Guidelines for outcome-based specifications in road mitigation

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Executive summary

As national road administrations increasingly use contract types in which the constructor not only builds but also designs the desired road or road modification, including mitigation measures for wildlife, a new set of procurement specifications is needed. Procurement documents should no longer present detailed technical specifications but should provide outcome-based specifications. Outcome-based specifications can best be defined as specifications based on what providers will achieve and not on what they will do. The reason that more and more governmental agencies are shifting to an outcome-based approach in procurement is the aim to deliver more value within constrained budgets. The approach also means - which is often seen as an advantage - that the contractor becomes more responsible for risk management while simultaneously getting more control and freedom in carrying out the project. Furthermore, an outcome-based approach is assumed to provide a better breeding ground for innovations and increase cost-efficiency over the more traditional contracting models with prescribed products or services.

Outcome-based specifications for the design and construction of road mitigation measures should have a clear link to the predefined objectives of the road project. In turn, the objectives of a road project will be derived from - national and international - obligations that result from environmental and transport legislation and regulations as well as ambitions elaborated in environmental and transport strategies and policies. Environmental objectives ultimately refer to improving or maintaining population persistence and, consequently, biodiversity conservation. Transport objectives, in this respect, refer to improving road safety and avoiding impacts on the natural environment, including wildlife. The challenge in an outcome-based procurement approach is to translate these objectives into clear and measurable functions that can be provided by road mitigation measures.

Here we develop guidelines for defining outcome-based specifications to help civil engineers produce functional road mitigation measures that comply with the current EU legal and policy frameworks. First, we identify what these frameworks mean for an outcome-based approach in procuring road mitigation projects and we discuss the implications for defining sound outcome-based specifications. Second, we analyse the outcome-based specifications, currently used in road mitigation procurement in the Netherlands. We evaluate the extent to which these specifications reflect the requirements of the EU legal and policy frameworks and their potential to link clear and measurable performance indicators to the required outcomes. Third, we provide a set of practical guidelines for defining outcome-based specifications for procuring road mitigation measures. The use of these guidelines is illustrated by two practical examples. Finally, we discuss the potential benefits and risks of well-defined outcome-based specifications, based on the guidelines presented here, for policymakers, road agencies and other stakeholders and we provide recommendations on how to implement outcome-based specifications in the procurement process.

EU regulations and policies provide a variety of requirements and ambitions that are of concern for road projects and that may help define sound road mitigation outcomes. We have identified fourteen indicators, all of which provide clues for defining outcome-based specifications to be used in road mitigation procurement. Besides these indicators, our review pointed out the importance of the measurability of effects, both from activities that damage the environment and activities that aim to mitigate such damage, as well as the use of baseline conditions or reference standards that allow for quantitative evaluations. Using indicators that directly relate to regulations and policies, adopting a quantitative approach and incorporating clear baseline conditions or reference standards in defining outcome-based specifications will inevitably improve the ability to judge whether or not performance requirements are being met.

Although still in development, the outcome-based approach currently used in the Netherlands is an illustrative case that may help others to move from detailed technical prescriptions towards more generic descriptions of functions. The Dutch specifications clearly reflect some of the key requirements and ambitions of the EU legal and policy frameworks; however, there is room for improvements, such as including indicators that relate to populations. Other improvements may be to (i) emphasize the impacts that need to be mitigated, (ii) quantify requirements and (iii) use baseline conditions or reference standards. Such improvements will inevitably allow the specifications to link to clear performance indicators.

We have identified eight guidelines for defining outcome-based specifications:
1. Link the specifications directly to the goals for mitigation;
2. Specify whether or not no-net-loss is the aim;
3. Use the 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 barrier to be mitigated and not to a single structure;
8. Keep the use of technical specifications to a minimum.

Using outcome-based specifications based on these guidelines may have value for all stakeholders involved. First, they may better ensure that the overall objective - either related to wildlife conservation or road safety - is being met. Second, they may significantly increase our knowledge base by forcing all those involved to gain more knowledge of what does and does not work. Third, they may guarantee a strong link to national and international regulations and policies and better support political and/or societal discussions on the need for and usefulness of road mitigation. And fourth, an outcome-based approach provides room for adaptive management. If road mitigation works designed and constructed on the basis of the best available knowledge fail to reach the desired outcome, corrective measures can be taken.

The use of outcome-based specifications may have certain disadvantages and risks when compared with the more traditional procurement approaches. First, they require better knowledge of mitigation measures and their effects than what we may have today. This implies that contractors may not yet be held fully responsible for a failure and/or that the costs of mitigation works may increase. Second, costs may increase due to the need for studies to assess baseline conditions or reference standards. Third, little is known about appropriate time spans for evaluation studies, which may result in wasting resources or drawing wrong conclusions on whether or not the measures are successful. Fourth, if not well regulated and safeguarded, knowledge of road mitigation effectiveness becomes an asset of private contractors and, consequently, may not be freely available to all stakeholders. And fifth, an outcome-based approach in road mitigation procurement requires a new judicial framework in which the responsibilities of both the road agency and contractors are clearly outlined.

The shift in mindset needed for an outcome-based approach to work may take considerable time. This may result in a phase in which a ‘mixed approach’ is used in which functional specifications are complemented by an abundance of design specifications. The risk of such a mixed approach is that innovations will be slowed down and the strength of control mechanisms will decrease. After all, if prescribed outcomes are not reached it will be difficult to point out the specific cause for the failure in the design. Is it the result of applying the prescribed design specifications or the result of decisions on the design made by the contractor? For example, if outcome-based specifications address population-level end goals but the number of wildlife crossing structures and/or length of wildlife fences is prescribed by

the road agency, the contractor may argue that goals were not met due to these prescriptions.

