Conférence Européenne
des Directeurs des Routes

Conference of European
Directors of Roads

CEDR Contractor Report 2018-2
Transnational Road Research Programme
Call 2013: Roads and Wildlife
Final Programme Report

Authors:
Edgar van der Grift, Wageningen Environmental Research, Netherlands
Eugene OBrien, ROD-IS, Ireland
Morten Elmeros, Aarhus University, Denmark
Vanya Simeonova, Wageningen Environmental Research, Netherlands
Seamus MacGearailt, ROD-IS, Ireland
Barry Corrigan, ROD-IS, Ireland
Ryan Wilson-Parr, ROD-IS, Ireland
Ciarán Carey, ROD-IS, Ireland

May 2018

CEDR Contractor Report 2018-2 is an output from the CEDR Transnational Road Research Programme Call 2013: Roads and Wildlife. The research was funded by the CEDR members of Austria, Denmark, Germany, Ireland, Netherlands, Norway, Sweden and the United Kingdom.

The aim of the CEDR Transnational Road Research Programme is to promote cooperation between the various European road administrations in relation to road research activities. The topics covered by this Call were developed by TG Research to fulfil the common interests of the CEDR members.

Partners:

ISBN: 979-10-93321-41-7

Table of Contents

Executive Summary

In recent decades, road administrations have become increasingly aware of the negative impacts of roads and traffic on wildlife. In most countries across Europe, road administrations have acknowledged their responsibility to control these impacts and have developed effective mitigation strategies. Currently, a variety of measures have been applied to compensate for, mitigate against and avoid impacts on wildlife. However, clear insights into what is most effective or most cost-efficient are often lacking.

To fill this gap, a Roads and Wildlife Research Programme commenced in 2013, as part of the CEDR Transnational Road Research Programme. The aim of this research programme was to understand the effectiveness of different mitigating and maintenance strategies in order to solve the conflict between wildlife and roads, and to investigate more cost-efficient methods for building and maintaining road structures as well as structures for reducing the impact on wildlife. In summary, the aim was to gain better knowledge and guidance on how to combine roads with the surrounding nature and wildlife. The national road administrations of Austria, Denmark, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom participated in this programme.

Four projects were commissioned through the Roads and Wildlife Research Programme: SAFEROAD, Harmony, SafeBatPaths and ECOROAD. This End-of-Programme report summarises the objectives, research approach, key findings and added value of these research projects. It also presents the executed and planned activities to disseminate the findings as well as potential synergies between the projects. Furthermore, it provides guidance on how the findings can be implemented and presents recommendations for future research.

1 Introduction

1.1 Roads and wildlife

In recent decades, road administrations have become increasingly aware of the negative impacts of roads and traffic on wildlife. Roads may cause wildlife mortality, inhibit wildlife movements and result in loss of habitat or habitat quality. In most countries across Europe, road administrations have acknowledged their responsibility to control these impacts and have developed a series of mitigation strategies. Currently, a range of measures have been applied to compensate for, mitigate against and avoid impacts on wildlife. However, a clear understanding of what is most effective or most cost-efficient is often lacking.

While developing and maintaining infrastructure for transporting goods and people across Europe is crucial, the retention of green infrastructure is of equal importance. Development of green infrastructure ensures that natural areas remain connected, the health of ecosystems is restored and species are allowed to thrive across their entire natural habitat. In the European Union (EU) Biodiversity Strategy, adopted in 2011, the development of green infrastructure is seen as the main driver to reconnect the landscape so that biodiversity can be preserved and ecosystems can continue to provide their invaluable services. Where transport and green infrastructures meet, appropriate measures should be taken to ensure that, while passenger and freight traffic must be facilitated, animal 'traffic' on the green network should not be obstructed and connectivity between habitats should be maintained.

1.2 CEDR Transnational Road Research Programme

In 2011, the Conference of European Directors of Roads (CEDR) launched the Transnational Road Research Programme. This programme can be seen as a follow-up to previous research programmes, organised under the ERA-NET ROAD brand, which aimed at the development of a platform for international cooperation and collaboration in research areas of common interest. The aim of the new programme is to initiate cross-national research that supports CEDR as its main goal, i.e. contributes to the development of road engineering as part of an integrated transport system under the social, economic and environmental aspects of sustainability and promotes co-operation between the national road administrations (NRAs).

1.3 CEDR Call 2013: Roads and Wildlife

In September 2013, a Call for research proposals was launched as part of the CEDR Transnational Road Research Programme. The Call focused on the issue of Roads and Wildlife and, more specifically, on cost-efficient road management for compliance with the demands from wildlife and cost-efficient mitigation strategies for roads and wildlife. The NRAs of Austria, Denmark, Germany, Ireland, Norway, Sweden, the Netherlands and the United Kingdom (UK) participated in this Call.

The aim of the Roads and Wildlife Research Programme was to understand the effectiveness of different mitigation and maintenance strategies in order to address the conflict between wildlife and roads and investigate more cost-efficient methods for building and maintaining road structures and structures for reducing their impact on wildlife. In summary, the aim was to gain better knowledge and guidance on how to integrate roads with the surrounding nature and wildlife.

In 2003, the handbook Wildlife and Traffic was produced as a result of an EU financed project (COST 341) in which several European countries collaborated. In this handbook, road-wildlife conflicts are identified and promising solutions are provided. Although the handbook is still valid and used as a source of information in many countries across Europe and beyond, some relevant information is obsolete or not included in the handbook. Therefore, the Roads and Wildlife Research Programme aimed not to replace, but to update, complement and expand the existing handbook.

1.4 Programme Executive Board

A Programme Executive Board (PEB) was established to evaluate proposals, select the research projects to be carried out and supervise these projects. The PEB consists of experts in the topic of Roads and Wildlife from each participating road administration. For the Roads and Wildlife Research Programme, the PEB consisted of the following experts:

- Lars Nilsson (2014–2015)/Anders Sjölund (2016–2017) (chair), Swedish Transport Administration, Sweden;
- Elke Hahn, Federal Ministry for Transport, Innovation and Technology, Austria;
- Erland Røsten/Ola-mattis Drageset, Norwegian Public Roads Administration, Norway;
- Hans Bekker/Adam Hofland, Rijkswaterstaat, the Netherlands;
- Marianne Lund Ujvári, Danish Road Directorate, Denmark;
- Tony Sangwine, Highways England, UK;
- Udo Tegethof, Federal Highway Research Institute (BASt), Germany; and
- Vincent O'Malley, Transport Infrastructure Ireland, Ireland.

1.5 Research projects

Within the Roads and Wildlife Research Programme, four research projects were approved and undertaken:

SAFEROAD

Title:	Safe roads for wildlife and people – Cost-efficient mitigation strategies and maintenance practices
Project partners:	Wageningen Environmental Research (Alterra) (the Netherlands); Swedish University of Agricultural Sciences (SLU) (Sweden); Minuartia (Spain); Calluna (Sweden); Institute for Natural Resource Conservation (INR) (Germany); Roughan & O'Donovan Innovative Solutions (ROD-IS) (Ireland); Norwegian Institute for Nature Research (NINA) (Norway).
Consortium leader:	Edgar van der Grift (Wageningen Environmental Research)
PEB Project Manager:	Lars Nilsson (2014–2015)/Anders Sjölund (2016)
PEB Vice-Project Manager:	Elke Hahn
Start:	May 2014
End:	October 2016
Website:	www.saferoad-cedr.org

Harmony

Title:	Procedures for the design of roads in harmony with wildlife
Project partners:	Roughan & O'Donovan Innovative Solutions (ROD-IS) (Ireland); Bureau Waardenburg (the Netherlands); Swedish National Road and Transport Research Institute (VTI) (Sweden); MTA Centre for Ecological Research (Hungary).
Consortium leader:	Eugene OBrien (ROD-IS)
PEB Project Manager:	Vincent O'Malley
PEB Vice-Project Manager:	Hans Bekker (2014)/Adam Hofland (2015–2016)
Start:	April 2014
End:	March 2016
Website:	www.harmony-project.net

