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MAINSTREAMING BIODIVERSITY WITHIN ROAD INFRASTRUCTURE PROJECTS

A PIARC COLLECTION OF CASE STUDIES

TECHNICAL COMMITTEE 3.4 *ENVIRONMENTAL SUSTAINABILITY IN ROAD INFRASTRUCTURE AND TRANSPORT*

STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020–2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

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A PIARC COLLECTION OF CASE STUDIES

TECHNICAL COMMITTEE 3.4 - *ENVIRONMENTAL SUSTAINABILITY IN ROAD INFRASTRUCTURE AND TRANSPORT*

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EXECUTIVE SUMMARY

2023R45EN

MAINSTREAMING BIODIVERSITY WITHIN ROAD INFRASTRUCTURE PROJECTS

A PIARC COLLECTION OF CASE STUDIES

This document is an appendix to the Full Report 2023R44EN, and it contains the Case Studies collected by the WG3.4.3 team; the chapters listed here are those that structure the Full Report. The case studies illustrate the theoretical elements written in the Full Report.

The development of transport infrastructure is one of the basic elements of the development of countries and their economies. Economic development is often accompanied by environmental protection problems, including biodiversity impacts, because they have not been taken enough into account. Preventing land fragmentation, preserving biodiversity and continuity of ecological corridors is one of the most important challenges for transport infrastructure stakeholders.

The report is a global guide for specialists and decision makers planning, implementing, and managing transport infrastructure. Improperly prepared road network development plans and projects may lead to deep changes in their surroundings. In addition to adverse impacts on humans, impacts on defragmentation and biodiversity are often final. Road and traffic impacts can often lead to irreversible changes. Repair attempts can often fail or involve long-term repair programs with significant economic impact.

Regardless of location in the world, several biodiversity-related activities are universal. These activities and measures were included in the report as recommendations for both newly developed transport solutions and those that have already been created, are exploited and have a significant impact on biodiversity. The report, prepared by members of TC 3.4.3 "Road and road transport impact on wildlife habitats and their interconnections", is based mainly on their experiences from many countries. In accordance with the already known principles that are used in transport solutions, it promotes the basic principle "avoid impact and if it is impossible, apply mitigation measures and, if necessary, also apply compensatory measures". Necessary action in the management of biodiversity also includes monitoring and evaluation of the effectiveness of the measures used.

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5. REGULATIONS / LAWS

Case studies

Regulations in European Union

Regulations in Canada

Regulations in Japan

5.1. Regulations in European Union

Author: Elke HAHN

The EU has developed quite strict and widespread nature conservation legislation. In regards to transportation infrastructure, the most important directives are:

The **Strategic Environmental Assessment (SEA) Directive**, the Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment. It has been in force since 2001 and applies to a wide range of public plans and programmes. The environmental report has to identify, describe and evaluate the "likely significant effects on the environment of implementing the plan or programme, and reasonable alternatives taking into account the objectives and the geographical scope of the plan or programme." (Art. 5, SEA Directive).

The **Environmental Impact Assessment (EIA) Directive**, the Directive 2014/52/EU, amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. It has been in force since 1985 and has been amended several times. The EIA procedure includes the development of an environmental impact assessment report, which should include an analysis of alternatives (including a "no project" alternative), a description of the baseline environmental conditions and their likely future trends, an assessment of the provisioned project impacts, as well as avoidance, mitigation and/or compensation measures, established for ensuring no significant impact. The following factors are named for the investigation about possible impacts: Population and human health, biodiversity, with particular attention to species and habitats protected under Directive 92/43/EEC and Directive 2009/147/EC, land, soil, water, air and climate, material assets, cultural heritage and the landscape as well as the interaction between these factors.

The **Habitats Directive**, the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, aims to ensure the conservation of a wide range of rare, threatened or endemic animal and plant species as well as rare and characteristic habitat types. It forms the cornerstone of Europe's nature conservation policy with the Birds Directive and establishes the EU wide Natura 2000 ecological network of protected areas, safeguarded against potentially damaging developments. Apart from that, the directive contains regulations for strict species protection for all species named in Annex IV, which is not restricted to the protected areas but has to be applied to the whole member state area.

The **Birds Directive**, the Directive 2009/147/EC on the conservation of wild birds. It aims to protect all of the 500 wild bird species naturally occurring in the European Union with great emphasis on the protection of habitats for endangered and migratory species. It establishes a network of Special Protection Areas (SPAs) including all the most suitable territories for these species. Since 1994, all SPAs are included in the Natura 2000 ecological network, set up under the Habitats Directive. Apart from that, the directive contains regulations for strict species protection for all wild bird species, which is not restricted to the protected areas but has to be applied to the whole member state area.

The **Aarhus Convention**, the United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters. It entered into force in 2001 and establishes a number of rights of the public (individuals and their associations) with regard to the environment.

The **Espoo Convention** sets out the obligations of Parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries. The Convention entered into force in 1997.

In 2013, the Commission adopted the **Green Infrastructure Strategy** promoting investments in green infrastructure, to restore the health of ecosystems, ensure that natural areas remain connected together, and allow species to thrive across their entire natural habitat, so that nature keeps on delivering its many benefits to us. The strategy promotes the deployment of green infrastructure across Europe as well as the development of a Trans-European Network for Green Infrastructure in Europe, a so-called TEN-G, equivalent to the existing networks for transport, energy and ICT. Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity. The Natura 2000 network constitutes the backbone of the EU green infrastructure.

The EU's **Biodiversity Strategy** for 2030 is an ambitious long-term plan to protect nature and reverse the degradation of ecosystems. It contains specific actions and commitments to be delivered by 2030. The Strategy aims to increase the environments and the societies' resilience to future threats like the impact of climate change, food insecurity or natural hazards, but also - as set in the post-COVID-19 context - disease outbreaks. It is a core part of the European Green Deal and is supposed to also support a green recovery following the Covid-19 pandemic.

5.1.1. References

- Strategic Environmental Assessment - SEA - Environment - European Commission (europa.eu)
- Environmental Impact Assessment - EIA - Environment - European Commission (europa.eu)
- The Habitats Directive - Environment - European Commission (europa.eu)
- The Birds Directive - Environment - European Commission (europa.eu)
- Aarhus Convention - Environment - European Commission (europa.eu)
- Environmental assessment | UNECE Espoo
- Green Infrastructure - Environment - European Commission (europa.eu)
- Biodiversity strategy for 2030 (europa.eu)

5.2. Regulations in Canada

Author: Mona ABOUHENIDY

5.2.1. International Guidelines - Canada

Road mitigation is an important means of preventing biodiversity loss and meeting international requirements for biodiversity conservation. Protecting Canada's wild species supports the **United Nations 2030 Agenda** and its global **Sustainable Development Goals** (SDG)—in particular SDG 11, Sustainable Cities and Communities; SDG 14, Life below Water; and SDG 15, Life on Land. It also supports specific SDG targets, as well as other international agreements and initiatives.

Work under this goal supports progress toward the **2020 Biodiversity Goals and Targets** for Canada and the global conservation objectives of the **United Nations Convention on Biological Diversity**—in particular, by ensuring that needed recovery strategies and management plans are in place and that appropriate collaborative action is taken on priority places, species and threats, and by helping to prevent and mitigate impacts from invasive alien species.

5.2.2. National Guidelines

The Federal Sustainable Development Strategy for Canada (FSDS) identifies guiding principles to ensure Canada and provincial, territorial and municipal jurisdictions can meet the international targets. Healthy wildlife populations is one of the goals of the FSDS, where all species have healthy and viable populations. Species can become threatened as a result of habitat loss or deterioration from human activities—for example, agriculture, urban development, invasive alien species, pollution and climate change. Climate change can also affect wildlife health and contribute to the spread of disease.

5.2.3. Provincial and Territorial Guidelines

territorial governments work collaboratively for the protection of species at risk, and many provinces and territories have put in place their own species at-risk legislation. In particular, provinces and territories lead in protecting terrestrial species on provincial, territorial and private land and share responsibility with Canada on protecting freshwater aquatic species. Meanwhile, the federal government leads on aquatic species, migratory birds and species on federal land.

Canada benefits from robust federal and provincial/territorial regulations, which include compliance with environmental legislation, and careful consideration of future operational impacts that might impose longer term environmental impacts (**see Appendix A** below). These assessments also allow transparent evaluation of the management trade-offs that may be required to manage impacts, which can help to satisfy public concerns regarding a given project.

The road engineering design process life cycle across Canada generally incorporates other forms of environmental assessment within functional design, detailed design and construction implementation. During these design stages, advice from an appropriate environmental professional (e.g. wildlife ecologist, vegetation ecologist) can help to identify and mitigate concerns, such as known wildlife travel routes or areas supporting rare plant communities.

Since most road ecology problems are project and site specific, identification and scoping of potential problems is a critical step in evaluating road development and management options to ensure solutions are practical and specific to the concern. For example, early design may recommend wildlife crossing structures be incorporated into a project, but not where.

Environmental professionals can help identify potential problems that could be alleviated through design changes, or flag sites where mitigation may be required, early enough in the process to incorporate into project budgets.

Annex A: Environmental Guidelines and Regulations in Canada		
Regulator	**Legislation**	**Description**
Federal…		
Impact Assessment Agency of Canada	*Impact Assessment Act*	Federal process for impact assessments and the prevention of significant adverse environmental effects. It focuses on major projects and their environmental effects on areas of federal jurisdiction and as a result of federal decisions associated with a project
Environment and Climate Change Canada	*Canadian Environmental Protection Act*	Broader legislative framework for preventing pollution and protecting the environment and human health. Through pollution prevention, the Act includes authorities to control emission performance standards for on-road and off-road vehicles, engines and equipment manufactured in Canada and imported into Canada. * Transport Canada has the authority for regulating emissions from large marine vessels, aircraft and trains through separate legislation.
Environment and Climate Change Canada	*Canada Wildlife Act*	Regulation of the creation, management and protection of wildlife areas for wildlife research activities, or for conservation or interpretation of wildlife.
Environment and Climate Change Canada	*Migratory Birds Convention Act*	Protection of migratory birds and of migratory birds sanctuaries.
…Federal		
Environment and Climate Change Canada	*Species at Risk Act*	Protection of threatened and endangered species and their critical habitat.
Fisheries and Oceans Canada	*Fisheries Act*	Broad protection for fish and fish habitat throughout Canada.

Annex A: Environmental Guidelines and Regulations in Canada		
Parks Canada Agency	*Canada National Parks Act*	Regulates parks, historical sites and wilderness areas set aside to protect habitats and species representative of Canadian biodiversity.
British Columbia		
Environmental Assessment Office	*Environmental Assessment Act*	Provides mechanism for the review of major projects and to assess their potential impacts on the environment.
Alberta		
Alberta Environment and Parks	*Environmental Protection and Enhancement Act*	Regulates the protection, enhancement and wise use of Alberta's environment. Projects reviewed under the Act are evaluated for potential impacts and if safe development can occur.
Saskatchewan		
Ministry of Environment	*Environmental Assessment Act*	Requires developments to undergo an Environmental Impact Assessment to evaluate the potential environmental impacts before any irreversible decisions are made that may lead to negative impacts on the environment, natural resources or public health and safety.
Manitoba		
Manitoba Conservation and Climate	*Environment Act*	Promotes environmental protection for public and private developments with the goal of maintaining resources for future generations.
Ontario		
Ministry of Environment, Conservation and Parks	*Environmental Assessment Act*	Regulates provincial and municipal planning and decision-making processes that considers potential environmental impacts of a development prior to project initiation.
Quebec		
Ministère de l'Environnement, de la Lutte contre les	*Loi sur la qualité de l'environnement*	Protection of the environment and safeguarding the living species that inhabit it. The Act requires that environmental

Annex A: Environmental Guidelines and Regulations in Canada		
changements climatiques, de la Faune et des Parcs		impact studies are carried out for any activities that may pose a high risk to the environment.
Newfoundland and Labrador		
Environment, Climate Change and Municipalities	*Environmental Protection Act*	Regulates developments to protect the environment and facilitate the management of natural resources in the Province.
New Brunswick		
Department of the Environment and Local Government	*Clean Environment Act*	Regulates the environmental impact assessment process for large scale projects (falling under Schedule A of the Act), which evaluates existing environmental conditions and potential impacts associated with the proposed development.
Nova Scotia		
Nova Scotia Environment	*Environment Act*	Promotes the protection of Nova Scotia's environment through environmental assessment regulations for new activities.
Prince Edward Island		
Department of Environment, Water and Climate Change	*Environmental Protection Act*	Promotes the protection of the environment through an environmental assessment process to evaluate potential impacts associated with new developments.
Yukon		
Environmental and Socio-economic Assessment Board	*Environmental and Socio-economic Assessment Act*	Promotes the protection and maintenance of environmental quality and heritage resources through an environmental and socio-economic assessment process.
Northwest Territories		

Annex A: Environmental Guidelines and Regulations in Canada		
Mackenzie Valley Land and Water Board	Mackenzie Valley Resource Management Act (MVRMA) – western NWT	Regulates development applications for projects within the Mackenzie Valley and areas in the region where land claims have not been settled to protect and manage the environment for current and future use.
Environmental Impact Screening Committee (EISC) and Environmental Impact Review Board (EIRB)	*Inuvialuit Land Claim Agreement – NWT (Inuvik Area)*	The Land Claim Agreement established Inuvialuit participation on co-management boards for Environmental Impact Screening and Environmental Review. These boards establish whether an impact assessment is required and the review those assessments. The federal Impact Assessment Act also applies, and assessments are conducted with both Inuvialuit boards and federal agency involvement.
Nunavut		
Nunavut Impact Review Board	*Nunavut Land Claims Agreement*	Establishes the co-management of development and processes for examining land use and development projects within the Territory. EIAs for projects managed through Nunavut Impact Review Board, and through the federal Impact Assessment Act process.

5.2.4. References

- Patriquin, D., Zeller, A. Truman, K., Hayes, R. and Gibbs, S. 2020. Synthesis of Practice for Management and Enhancement of Terrestrial Road Ecology. Ottawa, ON: Transportation Association of Canada.
- Federal Sustainable Development Strategy: https://app.fsds-sfdd.ca/index.html#/en/detail/all/goal:G09

5.3. Regulations in Japan

Author: Sone SHINRI

This section describes the considerations for securing biodiversity relevant to the road project.

5.3.1. International Arrangements

There are some international conventions on road network formation (e.g. Road Traffic Convention). However, these road-related conventions rarely include biodiversity as a special subject.

The Convention on Biological Diversity (Convention) is a representative short international agreement on biodiversity.

This treaty includes:

(1) Biodiversity Conservation

(2) Sustainable use of the components of biodiversity

(3) Fair and equitable sharing of benefits arising from the utilization of genetic resources.

This Convention on Biological Diversity also has other conventions, such as the Convention on the Protection of Species that migrate between national borders.

The above objectives must also be taken into account in the implementation of road projects.

5.3.2. National policy

Contracting Parties to the Convention on Biological Diversity (Convention) are obliged to develop domestic laws to achieve the three objectives of the Conventiony. However, this does not mean that they have to develop specialized laws corresponding to the Convention, but they can fulfill their obligations to the Convention by revising existing laws related to road management and infrastructure development or reviewing the operation of these laws.

5.3.2.1. Example of Japan's response:

In Japan, when ratifying the Convention on Biological Diversity, an inspection of road-related domestic laws and regulations was conducted. As a result, Japan responded to the ratification of the Convention on Biological Diversity by reviewing the operation of existing laws, such as the Environmental Impact Assessment Law, the Road Law, and the Law for Prioritizing Social Infrastructure Development, rather than developing new specialized domestic laws to respond to the Convention.

5.3.2.2. Protection of endangered species:

The survival and protection of species is one of the most important matters in ensuring biodiversity. It is extremely important for government agencies such as the Ministry of the Environment to be aware of the endangered species in a country and to recognize the extent of the risk of extinction. Road managers need to take measures to implement road projects according to this level of risk of extinction.

In the case of Japan, some raptors fall under the category of Endangered II (VU). In addition, not only endangered species, but also raptors in general have many habitats because of their extremely wide range. For this reason, many road projects have focused on the conservation of raptors as a top ecological species.

As a result, a great deal of knowledge has been accumulated and certain results have been confirmed with regard to the conservation of raptors. Some raptors have been categorized as endangered or threatened, and their extinction risk has been reduced as a result of surveys.

5.3.2.3. Example of Japan's response:

The Ministry of the Environment in Japan has been reviewing the Red List (list of endangered wildlife species). In the Red List 2020, the categories were reviewed for 74 species, and the number of endangered species increased by 40 species to a total of 3 716.

Road managers, with reference to the above list, give special consideration in Strategic Environmental Impact Assessments, Environmental Impact Assessments, etc. where Endangered Species II (VU) are associated with road projects.

Table 1: Overview of Red List Categories

Extinction (EX)	Species thought to be already extinct in our country.
Extinction in the Wild (EW)	Species that persist only in captivity, in cultivation, or in a wild state clearly outside their natural distribution range
Critically Endangered I (CR+EN)	Critically Endangered Species
Critically Endangered Class 1A (CR)	Extremely high risk of extinction in the wild in the very near future
Endangered I B (EN)	I. Those with a high risk of extinction in the wild in the near future, although not as high as Class A.
Critically Endangered II (VU)	Species at increased risk of extinction
Near Threatened (NT)	Species with a low extinction risk at present, but with the potential to become "endangered" depending on changes in habitat conditions

Lack of information (DD)	Species for which there is insufficient information to evaluate.
Threatened (species) Local populations (LP)	Populations that are regionally isolated and highly endangered.

5.3.3. Protection of upper ecosystem species

Environmental protection measures should be taken to eliminate or minimize adverse effects such as loss of wildlife habitat when implementing road projects.

In addition to the endangered species, it is necessary to protect the wildlife that composes the ecosystem for the preservation of the ecosystem. In the maintenance of the ecosystem, it is necessary to pay special attention to the species in the upper part of the ecosystem where the number of inhabitants is generally small.

In addition, from the viewpoint of ensuring the traffic safety of road users, it is also necessary to take care that large wildlife such as mammals do not encounter traffic accidents on the road.