Our recommendations for implementing the use of outcome-based specifications in procuring mitigation works are: (i) make sure that environmental authorities are closely involved in the procurement process in order to ensure that environmental objectives are adequately reflected in the contract; (ii) develop a generic set of functional specifications that can be easily adapted to the situation and ambitions of the project at hand; (iii) write outcome-based specifications in a style similar to the language of technical specifications; (iv) develop a clear set of performance indicators that accompany the outcome-based specifications; (v) contract an independent contractor to evaluate the road mitigation works on the basis of the provided performance indicators; (vi) develop a strategy to systematically assess baseline conditions and reference standards; (vii) develop an open-access database on road mitigation evaluations so that future projects will be able to learn from previous ones; (viii) evaluate the use of outcome-based specifications in road mitigation procurement as compared to the use of design specifications and gather empirical evidence on the possible benefits and/or disadvantages of the approach.

We further recommend carefully testing the guidelines presented here in practice and creating a generic set of functional specifications that can be derived from them. If deemed appropriate after testing, the guidelines should be modified to optimize their application in road mitigation projects throughout the EU.

1 Introduction

Because national road administrations increasingly make use of Design & Construct (D&C)[1] and Design, Build, Finance, Maintain (DBFM) contracts in road building, a new set of procurement specifications is needed. In these types of contracts the constructor not only builds but also designs the desired road or road modification, including mitigation measures for wildlife. This implies that procurement documents no longer present detailed prescriptions on the technical design and dimensions of road mitigation measures, e.g. wildlife crossing structures or wildlife fences, but that they provide descriptions on what the measures should achieve i.e. what the outcome should be of the desired measures. Hence, in procurement there is a shift from detailed design specifications - with the focus on input - to more general functional specifications - with the focus on output. It is the task of the contractor to translate these functional or outcome-based specifications (OBSs)[2] into technical solutions and - usually - to prove that the solutions are functional.

Outcome-based specifications can best be defined as specifications based on what providers will achieve rather than on what they will do. Hence, contracts under an outcome-based approach focus on the desired outcome of the work to be performed (the “what”) rather than the manner in which it is to be performed (the “how”) (North, 2014). The reason that more and more organizations - in particular governmental agencies – are shifting to an outcome-based procurement approach is the aim to deliver more value within constrained budgets (Turley et al., 2014). The approach also means - which is often seen as an advantage - that the contractor becomes more responsible for risk management while simultaneously getting more control and freedom in carrying out the project. Furthermore, an outcome-based approach is assumed to provide a better breeding ground for innovations and to increase cost-efficiency compared to the more traditional contracting models with prescribed products or services.

A key challenge in the use of an outcome-based approach is the development of measurable performance indicators that are tied to the required outcomes (North, 2014). Hence, although outcome-based specifications may be more generic than design specifications, they should allow for a direct link to key metrics that relate to the performance of the measures. If such metrics cannot be found, the use of an outcome-based approach should be reconsidered. After all, without proper metrics an objective performance assessment cannot be made, which inhibits the functioning of a risk and rewards payment model.

Outcome-based specifications for the design and construction of road mitigation measures should have a clear link to the predefined objectives of the road project. In turn, the objectives of a road project will be derived from - national and international - obligations that result from environmental and transport legislation and regulations as well as ambitions elaborated in environmental and transport strategies and policies. Environmental objectives ultimately refer to improving or maintaining population persistence and, consequently, biodiversity conservation. In this respect, transport objectives refer to improving road safety and avoiding impacts on the natural environment, including wildlife. The challenge in an outcome-based procurement approach is to translate these objectives into clear and measurable functions that can be provided by road mitigation measures.

Here we develop guidelines for defining outcome-based specifications that can help civil engineers produce functional road mitigation measures that comply with the current EU legal and policy frameworks. First, we identify what these frameworks mean for an outcome-based approach in procuring road mitigation projects and we discuss the implications for defining

[1] Also referred to as Design & Build-contracts (D&B).
[2] Also referred to as performance-based specifications (PBSs; see also Turley et al., 2014).

sound outcome-based specifications. The focus here is on road mitigation measures that aim to increase road safety and reduce road-related wildlife mortality and barrier effects that potentially reduce the survival probability of wildlife populations. Second, we analyze the outcome-based specifications currently used in road mitigation procurement in the Netherlands. We evaluate the extent to which these specifications reflect the requirements of the EU legal and policy frameworks and their potential to link clear and measurable performance indicators to the required outcomes. Third, we provide a set of practical guidelines for defining outcome-based specifications to procure road mitigation measures. The use of these guidelines is illustrated by two practical examples. Finally, we discuss the potential benefits and risks of well-defined outcome-based specifications, based on the guidelines presented here, for policymakers, road agencies and other stakeholders, and we provide recommendations on how to implement outcome-based specifications in the procurement process.

2 EU legislation: What are our obligations?

Here we identify what current EU environmental and transport legislation means for an outcome-based approach in procuring road mitigation projects and we discuss their implications for defining sound outcome-based specifications. Our starting point is the study by Helldin et al. (2016), which identifies all EU regulations and agreements relevant to the issue of roads and wildlife and their requirements for road mitigation. We then analyze what these environmental and transport regulations imply for defining the outcomes that road mitigation measures must provide.