SafeBatPaths

Title:	Fumbling in the dark – Effectiveness of bat mitigation measures on roads
Project partners:	Aarhus University (AU/BIOS) (Denmark); University of the Basque Country (UPV/EHU) (Spain); Flagermus Forskning og Rådgivning (HJB) (Denmark); Grontmij (Denmark); Jasja Dekker Dierecologie (the Netherlands).
Consortium leader:	Morten Elmeros (AU/BIOS)
PEB Project Manager:	Marianne Lund Ujvári
PEB Vice-Project Manager:	n/a
Start:	September 2014
End:	June 2016
Website:	www.bios.au.dk/om-instituttet/organisation/faunaoekologi/projekter/safe-bat-paths

ECOROAD

Title:	Ecology and roads
Project partners:	Roughan & O'Donovan Innovative Solutions (ROD-IS) (Ireland); Wageningen Environmental Research (Alterra) (the Netherlands); Aarhus University (AU/BIOS) (Denmark).
Consortium leader:	Eugene OBrien (ROD-IS)
PEB Project Manager:	Vincent O'Malley
PEB Vice-Project Manager:	n/a
Start:	August 2016
End:	February 2017
Website:	www.ecoroad-cedr.org

Detailed information on the objectives and findings of these projects is provided in Sections 2, 3, 4 and 5 of this report.

1.6 Reader's guide

The key findings of the four research projects are presented in Sections 2 (SAFEROAD), 3 (Harmony), 4 (SafeBatPaths) and 5 (ECOROAD) of this report. These sections are based on the various deliverables of the projects (refer to Annexes A, B, C and D) and aim to summarize all key messages as well as the added value of each project.

Executed and planned activities to disseminate the project findings are presented in Section 6 of this report.

Potential synergies are explored in Section 7 of this report, i.e. how the four projects complement and strengthen each other. The section is based on an inventory by the coordinators of the SAFEROAD, Harmony and SafeBatPaths projects.

Guidance on implementing the findings of the projects is provided in Section 8 of this report. This section is based on the Workshop, Opportunities for implementation of findings across member states, organised during the Roads and Wildlife End-of-Programme Event, Cologne, Germany, 7th–8th November 2016.

Recommendations for future research are presented in Section 9 of this report. This section is based on identified knowledge gaps, as presented in the SAFEROAD, Harmony and SafeBatPaths project reports.

Final conclusions are provided in Section 10 of this report.

2 SAFEROAD

2.1 Objectives of the project

The aim of the SAFEROAD project was to improve understanding of the functioning and effectiveness of different road mitigation strategies in order to find the best way to reduce the impacts of roads on wildlife and simultaneously enhance traffic safety. The project aimed to generate new scientific knowledge and insights on methods to help prevent wildlife mortality due to animal-vehicle collisions and to ensure that the barrier effect of roads is reduced sufficiently to maintain viable wildlife populations. The aim was also to transfer this knowledge into practical guidelines and tools that can be easily accessed and used by road agencies and other stakeholders.

2.2 Research approach

The research included the following:

- Reviews of scientific and non-scientific publications;
- Explorations of best-practices from across Europe and beyond;
- Re-analyses of existing data through meta-analysis in order to identify road mitigation effects that are not obvious in data analysis of a single project;
- Collection and analyses of new empirical data in a variety of case studies; and

- Analyses of mitigation effectiveness through population modelling.

The project comprised seven work packages concerning the following:

- Roads and wildlife: Legal requirements and policy targets;
- An outcome-based procurement approach;
- Effectiveness of road mitigation for wildlife populations;
- Cost-efficient road mitigation strategies for wildlife;
- Road maintenance practices to improve wildlife conservation and traffic safety;
- Monitoring road mitigation performance and effectiveness; and
- Integration and dissemination of project results.

2.3 Key findings

Roads and wildlife: Legal requirements and policy targets:

- Some international regulations and agreements are of particular relevance in relation to barrier effects for wildlife and road kill;
- Road kill may be considered deliberate killing, prohibited by legislation. However, infrastructure projects may derogate from the killing prohibition, provided that impacts on species are kept within an acceptable level. NRAs must ensure that incidental road kill does not exceed an acceptable level of impact and undertake appropriate anticipatory measures, where necessary, to comply with the objectives of EU Directives;
- Ambitious impact assessments and mitigation plans may be enough to fulfil the legal provisions regarding the protection of species, as indicated by EU case C-308/08 on road impacts on the Iberian lynx and a number of national Supreme Court cases. This implies that, in a development project where the best available mitigation measures are applied and impact assessment is reasonably well conducted, the developer is relieved from the requirement to prove that the impacts stay within acceptable levels; the burden of proof then lies with any party opposing the development;
- Multidisciplinary and species specific survey work, e.g. monitoring road kill and population trends, is needed to obtain scientific and technical knowledge, essential for compliance with the strict protection measures set out in EU Directives and relevant national conservation legislation;
- Applying the “1% criterion” to the toll from traffic mortality could facilitate impact assessment, but such an application is questionable;
- Environmental Impact Statements (EISs) address barrier effects and habitat fragmentation, but generally underemphasize wildlife road kill; and
- EISs generally miss the quantification of the expected effects, and in some cases the differentiation between effects of construction and operational phases.

Outcome-based procurement approach:

- EU regulations and policies provide a variety of requirements and ambitions that are of concern for road projects and may help in defining sound road mitigation outcomes;
- The use of outcome-based specifications may have certain benefits if compared with the more traditional procurement approaches, i.e.:
    1. They may more accurately ensure that the overall objective – either related to wildlife conservation or road safety – is being met;
    2. They may increase our knowledge base;
    3. They may guarantee a strong link with national and international regulations and policies;

4. They may better support political and/or societal discussions on the need and usefulness of road mitigation; and
5. They provide room for adaptive management.

- Only after the use of outcome-based specifications has been sufficiently tested, can conclusions be drawn on whether such benefits actually occur. The use of outcome-based specifications may have certain disadvantages and risks if compared with the more traditional procurement approaches, i.e.:
    1. They require more comprehensive knowledge on mitigation measures and their effects than what we may have today;
    2. Costs may increase due to the need for studies in which baseline conditions or reference standards are assessed;
    3. Little is known about appropriate time-spans for evaluation studies, which may result in wasting resources or incorrect conclusions on whether or not the measures are successful;
    4. If not regulated appropriately and safeguarded, knowledge on road mitigation effectiveness becomes an asset of private contractors and consequently may not be freely available to all stakeholders; and
    5. An outcome-based approach in road mitigation procurement requires a new juridical framework in which the responsibilities of both the road agency and contractors are clearly spelt-out.
- Practical outcome-based specifications for road mitigation can be developed with the help of the following guidelines:
    1. Link the specifications directly to the goals for mitigation;
    2. Specify whether no-net-loss is the aim or not;
    3. Use the Specific, Measurable, Attainable, Realistic and Timely (SMART) approach to develop clear and objective specifications;
    4. Make use of baseline conditions or reference standards;
    5. Link the specifications directly to the indicators used in regulations and policies;
    6. Link the specifications to multiple indicators whenever possible and relevant;
    7. Link the specifications to the road section to be mitigated and not to a single structure; and
    8. Minimise the use of technical specifications.

Effectiveness of road mitigation for wildlife populations:

- A meta-analysis of existing studies indicated that fences reduce road kill (all studied taxa together) by an average of 54%;
- The combination of fencing and crossing structures led to an 83% reduction in road kill of large mammals, compared to a 57% reduction for animal detection systems and only a 1% reduction for wildlife reflectors;
- Comparatively expensive mitigation measures (e.g. fences with crossing structures) reduce collisions between vehicles and large mammals much more than inexpensive measures (e.g. reflectors);
- There are insufficient data to answer many of the most important questions from road planners about the effectiveness of road mitigation measures;
- Selecting appropriate mitigation measures can be achieved with the help of the following guidelines:
    1. Provide clear goals for mitigation;
    2. Derive the need for provisions that restore road permeability from measured (e.g. through monitoring) or predicted (e.g. through model simulations) population level barrier effects;
    3. Select road mitigation types for which effectiveness is proven;

4. Include wildlife fencing if road-kill reduction is the aim, but combine fencing with wildlife crossing structures to prevent fence-induced barrier effects;
5. Select a fence type that addresses the requirements of all target species;
6. Base the road length over which fencing is needed on road kill or species distribution data, and account for potential fence end effects;
7. Select measures that create crossing opportunities in which the requirements of all target species are accounted for;
8. Base the density of crossing measures on the goals for mitigation; and
9. Select types of mitigation measures that have proven to be sustainable.