5.3.4. Measures against alien species

With the internationalization of human activities, such as international trade and the movement of people between national borders, species that did not previously exist in the area may become contaminated. They may be intentionally imported for the purpose of promoting agriculture, forestry, and fisheries, or they may be unintentionally introduced as a result of the import of agricultural products or the movement of international vessels.

5.3.4.1. Invasive Alien Species Control

In the case of road projects in Japan, there was a period in the 1980s and 1990s when non-native species were used to protect road slopes. However, it was discovered that these non-native species could expand their habitat from the road to the roadside area. At present, it is mandatory to use native species for planting on road slopes, and we carry out inspections and remove non-native species as necessary.

5.3.5. Regional Policy

Ecosystem characteristics vary from region to region. For this reason, regions need to define their ecological considerations according to their actual conditions.

Japanese Regional administrative organizations may prepare ordinances and plans on biodiversity that are consistent with national policies and that take into account the characteristics of the region. In addition, decisions on specific measures to reconcile road network planning with biodiversity are often developed at the planning stage of individual road projects, which is more detailed than the regional policy level.

5.3.5.1. Examples:

In the case of Japan, prefectures, which are the intermediary between the national government and municipalities, establish guidelines for nature conservation based on the actual natural and economic conditions of the prefecture through prefectural ordinances. In addition, information on the habitats of rare species in the region is stored.

6. STUDY MANAGEMENT DURING THE LIFECYCLE OF ROAD INFRASTRUCTURE

Case studies

Protection of migration corridors in spatial planning in the Czech Republic

Spatial Planning – the crucial tool
Good and bad examples from Austria

Detailed environmental processes in life cycle phases of road projects in Europe

Planning stages / construction / operation (maintenance) in Canada

Detailed environmental processes planning of road projects in Japan

6.1. Protection of migration corridors in spatial planning in the Czech Republic

Author: Kristýna NEUBERGOVÁ

The legal protection of migration corridors in the Czech Republic is generally based on the fact that migration corridors are designated for protected species of large mammals (large carnivores and moose). Local populations of these species cannot exist unless they are interconnected. Migration corridors are therefore an essential part of the habitat of these species (similar to, for example, amphibian migration corridors between breeding sites and terrestrial habitats). According to the Nature Protection Act, specially protected animals are protected not only as individuals, but their biotope is also protected.

6.1.1. Legal principles of inclusion of migration corridors into spatial plans

- Large carnivores and the moose belong to the "species of national importance" in the Czech Republic.
- Habitat of species of national importance is obligatory to be incorporated into spatial planning
- Habitat of protected species includes both the core areas and migration corridors connecting them

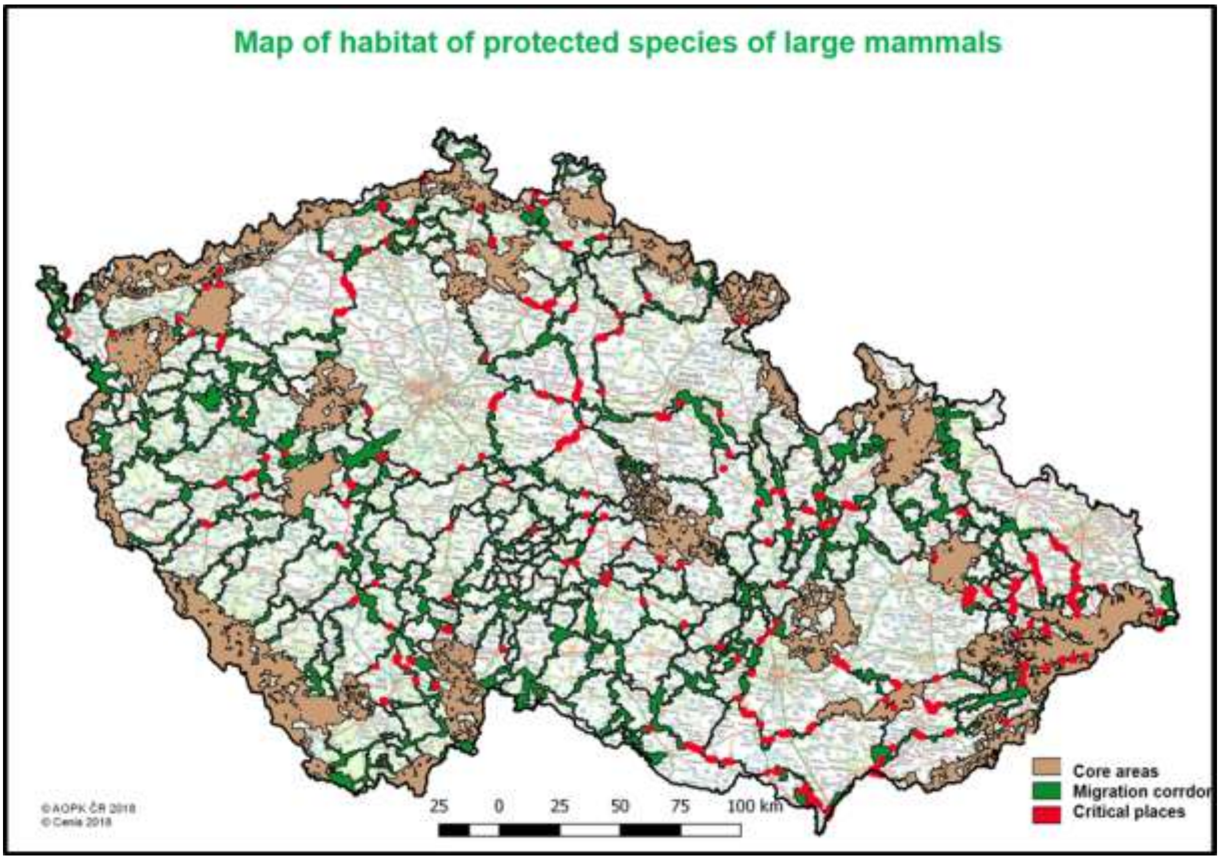

Figure 1: Map of habitat of protected species of large mammals in the Czech Republic

The biotope of four specially protected species of large mammals (wolf, lynx, bear and moose) was delineated as part of a large-scale research project in 2017. For practical reasons, the result is one common map of the biotope of all four protected species. The biotope consists of core areas (with conditions for the permanent existence and reproduction of these species) and migration corridors that connect these core areas to each other (Fig. 1).

The map 1:50,000 scale was used for definition of corridors. (1:10,000 for definition of critical sections of corridors). Urban areas are not part of the biotopes, even if the scale of the map does not allow their separation.

The map of the biotopes is provided as a .shp. layer for GIS and is available on the website of the Nature Protection Agency of the Czech Republic.

According to the Building Act, "territorial analytical documents" serve to identify the nature protection interests in spatial plans. Decree No. 500/2006 Coll. On Territorial Analysis documents (Annex 1) stipulates that the biotope of selected specially protected species of large mammals is provided by the Nature Conservation Agency of the CR as a binding territorial analytical document. The "biotope" including migration corridors must therefore be respected in all spatial plans (local and regional).

6.1.2. The nature protection authorities ensure the protection of the biotope of protected species of large mammals in two ways

1. Given that the wolf, lynx and bear belong to the species according to Annex IV. of the Habitats Directive, any intervention in their habitat must be evaluated to see if it will not threaten the favorable status of their protection in the areas where large carnivores are the object of protection. Territorial plans of all levels are also subject to evaluation.

2. Due to the fact that the wolf, lynx, bear and moose belong to specially protected species, it is not allowed to interfere harmfully in their natural environment (biotope including migration corridors). For interventions that could damage the biotope, it is necessary to obtain an exception from the nature protection authority. All interventions in migration corridors must be evaluated for possible damage to the habitat of the lynx, wolf, bear and moose.

6.2. Spatial Planning – the crucial tool: Good and bad examples from Austria

Author: Elke HAHN

The Austrian experience shows that the protection of wildlife corridors by spatial planning is one of the most important and crucial steps. Without the protection of wildlife corridors in spatial or land-use plans, the investments for crossing structures fail their effectiveness in a long term perspective.

In Austria, Spatial Planning is within the competence of the nine federal states (Bundesländer), which makes it difficult to set a common standard in the whole country. Some states have already incorporated wildlife corridors in their regional spatial programs, like Styria (Fig. 1) or parts of Salzburg (Pinzgau; Fig. 2). These regional plans are legally binding for all local plans, settlement development and infrastructure planning.

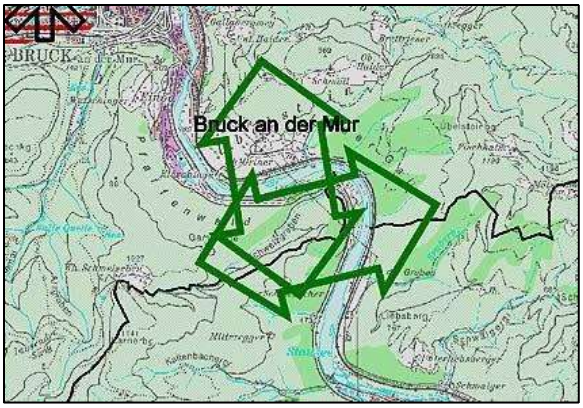

Figure. 1: Regional Spatial Programme for the Valley of the Mur, Styria: the green arrows indicate the wildlife corridors

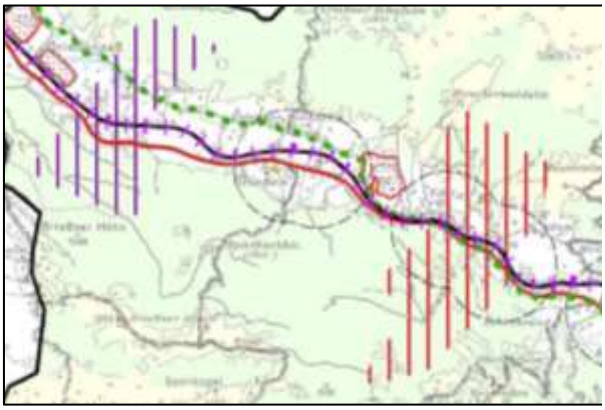

Figure 2: Regional Spatial Programme for Pinzgau, Salzburg; red stripes indicate supra-regional green corridors and lilac stripes regional green corridors

Another tool that starts to incorporate the wildlife corridors now is the so-called Forest Development Plan (Fig. 3). These plans show the functions (protection, recreation, social and economic services) and importance of forest areas. Styria has already incorporated the wildlife corridors in their Forest Development Plans, in the future hopefully other states will continue. It is not legally binding to incorporate the corridors in any planning processes, but nevertheless they are at least shown and available.

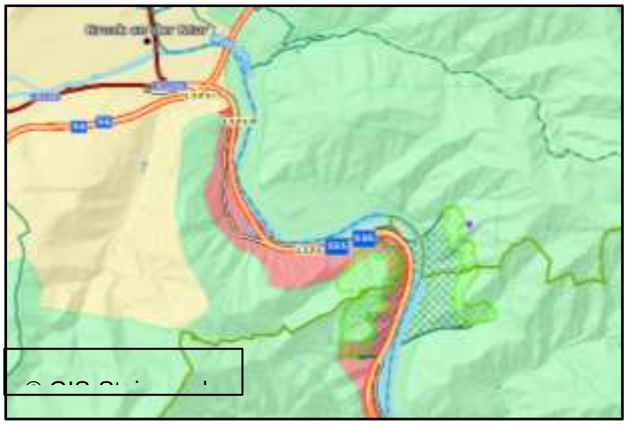

Figure 3: Forest Development Plan of Styria, Bruck an der Mur: Red indicates protection as the main functional priority of the forest, yellow recreation and green no special functional priority; Dark and light green cross hatch shows the wildlife corridor (Same example as above in Pic. 1)

Especially in mountainous regions, the protection of wildlife corridors are crucial, as all infrastructure and settlements gather along the valleys and thereby intersect the mountain habitats. The Rhein-Valley in Vorarlberg, in the most western part of Austria, shows what happens without proper strategic spatial planning. The valley is very densely populated and developed and by now there is no possibility left to connect the Natura 2000 area "Lauteracher Ried" with the hillslopes on the other side of the valley any more (Fig. 4). We have lost all possibilities for wildlife corridors crossing the valley!

Figure 4: Vorarlberg, Rheintal: the connection between the Natura 2000 site Lauteracher Ried and the hills of the valleys are completely intersected by settlements

Apart from regional spatial plans – or especially if those don't incorporate wildlife corridors – local spatial plans need to take wildlife corridors into account, especially if mitigation measures have been realised already. An example of a municipality in Salzburg shows what happens if it is not. A greenbridge was built there over a major road but later the settlement development did not take into account to keep the wildlife corridor and even the bridge itself free from the settlement development. So by now, the settlement expanded even onto the greenbridge (Fig. 5). Houses there have the addresses "Greenbridge No. 1 to 11"!!!

Figure 5: Salzburg, Göming: the settlement expanded on the greenbridge

6.3. Detailed environmental processes in life cycle phases of road projects in Europe

Author: Eric GUINARD

The general process is the same as it is in the full report, but being more detailed in the following Table 1. Upgrading is separate because it starts generally from design phase until management phase, except for small sectorial upgradings. Upgrading operations can have heavy impacts on biodiversity that have to be evaluated at design phase.

Table 1: Main transport infrastructure life cycle phases, subphases included in each one and process associated to Environmental Assessment (Source: BISON Project) [1]

Phase	Description	Subphases *[They could be adapted according to the topic addressed]*	Environmental process / tools
1. Strategic Planning	From the conception of Transport Policies, Plans and Programs, till the decision of developing an infrastructure is taken. It identifies needs, feasibility, priorities and priority areas or corridors where infrastructure will be developed.	1.1.Transport policy: Authorities define general goals and strategic vision for transport in a region or country. 1.2. Strategic transport plan: Authorities identify the needs and long-term vision for transport infrastructure development in a region or country. It includes programs and priorities and how to allocate resources. 1.3. Transport area or corridor delimitation (also called 'Project Planning'): A general strategy for a project delivery is developed with delimitation of the area or corridor where the project will be built	SEA Environmental analyses of transport plans and programs and choice of main transport infrastructure features including areas and transport corridor where Consideration of supranational, national to local regulation. Scoping: identification of contents and extent of the information to be submitted to the Competent Authority under EIA process. Description and maps of protected areas; ecological corridors (migration study for target species); protected habitats and species and concerned action plans, etc... Avoidance of effects on areas to be preserved from infrastructure development.
2. Design	Since the decision has been taken to the beginning of the construction. It includes the specifics of the infrastructure project.	2.1. Site or route selection (also called 'Concept design' and 'Informative Study'): The project's characteristics is broadly outlined by technical experts including choice of the route alignment or site where the project will be built. 2.2. Procurement: Provision of goods and services to realize a project are tendered and closed. 2.3. Detailed design (also called 'Constructive project'): Technical experts further elaborate the concept design including detailed prescriptions and budget for the infrastructure's construction.	EIA Environmental analyses of projects, with alignment choice. Identification of Impacts, cumulative effects, and potential benefits for biodiversity. Mitigation: Avoidance, Reduction Biological Survey and detailed studies on all topics, particularly ecological corridors. Detailed design of mitigation measures (ARC measures including fencing, fauna passages and other). Plan to protect biodiversity during construction.
3. Construction	Execution of the works.	3.1. Construction: The asset is constructed in line with design, budget and timeline.	Environmental Monitoring Program.
4. Operation & Maintenance	Lasts while the infrastructure remains operative and includes all aspects related to inspection/ maintenance tasks to ensure its integrity.	4.1 Operation and Maintenance: Infrastructure assets are managed and maintained during their use time.	Maintenance. Monitoring and evaluation of mitigation measures effectiveness.
5. Decommissioning	Starts once the infrastructure is no longer operative and extends until the land is restored or until the conditions establish in the EIA are fulfilled.	5.1 Decommissioning: Infrastructure is removed from service. 5.2. Repurposing: Obsolete infrastructure assets are repurposed recycled or removed and the land is reused or restored	Ecological Restoration.

[1][Environmental assessment: is a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. Environmental assessment can be undertaken for public plans or programmes on the basis of Directive 2001/42/EC (known as 'Strategic Environmental Assessment' – SEA Directive) or for individual projects, such as a motorway, an airport or a channel, on the basis of Directive 2011/92/EU (known as 'Environmental Impact Assessment' – EIA Directive)]

6.4. Planning stages / construction / operation (maintenance) in Canada

Author: Mona ABOUHENIDY

6.4.1. Study management during the Lifecycle of infrastructure - Canada

Mitigation practices are organised around the road management 'life cycle', the sequence in which Canadian roads are planned, built, operated and upgraded. This sequence provided a logical organization for presenting mitigation practices in a manner that would be useful to transportation managers, environmental specialists and engineers in identifying practices relevant to their projects.

The **roadway management life cycle** typically triggers a return to the planning stage when change is required (Fig. 1). The upwards feedback loops on the road management life cycle (Fig. 2) represent the need to return to the planning step when conditions change or significant potential impacts are likely. Planning reviews are also required when mitigation options are identified, and so there is opportunity to apply the mitigation hierarchy. The detail and depth of assessment at each stage in the road management life cycle depends on the scale of the project, the potential ecological impacts and regulatory approval pathways.

Figure 1: Categories of current Canadian road ecology mitigation (TAC, 2020)

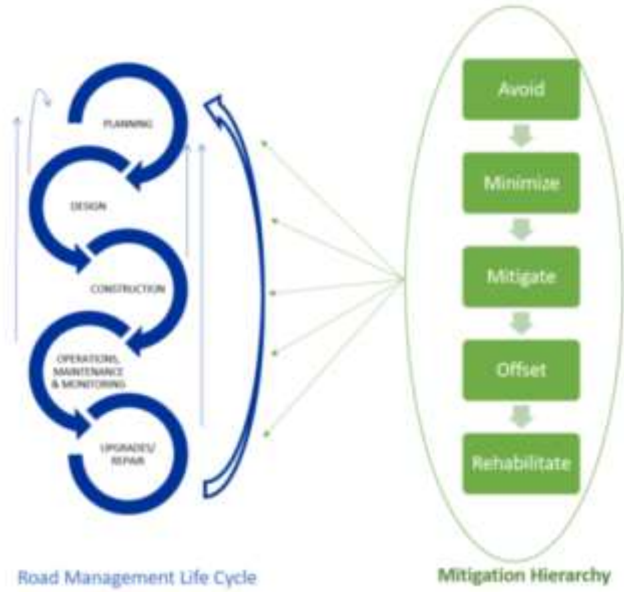

Figure 2: Integration of road management life cycle and mitigation hierarchy (TAC, 2020)

Reference

- Patriquin, D., Zeller, A., Truman, K., Hayes, R. and Gibbs, S. 2020. Synthesis of Practice for Management and Enhancement of Terrestrial Road Ecology. Ottawa, ON: Transportation Association of Canada.

