. Herranz

#2 An analysis of Vulture mortalities on powerlines in South Africa from 1996 – 2018 - Lourens Leeuwner, Kishaylin Chetty

#3 Hotspots in the Grid: The Spatial Distribution of Bird-Energy Interactions in Europe and North Africa - Jethro Gauld, Wolfgang Fiedler, Steffen Oppel, Andrea Flack, Flavio Monti, Olivier Duriez, Andrea Sforzi, Carlos Carrapato, Thomas Lameris, Andrea Flack, Andrea Koelzsch, Guilad Friedemann, Ivan Pokrovsky, Klaus-Michael Exo, Ramunas Zydelis, Midaugas Dagys, Ran Nathan, Bernd Vorneweg, Dimitri Giunchi, Hristo Peshev, Jocelyn Champagnon, Johannes Fritz, Martin Wikelski, Emmanuel Pixner, Jose Manuel Lopez-Vazquez, Mariëlle Van Toor, Jonas Waldenström, Julio Blas, Pascual López-López, Peter Desmet, René Janssen, Robin Séchaud, Stefan Garthe, Stoyan Nikolov, Vladimir Dobrev, Volen Arkumarev, Elzbieta Kret, Victoria Saravia, João P. Silva, Philip W. Atkinson, Paul Record, Aldina Franco

#4 Using drones to track nest occupancy - Hippolyte Pouchelle, Erwan Carfantan Dorothée Labarraque

#5 Artificial Intelligence-Based Detection of (no-)Animals in Camera Trap Images - Fraser Shilling

SESSION 5.3.4B. CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY – 2

#1 Validity of road-based data collected by volunteers for wildlife population monitoring - Silviu Petrovan, Candida Vale, Neftali Sillero

#2 Identifying risk areas for hedgehog road collisions using citizen science data - Fiona Mathews, Patrick Wright, Frazer Coomber

#3 A vision of a sustainable infrastructure by 2050 in different countries - Amanda Sjölund, Linda Larsson

Poster Communications

SESSION 1.1.3.

INNOVATIVE SOLUTIONS FOR LINEAR INFRASTRUCTURE IMPACT ASSESSMENT, MITIGATION AND MONITORING

#1 Wildlife crossing structures aid bats with a high-risk collision to cross the road safely - Célia Lhérondel, Cédric Heurtebise, Thibaut Ferraille, Philippe Chavaren, Benjamin Allegrini, Fabien Claireau

#2 Geographically Weighted Regression for modelling amphibian road-kills: comparison with other modelling methods - Diana Sousa Guedes, Marc Franch, Neftalí Sillero

#3 Are roads and railroads barriers for the moor frog? - Edgar A. van der Grift, G. Arjen de Groot, Fabrice G. W. A. Ottburg, Dennis R. Lammertsma, Ivo Laros, Jan Bovenschen

#4 Evaluating the effectiveness of a wildlife overpass in restoring gene flow in a slow worm population - Edgar A. van der Grift, G. Arjen de Groot, Fabrice G. W. A. Ottburg, Hugh A. H. Jansman, Ivo Laros

#5 Use of wildlife overpasses by roe deer: What are the effects of human co-use? - Edgar A. van der Grift, Dennis R. Lammertsma, Martin Waanders

#6 Comparative study between environmental DNA method and electrical fishing method - Florent Skariak, Amandine Hibert

#7 gDefrag: a graph-based tool to prioritize linear infrastructure defragmentation - Frederico Mestre, A. Márcia Barbosa, Fernando Ascensão

#8 Development of a Video Image Analysis System for Reducing Operation on Surveys of Wildlife Behavior - Fumihiro Hara, Masato Sato, Misako Noro

#9 Effectiveness of road and railway bridges for reindeer and wildlife movements – an ongoing project - Jan Olof Helldin, Mattias Olsson, Torbjorn Nilsson, Niklas Kemi