Cost-efficient road mitigation strategies for wildlife:

- In general, road mitigation for wildlife should firstly focus on reducing mortality and secondly focus on providing permeability; however, exceptions may exist;
- A significant part of traffic-induced mortality in wildlife occurs at rather few locations in the road network, which implies that, with limited but well targeted mitigation efforts, accident numbers can be substantially reduced;
- Ungulate-vehicle collision clusters can be explained by and predicted from a combination of landscape and road factors, operating primarily at local scale and typically relating to either road accessibility, road attractiveness, traffic speed or traffic volume;
- Inclusive fencing-crossing systems – i.e. fencing systems that combine wildlife fences with escape ramps, electrified mats, cattle guards or gates to secure fence openings, warning systems to alert drivers approaching fence ends, and safe crossing facilities for wildlife – appear to be the most effective albeit relatively expensive mitigation approach;
- Where ungulate-vehicle collisions are not clustered but are more widely dispersed along roads, mitigation options may be found in the development of intelligent in-car animal detection and driver assistance systems that may automatically adjust vehicle speed or shorten reaction time. Furthermore, mitigation options may also result due to driver education, possibly based on risk prediction models that can teach drivers to identify hazardous situations and adapt driving behaviour pre-emptively. Such options are generally only feasible on roads with low traffic speed and volume;
- Mitigating against wildlife-vehicle collisions can produce significant socio-economic benefits;
- Currently, cost-benefit analysis (CBA) for mitigation against ungulate-vehicle collisions underestimates the potential benefits; benefits should include not only costs for human injuries or material damage in accidents, but also the overall costs of managing this conflict, as well as consumptive, non-consumptive and non-monetary values of wildlife that cannot be appropriately monetized and must therefore be integrated in the analysis via policy objectives or legal requirements;
- Implementing cost-efficient mitigation strategies can be achieved with the help of the following guidelines:
  1. Develop a multi-stakeholder policy on mitigation for wildlife;
  2. Acknowledge the full costs of wildlife-vehicle collisions or traffic related mortality in wildlife;
  3. Improve empirical data on mortality/collisions and establish reliable and long-term geo-referenced statistics;
  4. Develop a targeted mitigation approach to reduce wildlife-vehicle collisions and simultaneously maintain road permeability for wildlife along identified accident clusters;
  5. Ensure correct monitoring and evaluation of mitigation activities and initiate experimental studies; and

6. Initiate cooperation with stakeholders and support research on innovative approaches.

Road maintenance practices to improve wildlife conservation and traffic safety:

- Existing guidelines and handbooks provide only brief and mostly general recommendations for maintenance of wildlife-related issues;
- As indicated by a questionnaire among NRAs, wildlife mitigation measures are generally regularly inspected and repaired but the lack of inventories and specifications of standards to be complied with, make it difficult to undertake appropriate maintenance;
- Applying maintenance practices to enhance biodiversity in roadside habitats is an increasing practice throughout Europe. However, in many countries, verge maintenance strategies focus only on reducing large-mammal hazards to traffic safety;
- Animal-vehicle collisions involving large animals and causing human injuries or fatalities are registered all over Europe by traffic police. However, the results are rarely reported to road operators and when available, data accuracy is often poor and not applied to define mitigation measures;
- Evaluation of the effectiveness of maintenance practices is key to identify and expand the most cost-effective practices but such evaluations are only reported occasionally;
- Implementing maintenance strategies that address road-wildlife issues can be achieved with the help of the following guidelines:
  1. Standards on wildlife-related topics must be included in general Road Maintenance Guidelines to allow for correct maintenance of wildlife provisions;
  2. Wildlife maintenance actions should be adequately planned and prioritized to enhance their cost-benefit ratio;
  3. NRAs can favour biodiversity conservation and green infrastructure development by conducting wildlife-friendly roadside habitat management;
  4. Animal-vehicle collisions should be accurately monitored to assess where conflict sites are located and to evaluate which mitigation measures are most effective;
  5. Develop and monitor an adaptive road-wildlife maintenance strategy;
  6. Cooperation between stakeholders is needed to ensure information flow during the entire road life-cycle; and
  7. Cooperation with external stakeholders can benefit wildlife-road maintenance.

Monitoring road mitigation performance and effectiveness:

- The following guidelines may assist road planners in their assessments of whether mitigation measures are functioning in conformance with the provided outcome-based specifications:
  1. Select performance indicators that are most closely related to the desired outcome;
  2. Select a study design that incorporates the assessment of reference values, such as baseline conditions or reference standards;
  3. Select a study design that incorporates data collection at control sites, which ensures that measured changes can be attributed to the mitigation;
  4. Select survey methods that are most accurate, informative and efficient;
  5. Select an appropriate spatial scale for data collection, matching the spatial scale of the road effect being mitigated and performance indicator selected;
  6. Time data collection on the basis of the goals for mitigation, life cycle of the target species and time an effect is expected;
  7. Base study duration on the expected sampling time needed for adequate statistical power;
  8. Use a sampling frequency that allows for rigorous estimates of the performance indicator;

9. Measure explanatory variables that may affect mitigation performance, e.g. (i) features of the road and traffic; (ii) features of the road mitigation works; (iii) features of the surrounding landscape; and (iv) weather conditions; and
10. Ensure the evaluation report and raw data are made widely available.

- The following recommendations may assist road authorities to implement the guidelines presented for evaluating road mitigation performance:
  1. Ensure the preparation of an evaluation plan for planned road mitigation measures is an inseparable part of the legal processes that must be followed during the road planning and procurement stages;
  2. Form an independent advisory board, consisting of experienced road ecologists, to assist the road agency in:
     - Preparing goals of mitigation;
     - Planning and conducting scientifically sound evaluations; and
     - Ensuring that acquired knowledge and best-practices will be available to all stakeholders.
  3. Develop a strategy for systematic assessments of baseline conditions and reference standards;
  4. Arrange close collaboration between ecologists and those who plan, design, construct and manage the road;
  5. Facilitate greater involvement of ecologists within road authorities in the procurement process of road mitigation works, including:
     - Writing clear goals of mitigation;
     - Organising the collection of baseline information; and
     - Judging plans proposed by contractors.
  6. Involve stakeholders when possible in the preparation of the performance evaluation, such as non-governmental organizations (NGOs), nature managers and private land owners;
  7. Secure all necessary resources for the evaluation of road mitigation performance in advance;
  8. Contract an independent contractor to evaluate road mitigation performance; do not put both the design/construction and evaluation of the mitigation measures – whether the objectives are being met – into one contract;
  9. Document both research methods, results and conclusions systematically, thus allowing for:
     - Quick reference;
     - Appropriate comparisons between projects; and
     - Use in meta-analysis.
  10. Analyse and report all data in a timely manner to ensure that existing structures can be modified within an adaptive framework and the design of future mitigation measures can be improved;
  11. Arrange peer review of reports and, if appropriate, aim for publication in scientific journals to improve the quality and rigour of the scientific methods as well as improving access to the findings; and
  12. Ensure the outcome of all evaluations, including research reports and raw data, is made widely available through an open access database.