6.5. CASE STUDY IN JAPAN: STUDY MANAGEMENT

Author: Sone SHINRI

6.5.1. SEA in strategic planning phase

There is a stage to decide whether a road project should be implemented, and if so, which is the best route among several candidate routes. At this stage, social, economic, and environmental conditions should be comprehensively considered. As for environmental considerations, in addition to the impact on the human body such as noise and air pollution, the impact on biodiversity should also be fully considered.

At the strategic environmental assessment stage, decisions are made based on a variety of factors, including social, economic and environmental factors. Biodiversity conservation is one of these factors. Since there are a wide range of factors to be considered, the assessment is often carried out based on literature review only, not on field measurements.

Where the presence of habitat important for biodiversity is identified in the literature, consideration will be given to rerouting to minimise the impact on that habitat. If it is certain that the habitat will be severely damaged, cancellation of the road project may be an option.

6.5.2. Critical habitat: Japan

In Japan, prefectural governments collect and organize the results of surveys on living organisms and ecosystems conducted by government agencies and private researchers. Most of the prefectures make a map of biodiversity by comparing the observation results with the map of the region. Road administrators refer to this map of biodiversity when they conduct strategic environmental assessment.

When a habitat that is extremely important for ensuring biodiversity is discovered, the area is usually designated as a national or prefectural nature park. In these natural parks, the results of detailed surveys on the habitats of biological species have been accumulated. Road administrators can refer to the results of these surveys. As a result, it is possible to obtain a certain level of information on biodiversity required for strategic environmental assessment in natural parks through literature surveys.

Within the Natural Park, development activities such as road projects are only permitted where the impact on the natural environment is below a certain level. It is therefore rare for very serious damage to wildlife to occur at the stage of carrying out a Strategic Environmental Assessment.

6.5.3. Introduction of Strategic Environmental Assessment Reduces Serious Conflicts: The Case of Japan

In the case of Japan, the introduction of strategic environmental assessment took place in the 2000s. This initiative promoted public involvement in decision-making at the stage of deciding the size and location of the route in a series of road projects carried out by road managers. By involving the public in the decision-making process, routes that minimize the impact on the human body, such as noise and air pollution, as well as the impact on the natural environment, were selected.

With public participation in decision making, consensus building can take as short as one year or as long as five to six years. During this time, the administrative effort required for dialogue with the public can be very burdensome for road managers. Now, well after its introduction, a significant part of the administrative procedures for public involvement is outsourced to construction consultants specialising in public involvement. As a result, it has become possible to reduce the direct burden on road managers and to take advantage of the expertise of specialist consultants.

Since the introduction of public involvement, serious conflicts between citizens and road managers over the implementation of road projects have almost disappeared in Japan. In addition, the public participation in the decision-making stage has enabled the subsequent environmental impact assessment procedures to be carried out smoothly. As a result, the level of satisfaction of both citizens and road managers has increased.

6.5.3.1. Environmental impact assessment

An environmental impact assessment is usually carried out after a strategic environmental impact assessment. Once the size and location of the road have been determined, the relevant impacts of the road project are predicted and, if necessary, measures to reduce the environmental impact are considered.

In the environmental impact assessment stage, it is necessary to carry out a survey of the existing situation, which is the premise of the environmental impact prediction, if necessary. For example, if there is a concern about the impact of noise or air pollution, it is necessary to conduct an actual measurement survey.

It is also necessary to conduct actual measurement surveys on biodiversity. For habitats above a certain size, it is necessary to conduct an actual survey even if no important species have been identified from the results of literature surveys.

Compared to the Strategic Environmental Assessment stage, the environmental impact prediction is more concrete because the road project is more specific and the results are based on the actual measurement survey. Therefore, the effects of environmental protection measures, such as reduction, avoidance and compensation, can be predicted more concretely.

The results of the environmental impact assessment will be reflected in the more detailed design of the road plan, environmental measures during construction, and environmental measures during maintenance and management.

6.5.3.2. Design

During the design phase of the road structure, various considerations are made based on the environmental impact assessment. Specific provisions will be made for structures where the road avoids or minimizes the impact on critical habitats, crossing facilities for animals, ecological transplantation, creation of alternative habitats, etc.

6.5.3.3. Construction phase

The construction of the road may have a negative impact on the ecosystem due to noise and the presence of construction workers. In addition, construction vehicles may cross through the surrounding ecosystem.

During the breeding season, organisms may be hypersensitive, so road managers need to take measures to reduce the impact on the surrounding ecosystem as necessary, such as minimizing construction during the breeding season.

6.5.3.4. Approach to the Environmental Impact Assessment Stage

1) In assessing the environmental impact of road projects, it may be necessary to consider the impact factors on animals, plants and ecosystems, such as "the impact of the existence of the road", "the impact of alterations caused by construction", and even "the impact of noise caused by the operation of construction machinery" if the construction site is close to animal breeding grounds, etc. The effects of these factors can be roughly divided into "direct effects" and "indirect effects" (Table 1.1-1).

6.5.3.5. Maintenance and management stage

During the maintenance phase, large mammal crossings, for example, can create traffic safety issues for vehicles in motion.

It is necessary to continue monitoring the growth of vegetation after transplanting.

6.5.3.6. Post survey

The effectiveness of conservation measures for ecosystems may not be determined. Effective conservation measures can be realized only after the accumulation of results. For this reason, it is desirable to conduct ex-post surveys to confirm the effectiveness of conservation measures. In particular, it is necessary to confirm the effectiveness of compensatory measures.

CASE STUDIES

Table 1.2-1 Examples of environmental conservation measures for animals, plants and ecosystems in Japan

Types of conservation measures / Types of targets	Investigation and review	Environmental conservation measures (including measures for projects not subject to assessment)															Monitoring and post-survey	maintenance and management	the others
		Existence and use of roads				Implementation of construction					Common (existence and service of the road/construction implementation)								
		Route Selection	Securing travel routes	Greening and use of topsoil	Forest reserve or preserve	Construction that avoids the breeding season, etc.	Acclimatization to construction	Consideration for heavy machinery used	Nesting site monitoring (video and visual)	Education of construction personnel	Modification minimization	Improved lighting fixtures	shielding measures	Measures for turbid water and water quality	Transplantation and relocation	Creation of alternative habitats, etc.			
general (The conservation target is not limited to a specific species or taxon)		one		four	one						one					one		one	two
mammal	2 (9)		6 (25)													3 (1)	1 (15)		2 (1)
birds (Birds of prey)			three			15 (2)	14	13 (2)	17 (7)	12		three	6 (1)			14			18 (1)
birds (other than birds of prey)	2 (1)		two			one	one		2 (1)				1 (4)			one			three
amphibian reptiles	two		5 (2)								one	(1)		1 (1)	5 (7)	4 (6)	two		1 (1)
fishes	(5)		1 (1)											two	3 (5)	2 (3)			
insects	(8)	one										(1)			4 (11)	4 (7)			(1)
plant	2 (65)				two										27 (66)	two	2 (56)	2 (1)	five
the others	1 (2)		1 (1)												2 (1)	two			

The numbers in the table are the number of cases published in" Examples technical Guideline of Environmental Impact assessment of Road Project in Japan", National Institute of Lana and Infrastructure Management(NILM). The number in parentheses is the number of cases published in the former case studies of the former collection (NILIM).

For details, please refer to each item and each case study.

7. OVERVIEW OF MITIGATION MEASURES FOR FAUNA, FLORA AND NATURAL HABITATS

Case studies

Wildlife Mitigation and Road Infrastructure in Canada

Improving road safety by judiciously extending large wildlife exclusion fences and adding wildlife crossings in the right-of-way of a national highway near the Quebec City area, Canada

Migration Study of Selected Animal Species on Operated Sections of Motorways, Expressways and Selected 1st Class Roads (HBH, 5/2017) (Slovakia)

Project LifeSaveCrossings (EU)

EU Defragmentation Map

Defragmentation Programme Netherlands

Defragmentation Programme Austria

CASE STUDIES

7.1. Wildlife Mitigation and Road Infrastructure in Canada

Author: Mona ABOUHENIDY

Canadian roadways provide an essential link connecting people, goods and services through both urban and rural spaces. However, they often lie within natural or naturalized landscapes, and their design and operation can influence the ecological function of adjacent lands as well as the species that live within those habitats. Road ecology has developed into an established research and applied discipline that offers mitigating practices and management approaches to address impacts to natural ecosystems, as well as to public safety and adjacent land use. Throughout the life cycle of a road, from design, through construction, operation, maintenance to decommissioning, planning is one of the most important tools for managing potential road ecology concerns.

Within Canada, road networks cross urban, rural and natural or wilderness areas, each with different types of species, including species at risk, and natural communities and ecosystems, generating regionally specific road ecology concerns. Northern and southern Canadian landscapes also differ in terms of climatic conditions, level of development and specific to the North, Indigenous co-management requirements. Despite this range of diversity, mitigation can be categorized relative to the type of road ecology concern. Canadian mitigation falls into the following categories:

Mitigation of wildlife vehicle collisions (WVCs)

- Planning for avoidance
- Collision warning systems
- Wildlife guidance fencing
- Crossing structures

Vegetation management

- ROW naturalization
- Wetland management
- Pollinator habitat management
- Invasive and weed species control
- Conventional right-of-way (ROW) management (mowing, weed management, revegetation)

Emerging concerns

- Northern road management
- Caribou management, as a species at risk
- Bat use of bridges, including species at risk
- Mitigation of night lighting impacts on nocturnal species
- Restoration of habitat connectivity
- Mitigation of climate change and spread of invasive species

7.2. IMPROVING ROAD SAFETY BY JUDICIOUSLY EXTENDING LARGE WILDLIFE EXCLUSION FENCES AND ADDING WILDLIFE CROSSINGS IN THE RIGHT-OF-WAY OF A NATIONAL HIGHWAY NEAR THE QUEBEC CITY AREA, CANADA

Author: Martin LAFRANCE

7.2.1. Introduction

About 70 km east of Quebec City, Highway 138 (Route 138) crosses exceptional habitats for moose (*Alces americanus*), which annually contributes to the occurrence of several collisions between vehicles and moose (Fig. 1). This private territory of nearly 1,600 km² is mainly used for logging, hunting, and fishing. In the road sector associated with this area, the average annual daily traffic on Route 138 is 6,600 vehicles per day but reaches 8,900 vehicles per day in summer. These flows have been stable over the past 20 years, while moose densities in this sector have been increasing. According to inventories conducted in the Seigneurie de Beaupré, there was an average of 10.6 moose/10 km² in the 2004 winter, whereas in 2013 there were 14.8 moose/10 km².

Mitigation measures application on Quebec's highways to prevent wildlife collisions is relatively recent, with the first large wildlife exclusion fences along highways being erected in the mid-2000s. The planning and design of large wildlife control devices for this project was based on recommendations from experiments conducted in Western Canada (Clevenger and Waltho, 2003) and in Finland (Väre, 2002) for deer that could potentially behave similarly to those found in Eastern Canada. According to the literature and experts consulted, an underpass should have a minimum height of twice the height of an adult bull moose, or 5 m, and an openness index [2] greater than 4. This was the minimum value to ensure that the structure attracts ungulates, that it does not create a tunnel effect, and maximizes clarity when closer.

7.2.2. Fencing without wildlife passage (Phase I): trial and error

To secure the most problematic road section, the Quebec Ministry of Transports and Sustainable Mobility (MTMD) first identified collisions involving large wildlife with motor vehicles. At the same time, the MTMD inventoried for several months the fresh tracks left by deer in the sandy substrate along Route 138.

In 2007, 6 km of metal fences with 2.4 m height were installed in the most accident-prone sector, that is, between kilometer markers 427 and 433 (Fig. 1). At the time, it seemed unfeasible to integrate a large wildlife crossing structure under the road in this area, given the road embankment's low height relative to the surrounding natural terrain elevation and the absence of a good-sized stream crossing. Boulder fields (200-1100 mm by 3 m wide stones) hard to cross were installed at the ends of the fences to prevent moose from entering and running along the interior of the fenced area. A wildlife cattle guard (Texas gate), land access gates and emergency exits to evacuate moose from the fenced area were also constructed. A specific road sign plan, which is characterized by the installation of several signs at the roadside to make users aware of the risks of collision with a moose, completed the road safety devices deployed in 2007.

[2] An underpass openness index (OI) is calculated by the formula: (width x height)/length

As of 2008, the installed devices were effective, and few collisions occurred within the fenced segments. However, track monitoring has shown that new moose movement corridors have developed following the fences installation; moose cross at the western end of the fence between kilometers 426 and 427 and to a lesser extent, at the eastern end of the fence (kilometer 433). By 2010, the accident-prone zones had shifted to the fence's ends; addition of fences without wildlife passage did not reduce the total number of accidents. In 2011, for the first time, the total number of accidents exceeded the pre-fence number.

7.2.3. Extending fences can be strategic if suitable wildlife crossings are incorporated (Phase II)

While this important "end effect" was experimented on Route 138, the analysis of photographic and video surveys on the use of wildlife crossings, built as part of another road project, the redevelopment of Route 175 between the Quebec City and the Saguenay region confirmed that moose successfully cross underpasses even if these have a very low openness index. Some of the crossed structures had openness index values as low as 1.3 and a vertical clearance below the average height of an adult bull moose (Fig. 2). Thus, it appeared that moose, at the densities encountered at this location in Quebec, venture into more closed structures than the moose populations monitored elsewhere in the world.

Therefore, in 2014, a second phase of the work was carried out. The MTMD extended the fences by 1.5 km to the east and 6 km to the west (Fig. 1), corrected the fences ends, then built two underpasses for large wildlife characterized by a low openness index, without having to significantly modify the road profile. These were placed near kilometers 427 and 433 (Figure 1), where the fences installed in 2007 ended, an area where moose crossings were more frequent. The crossings are 26 m long, only 6 m wide and 4.0 m (km 427) and 3.8 m (km 433) high respectively. Their openness index is 0.9 each (Fig. 2).

The use of wildlife crossings and fence ends with special emergency exits is monitored using Reconyx HC600 thermal cameras, which detect temperature changes in the view field of the lens. A review of the use of the two wildlife crossing photographic records since 2015 shows that moose extensively use these two secured corridors in their early years of operation. Most recorded large wildlife crossings were by moose (Fig. 3a). Most of the remaining crossings were by white-tailed deer (*Odocoileus virginianus*) (Fig. 3b).

Collision statistics show that there have been virtually no collisions with large wildlife between kilometer markers 421 and 435 since the fencing was extended and the two wildlife crossings were built. The few accidents that occurred since then involved animals entering the fenced area through a gap in the fence, such as between two poles displaced by the freeze-thaw action of the soil. These results contrast with the situation from 2010 to 2014, when an average of 19 moose collisions occurred annually within this section.

7.2.4. Considerations

When considering how far to extend fencing, it is a good idea to take a step back and look at the area under consideration with aerial photographs that clearly show the landscape features. This involves looking for wildlife corridors such as river corridors and power transmission rights-of-way or, on the contrary, identifying uninviting areas such as cliffs or rockslides. In this project, the choice to extend the fences to the west had two advantages. The first was to intercept moose moving along the axis of the Hydro-Quebec power line that crosses the road at two locations, kilometers

425 and 422. The second advantage was to end the fences in a more densely populated and lit area, therefore less attractive to moose. On the east side, the extension of the fences helped to channel moose movements into the crossing and the fences end in a steep slope, in a location less suitable for large wildlife. The fence ends were designed so that moose attempting to leave the fenced area would be directed into the forest and to avoid directing moose approaching the fenced area from the outside onto the road. A 100 m section of a secondary fence was installed from the main fence, 10 m from each end, on a perpendicular axis to the road towards the forest. At the junction of these fence ends, a one-way gate was installed to allow moose to move from the unfenced side into the forest within the fenced area (special emergency exit; Fig. 1). Fence segments located near the crossings were funneled so that animals along the fence would be guided to the crossing entrance. An additional fence segment starting near the entrance to a wildlife crossing and extending approximately 100 m into the forest, along the crossing axis, was also installed to direct animals following the main fence from further away into the crossing (Fig. 4a and 4b).

The idea of securing a road by fencing off large wildlife movements over long distances is an inefficient and expensive option. Moose movements are influenced by the landscape's characteristics, and they can bypass fence segments of more than 10 km in length since their home range size can be more than 100 km2. It is therefore essential that the animal be directed to a location specifically designed to allow a safe road crossing.

The addition of wildlife crossings is a way not only to maintain biological corridors on both sides of the road and reduce habitat fragmentation, but also to reduce the risk of large wildlife intrusion into the fenced areas gaps. These are essential road safety features that should be incorporated into any wildlife fencing project.

As part of a safety features improvement project to prevent collisions with large wildlife along Route 138, numerous crossings were documented within culverts under the highway which had an openness index as low as 0.9. Similar results were observed for crossings under Route 175 in the Réserve faunique des Laurentides, for bridges with openness indices of 1.7 and 1.3. The hypothesis that other structures with such indices could make road infrastructures permeable to moose movements therefore seems relevant. Nevertheless, the openness index has its limitations and is increasingly probed; some studies suggest that it should never be used alone as a guarantee of success (Iuell et al., 2007; Clevenger and Huijser, 2011). For other more sensitive species, such as woodland caribou (*Rangifer tarandus*), further studies and monitoring are obviously needed to better understand the effects of different passage characteristics on crossing success.