#10 Optimising the ring road of Europe's capital: integrating enhancements in mobility, ecology and public involvement - Jelle Vercauteren, Guy Heutz

#11 Quantifying the individual impact of artificial barriers in freshwater: operationnal technology transfer of a standardized and absolute index of genetic connectivity to regulatory studies - Jérôme G. Prunier, Camille Poesy, Vincent Dubut, Charlotte Veyssière, Géraldine Loot, Nicolas Poulet, Sylvain Moulherat, Simon Blanchet

#12 Standardisation of camera-trap monitoring of wildlife crossings - Jim Casaer Jim, Lien van Besien, Tanja Milotic, Peter Desmet, A. Patrick Jansen

#13 Biodiversity information tool to supporting Environmental impact assessment - Jordi Solina, Gemma Vila, Paula Bruna, Eva Lahoz, Anna Ferrés, Israel Estopà, Susanna Carbajo, Antoni Sorolla

#14 Predicting wildlife collisions hotspots based on machine learning and GIS: A case study in a tropical dry forest area in Colombia - Juan Carlos González-Vélez, Juan Carlos Jaramillo-Fayad, Juliana Ríos-Barberi, Juan Pablo Murillo-Escobar

#15 Ecologically friendly erosion control - Lien van Besien, Karl Fonteyne, Steven De Maesschalck, Jan Van Raak, Gregory Quaegebeur

#16 The NOTEE VA method - Ludovic Le Contellec, Caroline Mallo, Ian Jannet, Anaïs Bataille, Agathe Idelon, Guillaume Laffont

#17 Long-Term Monitoring of ecological Impacts from a Road Project in Denmark 2012-2020 - Martin A Hesselsoe, J. L. Nielsen, Nadieh deJonge, Rune Sø Neergaard, Per Gørtz5, Niels Krogh, Christina Steenbeck

#18 Mitigation measures for wet grasslands, wader birds and amphibians along rail and road infrastructure in south west Sweden - Mats Lindqvist, Moa Naalisvaara Engman, Ola Sjöstedt, Calle Bergil

#19. Prevention of Deer-train collisions by a deterrent sound - Minoru Shimura, Tomoyoshi Ushiogi, Masateru Ikehata

#20 Green Urban Areas: critical patches for biodiversity & ecosystem connectivity - Nefta-Eleftheria Votsi

#21 A clustering analysis should precede the identification of local factors: evidence based on the Czech WVC data - Richard Andrášik, Michal Bíl, Jiří Sedoník

#22 Use of drainage pipes as underpasses by wild mammals in Southeast Brazil - Scarlat Dalva Ferreira, Jorge Ferreira Lima Neto, Lerrane de Fátima Cunha, Carlos Henrique de Freitas

CHALLENGES AND OPPORTUNITIES FOR HABITATS RELATED TO LINEAR INFRASTRUCTURES

#1 New approach to mitigate bird-window collisions - Dominique Waddoup, Bettina Kain; Melanie Gröbl, Thomas Schuh

#2 Enabling wildlife to cross linear transport infrastructures - Examples of infrastructure requalifications - Collection of 12 sheets - Jean-François Bretaud, Jean Carsignol, Marc Gigleux, Alain Morand, Sophie Berlin, Agnès Rosso Darmet, Claude Guillet, Jonathan Jumeau, Christophe Herve

#3 Evidence of the positive impact vegetation management of power lines corridors on habitats and species: feed-back of LIFE Elia-RTE in Belgium - Jean-François Godeau

#4 Enhancing biodiversity on Great Britain's railway network - Richard Pywell, Neil Strong

#5 High occurrence of pollinating insects on new ecoduct in western Sweden - Sofia Berg, Mats Lindqvist

#6 Power line rights-of-way and pollinators: A partnership to develop! - Véronique Michaud

LINEAR INFRASTRUCTURE ECOLOGY

#1 Temporal patterns of humans and ungulates at bridges - Co-existence or disturbance? - Fabian Knufinke, Jan Olof Helldin, Manisha Bhardwaj, Mattias Olsson