2.4 Added value

The SAFEROAD project:

- Identifies all relevant international regulations and agreements for road planners in relation to road-wildlife conflicts and the requirements and responsibilities these imply;
- Results in a set of practical guidelines to develop outcome-based specifications for road mitigation procurement and identifies both the benefits and disadvantages or risks of an outcome-based procurement approach;
- Indicates that the effectiveness of many road mitigation measures is studied inadequately or not studied at all. Hence, there is insufficient information to answer many of the most important questions from road planners about the effectiveness of road mitigation measures;
- Concludes that fences – combined with crossing structures to prevent fence-induced barrier effects – are the best option if a reduction in road kill of terrestrial fauna is the aim, which is particularly true for large mammals. Animal detection systems may also be effective in reducing large mammal road kill, although reductions are less if compared with fences. Wildlife reflectors have not been proven effective;
- Presents a practical set of guidelines to help road planners select and implement the most appropriate and cost-efficient mitigation measures;
- Demonstrates the effects of reducing mortality and providing road permeability for various wildlife species and provides practical recommendations on how to apply this knowledge;
- Identifies key features that may cause clusters of animal-vehicle collisions and provides solutions to reduce accident numbers within and outside such clusters;
- Identifies practical ways to improve CBA for road mitigation measures;
- Describes the state-of-affairs on maintenance practices that relate to road-wildlife issues across Europe and presents a practical set of guidelines to help road planners implement effective maintenance strategies that address these issues; and
- Presents a practical set of guidelines to assist road planners in their assessments of whether mitigation measures are functioning in conformance with the provided outcome-based specifications and provides recommendations to implement these guidelines.

3 Harmony

3.1 Objectives of the project

The Harmony project aimed to provide guidance on how to best mitigate the negative effects of road infrastructure on wildlife in a balanced and cost-effective manner.

3.2 Research approach

The outputs of Harmony have been developed from expertise gathered though stakeholder interviews, literature review and experimental work and are presented in the various deliverable reports (refer to Annex B). The topics examined in the Harmony project included the following:

- Project Appraisal;
- Environmental Legislation and Guidelines;
- Procurement;

- Key Performance Indicators;
- Maintenance; and
- Follow Up.

Seven main reference countries had all topics examined: (1) Austria, (2) Belgium, (3) Hungary, (4) Ireland; (5) the Netherlands; (6) Sweden and, (7) UK. Four further countries had some but not all topics examined: (1) Denmark, (2) Norway, (3) Germany and, (4) Greece.

3.3 Key findings

Project Appraisal:

- Project Appraisal of Transport Infrastructure is the process of assessing whether capital expenditure is justified for a project. It should also ensure that funding is allocated to the most appropriate transport solution to achieve the objectives of that project and it should comply with planning policy and legislation. Project Appraisal Guidelines (PAGs) were examined and compared in nine countries, considering the attention afforded to biodiversity in the methodology:
  - Not every country's project appraisal takes account of nature or biodiversity (one of the nine did not);
  - CBA remains the main form of appraisal used throughout Europe; and
  - There are difficulties in assigning monetary values to biodiversity impacts.
- Recommendations:
  - Both the UK and Irish Guidelines provide clear and concise guidance that can be followed and adopted;
  - The appraisal process in both of these countries is kept as simple as possible without requiring a level of detail that becomes tedious for the appraiser and decision makers;
  - The introduction of a worksheet allows appraisal to be carried out at all stages of development and takes into account the level of detail made available to it at any one stage; and
  - The provision of a biodiversity impact appraisal table/Project Appraisal Balance Sheet should result in a more standardised and transparent system of project appraisal across European Member States.
- Adopting such processes, project appraisal across Europe would become more standardised and transparent.

Environmental Legislation and Guidelines:

EU countries carry out Environmental Impact Assessments (EIAs) and Appropriate Assessments (AAs) to comply with the EU Birds Directive and the EU Habitats Directive. EIAs and AAs were examined to provide insight into the current approach to Environmental Assessment being used in a range of European countries. Based on these findings, guidance is then provided on how the Environmental Assessment procedure could be improved across Europe.

<u>EIA Analysis</u>

- A comparative analysis of national guidelines from nine countries was carried out using a review template of 20 questions, providing the following results:
  - All countries provide guidelines that ensure compliance with EU Legislation;
  - Three of the nine countries do not have guidelines available for specific species or habitats; and
  - Four of the nine countries do not provide guidelines for all stages of EIA.

- 100 EIAs were examined, over 10 countries, to identify the degree of implementation under the headings of Screening, Scoping, Identification of Habitats, Impact Assessment Methodologies, Mitigation Measures and Monitoring;
- Degree of implementation varies on a five-point scale from 'Not Implemented' to 'Fully Implemented';
- The most common level of implementation is Fully Implemented but there is still a significant amount of non-compliance;
- A significant proportion of the EISs examined were found to not be using recent surveys (i.e. carried out within the past two years);
- Cumulative impacts are not suitably addressed in a significant proportion of the EISs examined; and
- Recommendations are to create guidelines with a standardised approach for specific topics, habitats and species, including:
    - EU Standard for EIA terminology;
    - EU Standard for competency requirements of an ecologist for EIA as per EIA Directive 2014/52/EU;
    - Guidelines for seasonal timing of surveys for different species and habitats in the various regions, covering all EU Member States;
    - Guidelines for assessment of cumulative effects; and
    - Guidance for Monitoring Plans and Enforcement Processes.

AA Analysis

- Comparative analysis was carried out of national guidelines from nine countries, using a review template of six questions, providing the following results:
    - Two of the nine countries do not provide guidelines for AAs;
    - Guidelines treat the significance of adverse effects, the difference between direct and indirect (external) impacts and mitigation; and
    - None of the guidelines have a chapter or paragraph about monitoring the impacts of a project or the effectiveness of mitigation measures.
- 44 AAs were examined over 10 countries. Experts examined each AA and filled out a 21 question template questionnaire; and
- Recommendations:
    - Education and training about the benefits and implementation of performance based measures, including training for Competent Authorities;
    - As for EIA, create an EU Standard for competency requirements of an ecologist for AA;
    - More detailed guidance, including possibly templates/examples of completed AAs for projects of varying complexity to ensure consistency of approach to AA; and
    - Recommendations for EIA are common to AA.

Review of Court Cases

In the matter of the EU Habitats Directive and EIA Directive, project proposals occasionally result in legal appeals such as Judicial Review or cases in the Court of Justice of the EU. While such cases may be uncommon, they can have a profound impact on the planning decisions of member states. The Harmony project examined nine court cases from seven countries. Some of the findings are as follows:

- The issues of assessment, based on part of a project, without considering related road links or future development, frequently arises when seeking development consent and in the courts;
- An impact on a priority habitat which could render the conservation status of the site as unfavourable partly due to the area of that habitat or the ability of the habitat to be

replaced, is considered to have an impact on the integrity of the site and is therefore significant;
- In many cases, measures proposed as mitigation are more correctly considered as compensation from a legal perspective;
- The absence of a Natura 2000 Site Designation when assessing the impact of a road project on Habitats Directive Annex I habitats and Annex II species, can be the result of a failure of the state to correctly designate the site; and
- Recommendations:
    - Each NRA to circulate regular updates on recent Court of Justice of the EU rulings with a non-technical summary of how they may affect project development and EIA/AA to ensure all project developers incorporate most recent developments;
    - Consideration should be given to the quality of the habitat to be impacted, regardless of the designation status (as there have been cases where a Member State has failed to correctly designate an area/site);
    - Greater certainty in planning routes will result from a clearly defined, well justified and complete list of Natura 2000 sites;
    - Clear distinction is required between mitigation and compensation;
    - Improved guidance on the assessment of cumulative impacts would be beneficial; and
    - Clearer guidance is required on impacts on Annex and Priority habitats, outside of designated sites but affecting the integrity of that site.