2.1 Environmental regulations

Helldin et al. (2016) identified six environmental regulations and agreements as the most relevant to EU Member States in relation to mortality and the barrier effects of roads on wildlife:

- Habitats Directive (Directive 92/43/EEC, consolidated version 2007);
- Birds Directive (Directive 79/409/EEC, as amended by Directive 2009/147/EC);
- Environmental Liability Directive (Directive 2004/35/EC);
- Environmental Impact Assessment Directive (Directive 2011/92/EU, as amended by Directive 2014/52/EU);
- Convention on the Conservation of Migratory Species of Wild Animals (”Bonn Convention”, www.cms.int; see also Council Decision 82/461/EEC);
- Convention on the Conservation of European Wildlife and Natural Habitats (”Bern Convention”; ETS no. 104).

All these regulations and agreements explicitly address the conservation of species and deal with such matters as conservation objectives and responsibilities, levels of acceptable impact, priority species, principles for derogation and requirements for remedial action, research and monitoring.

2.1.1 EU Habitats Directive

The aim of the Habitats Directive is to “contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States…” (see Article 2). The focus is on maintaining or restoring, at favourable conservation status, the natural habitats and species of wild fauna and flora of Community interest, which are all listed in the Directive. The key indicators used are the conservation status of a natural habitat and the conservation status of a species. The conservation status of a natural habitat means “the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species…”. The conservation status of a species means “the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations…”. This applies to the ‘typical species’ of the natural habitats as well as to the ‘species of Community interest’ i.e. species that are endangered, vulnerable, rare or endemic. The primary means of realizing the aim of the Directive is to develop a coherent ecological network of special areas of conservation across Europe, better known as Natura 2000 (see Article 3). The Habitats Directive sets out clear rules for the designation of individual sites that host valuable natural habitats and/or species. Plans and projects that will likely have a significant effect, either individually or in combination with other plans or projects, are appropriately assessed on their implications for the site in view of the site's conservation objectives, i.e. the favourable conservation status of its habitats and/or species of Community interest.

Implications for defining outcome-based specifications:

- An important notion is that the Habitats Directive itself uses an outcome-based approach as the end goals are formulated in terms of maintaining or restoring the favourable conservation status of habitats and species. Hence, the Directive does not provide exact prescriptions on what should or should not be protected, but presents functional targets that should direct all conservation efforts. Consequently, the Directive in itself may provide a practical framework for outcome-based specifications in road mitigation projects as the end goal - preserving biodiversity - is the same. In the Habitats Directive, the conservation status of a species is 'favourable' when: (1) population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, (2) the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future and (3) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis. These criteria imply that population viability, species distribution and available habitat are the indicators used to assess whether or not conservation efforts are successful. It makes sense to use these indicators in defining outcome-based specifications for road mitigation as this will result in a clear and direct link between what is aimed for in the road mitigation project and the national biodiversity conservation objectives.
- The Habitats Directive emphasizes the need for the ecological coherence of the Natura 2000 network (see Article 3 and 4), especially in relation to compensatory measures if negative impacts of plans or projects cannot be avoided. In this respect it also encourages maintaining and developing landscape features which are "essential for the migration, dispersal and genetic exchange of wild species" (see Article 10). Furthermore, it prohibits the deliberate disturbance of animal species, e.g. during the period of migration (Article 12, but see also Article 6(3)). These provisions emphasize the understanding that movements of animals (and plants) across the landscape are of importance to maintain or restore the favourable conservation status of a species. Consequently, ensuring the potential for wildlife movements across the landscape, including roads, can be a useful principle in defining outcome-based specifications for road mitigation.
- The Habitats Directive prohibits all forms of deliberate capture or killing of the species listed in Annex IV (see Article 12(1)). This prohibition, which applies to all stages of life of the animals, is important as it is linked to the population of a species, which constitutes one of the criteria for assessing the conservation status of a species. After all, capture or killing may lead to an immediate direct (quantitative) decline in a population or they could have other more indirect (qualitative) negative effects. Roads and traffic may lead to the entrapment of wild animals - e.g. in drainage systems - and wildlife mortality from animal-vehicle collisions. However, these forms of 'capture and killing' are not considered deliberate. In the guidance document on the strict protection of animal species of Community interest under the Habitats Directive (EC, 2007) drafted by the Environment Directorate-General of the European Commission, roadkill is explicitly mentioned as an example of incidental killing that falls under Article 12(4). The Habitats Directive prescribes the establishment of a system to monitor the incidental capture and killing of the animal species listed in Annex IV. Using the monitoring data, Member States will have to take the further conservation measures needed to ensure that incidental capture and killing does not have a significant negative impact on the species concerned. These provisions in the Habitats Directive support the use of roadkill-related objectives or indicators - with roadkill being a result of either entrapment or collisions - in defining outcome-based specifications. It also emphasizes the importance of focusing on

population viability again as incidental capture or killing should not have a significant negative impact on the species.

2.1.2 EU Birds Directive

The Birds Directive aims to protect all wild bird species naturally occurring in the European Union. As Article 1 states, it "covers the protection, management and control of these species and lays down rules for their exploitation". The Birds Directive establishes a network of Special Protection Areas (SPAs) for endangered and migratory species. These SPAs are included in the Natura 2000 ecological network set up under the Habitats Directive. The Birds Directive also regulates the hunting of birds and bans activities that directly threaten birds, such as their deliberate killing, capture or disturbance. The focus is on maintaining or restoring populations. Article 2 states: "Member States shall take the requisite measures to maintain the population of the species…..at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level".