#2 Bird species more frequently recorded in roadkill studies in Europe: A review using a trait-based - Federico Morelli, Ricardo Rodríguez, Yanina Benedetti, Juan D. Delgado

#3 Effects of noise from transport infrastructure on bats - Fiona Mathews, Finch Domhnall, Jerem Paul

#4 Modelling roadkill hazard zones for ten different vertebrate species in Austria using remote sensing data, expert knowledge and previous studies - Florian Heigl, Daniel Dörler, Mathias Schardt, Florian Schöggl, Carina Sobe, Rainer Prüller, Silke Schweiger, Susanne Stückler, Norbert Teufelbauer, Christina Nagl, Erwin Nemeth

#5 Roads as a driver of changes in the bird community and disruptors of Ecosystem Services provision - Joana Araújo, Rodrigo Bergamin, Inês Catry, Fernando Ascensão

#6 Potential ecological impacts and their mitigation of Central Asia-South Asia (CASA-1000) transmission line: Afghanistan part - Khalid Farooq Akbar

#7 Evaluation of selected methods to control invasive species along transportation linear infrastructures: a preliminary approach - Mariana P. Fernandes, Paula Matono, Anabela Belo, Carla Pinto-Cruz

#8 A chronicle of brown bear-vehicle collisions in Greece - Maria Psaralexi, Yiorgos Mertzanis, Maria Lazarina, Danai-Eleni Michaelidou, Stefanos Sgardelis

#9 Mitigation measures on Alqueva Irrigation Project canals - Rita Azedo, Ana Ilhéu

#10 Measures to favour the pollinators in environmental restoration - Susanna Carbajo, Jordi Solina, Israel Estopà, Antoni Sorolla, Anselm Rodrigo, Jordi Bosch

#11 Monitoring fauna in the road environment - Teillagorry Manon, Anne-Claire De Rouck, Florian Fournier, Olivier Pichard

#12 Temporal patterns in animal-vehicle collisions based on neural networks and temporal density functions - Victor Javier Colino-Rabanal, Roberto Rodríguez-Diaz, Maria Jose Blanco-Villegas, Miguel Lizana Avia

CITIZEN SCIENCE AND THE INVOLVEMENT OF CIVIL SOCIETY

#1 A comparison of state-wide databases related to bird roadkill in Czechia - Michal Bíl, Zbyněk Janoška, Jan Kašinský, Jan Kubeček

LEGISLATION AND POLICY

#1 Risk-based Conservation Plan of fauna passages - Claudia Rodrigues

#2 The Impact on Bats of Traffic Infrastructure: Eurobats Guidance - Jean Matthews, Fabien Claireau, Jasja Dekker, Branko Karapandža, Primož Presetnik, Charlotte Roemer

Workshops

SESSION 2.1.1. A REVIEW OF WILDLIFE-VEHICLE CONFLICT OBSERVATION SYSTEMS

Fraser Shilling, Wendy Collinson, Michal Bil, Diemer Vercayie, Florian Heig, Sarah E. Perkins, Sandra MacDougall

SESSION 2.1.2. MITIGATING RAILWAY IMPACTS ON WILDLIFE

Andreas Seiler, Marina Torrellas, Carme Rosell, Manisha Bhardwaj, Mattias Olsson

SESSION 2.1.3. ADVANCING THE ROLE OF NGOS TO PROMOTE WILDLIFE-FRIENDLY INFRASTRUCTURE

Rob Ament, Kate Newman, Nilanga Jayasinghe

SESSION 2.2.1. DEVELOPMENT OF AN INDICATIVE EUROPEAN DEFRAGMENTATION MAP (IEDEM) AS A CONTRIBUTION TO PRESERVING EXISTING NATIONAL AND INTERNATIONALLY IMPORTANT GREEN INFRASTRUCTURE WHILE TRANSPORT INFRASTRUCTURE IMPROVEMENTS ARE DELIVERED WITHIN EUROPE