Procurement:
Structured interviews were carried out using a questionnaire to gather information. The questionnaire consisted of 10 questions related to procurement. 12 interviews were carried out over nine countries. Some findings from the questionnaires were as follows:
- In formulating the requirements, five interviewees responded that ecological experts are always involved while the other respondents indicated that this only happens sometimes;
- In only two countries, ecological experts are always involved in assessing tenders; in two countries, they are reported to never be involved;
- In two countries, the contractor is not required to demonstrate ecological expertise during procurement; and
- Recommendations:
    - The Contracting Authority needs to have appropriate ecological resources. This is to ensure that suitable provisions for wildlife protection are included in model contract procurement documents, and to undertake reviews of individual schemes at various stages of implementation;
    - At project level, the Contracting Authority should have ecological expertise, particularly for environmentally sensitive areas, to carry out monitoring throughout the life of the project;
    - At a European level, consideration should be given to removing the restriction to consider past performance at tender stage, at least for Maintenance Contracts where track record is an important consideration to provide confidence that the required outcomes have a reasonable prospect of being achieved;
    - There would be environmental advantages to increased use of Quality Assessment in the procurement process and to include ecological requirements within the Quality Assessment – in particular where there are environmental sensitivities – e.g. proximity to a Natura 2000 site; and

- Specialist ecologists should be engaged in both implementation and monitoring roles in the preparation and procurement of large Works and Maintenance Contracts.

Key Performance Indicators:

- Parameters that effectively and easily provide a measure of a transportation-related environment's condition are desirable. This is especially the case when examining the functionality of a mitigation structure or its effect on the surrounding environment. The development of suitable ecological/biological indicators would be beneficial to the implementation of most projects. 'Indicators' are understood as parameters, which reliably show the performance of wildlife mitigation measures;
- Recommendations:
  - Indicators should be easy to measure, comparable and reproducible;
  - Indicators to be measured have to take the EIS into account;
  - It is important to establish a baseline beforehand, on which the indicator(s) will be modelled and this necessitates the availability of sufficient base data;
  - The indicators should already be considered during the procurement process;
  - Indicators should reliably show if a mitigation structure is functioning as planned;
  - In the specific case of mitigation structures such as wildlife bridges, the indicator(s) used should be able to document 'negative' outcomes as well, e.g. when a structure is not used by the target species;
  - The indicators used should include a 'positive' element, i.e. preferably include an incentive that reliably leads to the outcome planned; this could be, for example, an economic benefit for the contractor when performing well; and
  - Indicators have to consider that different species might be measured; this might necessitate the use of a different indicator.
- In general, indicators will have to be adapted specifically for each project. However, based on the underlying research for this chapter, we recommend the following two indicators for use in mitigation of wildlife in road projects:
  - Road kill (according to a pre-specified process of measurement); and
  - Usage of crossings (using a pre-defined method of measurement and a pre-specified target species list/formula).
- Care has to be taken that indicators will not be used solely as performance measures, e.g. by a subcontractor. This might otherwise lead to an incentive to fulfil certain ecologically relevant obligations irrespective of the actual need, leading to unintended consequences.

Maintenance:

The project investigation into maintenance practices included interviews with road maintenance experts, a workshop relating to maintenance at the Infra Eco Network Europe (IENE) 2014 Conference in Malmö, Sweden, a literature review and experimental work. Some findings from the workshop were as follows:

- Of the interviewees, 53% have experienced problems with wildlife during maintenance. Some of the problems mentioned include the following:
  - Beavers that construct dams and obstruct culverts (e.g. in Sweden);
  - Mowing of red-listed plants at an improper time;
  - Animals may be lured into the verge area and hide which poses an increased collision risk;
  - Increase in marten and otter populations in the country, resulting in an increase in the numbers of road kill; and
  - Huge numbers of big-game that constitute a danger for traffic.

- The most common problems however were those caused by legal restrictions. All European countries have national species protection laws and EU Member States also have to comply with the EU Habitats and Birds Directives. According to these laws, certain activities cannot be carried out during specific times of the year because it may disturb protected species;
- The experimental work carried out found that the timing and intensity (i.e. the height and width of the mowed grass on the verges) of road maintenance are equally important. Timing is important because several arthropods and amphibians were detected in the habitats along the roads during their invasion and migration periods in spring and summer. The intensity of maintenance of road verges significantly determines the ground-dwelling fauna; and
- Recommendations:
    - A cost-efficient maintenance strategy is location-specific. However, two important considerations lie at the base of a cost-effective maintenance strategy that apply to the whole of Europe:
        - Plan ahead; and
        - Consider the function that the road component or mitigation measure has to fulfil for fauna.
    - More intensive exchange of experiences within and between road authorities will result in better recommendations and guidelines for maintenance and this will result in cost-savings;
    - An institutional memory should be established, e.g. a database with locations of the mitigation measures and experiences with maintenance techniques and methods;
    - To reduce costs, combine the maintenance of overpasses and verges with the maintenance of the surrounding landscape, where possible. For example, this can be done by involving the landowners or NGOs who own the land next to the road;
    - Many maintenance costs can also be diminished by consulting maintenance companies during the concept and design phase of a project to achieve designs which are easily maintained; and
    - The NRA needs to take the spatial and environmental differences into account when deciding about the methods of maintaining different road sections.

Follow-up:
The same structured interviews for procurement were used to gather information on follow-up practices across Europe. There were 17 questions on follow-up. As with procurement, 12 interviews were carried out across nine countries.

- Two respondents report the use of follow-up results for all six categories; three use the results for four of the categories; four use the results for two of the categories; two use the results for one of the categories; and one uses the results for none of the categories; and
- Recommendations:
    - The international evidence suggests that follow-up is rarely undertaken where there is no particular requirement for maintenance. Therefore, greater use of Maintenance Contracts will lead to increased maintenance and better environmental outcomes;
    - A tool or guidelines would help ensure compliance with legislation by ensuring standardised and regular follow-up;
    - The Aarhus Convention commits public authorities in the EU Member States to publish all environmental information. A unified database for information

retrieval would help to implement this in practice, increasing access to the information;
  - Both Maintenance Contractors and Contracting Authorities should have access to ecological expertise, either in-house or engaged, to ensure the environmental objectives of projects are achieved;
  - Contracting Authorities need to be adequately resourced in order to undertake follow-up measures. Follow-up actions including supervision should be undertaken by specialist personnel with the appropriate training to ensure that environmental measures are correctly implemented and maintained;
  - Contracts should include some performance based criterion, such as the achievement of a Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) award for the project, to focus the Contractor on environmental performance throughout the construction; and
  - In respect of existing roads, there are clear advantages to the procurement of maintenance contracts, as it increases the focus of both the Maintainer and the Contracting Authority. Further study may be warranted to understand the relative costs of public and private sector maintenance.

3.4 Added value

In general, European countries have started to address ecological issues in planning, design, construction and maintenance processes. However, there is scope for considerable further development, for example:

- The Harmony project addressed the following issues that are not significantly addressed in scientific literature:
  - Guidance on a consistent approach to EIA and AA;
  - Guidance on methods of procurement of road projects and mitigation measures; and
  - Europe-wide strategies for the maintenance of roads and mitigation measures.
- The portion of the project considering the contractual aspects of how ecology is considered in procurement and how the delivered product is followed up, are an important new avenue for some road authorities to consider. The various types of contract available will shape the delivery of the outcomes, with some being more favourable, depending on context, but appropriate follow-up practices ensure that the outcomes are delivered;
- The recommended approach for the inclusion of ecological issues in project appraisal will help to ensure that ecology remains a core part of any decisions made; and
- The field work carried out provides valuable insight into the quantifiable effects of maintenance practices on wildlife.

4 SafeBatPaths

4.1 Objectives of the project

The aim of the SafeBatPaths project was to convey the current extent of bat mitigation on roads in Europe and the evidence of effectiveness of implemented mitigation measures.

4.2 Research approach

The project comprised four work packages concerning the following:

- An overview of bat mitigation measures and monitoring, based on scientific and non-scientific papers and reports from bat and road experts;
- A critical literature review of the evidence of effectiveness of the presently advised mitigation measures and potential useful technical road structures, published in scientific and grey literature;
- A field experiment to assess the effectiveness of hop-overs; and
- Future research needs and guidelines to develop ecologically sustainable roads based on the results of the first work packages and discussions on a workshop for bat experts.