Implications for defining outcome-based specifications:

- Similar to the Habitats Directive, the end goal of the Birds Directive is to ensure the survival of populations of species of concern. Hence, the Birds Directive can also be seen as an outcome-based regulation, although it is stated less explicitly than in the Habitats Directive. Because the Birds Directive does not use the 'favourable conservation status' as key indicator, it consequently lacks the clear description of what is favourable and what is not, as included in the Habitats Directive. Instead, the Birds Directive states that the bird populations should be restored or maintained "at a level which corresponds in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements". As noted by Helldin et al. (2016), the Directive does not define the precise meaning of these requirements, and neither do the guidance documents on the Birds Directive that have been published by the European Commission (EC, 2006; EC, 2008a). The 'ecological requirements' likely refer to some sort of minimum population standards that need to be met to ensure that both the bird populations become or remain viable and that their functional role in the ecosystem is guaranteed. Taking into account economic and recreational requirements, as provisioned, likely implies that, for some species or situations, the minimum population standards should be higher in relation to the exploitation (i.e. marketing or hunting) of birds. The economic and recreational requirements may also imply that maximum population standards are applied for species that may impact economic interests - for example, serious crop damage - as the Directive covers not only the protection but also the management and control of birds. Bird populations are impacted by roads (Benítez-López et al., 2010). Considering the focus on population survival in the Birds Directive, the use of population-related indicators seems (highly) appropriate in defining outcome-based specifications for bird-related road mitigation. Similar to the Habitats Directive, such indicators will make a direct link between the road mitigation aimed for and the ultimate bird conservation goals.
- Within the SPAs, appropriate steps should be taken to avoid the pollution or deterioration of habitats or any disturbances affecting the birds in order to ensure their survival and reproduction in their area of distribution (Article 4). Furthermore, the Directive prohibits the deliberate disturbance of birds, particularly during the period of breeding and rearing (Article 5), because a disturbance would significantly affect the objectives of the Directive. Hence, although no direct references are made to the fragmentation of bird habitats, the Birds Directive provides some clues for including habitat loss and barrier issues in defining outcome-based specifications.

- The Birds Directive prohibits the deliberate killing or capture of birds (Article 5). However, neither the Directive nor any of the guidance documents provide a definition of 'deliberate'. The similarity of this Article 5 to Article 12 of the Habitats Directive makes it reasonable to assume that explanations for this phrase in the guidance document of the Habitats Directive (EC, 2007) also apply to the Birds Directive. As explained above, roadkill is not seen as a form of deliberate killing in the Habitats Directive. Instead, roadkill is categorized as 'incidental killing'. The Birds Directive does not provide any reference to incidental killing and hence provides no direct starting point for including roadkill issues in defining outcome-based specifications.

2.1.3 EU Environmental Liability Directive

The Environmental Liability Directive establishes a framework based on the 'polluter pays' principle to prevent and remedy environmental damage. The polluter-pays principle implies that an operator whose activity has caused environmental damage - or the imminent threat of such damage - is to be held financially liable. The Directive defines 'environmental damage' as damage to protected species and natural habitats, damage to water and damage to soil. Annex III of the Directive lists all of the dangerous activities to which the regulation applies. Operators carrying out other activities may also be liable, but in that case it must be shown that the damage was a result of error. Road construction or modification is not listed in Annex III. Possible modifications to Annex III, however, are currently being discussed and may result in extending strict liability to all professional activities that cause environmental damage or biodiversity damage (BIO Intelligence Service, 2014). Up to now, however, the Directive has not been applied to large-scale road projects.

Implications for defining outcome-based specifications:

- The Environmental Liability Directive links its provisions directly to the Habitats Directive and Birds Directive, including the habitats and species listed in these Directives as well as the indicator of 'favourable conservation status'. Article 2 states that the damage to protected species and natural habitats means "any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species". The clues it provides for defining outcome-based specifications for road mitigation are similar to those of the Habitats Directive, with an emphasis on indicators that relate to population dynamics and viability, species distribution and available habitat. Interesting in this respect, as also pointed out by Helldin et al. (2016), is that the Environmental Liability Directive draws more attention to the measurability of the damage and provides examples of factors that can be used to determine whether significant impacts occur. Examples of such factors are the number of individuals, population density, population viability, area covered and the species' capacity for propagation.
- The Directive states that the significance of environmental damage is to be assessed with reference to the 'baseline condition'. Here, baseline condition is defined as "the condition at the time of the damage to the natural resources and services that would have existed had the environmental damage not occurred, estimated on the basis of the best information available". This approach provides an interesting clue for defining outcome-based specifications in road mitigation. The Directive states that operators should take actions to prevent, minimize, restore, rehabilitate or replace damaged natural resources. The effect of these actions can only be properly measured if there is a clear standard or reference that should be met. Including such a standard or reference in outcome-based specifications will allow for both better descriptions of the end goal in quantitative terms and better road mitigation evaluations. This will consequently help to implement an effective risk and rewards payment model.

2.1.4 EU Environmental Impact Assessment Directive

The aim of the EIA Directive is to reduce the environmental impacts of plans and projects. To do so, the Directive prescribes that activities likely to significantly affect the environment are made subject to an environmental assessment prior to their approval or authorization. The Directive defines projects to which the Directive applies and provides guidelines for the assessment process, including public consultations. An environmental impact assessment (EIA) is mandatory for all projects - listed in Annex I - considered to significantly affect the environment. These include long-distance railway lines, motorways and express roads. For projects listed in Annex II, the national authorities have to decide whether an EIA is needed, taking into account the criteria laid down in Annex III. These projects include the railways and roads not included in Annex I.