Based on the results and observations made on Route 138, it seems necessary to position crossings at the ends of fences, if not, at locations where wildlife is used to circulating, including biological corridors, and to design the ends in a way that is convenient for the apparent conditions in the field to avoid end effects. Appropriate road signs should also be in place to let road users know about the end of the fenced area and the risk of collision with large wildlife.

7.2.5. Conclusion

The experience from various Quebec Ministry of Transports and Sustainable Mobility projects shows that wildlife fence installation is not sufficient to effectively reduce collisions with moose. Integrating wildlife crossings into fenced areas is necessary to sustainably reduce the risk of collision within and at the ends of these areas. The wildlife crossings reduce the risk of rapid exploitation of gaps in the fences by large wildlife and intrusions threatening the safety of road users.

The installation of a fenced area on Route 138 has reduced moose collisions, that was the primary objective. Landscape features (e.g., power transmission corridor crossing the road) and key movement corridors for large wildlife identification was an important step in developing the optimal solution for reducing road collisions, including the location of wildlife exclusion fences ends. In addition, suitable wildlife underpasses for moose and white-tailed deer can be constructed even under road sections with low vertical and horizontal clearances. Obviously, long term monitoring of these facilities' effectiveness is required. Even so, it can be assumed that providing a few low-index wildlife crossings in a fenced area can only improve road safety and wildlife habitat connectivity at relatively modest costs.

7.2.6. References

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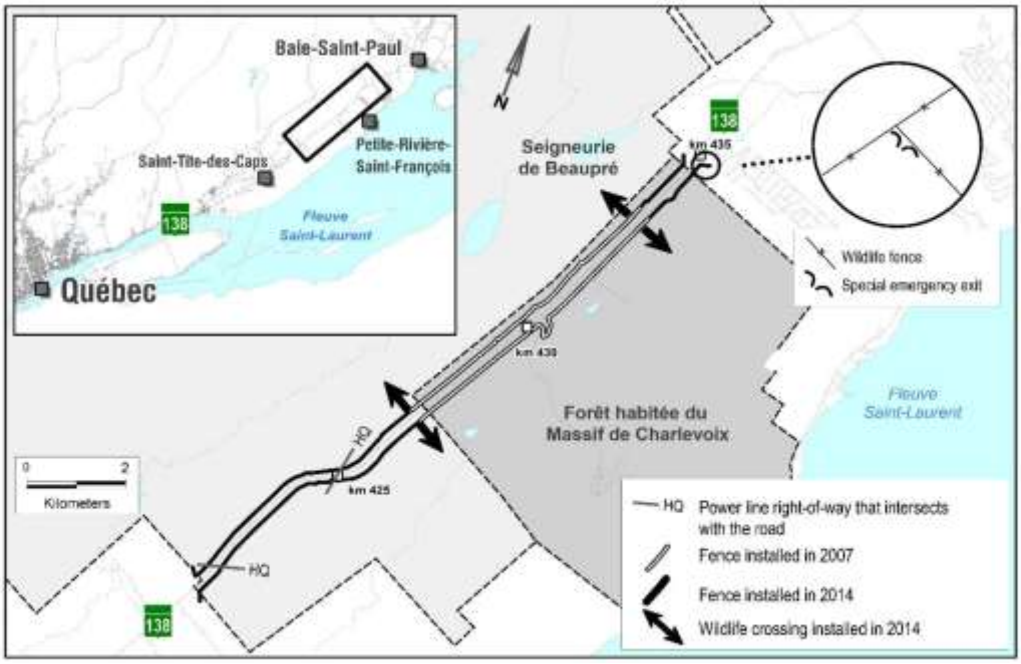
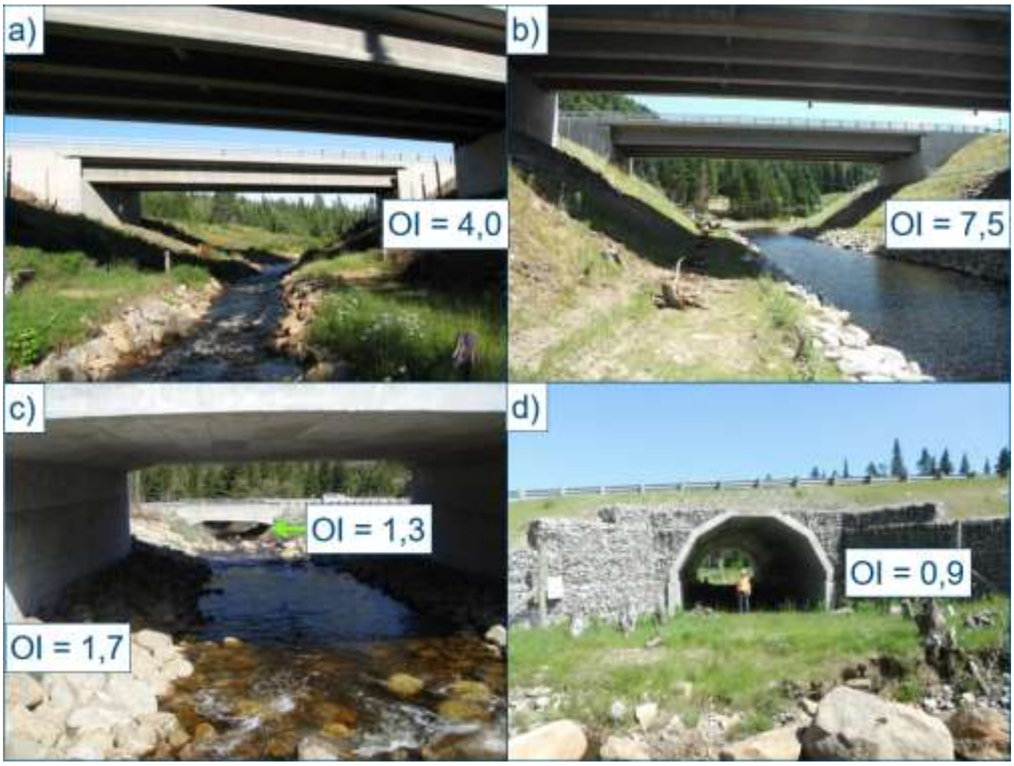


Figure 1. Section of Route 138 crossing excellent moose habitat and located on almost uninhabited territories (in light and dark grey). The location of the large wildlife control devices installed during phase 1 (in 2007) and phase 2 (in 2014) of the work are also illustrated.

Figure 2. Illustration of openness indices [OI = (width × height)/length] associated with different large wildlife underpasses: a) Lac à Noël outlet crossing/2 bridges (Hwy 175, mile 94), OI = (27.0 × 7.5)/50 = 4.0; b) Taché Creek crossing/2 bridges (Hwy 175, mile 74), OI = (35.5 × 9.5)/45 = 7.5; c) bridges on the east [foreground : OI = (9.1 × 2.5)/13 = 1.7] and west pavements [background: OI = (9.3 ×1.8)/13 = 1.3] of Bureau Creek (Route 175, kilometer 86; d) wildlife crossing (Route 138, kilometer 433), OI = (6 × 3.8)/26.6 = 0.9.

a)



b)

Figure 3. Examples of photographs taken by a self-triggering camera illustrating the use of one of the wildlife crossings under Highway 138 by a) mooses (Alces americanus) and b) white-tailed deer (Odocoileus virginianus).

a)

b)

Figure 4. Layout of fence segments at wildlife crossing approaches to promote discovery and use. View a) towards the crossing; b) towards the forest.

7.3. Migration Study of Selected Animal Species on Operated Sections of Motorways, Expressways and Selected 1st Class Roads (HBH, 5/2017; Slovakia)

Author: Zuzana MENKEOVÁ

7.3.1. Introduction

The Final Report of the Migration Study of Selected Animal Species on Operated Sections of Motorways, Expressways and Selected 1st Class Roads, which the company HBH projekt spol. s.r.o. prepared for Národná diaľničná spoločnosť, a.s. (National Motorway Company) from 2014 to 2017, is a document that evaluates the results of three years of work and proposes design priorities in the conflict of road transport versus animal migration for the existing superior road infrastructure managed by Národná diaľničná spoločnosť, a.s. (sections put into operation until 31/12/2013).

The Migration Study was prepared due to the need to improve the current situation in terms of animal migration on the existing operated roads. This can be described by two main points:

- **a large number of collisions between vehicles and animals.** That results in road accidents with negative effects on lives and health of inhabitants, death of animals and economic damage to vehicles and to the property of Národná diaľničná spoločnosť, a.s.
- **protection of animal migration routes in Slovakia conceptually unresolved so far.** An approved and statutory concept that would provide an unambiguous basis for defining the core areas and migration corridors and thus would allow addressing the collision points with the road network systematically is still missing. The Territorial System of Ecological Stability is the only supporting document today, however, due to a different methodological base it is often not suitable in terms of animal migration.

The Migration Study is used as a supporting document for the design and later implementation of particular measures intended to improve the situation in terms of animal migration on the sections of roads and motorways in question. Its detail level corresponds to the initial Migration Study - by addressing the overall concept of permeability for wildlife on longer motorway and road sections and by assessing whether the route with the proposed passages will be sufficiently permeable to animals. A detailed design of particular migration structures is the subject-matter of the further stages of project documentation on the basis of a detailed migration study.

7.3.2. Summary of sub-reports

As a result, several new migration structures of various categories have been proposed on the monitored sections of the superior road infrastructure:

- Ecoducts
- Multifunctional overpasses
- Underpasses
- Alternative migration structures

7.3.2.1. Ecoducts

Ecoducts are special migration structures designed to maintain the continuity of ecosystems by restoring the "original terrain" and vegetation on its surface (Fig. 1). This type of overpass across a road is useful for the migration of a wider range of animals. Especially for those who find it natural to cross the road over it, in a corridor simulating, for example, ecotone communities, rather than cross the road under it through a dark underpass without vegetation. Ecoducts can generally be considered as the best possible solutions to migration issues not only on roads, but also, for example, on railways etc.

Figure 1: Ecoduct Lučivná - a view of the migration area (HBH, 2017)

7.3.2.2. Multifunctional overpasses

They are bridges carrying a forest or country road, modified so as to allow animal migration too. Part of such an overpass is thus usually greened, part is occupied by a paved road (Fig. 2).

Figure 2: Multifunctional overpass near the village Úsvit (HBH, 2017)

7.3.2.3. Underpasses

Underpasses are migration structures where migration takes place from below, below the level of traffic (Fig. 3). These structures are usually built on the route of roads and motorways in order to overcome terrain depressions, valleys, water areas, watercourses, tertiary roads, roads of all categories, railways, urban units etc. They represent the basic structures intended to reduce the barrier effect of roads.

Figure 3: Underpass with line greenery near the village Važec, (HBH, 2017)

7.3.2.4. Alternative migration structures

They are structures with defined migration profiles, in which several alternatives of migration corridor alignment across the road have been proposed. In such cases, it is possible to choose which migration structure will be built depending on the results of a detailed migration study.

7.3.3. Migration profile revision and assessment methodology

The revision of the profiles was carried out as a process of retrospective examination, correction of the profiles and their final assessment also on the basis of new data obtained in the last year of the Study. These are mainly the data on collisions with wildlife for years 2014 and 2015. Also the specification and verification of residential and movement data on wildlife by a field survey. The resulting data set was merged and represents complete information about almost the entire territory of Slovakia. The data were processed into input factors, issues of transport safety, fragmentation and migration of the interest group of animals. The resulting priority of the importance of designing a migration profile was identified by mathematical and analytical procedures. The input factors influencing the importance of the profile were assessed separately, and they were assigned a weight, priority in percent. A value of 100% defines the maximum priority. A standardized, comprehensive sequence of profiles based on their design importance is a result of this procedure.

7.3.3.1. Input factors

- Transport safety
- Accessibility of the migration barrier and the surroundings of the profile
- Protection of large mammals
- Profile sustainability
- Transregional connectivity

7.3.4. Revision output

At the time of processing the sub-reports on individual sections of roads, only data on collisions for 2012 and 2013 were available. At the end of all the work, new data on collisions from 2014 and 2015 were obtained for the migration profile revision. The processor had data for a four-year period available, where it is already possible to observe certain trends.

7.3.4.1. General conclusions

A significant reduction in the number of collisions can be observed on most profiles, which is the result of the systematic adding of fences to the hitherto unfenced sections of the motorway and expressway network.

- In some profiles, there is a one-year decrease in collisions. This can be caused e.g. by an unattractive crop in the profile, change of the country (new construction, forestry work) or also by missing data from this period.
- Some profiles also saw a one-year increase in collisions, which in turn may be due to an attractive crop but also to an error in the data (repeated counting of a knocked down individual from the data from hunters, the police or road maintenance).
- A total of 2,352 collisions were recorded on 109 migration profiles, which is approximately 5.4 collisions per year at a site of confirmed migrations (migration profile).

The Study creates an overall overview of the selected migration profiles with an indication of the partial results of the priority assessment as well as the overall priority of the profile construction.

7.3.5. Recommendations for detailed migration studies

This Study serves as a basic supporting document for identification of the state of the country fragmentation at a certain site and for proposing measures to ensure the migration permeability of a road for a certain group of animals. The recommended contents for a detailed migration study, which must be prepared in the next phase of the migration profile construction preparation:

1. Field survey update
2. Landscape structures around the profile update
    a. Assisting element assessment
    b. Restrictive element assessment
3. A project of measures intended to ensure the migration permeability of the profile
4. Recommendations for the construction of structures
    a. Dimensions of the structures
        i. Overpasses
        ii. Underpasses
    b. Measures to increase the functionality of migration structures

i. Creation of stepping stones - habitats and natural bio-corridors for directing animals to the migration structures
ii. Creation of a protection zone around the migration structures
iii. Ensuring the connection of the structure to the wider country

7.3.6. A project of measures intended to ensure the migration permeability of the profile

- The project of measures includes a detailed design of the migration structure (if necessary), including its particular location, as well as a detailed design of other additional measures that serve to ensure the efficient functioning of the migration profile.
- On the basis of updated supporting documents (landscape structure and migration route), an ecologist, in cooperation with a designer, shall determine the central width of the ecoduct or the multi-purpose bridge as for overpasses, and the width and height of the underpass as for underpasses.
- The designer, in cooperation with the ecologist, shall check the migration structure integration into the ecosystem in the field and shall specify the location of the animal passage (direct connection to the forest stand or escape cover in a field area) so that animals have undisturbed and safe access to the structure.
- The project must also include negotiations with state nature conservation authorities, relevant municipalities and other affected entities and institutions.

7.3.7. Recommendations for the construction of structures

7.3.7.1. Dimensions of the structures

The appropriate dimensions of a migration structure always depend on local factors. Especially on the ecological conditions of the surroundings and the overall technical design, including the elimination of disturbing effects. The dimensions completely sufficient in an ideal ecological environment may be completely insufficient in the presence of disturbing effects. Therefore, it is not possible to approach the recommended dimensions uniformly, but they must always be adjusted according to the local situation.

7.3.7.2. Overpasses

The width of an overpass (Fig. 4) is the most important assessed dimension parameter. As overpasses often have a hyperbolic shape for better animal guidance, the width of the overpass varies along their length. The following ones are basic for the assessment:

- Minimum (central) width (a) - this is a basic parameter, if the width of an overpass in general is discussed, this dimension is meant.
- Maximum (side/entrance) width (b) - this is a dimension important for animal guidance assessment.

In multi-purpose structures (carrying a country road or road), the width of the structure increases depending on local conditions (road surface, traffic volume). However, this does not mean adding the width of the road to the width required for migration automatically.

Figure 4: Ecoduct Moravský svätý Ján, (NDS, 2018)

7.3.7.3. Underpasses

Concerning underpasses (Fig. 5), all three parameters must be assessed and optimized simultaneously (the width, height, index I). In multi-purpose structures (carrying a country road or road), the width of the structure increases depending on local conditions (road surface, traffic volume). However, this does not mean adding the width of the road to the width required for migration automatically.

Figure 5: Bridge on D1 Motorway used as a wildlife underpass, (HBH, 2017)

7.3.8. Measures to increase the functionality of migration structures

Creation of stepping stones - habitats and natural ecological corridors for directing animals to the migration structures

- The more natural conditions in the vicinity of the migration structure, the better fulfillment of the function of the structure. That way it can also carry a higher migratory pressure. These measures will significantly expand the range of animal species that will be able to use the migration structure. The structure will be functional for both category A and B animals, as well as for smaller species of mammals, reptiles, amphibians, insects, etc.
- Above all, it is a matter of creating a belt of taller greenery (trees) that attracts and guides wildlife from the wider surroundings. And also creating small shades and wetlands for amphibians, heat stone embankments for reptiles and other thermophilic animals. Adding branches or whole trees in the structure and its surroundings in order to improve the migration possibilities for small animals, etc.

7.3.9. Creation of a protection zone around the migration structures

- The protection zone is important especially for structures of regional and transregional interest, where long-distance migrations of large mammals (the bear, wolf, moose, lynx, deer) are expected. These animal species are also more sensitive to the quality of the environment, undisturbed access to the migration structure is one of the key conditions for preserving their migration. The protection zone can be solved by creating a biocentre consisting of the structure and its immediate surroundings.
- It is necessary to set land use limits in this zone and to prohibit activities that could have a negative impact on animal migration. These activities include, for example: clearcutting forestry and clear felling; restoration of forest stands in fences; hunting, trapping, and scaring of wildlife; location of buildings and equipment producing noise and light pollution; establishment of hiking trails and recreational areas, etc. On the contrary, close to nature management, prevention of poaching, increasing the usability and attractiveness of the environment, etc. should be preferred.
- The inclusion of this measure in the project of a migration structure represents an effective protection against the negative development of the immediate surroundings of the migration structure, which could jeopardize its functioning and thus the meaningfulness of the investment in the future.

7.3.10. Ensuring the connection of the structure to the wider countr

- The purpose of this measure is to ensure the functionality of the migration structure in the wider context of the country, conservation of biodiversity and animal migration routes.
- The measure consists mainly of updating the original TSES, as the construction of the new migration structure will fundamentally change the spatial relations of the affected area as well as the animal migration routes.
- In the case of any project that may have a direct or indirect impact on migration routes, or the new TSES, it is always necessary to assess the project according to Act 24/2006 Coll. on environmental impact assessment and on amendments to certain acts.