4.3 Key findings

The key findings of the SafeBatPaths project are as follows:

- Bat mitigation is well established in road development and renovation projects in Germany, France, Ireland, the Netherlands and the UK. Bat mitigation schemes have also been employed in recent road projects in other countries, e.g. Poland and Spain;
- The initial research and monitoring projects have primarily focused on describing bats' use of mitigation structures, but there is little known about the effectiveness of the mitigation. There is an urgent need for appropriate evaluations of the effectiveness of the presently advised and implemented mitigation measures for bats on both a site-specific level and landscape/population level as undertaken in a few recent studies in the UK;
- Hop-overs indicate some potential for reducing bat-vehicle collision risk and do not appear to represent a major barrier for commuting *Myotis daubentonii* and *Pipistrellus pygmaeus*. However, the variation between sites is large. At one research site, more than 50% of the bats crossed the hop-over gap at hazardous heights. A large proportion of bats flew between the screens, experiencing an increased collision risk if the hop-over had been installed on a road;
- Monitoring to record potential use is often only carried out in the first few years after construction, which may not show the full potential of the road mitigation measures. Comprehensive post-construction monitoring projects are carried out on some road schemes; however, the results are published in confidential reports only;
- Recommendations for bat mitigation on roads are as follows:
    - Given the lack of evidence of the effectiveness of bat mitigation schemes, a precautionary and species-specific approach is advised;
    - Mitigation strategies should consider all relevant aspects of road effects, e.g. mortality, road permeability, habitat degradation and loss of roost sites; and
    - Passages and guiding structures should be in operation before existing habitats are destroyed and before the road opens to traffic.
- Recommendations for monitoring are as follows:

- Monitoring should focus on estimating the effectiveness of road mitigation measures;
- The study design should be rigorous and quantitative for both pre- and post-construction studies to allow accurate comparison and should include control sites;
- Long-term monitoring schedules should be integrated in the general road maintenance plan; and
- Monitoring reports should be publicly accessible to increase exchange of knowledge and development of ecologically sustainable road infrastructures.

4.4 Added value

The added value of the SafeBatPaths project is as follows:

- The project has clarified the present scope of bat mitigation in Europe, and has clarified knowledge gaps which should be researched in order to develop ecologically sustainable road infrastructures and cost-effective mitigation schemes for bats; and
- The review of the evidence of effectiveness of bat mitigation measures and the results from the field experiment were collated in a practical end-user guideline.

5 ECOROAD

5.1 Objectives of the project

The aim of the ECOROAD project was to: (1) produce new ecology chapters to complement the existing COST 341 Handbook and produce it in the form of a CEDR Roads and Wildlife Manual; (2) organise a one-day (lunch to lunch) End-of-Programme Event; and (3) prepare and produce this final End-of-Programme Report.

5.2 Research approach

CEDR Roads and Wildlife Manual
The gathered information in the SAFEROAD, Harmony and SafeBatPaths projects was reviewed and filtered to produce a practical pan-European document in the style of the COST 341 Handbook. A first draft of the Manual was presented and discussed with stakeholders during the End-of-Programme event in Cologne, Germany, to ensure that the proposed Manual will effectively inform end users on the practicalities of implementation of best practice approaches. Feedback on the Manual was also sought from key contributors to the three background projects. Second, third and fourth drafts of the Manual were discussed in detail with the PEB, which ensured that the structure, writing style and content are suitable for the end users and that the focus is on practical recommendations that can be implemented on the ground.

End-of-Programme Event
The event was organised in BASt, Cologne (Köln), Germany, on 7th–8th November 2016. Firstly, a detailed programme and a promotional strategy for the event were prepared, in consultation with the PEB. Secondly, an invitation list was prepared, invitations were sent and the event was announced on the Internet. Thirdly, all necessary travel and logistical affairs were arranged.

During the event, the first authors of each chapter of the Manual presented the key findings and recommendations. Potential pathways to implement the recommendations were explored during an interactive session in which the 'what', 'how' and 'who' were discussed for each topic addressed in the new Manual. Both Engineers and Ecologists participated to ensure that both perspectives were heard and understood. The focus of the event was not only on the exchange of knowledge and experience, but also on facilitating and strengthening the network of professionals that are dealing with road-wildlife issues.

End-of-Programme Report
Based on the outputs of the SAFEROAD, Harmony and SafeBatPaths projects, this final report was prepared to produce a concise document that brings together the findings and recommendations from these three projects as well as the results from the End-of-Programme Event.

5.3 Key findings

For the key findings of the ECOROAD project, refer to Sections 7, 8 and 9 of this report.

5.4 Added value

The added value of the ECOROAD project is:

- The CEDR Roads and Wildlife Manual deepens the knowledge base in areas such as monitoring, maintenance, procurement and legislation. It provides clear guidance and facilitates uptake of the research findings and recommendations. It complements the existing COST 341 Handbook, thus providing an addition to the toolbox of road authorities and other stakeholders;
- The final dissemination event in Cologne, Germany, informed the roads/ecological community of the findings and recommendations, and provided a forum for engagement and discussion of the best means of ensuring implementation of the findings; and
- The final report provides a clear summary of what has been achieved in the SAFEROAD, Harmony and SafeBatPaths projects and summarises the recommendations given by both the researchers and stakeholders on how to implement the outcomes of these projects.

6 Dissemination of findings

The four projects provide new knowledge and different sets of practical guidelines to practitioners involved in road planning, construction and maintenance. A variety of dissemination actions have been carried out or are planned to promote use of the outcomes of the projects and ensure that they have impact. These include the following actions:

- All project deliverables will be made available through the project websites, the CEDR website and the IENE website (refer to the Web links of this report);
- The CEDR European Handbook for Roads and Wildlife, compiled in the ECOROAD project, presents all key findings of the SAFEROAD, Harmony and SafeBatPaths projects and provides guidance for their implementation in the daily practice of road planning, construction and maintenance;
- Research findings have been and will be presented at (inter) national conferences where both scientists and practitioners convene, such as:

  - IENE International Conferences;
  - International Conference on Ecology and Transportation (ICOET) International Conferences;
  - Australasian Network for Ecology and Transportation (ANET) International Conferences;
  - International Congress for Conservation Biology (ICCB) International Conferences; and
  - National conferences and seminars.
- Within the SAFEROAD project, six scientific papers were drafted and the SafeBatPaths project drafted one scientific paper; these will be submitted to peer-reviewed journals and will ensure that the research is presented to the scientific community.

7 Synergies

The four projects carried out as part of the Roads and Wildlife Research Programme complement and strengthen each other. This is partly the result of the selection of projects that address different research topics of the Call and partly the result of careful reconciliation between the projects in the earliest project stages on topics where some overlap was expected. Furthermore, synergies occur where the different projects, independently from each other, present similar findings or provide similar recommendations.

The main synergies – i.e. the way in which their combined effect will be more effective than the sum of their individual effects – between the four projects are as follows:

- Similar conclusions on the scarcity of appropriate studies that address the effectiveness of mitigation measures and, consequently, on the lack of fact-based decision making in road mitigation planning;
- Similar conclusions on the need for better definitions of the goals for mitigation in road projects and more high-quality evaluations of mitigation performance;
- Similar conclusions that performance evaluations of wildlife crossing structures should go beyond registering the use of the structures by wildlife and preferably assess the effects of the measure at wildlife population level;
- Similar conclusions that the reporting and accessibility of studies and data that address the effectiveness of road mitigation need improvement and how this could be achieved;
- Presented guidelines for evaluating road mitigation performance simultaneously apply to evaluations of maintenance practices. Such evaluations are vital as currently little is known about the effects of individual maintenance measures. Therefore, little can be concluded on the cost-effectiveness of these measures;
- The practical set of guidelines on defining outcome-based specifications for road mitigation projects in which an outcome-based procurement approach is used also provides recommendations to improve technical specifications in more conventional procurement approaches;
- The conclusion that ecologists should be involved from the earliest stages of road planning and some tasks should even be arranged before a project starts. Examples include the assessment of baseline conditions or reference standards or the setup of web-based portals for accessing data and research publications; and
- Strong similarities between the recommendations for the implementation of effective road mitigation strategies provided by the research and provided by practitioners during the ECOROAD workshop in Cologne, Germany.