Implications for defining outcome-based specifications:

- The Directive presents a checklist of what should be included in an EIA. Article 8a(1) adds that a "decision to grant development consent shall incorporate…..a description of any features of the project and/or measures envisaged to avoid, prevent or reduce and, if possible, offset significant adverse effects on the environment as well as, where appropriate, monitoring measures". Annex IV specifies that such a description should explain the extent to which significant adverse effects on the environment are avoided, prevented, reduced or offset and should cover both the construction and operational phases. This implies that outcome-based specifications for road mitigation measures should preferably be quantitative and relate to the extent to which impacts are reduced. In this respect it is also noteworthy that the EIA report should include a baseline scenario, i.e. a description of the relevant aspects of the current state of the environment (see Annex IV). Including such a reference point in outcome-based specifications will inevitably improve the ability to judge whether or not performance requirements are being met.
- It is the duty of the Member States to make sure that the proposed mitigation measures are implemented and an appropriate procedure for monitoring is set up. In this respect Article 8a(4) of the Directive adds: "The type of parameters to be monitored and the duration of the monitoring shall be proportionate to the nature, location and size of the project and the significance of its effects on the environment." Hence, relatively large projects may require monitoring with more or different parameters and over a longer time period than small projects. As monitoring is a key part of an outcome-based approach in road mitigation, such differences between projects may result in different outcome-based specifications. For example, the time period over which the performance requirements should be met may vary, depending on the size of the project and its environmental impacts.

2.1.5 Convention on the Conservation of Migratory Species of Wild Animals

The Bonn Convention is an environmental treaty under the aegis of the United Nations Environment Programme (UNEP). It is a global convention, signed in 1979 and formally approved by the EU in 1982. It aims for the conservation and sustainable use of migratory animals, their habitats and migration routes. The Convention makes a distinction between migratory species threatened with extinction (listed in Appendix I) and migratory species that need or would significantly benefit from international cooperation (listed in Appendix II). For the species listed in Appendix I the Convention strives towards strict protection of the animals, conservation or restoration of their habitats, mitigation of migration barriers and control of other factors that might endanger them. Article III(4) states the following about mitigating barriers: "…..to prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species". For the species listed in Appendix II the Convention encourages participating states

to make international agreements. The objective of such agreements should be "to restore the migratory species concerned to a favourable conservation status or to maintain it in such a status". Such agreements may range from legally binding treaties to less formal instruments, such as Memoranda of Understanding.

Implications for defining outcome-based specifications:

- The Bonn Convention uses the favourable conservation status of a species as an indicator of success, thus providing similar clues for defining outcome-based specifications for road mitigation as does the Habitats Directive, with an emphasis on indicators that relate to population dynamics and viability, species distribution and available habitat. The Bonn Convention, however, presents an extra condition for judging a conservation status as favourable: "the distribution and abundance of the migratory species approach historical coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management" (see Article I). Hence, historical distributions and abundance levels are used as references to assess whether a conservation status is favourable or unfavourable, considering the ecological potential and issues of wildlife management. Consequently, in an outcome-based approach for road mitigation consideration should perhaps be given not only to the actual distribution and abundance of (migratory) species of concern, but also to historical distributions and abundances. Such an approach demands a set of specifications different than the specifications for road mitigation measures in the species' actual range since, for example, the use of crossing structures may be not expected in the short term.
- With a focus on migratory animals, the Bonn Convention is by definition not limited to areas that are permanently inhabited by the species of concern. The aim is to protect the species throughout its range, which is defined as "all the areas of land or water that a migratory species inhabits, stays in temporarily, crosses or overflies at any time on its normal migration route." In road mitigation special attention could be given to migratory species. As such species may not be present at the road corridor throughout the year, outcome-based specifications for road mitigation measures and the accompanying performance indicators should account for the temporal variability in the use of the mitigation measures.

2.1.6 Convention on the Conservation of European Wildlife and Natural Habitats

The Bern Convention is a binding international agreement between both EU Member States and Non-Member States that came into force in 1982. The Convention aims to conserve wild flora and fauna and their natural habitats, to promote cooperation between states and to give particular attention to endangered and vulnerable species including endangered and vulnerable migratory species (Article 1). The Convention also takes into account the impact that other "planning and development policies" may have on species and habitats (Article 3). The Bern Convention, which pre-dates the Habitats Directive, had an important influence on both its conception and drafting (EC, 2007). Although they have substantially similar objectives, they present different frameworks for nature conservation and different lists of species of concern. In 1996 the Bern Convention initiated the creation of the so-called 'Emerald network' - a network of Areas of Special Conservation Interest (ASCIs), which is complementary to the Natura 2000 network initiated by the Habitats Directive.

Implications for defining outcome-based specifications:

- The focus in the Bern Convention is to maintain or restore the population of wild flora and fauna at a level "which corresponds in particular to ecological, scientific and cultural requirements, while taking into account of economic and recreational requirements…." (Article 2). The wording here is identical to the wording in the Birds Directive. Like the Birds Directive, the Convention does not define the precise meaning of these

requirements, nor do the documents with further recommendations and resolutions to the Convention. Therefore, as discussed earlier, 'ecological requirements' likely refer to some sort of minimum population standards that need to be met to ensure that both the bird populations become or remain viable and their functional role in the ecosystem is guaranteed. Taking into account economic and recreational requirements also likely implies that, for some species or situations, higher minimum population standards should be applied in relation to the exploitation of the species and/or maximum population standards should be applied for species that may impact economic interests. Considering the focus on population survival in the Bern Convention, the use of population-related objectives or indicators seems appropriate in defining outcome-based specifications for road mitigation. As with the Habitats and Birds Directive, such indicators will make a direct link between the road mitigation aimed for and the ultimate conservation goals.