Marita Böttcher, Cindy Baierl

SESSION 2.2.2. HELPING TIGERS, RHINOS, AND ELEPHANTS CROSS THE ROAD: WILDLIFE FRIENDLY INFRASTRUCTURE MEASURES IN ASIA

Nilanga Jayasinghe, Nirmal Bhagabati, Kate Newman, Hanna Helsingen, Rodney van der Ree

SESSION 2.3.1. WILDLIFE AND TRAFFIC HANDBOOK UPDATE: TOWARDS EUROPEAN STANDARDS FOR FAUNA PASSAGES AND FENCING

Carme Rosell, Luc Chrétien, Eric Guinard, Antonio Righetti, Cécile Eicher, Marguerite Trocmé, Václav Hlaváč, Andreas Seiler

SESSION 2.3.2. NFRASTRUCTURE, BIODIVERSITY AND HEALTH

Wendy Collinson, Fraser Shilling, Yannick Autret

SESSION 2.3.4. CORRIDORS AND CROSSINGS: "GUIDANCE FOR CONNECTIVITY CONSERVATION IMPACTED BY LINEAR TRANSPORTATION"

Rob Ament, Rodney van der Ree

SESSION 3.1.1. THE POTENTIAL OF SMART TECHNOLOGIES FOR ECOLOGICAL PLANNING AND LANDSCAPE MEASURES

Sven Reiter

SESSION 3.2.1. AN INTERNATIONAL STRATEGY AND ACTION PLAN FOR STAKEHOLDERS' ENGAGEMENT ON SUSTAINABLE TRANSPORT AND OTHER LINEAR INFRASTRUCTURE

Lazaros Georgiadis, Rob Ament, Anders Sjolund, Elke Hahn, Marita Böettcher, Rodney van der Ree, Kate Newman, Wendy Collinson, Lourens Leeuwner, Fraser Shilling, Hans Bekker, Yun Wang, Fiona Mathews, Andreas hSeiler, António Mira, Carme Rosell

SESSION 3.2.2. PLANTING AND PRESERVATION OF TREES ON DAMS AND DYKES AS A PART OF GREEN INFRASTRUCTURE: CONFLICTS - SOLUTIONS - IMPLEMENTATION

Katharina Dujesiefken, Piotr Tyszko-Chmielowiec

SESSION 3.3.1. GLOBAL CONGRESS: LINEAR INFRASTRUCTURE AND ENVIRONMENT (GCLIE): A PLATFORM TO ENHANCE COOPERATION AND COORDINATED ACTION BETWEEN THE EXISTING CONTINENTAL CONFERENCES ON ECOLOGY AND INFRASTRUCTURE

Fraser Shilling, Wendy Collinson-Jonker

SESSIONS 3.3.2. AND 3.3.3. ROAD SIDES AS ECOLOGICAL TRAPS – CHALLENGES AND SOLUTIONS: CHANGED BIOTIC INTERACTIONS DUE TO NON-NATIVE SEED MIXTURES AND INVASIVE ALIEN PLANTS

Johannes Kollmann, Larissa Uhe, Marcello D'Amico, Hans Martin Hanslin, Knut Anders Hovstad, Svenja Kroeger, Tommy Lennartsson, Jörgen Wissman, Anna Westin, Jan-Olof Helldin, Jan Christian Habel

Side Events

LIFE LINES FINAL SEMINAR

SESSION 1.2.1. LIFE LINES FINAL SEMINAR – 1

#1 Linear Infrastructure Networks with Ecological Solutions - Nuno M. Pedroso, Anabela Belo, João Craveiro, Sofia Eufrázio, Mariana P. Fernandes, Paula Matono, André Oliveira, Tiago Pinto, Carla Pinto-Cruz, Luis Guilherme Sousa, António Mira

#2 IP's participation in LIFE LINES: Reducing fauna roadkills and defragmenting habitats - Graça Garcia