8 Implementation of findings

Within each research project, recommendations have been provided on how to implement the findings or guidelines (refer to Sections 2, 3, 4 and 5 of this report). Additionally, opportunities for implementation of the research outcomes across member states have been explored by practitioners during the End-of-Programme Workshop in Cologne, Germany. In an interactive session, all attendants of the workshop were asked to identify practical steps needed for implementing the outcomes in the current practices of road planning, building and operating. The proposed steps for implementation are ordered by topic, in conformance with the structure of the CEDR Roads and Wildlife Manual.

Environmental policy and legislation for road planning:

- At an early stage, develop a road mitigation plan at a strategic level to ensure greater coherence between project-related plans, thus strengthening the links between Strategic Environmental Assessment (SEA) and EIA;
- Choose an integrated planning approach for road mitigation in which bottlenecks at local, regional and national road networks are jointly addressed;
- Pursue consensus across the EU on how to interpret and apply the Nature Directives in road planning;
- Embed road mitigation planning in the current initiatives for developing a trans-European green infrastructure;
- Arrange frequent and systematic feedback between policy makers and road planners in order to implement the legislation and policy plans in a coherent manner;
- Enhance awareness of road impacts and the need to fill current knowledge gaps among all relevant actors. This should make the issue a shared responsibility and solving it a collaborative action;
- Arrange inter-institutional agreements, e.g. between road and environmental agencies, to strengthen collaboration and ensure that procedures and divisions of tasks and responsibilities are clearly set out;
- Make use of interdisciplinary teams of experts in road planning, procurement, construction and maintenance to ensure all relevant issues are correctly addressed and in a timely manner; and
- Initiate capacity building of experts within the road authorities through training to enable them to apply new knowledge and methods of working.

Road mitigation strategies:

- Develop a vision on defragmentation from a landscape perspective, in which population level impacts are addressed and clear goals for mitigation are defined that link with (inter) national legislation and policies;
- Develop practical approaches to address cumulative impacts across projects systematically in order to prevent a staged loss of biodiversity. This is where the loss in each stage is considered acceptable but the combined loss over all stages results in a significant impact;
- Pursue stronger collaborations between engineers and environmental experts to increase cost-effectiveness of road mitigation strategies and allow for compliance with the latest knowledge on mitigation performance; and
- Acquire knowledge and develop mitigation strategies not only for ‘indicator’ or ‘umbrella’ species but also for less prominent species, to avoid a bias in mitigation planning towards the more visible or popular wildlife species.

Mitigation measures for bats:

- Acquire further knowledge on the effectiveness of the mitigation measures currently used or planned and ensure all research data and results are widely available; and
- Pursue improved collaboration between the road and environmental authorities and researchers, to avoid ineffective measures being applied. Ensure all innovative measures are correctly tested before being widely used.

Procurement and performance indicators:

- Develop a systematic and transparent approach to define SMART goals for mitigation and an appropriate set of performance indicators with which the functioning of the measures can be evaluated;
- Develop financed evaluation plans for planned road mitigation measures in the earliest stages of a project to gain a clear view on a feasible set of performance indicators from both a practical and financial perspective; and
- Make performance evaluations an obligatory part of road mitigation projects.

Maintenance:

- Adopt a process in preparing maintenance plans that allows for the definition of clear ecological goals for road verges, including goals for being habitat refuges and goals for avoiding ecological traps or population sinks;
- Secure appropriate budgets for maintenance of road verges and mitigation measures in a timely manner and ensure that the necessary maintenance is carried out consistently;
- Move from reactive to pro-active maintenance measures to address issues that relate to invasive species;
- Raise awareness of ecological issues in maintenance among both road authorities and contractors, and arrange training to deal more effectively with road-wildlife conflicts;
- Establish a clear and systematic process for registering and evaluating road-kill data;
- Improve the enforcement of maintenance contracts through well described targets and clear procedures and instructions for technical checks and performance evaluations;
- Develop stimuli for good results and/or penalties for poor performance of maintenance operations as well as a transparent method to evaluate maintenance impacts;
- Arrange close cooperation between road and environmental authorities, road operators, traffic police and researchers in order to implement road kill management; and
- Arrange close cooperation between road and environmental authorities and researchers to be able to carry out, for example, road-kill hotspot analysis, performance evaluations and population viability assessments.

Performance evaluation of mitigation measures:

- Move towards an adaptive planning approach in road mitigation, based on feedback from well-designed performance evaluations;
- Develop a standard monitoring reporting scheme for road authorities across the EU to improve the quality of monitoring reports and better allow for cross-project comparisons and analyses; and
- Improve the storage of and access to monitoring data, and enhance the use of the data through web-based tools.

9 Recommendations for future research

It is recommended to focus future research on the following issues:

- Effectiveness of the different types of road mitigation measures and the key features of these measures that determine their performance. Such research, if conducted correctly, will result in further knowledge about what works and what does not, will provide better insight into the cost-effectiveness of measures and, consequently, will allow for better decisions on what road mitigation to apply in specific situations;
- Effectiveness of the different types of maintenance measure and the key features of these measures that determine their performance. This will result in improved knowledge in relation to effectiveness, will provide better information on the cost-effectiveness of measures and, thus, allow for enhanced decisions on what maintenance strategies to apply;
- The development of more user-friendly simulation models and web tools that can be used by road planners to identify potential impacts of road projects on wildlife populations, identify appropriate and feasible goals for mitigation that address these impacts and help in the preparation of scientifically-sound monitoring programmes and evaluation studies in which population-level indicators are used. Such aids will enable the road planner to address population level impacts more appropriately and to better comply with the objectives and regulations of EU Directives and agreements; and
- The feasibility and practical application of outcome-based specifications in road mitigation procurement, as compared to the use of design specifications. Such research will provide empirical evidence on the possible benefits and/or disadvantages of an outcome-based procurement approach and, consequently, allow for better judgement of when such an approach can be applied and when other approaches should be preferred.

10 Conclusions

The successful implementation of the research findings of the Roads and Wildlife Research Programme is mainly the responsibility of the road authorities. Firstly, it may demand a fresh mind-set in order to apply the new insights and recommendations in road mitigation and road maintenance practices to enhance the sustainability of road infrastructure. Secondly, it may require additional skills and expertise and a more transdisciplinary way of working that allows engineers and ecology experts to work in closer collaboration. Some recommendations may mean that new legal regulations should be established in which changes in procedures and the division of responsibilities are changed. Furthermore, more effective coordination and cooperation is needed to ensure that all mitigation measures are incorporated into the specific projects and these are followed through in an integrated way to the completion of the project.

This report and the research projects it is based on, clearly indicate that some prominent knowledge gaps on the effectiveness of mitigation and maintenance measures still exist and that filling these gaps will be highly beneficial to all efforts taken to avoid road impacts and develop sustainable transport networks. However, it is not advisable to postpone implementation of the findings of this research programme until all gaps have been addressed. The recommendation is to adopt a ‘learning by doing’ approach in which scientifically-sound road mitigation and maintenance practices are immediately pursued, but are consistently accompanied by evaluation studies in which further insights are gained into what works best. Such evaluation studies should preferably be initiated and overseen by the road authority to ensure that the outcome will be available to all future road projects.

It is vital to frequently exchange new knowledge and best-practice between all stakeholders in order to avoid the repetition of mistakes and increase the effectiveness of mitigation and maintenance actions. Cooperation is also essential to address new challenges, such as climate change, or new policy strategies, such as the development of green infrastructure. Only then can we have a chance of creating a sustainable road network that addresses the needs of both wildlife and people.

Acknowledgements

The research presented in this report was carried out as part of the CEDR Transnational Road Research Programme Call 2013. The funding for the research was provided by the national road administrations of Austria, Denmark, Germany, Ireland, Norway, Sweden, the Netherlands and the United Kingdom.

The report was produced under contract to CEDR. The views expressed are those of the authors and not necessarily those of CEDR or any of the CEDR member countries.