2.2 Transport regulations

Helldin et al. (2016) identified the European Agreement on Main International Traffic Arteries (TRANS/SC.1/2002/3) as relevant to EU Member States in relation to mortality and barrier effects of roads on wildlife. Besides this agreement, we also address the Directive on Road Infrastructure Safety Management (Directive 2008/96/EC; 19 November 2008) here because, for example, wildlife-vehicle collisions can be seen as a concern of both nature conservation and road safety.

2.2.1 European Agreement on Main International Traffic Arteries

The European Agreement on Main International Traffic Arteries sets out the conditions to which the main international traffic arteries in Europe - the so-called international E-road network - should conform. The aim is to lay down a coordinated plan for the construction and development of roads adjusted to the requirements of future international traffic and the environment. Annex I provides a list of roads the Agreement applies to. Annex II provides all the technical provisions agreed upon. As stated in Article 3, "the roads of the international E-road network shall be brought into conformity with the provisions" of this annex. These provisions "take into account various criteria including traffic safety, environmental protection, fluidity of traffic flow and comfort of road users…", and apply to both the construction of new roads and the modernization of existing ones.

Implications for defining outcome-based specifications:

- Annex II of the Agreement prescribes that roads must be designed to harmonize with landscapes. It also states that when a new project is proposed or existing roads are upgraded, consideration should be given to the direct and indirect effects of the roads and traffic on, among other things, fauna and flora. Positive effects on the environment should be maximized and the negative ones should be corrected. In Article IV.6.3 of the Annex - a provision on the "protection from and of animals" - it specifies that "in order to protect users from animals adequate fencing shall be provided wherever the topography indicates a risk of animals crossing" and "protective measures must also be taken for the animals themselves, such as over- or underpasses of suitable size and shape". As Helldin et al. (2016) already concluded, the Agreement addresses animal roadkill and barrier effects most clearly here as compared to the previous environmental agreements and it directly recommends installing fences and wildlife crossing structures. The Agreement does not include any performance specifications for these measures or a set of criteria stating when such measures should be applied. Hence, clues for outcome-based specifications do not go beyond the observation that both roadkill and barrier issues should preferably be addressed, and that the motivation for mitigation measures is based on both traffic safety and environmental concerns.

2.2.2 EU Directive on Road Infrastructure Safety Management

The Directive on Road Infrastructure Safety Management was initiated to limit the number of road fatalities. The Directive aims to ensure that safety is integrated into the planning, design and operation of all road infrastructure on the Trans-European Road Network (TEN-T). It attempts to bring road safety management to higher standards and encourages the exchange of best practices and knowledge of cost-effective measures. The Directive does not impose specific technical standards but invites Member States to make better use of existing practices and procedures. Article 1 notes that "This Directive requires the establishment and implementation of procedures relating to road safety impact assessments, road safety audits, the management of road network safety and safety inspections by the Member States". Although only roads of the TEN-T network are addressed in the Directive, it also states that Member States may apply the provisions of this Directive, as a set of good practices, to national road transport infrastructure not included in the TEN-T network that was constructed using Community funding in whole or in part. The Directive addresses safety issues for roads that are at the design stage, under construction or in operation.

Implications for defining outcome-based specifications:

- The Directive makes no direct reference to road safety issues related to wildlife. Annex III provides a set of potential remedial measures for road sections where safety needs to be improved. Wildlife fences or crossing structures are not mentioned in this list of examples of remedial measures. Some of the listed measures, however, are currently applied in efforts to avoid wildlife-vehicle collisions, such as reducing speed limits and the use of intelligent road signs. Lacking any reference to specific safety issues related to wildlife, the Directive provides only a few clues for defining outcome-based specifications. The most obvious clue is that, in line with the overall aim of the Directive, road safety objectives may be a starting point for specifications in road mitigation projects in addition to specifications that relate to environmental objectives.
- The Directive urges Member States to report regularly on the implementation of the provided guidelines on infrastructure safety management. This should allow for the systematic improvement of infrastructure safety within the EU. Furthermore, it should "allow other Member States to identify the most effective solutions, while the systematic collection of data from before/after studies should allow selecting the most effective measure for future action". This statement emphasizes the importance of studies in which the effectiveness of remedial measures are assessed and points out "before/after studies" as an appropriate means to carry out such evaluations. A before-after approach implies that the before-situation is used as a baseline to which the effects of a remedial measure can be compared. The use of such a baseline can be incorporated into outcome-based specifications for road mitigation measures, allowing for better assessments of whether or not the measures are performing well.

2.3 Implications for outcome-based specifications

In our review of EU environmental and transport regulations we have identified fourteen 'indicators' that provide clues for defining outcome-based specifications in road mitigation projects (Table 2.1).

- All environmental regulations, except EIA, refer to population viability as one of the end goals, and in HD, ELD and BONN this is one of the criteria to assess whether or not a protected species has reached the 'favourable conservation status'. In addition, BD and BERN implicitly emphasize the importance of population size in view of species conservation as well as economic and recreational requirements. ELD also refers to population size as well as two other measures that relate to wildlife populations. These could be used to determine whether significant impacts occur, but they could

simultaneously be used to determine whether impacts are sufficiently mitigated. The strong emphasis on population-level indicators is not surprising as the ultimate goal of all these regulations is to protect nature and preserve biodiversity. Including population-related requirements in outcome-based specifications would therefore be a logical approach in road mitigation procurement.

Table 2.1. Indicators extracted from EU environmental and transport regulations that provide clues for defining outcome-based specifications in road mitigation projects.