#3 Bustards and power lines in Portugal: an overview of research done so far and its implications on impact assessment, mitigation and planning - João Paulo Silva, Ana Teresa Marques

#4 Predicting wildlife-vehicle collisions using movement simulation models with the novel software SiMRiv - Lorenzo Quaglietta, Miguel Porto, Adam Ford

#5 LIFE, Biodiversity and Infrastructures - Isabel Lico, Ana M. Santos

#6 Implementation of volunteer environmental programs - Rosa Coelho, Marta Mattioli, Lúcia Pereira

SESSION 1.2.2. LIFE LINES FINAL SEMINAR – 2

#1 Assessing behaviour states in a forest carnivore in a road-dominated landscape with hidden Markov models - Eduardo Ferreira, Francesco Valerio, Nelson Fernandes, João Craveiro, Pedro Costa, Denis Medinas, João Paulo Silva, Carlos Carrapato, Filipe Carvalho, António Mira, Sara Santos

#2 Effectiveness of amphibian mitigation measures to reduce roadkills in low traffic roads - Tiago Pinto, Luis Guilherme Sousa, António Mira

#3 Road effects on Tawny owls (Strix aluco): patterns in road-kills, abundance, population trend, and movements - Rui Lourenço, Fernando Goytre, Shirley van der Horst, Ana Marques, Denis Medinas, André Oliveira, Pedro Pereira, Pandora Pinto, Sara Santos, António Mira

#4 Minimization of electrocution risk in priority areas for the Iberian Imperial Eagle (Aquila adalberti) - Paulo A. M. Marques, Bruno H. Martins , Liliana Barosa, Hugo Lousa, Carlos Rochinha, Rita Alcazar

#5 Protocols Avifauna – Joint efforts to mitigate bird mortality in powerlines - Julieta Costa, Rita Alcazar, Samuel Infante, Rui Machado, Rita Ramos, Paulo Alves, Carlos Rochinha

#6 Can power lines poles bases be used as habitat promotion? - Mariana P. Fernandes, Paula Matono, Carla Pinto-Cruz, Anabela Belo

LIFE SAFE CROSSING WORKSHOP: INNOVATIVE TECHNIQUES TO MITIGATE TRANSPORTATION INFRASTRUCTURE IMPACT ON LARGE CARNIVORES

SESSION 3.1.2. LIFE SAFE CROSSING SEMINAR: INTRODUCTION TO THE WORKSHOP AND TOPICS CONCERNING LARGE CARNIVORES AND TRANSPORT

#1 LIFE SAFE-CROSSING: the project overview - Annette Mertens, Simone Ricci, Fabio Papini