Web links

Web links to the projects of the Roads and Wildlife Research Programme are as follows:

SAFEROAD	www.saferoad-cedr.org
Harmony	www.harmony-project.net
SafeBatPaths	www.bios.au.dk/om-instituttet/organisation/faunaoekologi/projekter/safe-bat-paths
ECOROAD	www.ecoroad-cedr.org

Other relevant web links:

CEDR	www.cedr.eu
IENE	www.iene.info
ICOET	www.icoet.net
ANET	www.ecologyandtransport.com

Annex A: List of SAFEROAD deliverables

Technical report 1: Helldin, J.O., Broekmeyer, M., Campeny R., Kistenkas, F., 2016, Roads and wildlife: Legal requirements and policy targets, SAFEROAD Technical report 1.

Technical report 2: Van der Grift, E.A., Seiler, A., 2016, Guidelines for outcome-based specifications in road mitigation, SAFEROAD Technical report 2.

Technical report 3: Seiler, A., Klein, J., Chapron, G., Van der Grift, E.A., Schippers, P., 2016, Modelling the performance of road mitigation strategies: Population effects of permeability for wildlife, SAFEROAD Technical report 3.

Technical report 4: Seiler, A., Olsson, M., Rosell, C., Van der Grift, E.A., 2016, Cost-efficacy analysis: wildlife and traffic safety, SAFEROAD Technical report 4.

Technical report 5: Rosell, C., Helldin, J.O., Reck, H., Navàs, F., Cama, A., OBrien, E., 2016, Road maintenance guidelines to improve wildlife conservation and traffic safety, SAFEROAD Technical report 5.

Technical report 6: Van der Grift, E.A., Seiler, A., 2016, Guidelines for evaluating the performance of road mitigation measures, SAFEROAD Technical report 6.

Technical report 7: Seiler, A., Sjölund, M., Rosell, C., Torellas, M., Rolandsen, C.M., Solberg, E.J., Van Moorter, B., Lindstrøm, I., Ringsby, T.H., 2016, Case studies on the effect of local road and verge features on ungulate-vehicle collisions, SAFEROAD Technical report 7.

Scientific paper 1: Van der Grift, E.A., Rytwinski, T., Soanes, K., Van der Ree, R., Effectiveness of road mitigation for wildlife: A review

Scientific paper 2: Rytwinski, T., Soanes, K., Jaeger, J.A.G., Fahrig, L., Findlay, C.S., Houlahan, J., Van der Ree, R., Van der Grift, E.A., 2016, How effective is road mitigation at reducing road-kill? A meta-analysis. PLoS ONE 11(11): e0166941. doi:10.1371/journal.pone.0166941

Scientific paper 3: Ottburg, F.G.W.A., Van der Grift, E.A., Effectiveness of road mitigation measures for a common toad (*Bufo bufo*) population in the Netherlands

Scientific paper 4: Rolandsen, C.M., Van Moorter, B., Panzacchi, M., Roer, O., Solberg, E.J., You shall pass! A mechanistic evaluation of mitigation efforts in road ecology

Scientific paper 5: Seiler, A., Klein, J.G., Chapron, G., Van der Grift, E.A., Schippers, P., Effects of roads on wildlife population viability

Scientific paper 6: Van der Grift, E.A., Huijser, M.P., Purdum, J.P., Camel-Means, W., Estimating crossing rates at wildlife crossing structures: methods matter!

Movie: Van der Grift, E.A., Ottburg, F.G.W.A., 2015, Tunnels for toads

Web tool: Van der Grift, E.A., Schippers, P., De Jong, A., Knapen, R., Road Mitigation Calculator (www.roadmitigationcalculator.eu)

Final report: Van der Grift. E.A., Seiler, A., Rosell, C., Simeonova, V., Safe roads for wildlife and people: Final report of the SAFEROAD project.

Annex B: List of Harmony deliverables

Deliverable Report B: Corrigan, B., Mac Gearailt S., Leahy, C., Carey C., 2016, Final Report, Harmony project Deliverable B.

Deliverable Report C: Ni Choine, M., Gavin S., Wansink, D., 2014, Environmental Legislation and Guidelines, Harmony project Deliverable C.

Deliverable Report D: Gavin S., Corrigan, B., Carey C., Ni Choine, M., Wansink, D., 2015, Recommendations on Appraisal Process & Report on Consultations, Harmony project Deliverable D.

Deliverable Reports E (A): Tschan, G., Ó Catháin, E., Corrigan, B., Carey C., Mac Gearailt S., 2016, Report on Procurement, Follow-up and Performance Indicators, Harmony project Deliverable E, Part A.

Deliverable Reports E (B): Tschan, G., Ó Catháin, E., Corrigan, B., Carey C., 2016, Handbook on procurement and follow-up (incl. performance indicators), Harmony project Deliverable E, Part B.

Deliverable Report F: 2016, Preliminary Maintenance Report Part A: Ecological functions of roads, Harmony project Deliverable F.

Deliverable Reports G (A): Wansink, D., Tukker, A., Weiperth, A. Puky, M., Gal, B., 2016, Cost-effective maintenance to support the ecological functions of roads, Harmony project Deliverable G, Part A.

Deliverable Reports G (B): Carey C., OBrien, E., Wansink, D., Corrigan, B, 2016, Maintenance Handbook, Harmony project Deliverable G, Part B.

Annex C: List of SafeBatPaths deliverables

SafeBatPaths Technical Report 1: Christensen, M., Fjederholt, E.T., Baagøe, H.J. & Elmeros, M. 2016. Hop-overs and their effects on flight heights and patterns of commuting bats – a field experiment - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 2: Dekker, J., Berthinussen, A., Ransmayr, E., Bontadina, F., Marnell, F., Apoznański, G., Matthews, J., Altringham, J.D., Ujvári, M.L., Phelan, S.-J., Roué, S., Kokurewicz, T., Hüttmeir, U., Loehr, V., Reiss-Enz, F., Fjederholt, E.T., Baagøe, H.J., Garin, I., Møller, J.D., Dalby. L., Christensen, M. & Elmeros, M. 2016. Future research needs for the mitigation of the effects of roads on bats - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 3: Dekker, J., Garin, I., Møller, J.D., Baagøe, H.J., Christensen, M. & Elmeros, M. 2016. Richtlijnen voor het mitigeren van effecten van wegen op vleermuizen - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 4: Elmeros, M., Dekker, J., Baagøe, H.J., Garin, I. & Christensen, M. 2016. Bat mitigation on roads in Europe – an overview - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 5: Elmeros, M., Baagøe, H.J., Dekker, J., Garin, I., Christensen, M. & Møller, J.D. 2016. Bat mitigation measures on roads – a guideline - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 6: Garin, I., Dekker, J., Møller, J.D., Baagøe, H.J., Christensen, M. & Elmeros, M. 2016. Guía para mitigar los atropellos de murciélagos - SafeBatPaths Technical Report.

SafeBatPaths Technical Report 7: Møller, J.D., Dekker, J., Baagøe, H.J., Garin, I., Alberdi, A., Christensen, M. & Elmeros, M. 2016. Effectiveness of mitigating measures for bats – a review - SafeBatPaths Technical Report.

Annex D: List of ECOROAD deliverables

CEDR Roads and Wildlife Manual: OBrien, E.J., Van der Grift, E.A., Elmeros, M., Wilson-Parr, R. & Carey, C. 2017. CEDR Contractor Report 2017-1. CEDR Transnational Road Research Programme Call 2013: Roads and Wildlife. CEDR, Brussels.

Final Programme Report: Van der Grift, E.A., OBrien, E.J., Elmeros, M., Simeonova, V., MacGearailt, S., Corrigan, B., Wilson-Parr, R., Carey, C. 2017. CEDR Contractor Report 2017-2. CEDR Transnational Road Research Programme Call 2013: Roads and Wildlife. CEDR, Brussels.

Ref: CEDR Contractor Report 2018-2 (May 2018)

Call 2013: Roads and Wildlife – Final Programme Report

Conference of European Directors of Roads (CEDR)

Ave d'Auderghem 22-28

1040 Brussels, Belgium

Tel: **+32 2771 2478**

Email: **information@cedr.eu**

Website: **http://www.cedr.eu**