Legend: X = indicator is mentioned in the document; - = indicator is not mentioned in the document; HD = Habitats Directive; BD = Birds Directive; ELD = Environmental Liability Directive; EIA = Environmental Impact Assessment Directive; BONN = Convention on the Conservation of Migratory Species of Wild Animals (”Bonn Convention”); BERN = Convention on the Conservation of European Wildlife and Natural Habitats (”Bern Convention”); MITA = European Agreement on Main International Traffic Arteries; RISM = Directive on Road Infrastructure Safety Management.

Indicator	Environmental regulations						Transport regulations	
	HD	BD	ELD	EIA	BONN	BERN	MITA	RISM
Related to populations								
Population viability	X	X	X	-	X	X	-	-
Population size	-	X	X	-	-	X	-	-
Population density	-	-	X	-	-	-	-	-
Capacity for propagation	-	-	X	-	-	-	-	-
Related to species distribution								
Actual distribution	X	-	-	-	X	-	-	-
Historical distribution	-	-	-	-	X	-	-	-
Related to species abundance								
Actual abundance	-	-	-	-	X	-	-	-
Historical abundance	-	-	-	-	X	-	-	-
Related to habitat								
Habitat availability	X	X	-	-	X	-	-	-
Habitat quality	X	X	-	-	-	-	-	-
Related to road barriers								
Wildlife movements	X	-	-	-	-	-	X	-
Migration routes	-	-	-	-	X	-	-	-
Related to wildlife-vehicle collisions								
Wildlife mortality (roadkill)	X	-	-	-	-	-	X	-
Road safety	-	-	-	-	-	-	X	X

- Two environmental regulations - HD and BONN - refer to species distribution, i.e. the natural range of a species, as one of the criteria to assess whether a species has reached ‘favourable conservation status’. Roads may prevent a species from using its natural range to the full. Habitat patches may become isolated with an increased extinction risk for the population and a decreased probability, if extinction occurs, that

individuals from neighbouring populations will recolonize the site. Road mitigation measures may be motivated by, among other things, the aim to prevent such road-induced changes in species distribution; consequently, it seems appropriate to include requirements that relate to species distribution in outcome-based specifications.

- One environmental regulation - BONN - refers to species abundance, again as one of the criteria to assess whether a species has reached 'favourable conservation status'. This indicator relates to the relative representation of a species in a particular ecosystem. Road impacts, such as reduced access to feeding grounds or increased mortality due to wildlife-vehicle collisions, may negatively affect species abundance (see e.g. Fahrig & Rytwinski, 2009). Even if, due to the construction and use of a road, population viability is not significantly affected and the natural range of a species is not reduced, species abundance may decline. Thus, measurements of species abundance can be seen as a means to detect less obvious changes in wildlife populations. Inclusion of this indicator in outcome-based specifications should therefore be considered, especially when populations seem relatively small and thresholds for population viability are just met.
- Three environmental regulations - HD, BD and BONN - refer to habitat-related indicators to assess whether or not conservation efforts are successful. All three regulations present habitat availability, i.e. habitat quantity, as one of the criteria to assess whether a species has reached 'favourable conservation status'. HD and BD also refer to habitat quality when prohibiting the deliberate disturbance of animal species in their natural habitats and dictating that appropriate steps should be taken to avoid pollution or deterioration of habitats. Direct and indirect habitat losses are well-known impacts of roads on wildlife (Forman et al., 2003). Habitat may be lost directly due to road construction or indirectly due to the disturbing effects of traffic (see e.g. Reijnen & Foppen, 2006; Parris, 2015). These habitat-related impacts are usually addressed by a variety of measures, such as off-site habitat restoration, modification of the vertical alignment of the road or screening. In this respect, paying attention to habitat quantity and quality while formulating outcome-based specifications seems a sensible thing to do.
- Two environmental regulations - HD and BONN - and one transport regulation - MITA - refer to indicators that relate to the barrier effect of roads. HD contains provisions that emphasize the understanding that animal movements across the landscape are of importance to maintain or restore the favourable conservation status of a species. BONN emphasizes the importance of protecting migration routes. MITA explicitly mentions over- or underpasses - 'of suitable size and shape' - to enable animals to cross roads safely. Migrations to, for example, breeding or wintering habitats and dispersal movements of, for example, young animals to establish their own territories should not be hindered. This corresponds with the meta-population theory and our current knowledge of the importance of landscape permeability and habitat connectivity (see e.g. Van der Grift et al., 2003; Opdam & Steingröver, 2008). Roads may inhibit or even fully block wildlife movements, even for species that fly (see e.g. Jones & Bond, 2010). Crossing structures, such as wildlife overpasses or tunnels, aim to mitigate these effects, which advocates including barrier indicators in outcome-based specifications.
- One environmental regulation - HD - and two transport regulations - MITA and RISM - refer to indicators that relate to wildlife-vehicle collisions. HD addresses the issue from a nature conservation perspective, RISM from a road safety perspective and MITA from both perspectives. Wildlife road mortality is one of the most visible impacts of roads. It may reduce population abundance, lower genetic diversity and increase the extinction probability of (local) populations (see e.g. Jackson & Fahrig, 2011). If large mammals are involved, road safety becomes an issue with both economic and human health concerns. Currently, road mitigation projects are often initiated at observed or expected roadkill

hotspots. It is not uncommon that road mitigation plans consist primarily or solely of measures that aim to reduce roadkill, such as wildlife fences, reflectors or repellents. This supports the use of roadkill-related indicators in defining outcome-based specifications.