7.3.11. Conclusion

The Final Report of the Migration Study of Selected Animal Species (the bear, wolf, lynx, wild cat, deer, moose, roe deer, wild boar, mouflon, fallow deer) on Operated Sections of Motorways, Expressways and Selected 1st Class Roads (put into operation until 31/12/2013) provides a summary and brief overview as well as an interpretation of the results of the Study, i.e. the sub-reports processed during the past 3 years, which have undergone an independent check by three opponents.

The Study presents a comprehensive view of the issue of migration corridors in Slovakia. Due to its scope and detail level, it takes into account all the key factors entering into the assessment of the migration needs of selected animal species on linear anthropic barriers such as motorways, expressways and 1st class roads. The Study was based on current, detailed data and data from the police, hunters, land-use planning documents, professional papers and databases, technical conditions, legislative standards and other important inputs, which are described in the individual sub-reports.

A separate field survey carried out for over three years and at different levels was one of the most important inputs within the preparation of this Study. The amount of hours spent in the field, using specialized monitoring or measuring devices, has provided a range of data that is unique in Slovakia and many of the obtained data are still not provided in any available databases or papers. The data obtained this way have supplemented, verified and expanded the data from official statistics. In combination with the professional processing of the data, this Migration Study forms a quality supporting document for solving the issue of migration corridors in Slovakia, not only for the selected part of the superior road infrastructure.

Looking at this issue in general, it can be stated that animal migration in collision with traffic is becoming an increasing problem and has to be addressed in order to avoid an increase in damage and to increase transport safety. Last but not least, this issue must also be seen as ensuring the ecological functionality of the country and thus increasing its value.

7.3.12. Reference

HBH Projekt spol. s r.o., *Migration Study of Selected Animal Species on Operated Sections of Motorways, Expressways and Selected 1st Class Roads.* Banská Bystrica, 2017. Final Report

7.4. Project LIFE Safe-Crossing

Author: Annette MERTENS

7.4.1. Highlights

Implementation: 2018-2023

Countries: *Italy, Spain, Romania, Greece*

Contact organisation: *Agristudio S.r.l.*

Contact Person: *Annette Mertens, mertens.annette@gmail.com*

More information: *https://life.safe-crossing.eu/, http://www.lifestrade.it/index.php/en/*

Target species: *Brown bear, Apennine brown bear, Wolf, Iberian lynx*

7.4.2. Introduction

The LIFE SAFE-CROSSING project (LIFE17NAT/IT/464) aims at the reduction of the negative impacts of roads on endangered large carnivore populations in Italy (Apennine brown bear, wolf), Spain (Iberian lynx), Greece (Brown bear) and Romania (Brown bear). Roads represent important threats for these species, both in terms of direct mortality in road collisions as well as in terms of habitat fragmentation. In Italy the Apennine brown bear is extremely endangered and in the past years repeatedly individuals have been killed on roads. Besides this, roads represent an important barrier for the dispersal of the species into new ranges. In Romania the brown bear enjoys a favourable conservation status but increasing numbers of individuals are killed on roads (and railways). In Greece the Egnatia Highway represents an important barrier for the movement of bears, and bears also repeatedly get killed on this road, as well as on state roads. In Spain the Iberian lynx has recently recovered its conservation status but killing on roads is still one of the major threats for the species.

The LIFE SAFE-CROSSING project therefore aims at the following objectives:

- Demonstration of the use of the innovative Animal-Vehicle Collision (AVC) Prevention tools, which have been developed in the frame of the previous LIFE STRADE project (LIFE11BIO/IT/072)
- Reduction of the risk of traffic collisions with the target species
- Improve connectivity and favorable movements for the target populations
- Increase the attention of drivers in the project areas about the risk of collisions with the target species

The project involves 13 partners NGO, private companies and public bodies.

7.4.3. Key actions

The main actions of the LIFE SAFE-CROSSING Project are:

- Installation of innovative systems for the prevention of Animal-Vehicle Collisions
- Adaptation of existing crossing structures to reduce habitat fragmentations
- Raising awareness of drivers and the general public regarding the importance of an adequate driving behaviour

The present case study regards the installation of innovative AVC prevention tools, namely:

1. Installation, in specifically identified sites, of AVC PS (Animal-Vehicle Collision Prevention System) (Fig. 1), which act simultaneously on the animals on the road sides and on the drivers. The AVC PS have the following functioning and structure (Figure 1): A set of passive infrared (PIR) sensors and/or a thermal camera (1) registers the presence of an approaching animal and sends the information to the electronic control unit (2). This unit triggers an alert signal for drivers (3), inviting them to slow down to an acceptable speed. A radar doppler sensor (4) measures whether the car actually slows down. If it does, the system stops to act. Otherwise, the radar sends a signal back to the control unit. This activates an acoustic scaring device (5), which shall drive the animal to escape.

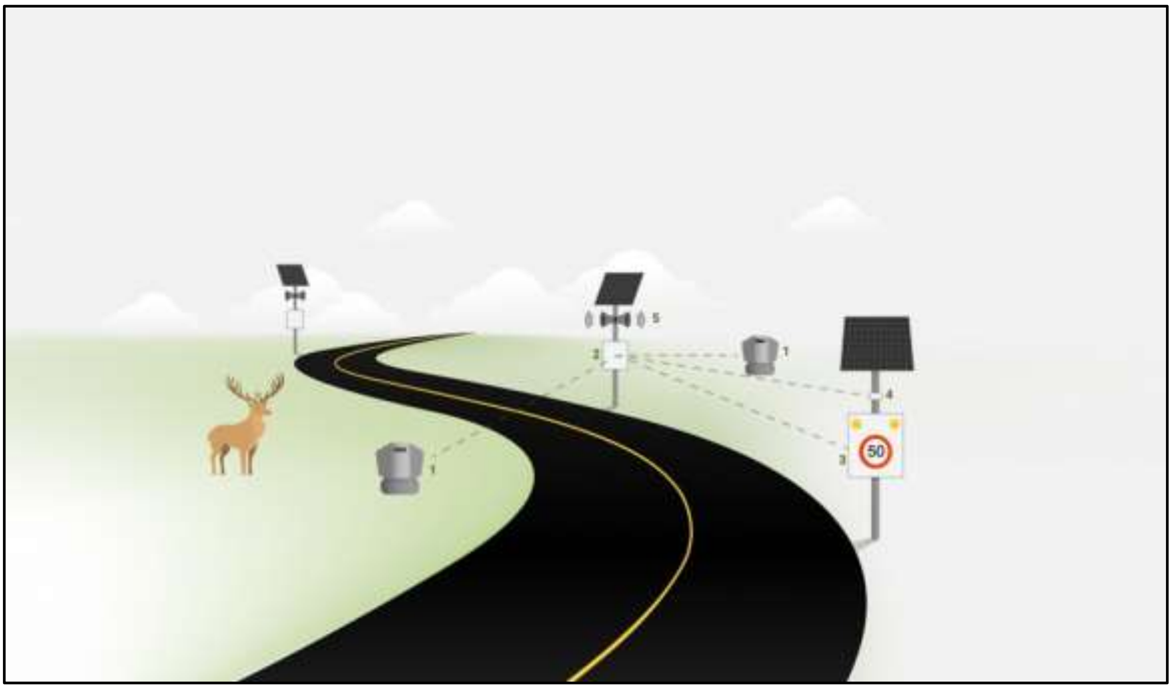


Figure 1: Functioning of the AVC PS system

The functioning of the system is controlled through a modem, which sends an email each time a component is triggered (wildlife presence sensors and acoustic scaring device), and also sends information about the charge level of the batteries. Moreover, remote information can be received about the functioning of the flashing lights, and on whether the passing vehicles slow down or not. A specific software has also been developed in order to collect all this type of information, as well as an App through which is possible to control and change the setting of the different components of the systems.

The added value of these systems is that they intervene only in risk situations, when there is the simultaneous presence of an animal on the road side and the approach of a car that proceeds at too high speed. This shall help to reduce habituation of both wildlife and the drivers, and it also favours environmental connectivity.

These devices have been developed and tested in Italy in the frame of the LIFE STRADE project (2012 – 2016), and in the frame of the LIFE SAFE-CROSSING project it is installed in 27 sites in the four project countries.

2. Installation of a “virtual fence” (Fig. 2): it consists of a series of sound and light emitters, attached to posts on the road sides (Figure 2), and is designed to deter animals in the vicinity of roads when vehicles approach. These devices are activated by the headlights of approaching vehicles and upon activation start producing a sound and light signal, in order to prevent animal crossing. The components of the virtual fence are placed on both sides of the road and on each side are spaced 50 meters from each other. They work autonomously with a solar powered system and the single devices can be linked to each other through Wifi, which allows activation of all the devices when the first one is triggered by the headlights of the upcoming vehicle.

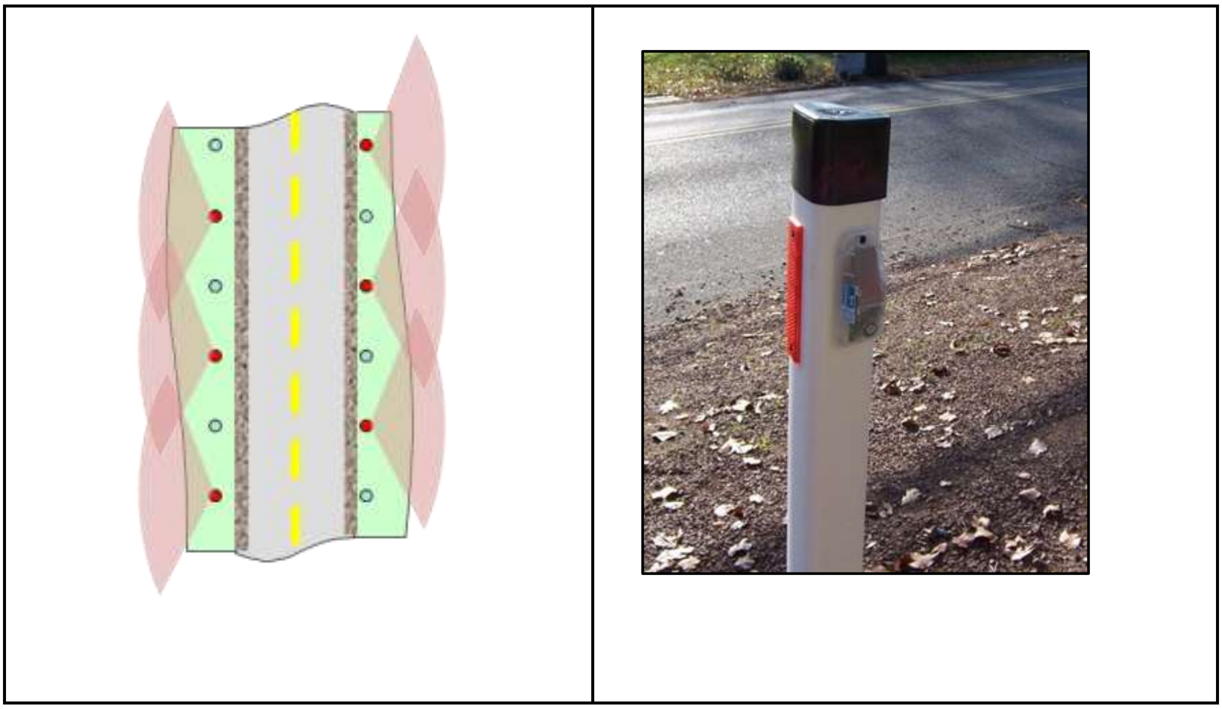


Figure 2: The functioning of the virtual fence

This type of virtual fence will be complementary to the installation of the AVC prevention systems, in order to increase the length of their effectiveness. This system has been developed by the Austrian company iPTE and in the frame of the LIFE SAFE-CROSSING project the fence is installed on 35 km of roads in Romania, Italy and Spain.

3. Development of road information panes through an innovative neuromarketing technique. Neuromarketing is a new field of marketing which uses medical technologies to study consumers' sensorimotor, cognitive, and affective response to marketing stimuli. In the frame of the project it has been used to study the reaction of test persons to different features (colours, texts, pictures etc.) to a set of 4 different specifically designed road panels, in the four project languages. These have been shown to 36 test persons who have simultaneously been submitted to an Electroencephalogram and the application of a special eye movement sensor. These tools have allowed us to identify the most efficient panels and to know how to optimize the panels from the graphic point of view. 120 of these panels are now installed on the most critical roads.

Figure 3: Awareness raising panels developed through the neuromarketing technique

7.4.4. Results

Effectiveness of the AVC PS: in the frame of the LIFE STRADE project 17 AVC prevention systems were installed in central Italy. The effectiveness of the systems was evaluated on the basis of their activations. The devices were active for a total of 2.399 days. The number of activations of the sensors indicating the presence of animals near the road was 7.459, whereas the acoustic scaring devices were triggered 4.635 times, indicating the number of times there were vehicles passing in the 3 minutes after the detection of an animal and therefore a high-risk situation. The effectiveness of the systems in all these cases was around 100%. The main limit of the AVC PS is that it acts in well-defined areas, which clearly depend on the number of PIR installed sensors or thermal cameras.

Effectiveness of the virtual fence: The evaluation of the effectiveness of the virtual fence in the project areas is ongoing, because the first installation of the first 2 Km of virtual fence started in Romania in July 2020.

7.4.5. Financing

Both the LIFE STRADE and the LIFE SAFE-CROSSING project are EU-funded projects, cofounded by own funds of the partners.

LIFE STRADE: Total budget: 1.978.917 €, EU co-financing: 60%

LIFE SAFE-CROSSING: Total budget: 4.224,070 €, EU co-financing: 75%

7.5. THE INDICATIVE EUROPEAN DEFRAGMENTATION MAP

Author: Elke HAHN

Biological diversity is a fundamental basis for life and human health. In order to safeguard nature's ecosystem services for future generations, it is essential to conserve as many species as possible with their genetic diversity and the diversity of their habitats. Biological diversity in Europe remains under serious threat. The main reasons for this threat to animal and plant species are the destruction, isolation and fragmentation of their habitats. Climate change has added a new dimension to this danger. This increases the need for landscape connectivity for populating and repopulating habitats and for genetic interaction between populations.

Many member states have national concepts for a biotope network and for connecting habitats. Combining these creates a central European network. The Indicative European Defragmentation Map is a first compilation of the planned networks in – Austria, Belarus, Belgium (Flame), Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and Switzerland.

The map provides an initial overview of an important part of Europe's green infrastructure – the ecological core areas and the connecting ecological corridors within and between member states that form a Europe-wide network of green infrastructure which strengthens, inter alia, the EU Natura 2000 Network.

Member states had already made efforts in the past to avoid fragmentation and habitat destruction caused by linear infrastructure projects where possible and to take compensatory measures. These compensatory measures include the restoration of habitats. Preventive and mitigation measures include the construction of crossings above and below motorways and railway lines. These artificial measures are also a component of green infrastructure and are illustrated on the map, insofar as data about those wildlife crossings were available.

By compiling the networks and defragmentation measures in the newly developed map, an assessment of fragmentation due to the planned (Trans-European Network-Transport) TEN-T now is possible because detailed country-specific concepts are available.

The member states have developed their own planning instruments, on the basis of EU regulations, for assessing the impacts of fragmentation as intervention. For a better understanding of the mapped data, supplementary information on the network planning of the individual countries are available. These guidelines or information sheets provide background and additional information, for example about the methods and regulations on the individual network of the countries and the responsible institutional contacts. Further, they contain regulations on preventing fragmentation and on planning and constructing wildlife crossings for biological diversity in these countries.

Efforts had already been made in the past to visualize ecological coherence for biodiversity conservation throughout Europe with the Pan European Ecological Network (PEEN) [1]. However, the PEEN-Map was not detailed enough to estimate the impacts, for example of linear infrastructure plans at EU level. This was due to the fact that when the map was drawn up (Fig. 1), there were an insufficient number of detailed concepts in many countries, or these concepts had not been published and were therefore not accessible.

In May 2018 the EEA published an information strategy to support policy and decision-making on Green Infrastructure (GI) and restoration planning. This methodological guidance should promote mapping and planning the GI as a dynamic and resilient network.

An important step of the potential GI is shown that integrates the natural capacity of areas to deliver ecosystem services with the core habitats and wildlife corridors for large mammals within the EU territory [2].

As a further step and extension the Trans-European Network-Transport (IEDeM) could be used, because this map integrates existing and potential national networks as a summary of different types of ecosystems (woodlands, wetlands, dry and open habitat) interlinked by corridors.

7.5.1. Potential scope of application

The IEDeM can support the integration of environmental concerns into European transport infrastructure planning, i.e. the Trans-European Transport Network (TEN-T). European transport planning also set itself the task, with the 2011 White Paper, of becoming more sustainable and environmentally friendly: "…In practice, transport has to use less and cleaner energy, better exploit a modern infrastructure and reduce its negative impact on the environment and key natural assets like water, land and ecosystems…" [3].

An overlay of the Indicative European Defragmentation Map (IEDeM) with the planned and in some cases established corridors of the Trans-European Network-Transport (TEN-T) visualises existing and future fragmentation of the European biotope network by TEN-T. Extending the TEN-T will lead to an additional loss of habitats and to further fragmentation. In order to reduce the environmental impacts of the expansion and construction of the European transport network, preventive and mitigation measures to conserve the European biotope network are required in addition to measures that can at first only be outlined at national level. In accordance with the user-pays principle, these mitigation measures have to be financed from the transport budget because they would not be necessary if infrastructures were not being built. Where the existing infrastructure of the Trans-European Transport Network has already led to fragmentation of important habitat corridors, reconnection through functional wildlife crossings is required. To achieve this, the establishment of a reconnection programme for TEN-T is recommended, financed from the transport budget.

The construction of these wildlife crossings is intrinsically linked to the creation and restoration of an ecological hinterland connection. As well as making the European transport infrastructure more environmentally friendly, the map, once developed further, could also provide a basis for a new support programme along the lines of a Trans-European Network Green Infrastructure by defining areas eligible for support.