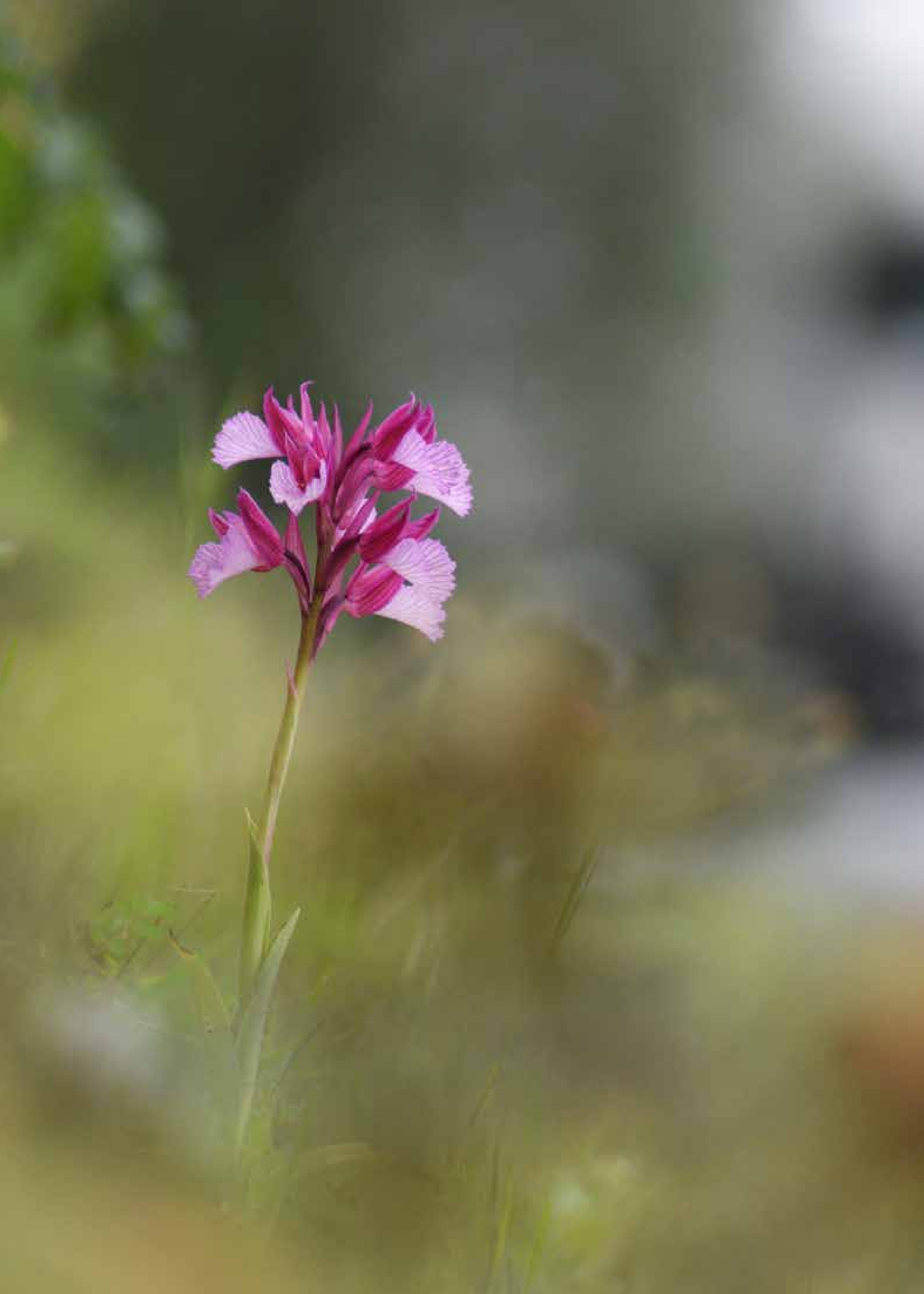
#2 Large carnivores and transportation infrastructure: a review - Djuro Huber

#3 Planning measures to avoid Animal-Vehicle Collisions: the approach of the LIFE SAFE-CROSSING Project targeting the Apennine brown bear - Mario Fabrizio, Giovanna Di Domenico, Antonio Antonucci

#4 Adapting underpasses to be used as wildlife crossings: An action of the LIFE SAFE-CROSSING project to reduce large carnivore habitat fragmentation - Marcos López, Carme Rosell, Marina Torrellas, Matias De Las Heras Carmona

#5 LIFE SAFE-CROSSING in Greece: Analysis and mapping of crossing structures on the A29 and activities to enhance connectivity through interventions on underpasses and road sides - Maria Psaralexi, George Lyberopoulos, Elina Theodoropoulou, Yiannis Tsaknakis, Athanasios Tragos, Yiorgos Lazaros, Niki Voumvoulaki, Carme Rosell, Marina Torrellas, Spyros Psaroudas, Yiorgos Mertzanis

#6 Increasing awareness to encourage the adoption of driving behaviour to reduce AVC risk: new approach applied at LIFE SAFE-CROSSING - Laura Scillitani, Roberta Latini, Annette Mertens, Simone Ricci



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