The Indicative European Defragmentation Map makes it possible to estimate the scale of planned fragmentation by the TEN-T at European level as a first step. The actual scale of fragmentation can only be assessed at national level, including transboundary linkages.

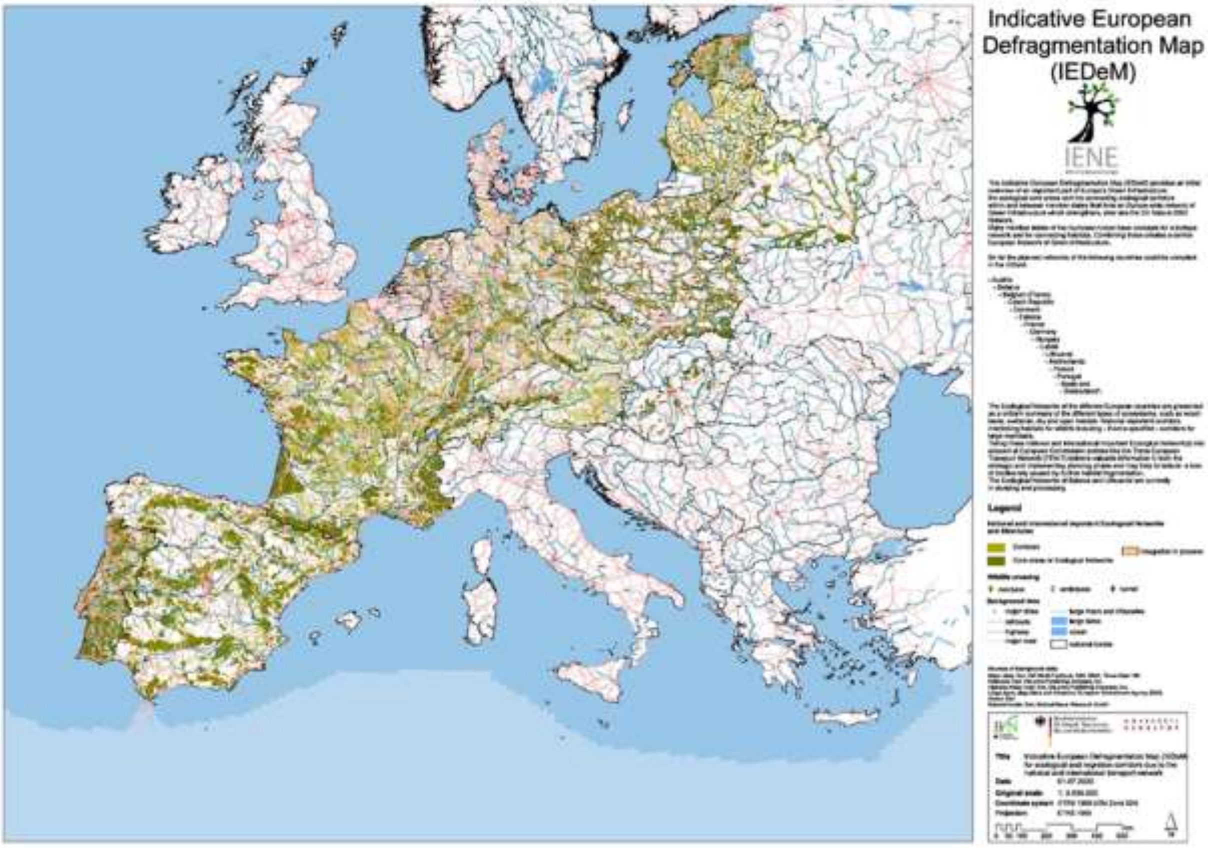


Figure 1: The Indicative European Defragmentation Map for ecological and migration corridors due to the national and international transport network

7.5.2. References:

1. https://www.researchgate.net/publication/226412795_The_pan_European_ecological_network_PEEN
2. https://www.eustafor.eu/uploads/ReportGI_EUSTAFORcomments.pdf
3. see: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52011DC0144 https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_en.pdf

7.6. The Dutch multi-year Program for Defragmentation (MJPO)

Author: Elke HAHN

7.6.1. Abstract

In the past few decades, the construction of highways, waterways and railways has left the natural areas in the Netherlands fragmented. Wildlife has increasingly become trapped in unnaturally small habitats. The Dutch Multi-Year Program for Defragmentation (MJPO) took care of fragmented nature by installing structures such as ecoducts, ecoculverts, wildlife crossings and banks along existing infrastructure that are easily passable for wildlife. These structures allow wild boars, otters, deer, badgers, salamanders, frogs, even bats and butterflies to cross infrastructure safely. These efforts have expanded the habitat of wildlife while increasing their access to food and shelter, and improving their chances of finding suitable mates. At the same time, these structures have reduced the number of wildlife casualties due to traffic movement or drowning.

7.6.2. Organization

At the launch of the Dutch Multi-Year Program for Defragmentation in 2005, the locations in need of defragmentation were identified. This program gave an overview of all the bottlenecks defined and the defragmentation measures constructed. The bottlenecks were sorted by their province and elaborated with the reconnected natural areas, target species, types of infrastructure and the partners involved.

The Directorate-General for Public Works and Water Management, Rijkswaterstaat and ProRail were in charge of executing the Dutch Defragmentation Program (MJPO), commissioned by the Central Government and under the auspices of the provincial authorities. The program was completed in 2018.

7.6.3. Results

At the end of the programme (Fig. 1), 72% of the 176 bottlenecks had been removed by installing a variety of wildlife crossings and structures. Many of these structures are used by the wildlife for which they were designed. Around 23% of the bottlenecks were partially solved, which means that not every planned measure to solve the bottleneck has been implemented (yet). Of the 592 measures implemented throughout the country, 85% have been realized. It is expected that of the remaining part, around 10% will be realized in the coming years as these measures are adopted by larger infrastructural projects. Around 5% cannot be constructed in a cost-effective manner and will, therefore, have to be resolved at a later stage.

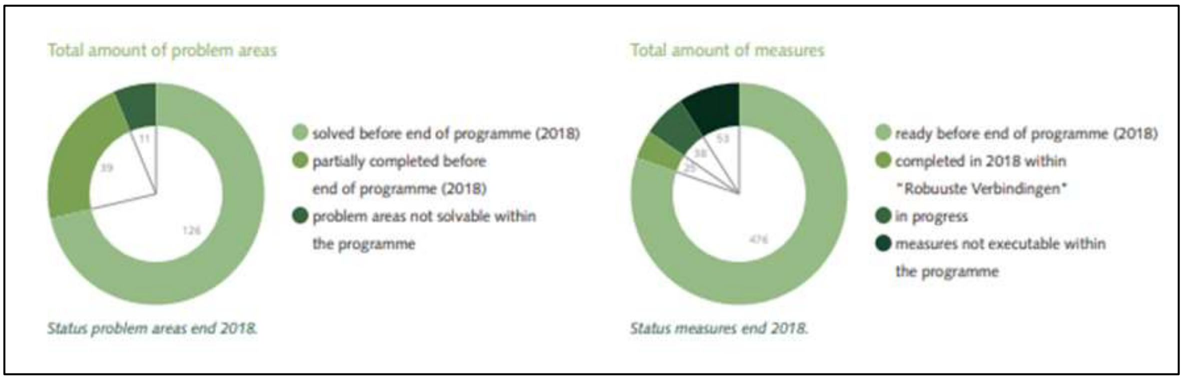
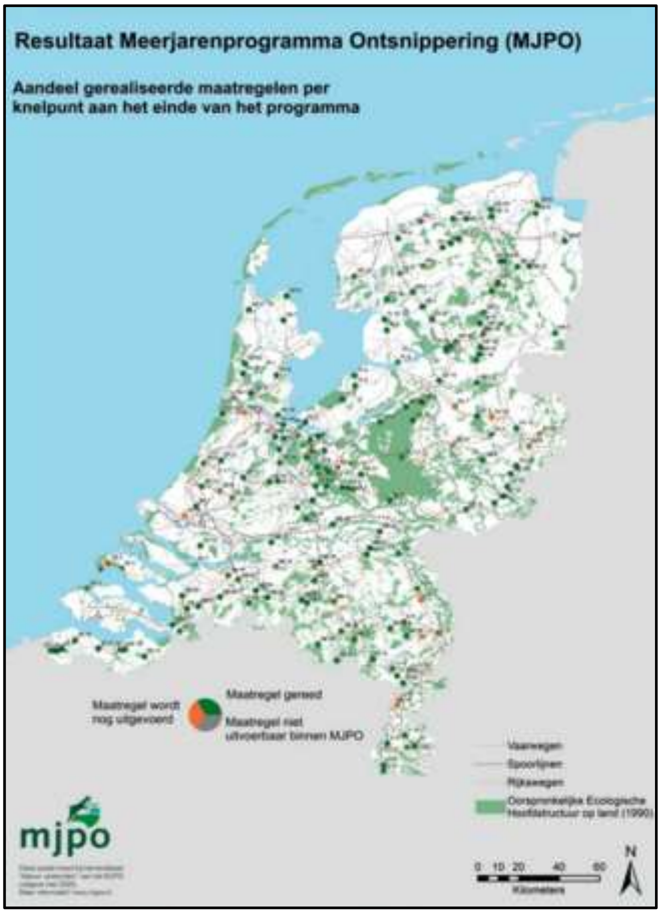


Figure 1: Descriptive statistics of the problem areas and the measures applied

7.6.4. Sharing knowledge

The programme delivered a significant contribution to the Netherlands Nature Network (NNN), the Dutch network of existing and new wildlife conservation plans. Defragmentation will remain an important issue in new infrastructure development projects, warranted by the Nature Conservation Act.



Therefore the knowledge gained during the lifetime of the MJPO will be shared with the provincial authorities, other nature management and conservation organizations, and foreign organizations that are working on infrastructure projects since defragmentation is not only a Dutch issue.

The international interest in this theme was apparent during the IENE2018 Conference (Infrastructure Ecology Network Europe), which was attended by 400 participants from 35 countries.

Figure 2: MJPO defragmentation Map in the Netherlands

7.7. Austria's Defragmentation Programme

Author: Elke HAHN

7.7.1. Abstract

Austria has a total of about 2000 km of motorways. Since 1986 it is obligatory to fence them on both sides for traffic safety reasons. Since then Austrian motorways have built a barrier to most of the terrestrial fauna species. In the early 1990s the first wildlife overpass was built above the A4. In 1997, the first version of the Guidelines for wildlife protection was released.

In 2001 a study by Völk et al, from the University of Natural Sciences on behalf of the Ministry for Economics (by then responsible for high level roads), investigated the fragmentation effects caused by motorways. The study showed the conflict points between wildlife corridors and the fenced motorways. In 2005 this work was continued by Proschek, WWF, on behalf of the Ministry for Transport, Innovation and Technology to prioritize the most important locations for refitting wildlife passages in the network of existing motorways.

In 2006 this study lead to a Directive of the Ministry for Transport, Innovation and Technology regarding "Habitat connectivity", which obliged the Motorway company, ASFINAG, to install 20 wildlife over-passes above existing motorways to connect internationally important corridors within 20 years, to design and construct wildlife passages according to the guidelines along new motorways and to evaluate the functionality of wildlife passages.

In 2007 the new version of the Guidelines for wildlife protection were released, defining the distances between and the design of wildlife crossings.

The Directive "Habitat connectivity" is being implemented in locations where the circumstances allow it. 4 bridges have been built, 5 more will be constructed in the near future. But about half of the necessary locations face big difficulties either caused by the lack of legal protection of the corridors in spatial plans or by other linear transportation infrastructures very close to the motorways.

Some problems but also successes are shown on the basis of an area in Lower Austria (Fig. 1). A main wildlife corridor connecting the Alps with the Czech Republic is intersected – among others – by the A1 West Highway.

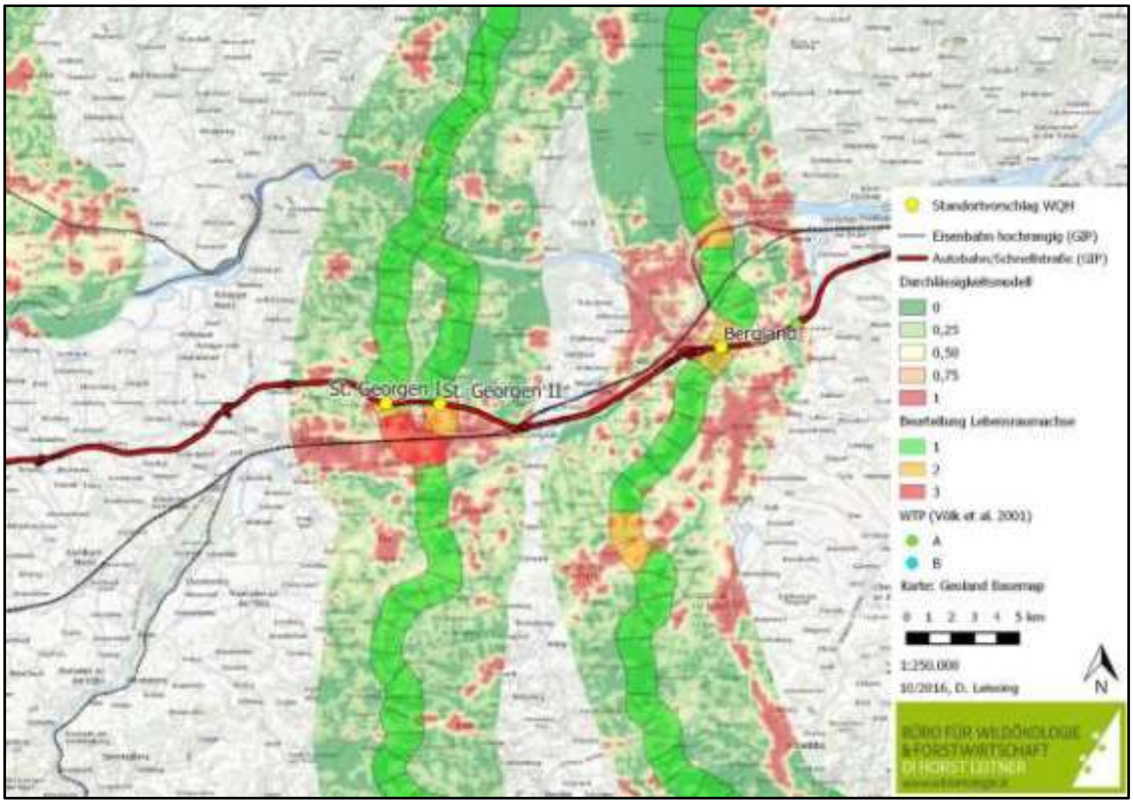


Figure 1: Wildlife corridors with bottleneck situations caused by motorway, railway and settlements

The eastern location shows one example of successful retrofitting of a wildlife crossing over the existing motorway, the greenbridge "Bergland" (FIg. 2). It was constructed in 2015 with a width of 60m and connects two parts of a forest, which were fragmented by the motorway so far.

Unfortunately the corridor has not been protected by spatial planning yet (FIg. 3 to 7).

Figure 2: Google Maps View of the greenbridge location


Figures 3 and 4: Construction of the Greenbridge

Figure 5: Greenbridge Bergland


Figures 6 and 7: Greenbridge surface

In the western part of the corridor two crossings, St. Georgen I and II, should be built. But south of the motorway the new high speed railway line intersects the corridor as well. The noise protection walls of the railway form an impermeable barrier for wildlife, therefore the retrofitting of a crossing over the motorway would not help to defragment the corridor (FIg. 8 and 9). In that case, the construction of a greenbridge over the highway would only be useful if the railway company would as well construct measures to make their infrastructure permeable for wildlife again. Strong cooperation from both stakeholders is needed!

Figures 8 and 9: High speed railways with noise protection screens parallel to the motorway

8. MONITORING / EFFICIENCY EVALUATION

Case studies

8.1. How to evaluate barrier effects: case study in France

Author: Olivier PICHARD

There are many techniques for assessing the barrier effect of a road (Fig. 1). The main techniques are based on monitoring animal populations in the vicinity of the infrastructure. The ideal solution is to use a standardized protocol such as Before-After Control-Impact (BACI). This involves conducting inventories of animal populations over a complete life cycle in the absence of the road and then using the same protocols after the road is built, at different time steps (n+1, n+3, n+10 etc...). The choice of species to be surveyed must be carefully adapted according to their response to fragmentation, but also according to their rarity in the study area.

Inventory techniques that allow for the collection of as much data as possible over the longest time period will be favored: camera traps, continuous audio recorders (audible and ultrasonic frequencies) and thermal cameras in particular. These techniques have the advantage of identifying species and providing information on their density. Other techniques based more on the presence of the species can usefully complete the previous techniques: environmental DNA or the punctual prospections.

Figure 1: examples of different techniques dedicated to evaluate and monitor barrier effect in the vicinity of fauna passage in France (National Road number 2) - top left : audio recorder for bats; below : camera trap; top right : thermal camera with camera trap; below: sampling of eDNA. photos: cc by sa 4 Olivier PICHARD.

8.2. How do we monitor in Canada?

Author: Mona ABOUHENIDY

A key aspect of mitigation planning should involve monitoring – important, but sometimes overlooked. Arguably, most mitigation efforts would ideally be monitored to confirm use of an area by wildlife, and apply adaptive management as required. This aspect of most projects is not consistently implemented, even those implemented under a legislated EIA process.

8.2.1. Before Construction: Planning and Design Phase

Since most wildlife management solutions are customized to site-specific conditions, monitoring is essential, both as part of the initial planning stage, and during operation. Monitoring of suspected crossing sites, or those where retrofitting is considered, prior to developing mitigation plans can ensure species-specific mitigation design. Monitoring data can also provide evidence of effectiveness for constructed measures, to help justify not only the initial investment at one site, but other future applications within a given jurisdiction.

Monitoring ideally begins at the project planning stage. Multiple studies have incorporated Before-After-Control-Impact (BACI) analysis into their monitoring design to aid in the design and site selection of the type of wildlife management and follow-up monitoring.

Depending on the solution, construction and implementation costs can be substantial and monitoring helps justify both initial and ongoing funding (e.g., for maintenance). Monitoring results have confirmed expectations relative to use and sometimes exceeded expectations.

8.2.2. During Construction

Monitoring design is important to move beyond simple counts of species use of mitigation structures toward evaluation of effectiveness. Standard experimental design, with proper control sites, and variables that allow comparison among multiple crossing sites (e.g. fencing locations, vegetation management, jump out types) will not only demonstrate use and achievement of conservation goals, but link use to specific features incorporated into mitigation design.

8.2.2.1. Other key factors include:

- A clear articulation of the intended type (daily, seasonal or occasional) and frequency of use for target species, factors that ideally were incorporated into initial mitigation design and founded on an understanding of species density in the crossing area, and past frequency and types of use, gained from analysis of past crossing incidents
- Control sites near the road, but beyond the road-effect zone for the target species, which will again depend on prior knowledge of the species behaviour relative to the road type
- Measurement of other explanatory variables, such as road noise, road types (for study of multiple mitigation sites), crossing structure design, use by people, domestic animals or livestock, structural features of the landscape and weather conditions (e.g. snow depth, rainfall)
- Sampling techniques that can monitor several species at once are more cost-effective, and thus preferred. This may require use of multiple techniques to reduce impact of sampling biases (e.g. use of camera traps and track beds together provide information on species, direction of travel and gait, as well as age and sex of animal). Other

techniques that have been used include survey of animal sign or direct observation, and hair trapping for visual identification or DNA analysis.

- Sampling frequency, timing and duration based on the objectives of both the mitigation and monitoring (e.g. seasonal use will require comparison across relevant seasons; daily use will require more intensive sampling). Monitoring over several years will help confirm use where annual variation is expected. Duration of sampling should also consider the lag time before wildlife learn to find and use the structure, which in some cases has occurred over several years.
- Thorough statistical analysis, with sufficient sample size (from survey frequency, timing and duration, or from multiple mitigation sites) to detect statistically significant differences

8.2.3. After Construction / Operational Phase

To ensure that monitoring is completed post-construction, project budgeting must include not only design and construction costs, but post-construction monitoring. Further, monitoring programs should consider and secure funding for surveys immediately after construction is completed, but also follow-up studies at appropriate time intervals to show patterns of use over time. Since wildlife may require some time to become accustomed to mitigation (e.g. wildlife crossing structures and fencing), monitoring should be scheduled over several years during the operational phase of a project. For example, monitoring wildlife movement after fencing installation can help assess whether it has been installed effectively, and inform adaptations for improved performance to maintain regulatory compliance, or project specific objectives. In some cases, monitoring has also identified unforeseen responses by wildlife to fencing, or crossing measures, leading to new mitigation practices.

Maintenance, monitoring and adaptive management are important for long-term success of any mitigation measures. For example, fencing requires periodic maintenance, as does roadside vegetation adjacent to crossing structures, and potentially also on overpasses to facilitate travel by target species. Vehicle and other damage can trigger more significant maintenance costs for fencing and, potentially, overpass structures, particularly where winter driving conditions may increase the risk of damage from vehicles, or in forested zones, where windfall is a risk. Monitoring and adaptive management can help identify concerns (Fig. 1, 2 and 3).

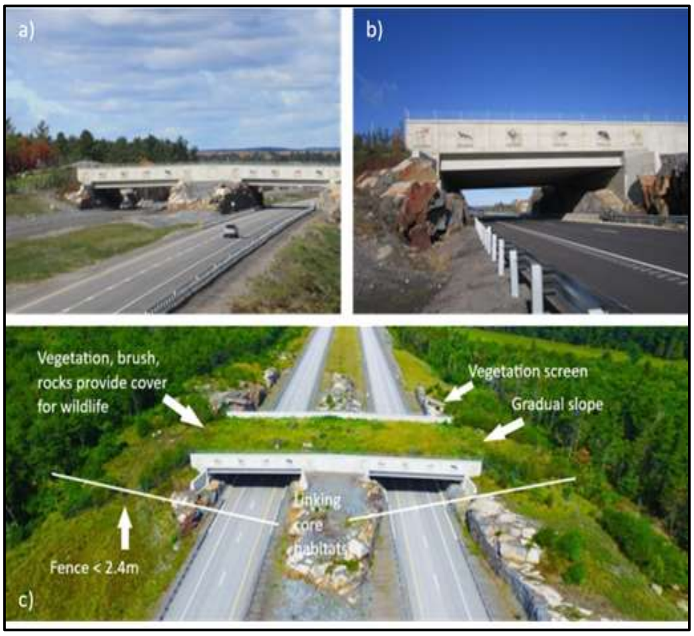


Figure 1: Monitoring overpass structure design – (a); (b); and (c) Highway 69, south of Sudbury, Canada near Highway 637 turn-off to Killarney, Canada. Fencing, roadside vegetation adjacent to crossing structures, and overpass structures requires periodic maintenance. Vehicle and other damage can trigger more significant maintenance costs for fencing and, potentially, overpass structures. This is why monitoring during and after construction is essential (Patriquin et al., 2021; Photo credits: EcoKare International and Ontario Ministry of Transportation).

Figure 2: Monitoring underpass structure design – (a) hydrological culvert for aquatic connectivity (Patriquin et al., 2021; photo credit: EcoKare International and Ministry of Transportation, Ontario); (b) fenced aquatic culvert gap (Patriquin et al., 2021; photo credit: EcoKare International and Ministry of Transportation, Ontario); (c) corridor trail below bridge structure (Patriquin et al., 2021; photo credit: EcoKare International and Ministry of Transportation, Ontario); and (d) terrestrial underpass with fencing treatment (Patriquin et al., 2021; photo credit: Martin LaFrance).

Figure 3: Monitoring underpass structure design for small to medium-sized animals - A vehicle collision with a small or medium wildlife species is less likely to result in human injury or death, but there is high potential for death of the animal. After construction monitoring is essential to ensure wildlife is using the structures put in place (Patriquin et al., 2021; (a) and (b) photo credits: Dr. Tony Clevenger; (c) and (d) photo credits: Kari Gunson).

8.2.4. References

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8.3. Example - Disturbance at the Voleč ecoduct

Author: Kristýna NEUBERGOVÁ

8.3.1. Introduction

As part of project-oriented teaching at the Czech Technical University in Prague, Faculty of Transportation Sciences, a survey of the functionality of selected ecoducts was conducted. One of them was the Voleč ecoduct, where noise and lighting measurements were measured and evaluated. The outputs presented in this case study were published in the bachelor's and master's thesis [1][2].

Ekodukt Voleč is located on the D11 motorway in the Pardubice Region and it was put into operation in 2006. Its minimum width in the axis of the road is 78 m, the minimum width is 37 m. The length is 80 m. The ecoduct has an illuminated part on one side, which serves to illuminate the section under the bridge (see Fig. 1).

Figure 1: Aerial view of the Voleč ecoduct and its condition (2015) [3][1]

The ecoduct is conveniently located, connects forest complexes and there are no residential buildings nearby. On both sides of it, a wooden noise barrier is built, which is about 3 m high. The wall is sometimes overgrown with climbing greenery, so it does not disturb the surrounding character. The whole ecoduct is overgrown with vegetation, only a footpath leads along it (Fig. 1).

To increase the functionality of the ecoduct, it is important to minimize disturbances. Disturbances mainly include noise, illumination and visual interference. In this case study, the outputs from the illumination and noise measurements on the selected ecoduct are shown.

8.3.2. Noise disturbance

The measurement took place on May 21, 2015 in windless weather and cloudy skies. It was measured from approximately 12 to 17 o'clock in the afternoon. The measurement interval at each measuring point was chosen to be 60 min. The measurement took place during peak hours, therefore the measured data can be considered as maximum on the assessed object.

The measurement was performed with a Norsonic 140 sound level meter. The sound level meter microphone was placed at a height of 0.90 m above the ground. This height was chosen because it represents the height of the ears of the presumed game species. It was chosen as the average among the main representatives of individual categories of animals - category A represented by deer, category B represented by roe deer and category C represented by fox.

Five measuring points were chosen on the ecoduct. The exact positions of these points and sound level meter location are drawn in figure 2 [3][2]. The measurement results are shown in the following table 1 [1].

Figure 2: Positions of the measuring points on the Voleč ecoduct and sound level meter location [3][1].

Table 1: Measured values [1]

Point	LAeq [dB]	Intensity [veh/hour]
1	56,9	1310
2	57,0	1455
3	60,0	1591
4	67,6	1634
5	56,9	1816

The lowest values of the equivalent sound pressure level (Laeq) were found in point 1 and point 2. This is achieved by the presence of a noise barrier and continuous vegetation on the bridge. The highest values were reached at measuring point 4 near the road. The measured values also show the shielding of point 3, i.e. the area of the entrance to the ecoduct compared to point 4. Point 5 is already located in the forest and shows significantly lower values of the equivalent sound pressure level.

There are no limits or standards for measuring noise and evaluating values in relation to wildlife. The migration of large mammals theoretically takes place here at night. However, even with lower night traffic, an undisturbed transition cannot be expected on the assessed ecoduct. The measured noise values were recorded at peak intensities during the day, but based on the results it can be assumed that the noise values even at night will be very significant on the ecoduct and its surroundings. Another problem of migration at night is the lighting from passing cars, which is discussed below.

8.3.3. Illumination intensity and visual disturbance

The photometric quantity of illumination intensity was chosen as one of the main investigated factors for the assessment of lighting conditions. The second factor chosen was visual disturbances. Together, these two factors are included in the concept of light interference.

The lighting conditions may be different in different places of the ecoduct, so several points were selected for the measurement (see Fig. 3).

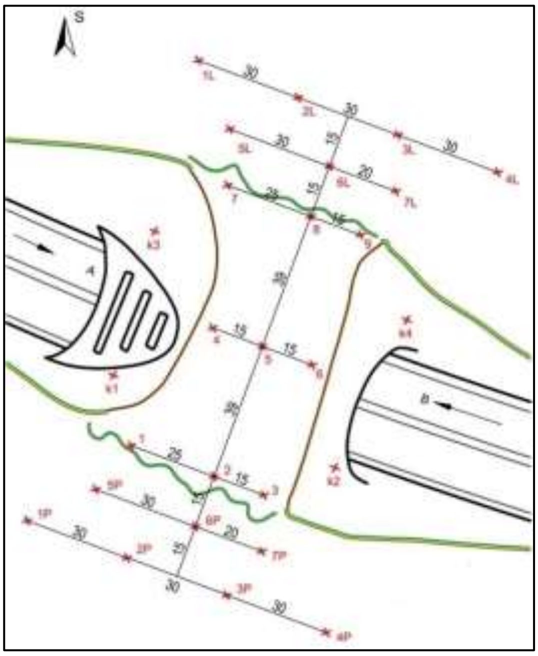

Figure 3: Location of measuring points on the Voleč ecoduct [2]

Measurements took place on March 23 and April 7, 2011 and was always started no earlier than 1.5 hours after sunset.

In both terms selected for measurement, climatic conditions with cloudy or partly cloudy skies without moonlight were suitable. A digital luxmeter (light meter) LX-1108 manufactured by Voltcraft was available for measurements. The maximum natural value of illuminance was 0.001 lx.

In one measuring period, a total of 4 measurements of the intensity of lighting from the road were carried out at each point of the ecoduct. The luxmeter sensor was always oriented towards traffic to record contributions and changes in lighting from light sources to the road- in direction A and B. For a more comprehensive evaluation, the investigated quantity was also recorded in two height levels - first at a height of 1 m and then at 2 m above the ground.

8.3.3.1. Illumination intensity

Emax values were measured. A graphical representation of EmaxØ values from both directions (A and B) is shown in Fig. 4. The highest value of the EmaxØ value from the measurement of both directions is always shown. The EmaxØ value in this figure always corresponds to the arithmetic average of the values recorded during independent measurements on two measuring days.

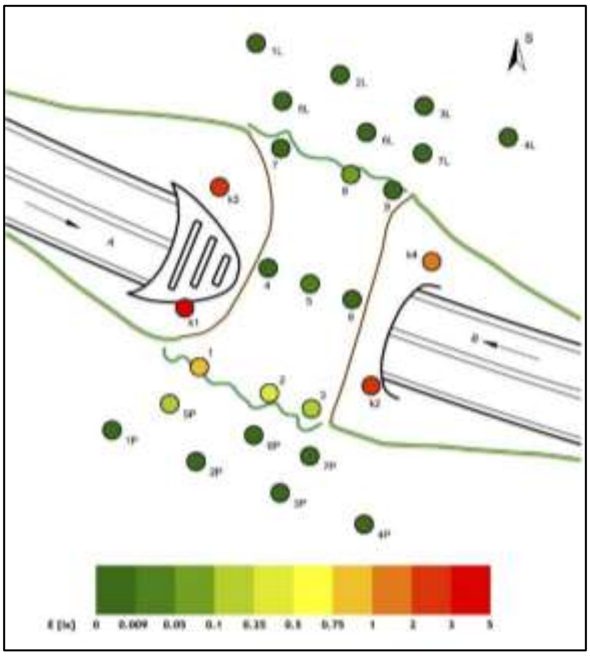

Figure 4: Graphical representation of E maxØ values from both directions (A and B) [2].

8.3.3.2. Visual disturbance

At each assessed point of the ecoduct, disturbances were evaluated and recorded according to a set scale:

A - No interference detected

B - Slight interference, distant visual contact

C - Significant interference, visual contact nearby

D - Very strong interference, immediate visual contact

A graphical representation of the visual disturbance is shown in the following figure 5 [2].

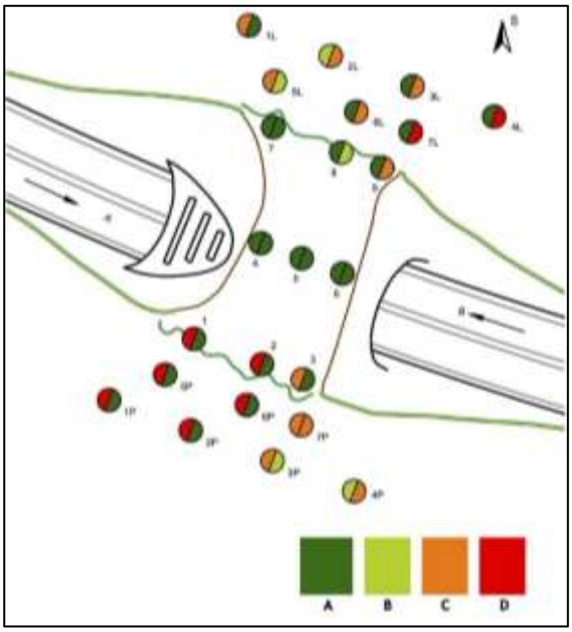

Figure 5: Graphical representation of visual disturbance from both directions (A and B) [2].

Measurements have shown that the points on the ecoduct, which are covered by noise barriers, are not significantly affected by interference. Thus, it can be stated that noise barriers made of non-transparent materials significantly reduce light disturbance, which was confirmed by measuring several other randomly selected points on the body of the ecoduct and supplemented by the assessment of visual disturbance (Fig. 6).

Figure 6: Situation and visual disturbance - view from point 5P direction A [2]

8.3.4. Conclusion

Measures to reduce noise, illumination intensity and visual disturbance are mainly various forms of noise barriers. Noise barriers thus serve a dual purpose, because they also serve as an ecoduct fence.

The Volec ecoduct is rated in the Czech Republic as one of the most successful and there are no significant problem areas. Only on the edge of the forest, especially along the road, it would be appropriate to also plant lower growth. Addition of a lower vegetation layer would create better road cover and reduce the spread of disturbance.

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8.4. INUVIK TUKTOYAKTUK HIGHWAY (NORTHWEST TERRITORIES - CANADA)

Authors: Mona ABOUHENIDY and **Jillian SIMPSON**

8.4.1. Northern Road Management in Canada

Northern transportation systems in Canada and other panarctic regions include all-weather and winter roads built on permafrost, and ice roads and ice bridges built across frozen waterbodies. Design and operation of such systems has historically required specialized engineering and environmental advice, given the frozen substrates on which they are constructed. Specific wildlife concerns must also be considered, given the undeveloped, natural landscapes across which these roads pass. Hiding cover can be limited in some areas, and winter road maintenance, as well as traffic, can disrupt natural patterns of movement, in turn affecting survival of species used by Indigenous communities (e.g. caribou).

The Inuvik Tuktoyaktuk Highway (ITH) has been a major priority for the territorial and federal governments since the 1960s (Fig. 1 and 2). It opened to traffic on November 15, 2017. The 140 km all-weather highway provides a land connection to the northern community of Tuktoyaktuk. Prior to this, the community was only accessible by airplane or the ice road. Approximately 71 km was built on Inuvialuit private lands which was managed by the Inuvialuit Lands Administration. The rest of the route is located on Crown lands. The administration of the Crown lands is by the Government of the Northwest Territories (GNWT). Goods can now be shipped year-round to Tuktoyaktuk.

Figure 1: Map of location of the ITH project (Toronto Star)

Figure 2: Completed highway project (ITH TAC Presentation)

8.4.2. Wildlife, Permafrost and Vegetation Mitigation Measures

Effects on wildlife and vegetation have been far less studied in Canada's North, and mitigation has instead been proposed as part of the environmental impact assessment process, for impacts triggering scientific, regulatory or public concern. Predicted effects on wildlife and wildlife habitat included habitat loss, physical or physiological disturbance, delayed or failed crossings and mortality associated with highway construction (TAC, 2020). Table 1 provides an overview of the mitigation strategies used.

Table 1: *The Inuvik Tuktoyaktuk Highway Mitigation Strategies – Summary Table*

Issue	Mitigations
Wildlife protection – General	- Wildlife will be given the right-of-way where possible - Post warning signage to stop traffic, or reduce speeds when wildlife spotted near roadway or where they frequent - During construction, an active surveillance program was implemented and Project Wildlife Monitors communicated daily observations to construction team - Constructing earthen berm barriers to minimize sound disturbance - Construct breaks in snow and windthrow berms to provide escape routes for wildlife - Access restrictions to the highway during peak caribou migration periods and highway closures during times of high caribou presence - Construction of wildlife passages / tunnels - Any vegetation clearing necessary for construction activities (e.g., to install water crossings), was conducted during frozen ground conditions, and done by hand, where practical - Highway construction activities during summer was primarily limited to road base compaction and grading, and culvert remediation and maintenance
Vegetation protection	- Chipping or mulching was used to add nutrients to the local soils, enhancing vegetation growth. - Keeping vegetation as a buffer between road and the land, as well as for aquatic habitats - Limiting vegetation clearing in areas with permafrost, so that the shade provided by vegetation can prevent ground thaw (i.e. tree clearing) and Hand-cutting of trees to reduce heavy machinery on the permafrost. - Dust and road salt use can impact adjacent vegetation, as well as the permafrost on which some roads may be built; as well as attract wildlife. Alternatives were used where possible

8.4.3.1. Wildlife

Caribou and other large mammals such as moose, grizzly bear, wolverine and fox are of keen interest to the communities surrounding the highway development for substance and cultural value. Roads and road management can affect wildlife in a variety of ways, including collision, but also through less obvious means, such as habitat alienation and disturbance. For example, caribou mortality and disruption to migration affects traditional hunting and cultural use of Northern Indigenous communities. Several populations of Canada's boreal caribou populations were listed under the federal Species at Risk Act (SARA), including the main Boreal population found across most of Northern Canada (Fig. 3 and 4).

Mitigations were developed to prevent sensory disturbance and mortality for caribou, including:

- During construction, an active surveillance program was implemented, in addition to posting warning signage to stop traffic, or reduce speeds when caribou were on or near the road.
- Constructing earthen berm barriers to minimize sound disturbance
- Caribou have the right-of-way at all times (a standard GNWT road mitigation practice)
- Speed reductions when animals are observed in proximity to the road surface or on it
- Increased signage and warnings regarding the potential for wildlife on the roadway
- Construct breaks in snow and windthrow berms to provide escape routes for wildlife
- Access restrictions to the highway during peak caribou migration periods and highway closures during times of high caribou presence

Figure 3: Wildlife crossing constructed for the ITH project (ITH TAC presentation)

Figure 4: Caribou crossing at the Inuvik-Tuktoyaktuk highway near Jimmy Lake, Northwest Territories (NNSL, 2018)

8.4.3.2. Protecting Permafrost and Vegetation

Construction projects located on permafrost terrain are often situated on sensitive tundra, which can be severely damaged by simply moving equipment over it. It is therefore vital to minimize the construction "footprint" and implement an environmental management plan to cover such issues as tundra sensitivity, air quality and noise, terrain and vegetation, wildlife, fisheries and aquatic resources, waste management and fuel / oil management. The design of projects in permafrost areas should incorporate the best practices for long-term permafrost preservation (Fig. 5; TAC, 2010).

Vegetation impacts must also be addressed, to mitigate habitat and biodiversity degradation effects on longer highway developments, but also concerns related to permafrost protection. Recommended practices include limiting vegetation clearing in areas with permafrost, so that the shade provided by vegetation can prevent ground thaw. Tree clearing should be minimized to protect permafrost layers. Since such clearing is sometimes done with excavation equipment, ensuring that trees are not uprooted, exposing and thawing underlying soils is an important mitigation. Hand-cutting of trees is preferred for this reason. Brush disposal is another concern in permafrost areas. Chipping or mulching will add nutrients to the local soils, enhancing vegetation growth. Burning is not recommended in permafrost areas, since it could cause ground subsidence. Vegetation may also be retained to serve as a visual buffer between a public highway, and other land uses, as well as physical buffer from aquatic habitats.

Figure 5: Permafrost layers at construction site (ITH TAC Presentation)

8.4.4. Regulatory Framework in Canada's North

Canada's three northern territories (Yukon, NWT and Nunavut) are managed jointly by federal, territorial and Indigenous governments, under regionally negotiated land claims agreements. As a result, community engagement is an important aspect of any new project design, including roads, and a stringent requirement under the respective federal, territorial and co-management environmental impact assessment (EIA) processes.

Specific to projects in the Western Arctic and Yukon North Slope, including the ITH Project, a Co-management System is used and is composed of five Co-Management Boards:

- Environmental Impact Screening Committee
- Environmental Impact Review Board
- Fisheries Joint Management Committee
- Wildlife Management Advisory Council (NWT), and
- Wildlife Management Advisory Council (North Slope).

During the planning, construction and operation of the ITH project (Fig. 6), three regulatory requirements for impact assessment were implemented:

- The Wildlife Effects Monitoring Program (WEMP) addresses monitoring and testing of predicted effects during the pre-construction, construction, and operations phases for key wildlife species (caribou, grizzly bear and wolverine).
- The Wildlife Protection Plan (WPP) describes wildlife and wildlife habitat mitigation measures, applicable legislation and regulations, monitoring, and reporting requirements applicable to species at risk and species of management concern, including caribou, grizzly bear, moose, furbearers (wolf, wolverine, beaver, muskrat, etc.), and birds. These species are protected by legislation, or are of importance to local Inuvialuit harvesters. The WPP identifies mitigation measures related to reestablishment of habitat

on disturbed sites, prevention of introduction of invasive plant species, and prevention of dust impacts.

- During construction of the highway, Environmental Monitors, reporting to the Inuvialuit Land Administration, monitored Project activities to observe whether work is conducted in accordance with applicable regulations, commitments, and mitigation measures.

Figure 6: ITH construction (ITH TAC Presentation)

8.4.5. References

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8.5. The Rt. Hon. Herb Gray Parkway (Ontario): A Parkway in a Prairie

Authors: Mona ABOUHENIDY and Jillian SIMPSON

The Rt. Hon. Herb Gray Parkway is the access road portion of a new end-to-end border transportation system between Windsor, Ontario and Detroit, Michigan; Canada's busiest land border crossing, which carries nearly one third of the trade between Canada and the United States.

The Provincial Environmental Assessment determined that much of the Parkway would need to remain in the existing highly urbanized corridor. The existing highway corridor which included 17 traffic signals, was congested with a mix of local and international traffic (Fig. 1). The congestion resulted in localized air quality impacts, diversion of trucks to local streets, and had a negative economic impact due to border delays.

The $1.4 billion Parkway includes an 11 km extension of the six lane Highway 401 and a parallel service road for local traffic.

The Ojibway Prairie Complex, which is adjacent to the Parkway, is the largest protected prairie in Ontario. It is home to more species at risk than anywhere in Ontario. Tallgrass prairie ecosystems are one of the most endangered vegetation communities on Earth and home to many rare species. Very little tallgrass prairie remains in North America with estimates ranging from five percent to less than one percent of the original ecosystem.

An ecosystem approach which aims to understand interactions between physical, biological and anthropocentric components and recognizes the need for conservation, was applied to address the unique environmental sensitivities within the Parkway throughout the planning, design and construction phases and will continue throughout maintenance and operation of the Parkway.

The Parkway's ecological approach has resulted in an increase of over 100 ha. of Tallgrass Prairie habitat. By building the highway below-grade with a series of 11 tunnels, the Parkway has re-connected communities on either side of the corridor. A multi-use trail system running the length of the Parkway provides an opportunity for active transportation and links users to community features through 50 access points. The new trail also offers opportunities for users to connect with nature and to develop a better understanding of the area's unique ecological features.

8.5.1. Wildlife Management:

One of the 11 tunnel tops is a dedicated ecopassage (Fig. 2 and Fig. 3). This is the largest ecopassage in Ontario with an area of 14,544m2, roughly the equivalent of 9 NHL hockey rinks. This ecopassage connects two natural areas that have been separated since the construction of Huron Church Road in the 1920s.

An estimated 200,000 species at-risk plants along with many rare associate plants were successfully transplanted to protected restoration areas outside the corridor. Between 2008 and 2014, 504 species at-risk snakes (i.e. Eastern Foxsnake and Butler's Gartersnake) were relocated from the construction footprint to protected Tallgrass Prairie areas. Relocated snakes have successfully selected new places to hibernate, lay eggs, and give birth to live young, exhibiting adaptability to new habitats. One particularly innovative approach was to use the foundations of former houses to construct hibernacula for snakes (Fig. 4).

The new expanded highway right-of-way now includes naturalized, meandering channels with new riparian cover. Refuge pools have been constructed that provide increased depth for fish during low flow periods. A new pond constructed on the Lennon Drain provides habitat for spawning, rearing, foraging and refuge for all of the resident species, including Northern Pike, a significant recreational fish within the Detroit River and some of its tributaries. The new pond has an area of approximately 2 ha and incorporates a permanent low flow channel. A new stormwater management system improves overall water quality for the receiving watercourses through the removal of sediment from highway runoff. New fish habitat has been created to address the lifecycle needs of important fish species. Table 1 summarizes the various mitigation measures applied to the Parkway.

Figure 1: Parkway pre-construction, Howard Ave., 2006 (Ministry of Transportation Ontario, 2016)

Figure 2: Parkway post-construction with dedicated ecopassage, Howard Ave., 2015 (Ministry of Transportation Ontario, 2016)

Figure 3: Aerial view of the tunnel top ecopassage at the Herb Gray Parkway project (Ministry of Transportation Ontario, 2016)

CASE STUDIES

Figure 4: Residential buildings were demolished on two residential streets and re-naturalized in areas of known species at risk snakes. (Ministry of Transportation Ontario, 2016)

Table 1: Summary Table of Mitigation Strategies for the Rt. Hon. Herb Gray Parkway

The Rt. Hon. Herb Gray Parkway Mitigation Strategies – Summary Table	
Issue	**Mitigations**
Vegetation protection	Tallgrass Prairie protection: Within the landscaped portions of the Parkway, 44.3 of the 120 ha of greenspace are created. Tallgrass Prairie communities. Beyond the limits of the Parkway, 35.1 ha of Tallgrass Prairie are being restored to provide new and higher quality habitat for several species at risk. Sod Mat Transplant Method: A sod mat method was developed to efficiently and effectively relocate SAR plants and associative vegetation in 1m by 1m sections. 850 tonnes of Prairie soil with native seed bank was salvaged through this method. Transplants are thriving (Fig. 5) Propagation of Colicroot: Through 10 scientific trials the Parkway team developed a successful method for growing Colicroot from seed. The successful method was used to meet the ESA permit compensation requirements and will have application to other restoration projects and will assist in the recovery of the species.
Wildlife protection	Snake Radio Telemetry: Development of new radio transmitter for implanting in the SAR snakes for radio tracking and monitoring of snake movements which has led to several scientific discoveries. Snake Habitat Features: Residential buildings were demolished on two residential streets and re-naturalized in areas of known species at risk snakes. The demolitions provided an opportunity to create live birthing areas and hibernacula using the foundations and debris. This maintained site fidelity for snakes which had previously overwintered in these locations. Snake Fence Designs: A new barrier fence was developed specifically for the Parkway to keep snakes out of the highway corridor. Due to their known ability to climb, Eastern Foxsnakes were used to test different fence designs/heights leading to a new permanent snake barrier design. 13 km of permanent snake barrier fence is installed (Fig. 6).
Fish habitat creation	Overall, 35,000 m2 of new fish habitat was created, and the new expanded highway right-of-way now includes naturalized, meandering channels with new riparian cover. Refuge pools have been constructed that provide increased depth for fish during low flows. A new pond constructed on the Lennon Drain provides habitat for spawning, rearing, foraging and refuge for all of the resident species, including Northern Pike, a significant recreational fish within the Detroit River and some of its tributaries. New stormwater controls provide overall benefits to water quality for aquatic life through the removal of sediment that would have previously been deposited in the drains from road surface runoff. Stormwater ponds adjacent to constructed pond habitats have outlets that provide extended flows to refuge habitat in otherwise characteristically low flowing systems.
Wetland Preservation & Restoration	The direct loss of 5.4 ha of provincially significant wetland from construction activities has been offset by the preservation of over 45 ha of provincially significant wetland and associated buffer lands. These lands will provide habitat for many species, improve water quality and add natural capacity for flood storage. These ecosystem services add resiliency to the effects of climate change.

Figure 5: Sod mat transplanting process to protect sensitive prairie grass ecosystem (Ministry of Transportation Ontario, 2016)

Figure 6: The smooth lower panels of this noise barrier wall prevent Eastern Foxsnakes from accessing the highway (Ministry of Transportation Ontario, 2016)

8.5.2. References

- A Parkway in a Prairie: The Rt. Hon. Herb Gray Parkway (2016). Resilient Infrastructure Report https://www.tac-atc.ca/sites/default/files/conf_papers/foster.pdf
- Detroit River Canadian Cleanup Presents: Ecohighway. https://www.youtube.com/watch?v=c0HBHwNjAA4
- https://www.hgparkway.com/sites/default/files/downloads/Interpretive%20Sign%2012%20-%20Tallgrass%20Prairie%20Restoration.pdf

9. FURTHER READING

9.1. Wildlife and Traffic' Handbook

The pioneer European handbook is being updated in cooperation with the project 'BISON' about infrastructure and biodiversity

'Wildlife and Traffic' is a **solution-orientated online handbook** focused on providing practical guidance about measures to **mitigate habitat fragmentation due to transportation infrastructures**. It is based on the first European handbook on the topic that was published in 2003 as the main output of the Cost Action 341 project promoted by the Infrastructure and Ecology Network Europe (IENE).

IENE is at present leading a **cooperative process to update the handbook in alliance with the HORIZON 2020 project BISON** 'Biodiversity and Infrastructure Synergies and Opportunities for European Transport Networks'. The alliance between IENE and the BISON team will allow the expansion of the contents and produce a complete new handbook tackling the issue of mainstreaming biodiversity and transport infrastructure development that will be available by the end of 2023. Cooperation with CEDR, PIARC and other organisations is also undertaken to enrich contents such as a new Chapter on Maintenance or the Glossary included in the handbook website.

The online handbook makes guidelines more accessible and attractive to encourage its application. It is also a living tool where new content can be easily included to promote **evidence-based, effective, feasible, innovative actions** reducing impacts of infrastructure and accelerating the application of positive actions to mainstream biodiversity in transportation infrastructure.

The handbook makes available to professionals involved in planning, construction, design and maintenance of transport infrastructure the knowledge produced by researchers and practitioners throughout the last decades of ecological mitigation, and best practice identified through a literature review and contributions from experts.

The online handbook is available at: https://handbookwildlifetraffic.info/

Check also:

Updated Chapter 7. Solutions

New Chapter 10. Maintenance of ecological asset

Transport Ecology Guidelines Portal

Glossary

9.2. THE BASIC PRINCIPLES FOR SUSTAINABLE TRANSPORT AND OTHER LINEAR INFRASTRUCTURE (TLI)

In the last years, principles for sustainable Transport and other Linear Infrastructure (TLI) , listed in the Table 1 below, have been developed by IENE (Infrastructure and Ecology Network Europe) and further improved with the outcomes of the FORUM ON SUSTAINABLE INFRASTRUCTURE: Integrating Climate Resilience and Natural Capital into Transport Infrastructure Planning and Design held in Hanoi, Vietnam in 2017 [1].

9.2.1. Reference

[1] Georgiadis L, et al: 2018. Towards developing sustainable Linear Transportation Infrastructure globally. Recommendations for priorities of international action. Final report of the IGELI project: International Guidelines for Ecologically-adapted Linear Infrastructure. IENE. Linköping, Sweden. P 40

Table 1 : Overview of all International Principles for Sustainable TLI [1]

	International Principles for Sustainable TLI
1	**Strong policy and legal framework:** Safeguarding landscape connectivity as a primary concern for any project scale, establishment and strengthening of a policy and legal framework of regulatory requirements for sustainable TLI development is necessary.
2	**Strategic planning:** Any major TLI should be based on an overall strategic plan, and designed and developed to guarantee ecological fluxes and well-connected wildlife populations before any implementation and funding decision is made. The "Mitigation Hierarchy" of 'Avoidance – Mitigation – Compensation' should also be implemented.
3	**Ecosystem approach:** TLI projects should combine habitat quality with healthy ecosystem functioning based on the "Precautionary Principle". The value of Natural Capital and ecosystems services should be included along with projects that acknowledge cultural diversity, as an integral component of ecosystems (www.cbd.int).
4	**Any case is a unique case**: Each TLI project is site-and species-specific and is therefore unique. Mitigation should be based on scientific and best available local knowledge without "copy and paste" from other projects.
5	**Multi-disciplinary and cross-sector cooperation**: To ensure integration and coordination, the establishment of multi-level governance and stakeholder engagement, with multi-disciplinary co-operation amongst different professionals (such as engineers, policy makers, economists, ecologists and environmentalists) as well as cross-ministerial agencies (such as, nature conservation, transportation,finances) should be applied.
6	**Stakeholder involvement and public participation**: Involvement of civil society and all the relevant stakeholders in the development of TLI projects.
7	**Responsible polluter pays principle**: Implementation of the "polluter pays principle" where the integration of environmental consideration is responsible for TLI investments, after clarifying the ethical and transparency concerns; this should include concrete mitigation measures from the onset of the TLI planning phase, until the tendering and contracting, and finally to the building and operating phases.
8	**Long life effective maintenance**: Inclusion of TLI maintaining mitigation measures in the budget for the life-cycle of the operation.
9	**Resilience to climate change**: TLI should be planned or adapted with consideration for their resilience to natural disasters and risks, associated with extreme weather events and climate change. This is especially the case for TLI, where responses to stronger and intense precipitation with larger bridges and culverts servicing both hydraulic and ecological connectivity purposes is a critical requirement.
10	**Adaptable infrastructure habitats**: Habitats related to TLI should be planned and managed in a manner that fulfils their potential as positive biodiversity refuges and ecological corridors.
11	**Environmental supervision**: Inclusion of environmental supervision that monitors the effectiveness of TLI features and the habitat and wildlife populations in all phases of programmes, plans and projects; this is within the Strategic Environmental Assessment, Environmental Impact Assessment to the design of full operation and maintenance.
12	**Culture of learning**: Establishment of a culture of learning to develop and support continuous evaluation and exchange of knowledge and experience between the interested, relevant and authorised organisations and state services.

World Road Association (PIARC)

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