Besides these indicators, the review of regulations has pointed out the importance of the measurability of effects, both of activities that damage the environment and activities that aim to mitigate such damage. For example, ELD provides very explicit examples of measures that allow for a quantification of effects, such as the number of individuals and population density. And EIA requests a description of the extent to which these measures avoid, prevent, reduce or offset adverse effects on the environment. In line with such a quantitative approach are the statements in four of the regulations - ELD, EIA, BONN and RISM - that refer to some sort of quantitative comparison using baseline conditions or baseline scenarios. These regulations make clear that the significance of environmental impacts as well as mitigation effects can only be assessed if measured or predicted conditions can be compared to a reference standard. RISM even explicitly mentions “before/after studies” as an appropriate means to carry out such comparative evaluations. Using both indicators that can be quantified and clear reference standards in defining outcome-based specifications will inevitably improve the ability to judge whether or not performance requirements are being met.

3 EU policies: What are our ambitions?

Here we identify what current EU environmental and transport policies mean for an outcome-based approach in procuring road mitigation projects and we discuss the implications for defining sound outcome-based specifications. The key question is what EU policies imply for defining outcomes that road mitigation measures must provide.

With respect to environmental policies, our focus was on two strategic plans: (1) *Our life insurance, our natural capital: an EU biodiversity strategy to 2020* (COM (2011) 244 final) (EC, 2011a); (2) *EU Green Infrastructure (GI) - Enhancing Europe's Natural Capital* (COM (2013) 249 final) (EC, 2013). The former includes current EU policies on biodiversity conservation and is highly relevant to the issue of roads and wildlife. The latter - which can be seen as a step towards implementing one of the EU Biodiversity Strategy targets - advocates the development of green infrastructure that provide a variety of ecosystem services. As grey and green infrastructure will inevitably cross each other, this strategy document is also highly relevant in view of road mitigation projects.

With respect to transport policies, our focus was on one strategic plan that addresses transport and environment policy: *Renewed EU Sustainable Development Strategy* (10917/06) by the Council of the European Union (EU Council, 2006). We also reviewed various other transport-related EU strategies, such as *Greening Transport* (OM(2008) 433; EC, 2008b) and *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system* (COM(2011) 144 final; EC, 2011c); however, we will not further analyze them here as they lack any reference to road impacts on wildlife.

3.1 Environmental policies

3.1.1 EU Biodiversity Strategy

The EU Biodiversity Strategy, adopted in 2011, aims to halt biodiversity loss in the EU and help stop global biodiversity loss by 2020. The strategy sets out six targets and outlines how these objectives can be achieved: (1) Protect species and habitats; (2) Maintain and restore ecosystems; (3) Achieve more sustainable agriculture and forestry; (4) Make fishing more sustainable and seas healthier; (5) Combat invasive alien species; (6) Help stop the loss of global biodiversity. In total 20 actions, divided over the six targets, have been defined to halt the loss of biodiversity. Targets 1 and 2 in particular are relevant in relation to road networks and road mitigation efforts as these address the issue of protecting and restoring biodiversity and associated ecosystem services. Target 1 aims at better conservation or a secure status for 100% more habitats and 50% more species, protected by EU nature law, by 2020. To achieve this objective, the strategy identified a number of actions to better implement the Birds and Habitats Directives in all Member States. Target 2 aims at maintaining and enhancing ecosystems and their services by restoring degraded ecosystems as well as establishing green infrastructure. This includes measures that ensure that ecosystems are better connected, within and between Natura 2000 areas as well as in the wider countryside. To achieve this objective, the strategy identified a number of actions in which (1) the state and economic value of ecosystems and their services are assessed, (2) ecosystems are restored, their services maintained and the use of green infrastructure promoted and (3) no net loss of biodiversity and ecosystem services is ensured.

Implications for defining outcome-based specifications:

- The EU Biodiversity Strategy is strongly linked to the EU regulations on biodiversity protection, i.e. the Habitats and Birds Directive. Target 1 fully focusses on reaching a favourable conservation status of all habitats and species of European importance and adequate populations of naturally occurring wild bird species. This link to the Nature

Directives and the indicators used implies that our conclusions on potential clues for outcome-based specifications resulting from our review of these Directives in the previous chapter also apply here.

- The European Commission explains that target 2 of the EU Biodiversity Strategy addresses the threats to European ecosystems and their services as a result of land fragmentation, i.e. the disconnection from one another of natural areas, “hindering the movement of animal and plant species across their natural habitat” (EC, 2016a). The impact assessment that accompanied the Strategy states that “the EU is one of the most fragmented regions in the world, with fragmentation of 30% of EU-27 land moderately high to very high due to urban sprawl and infrastructure development related to transport and energy” (EC, 2011b). Hence, the development and use of transport infrastructure, such as railways and roads, are considered one of the main causes of land fragmentation. The development of green infrastructure is seen as the main driver to reconnect the landscape so that biodiversity can be preserved and ecosystems can keep providing their invaluable services. Consequently, the actual distribution and movement of animal (and plant) species may be strong indicators for evaluating road mitigation initiatives and hence may serve as a cornerstone in defining outcome-based specifications for road mitigation projects.
- Besides the development of green infrastructure the EU Biodiversity Strategy emphasizes the need for a no-net-loss approach to ensure no further loss or degradation of ecosystems and their services overall. The Strategy takes this a step further than the Habitats Directive and Environment Liability Directive by pointing out the need for systematic compensation for displaced habitats both within and outside Natura 2000. The European Commission states clearly that “there is a need for, on the one hand, a clear hierarchical framework whereby degradation is avoided as far as possible, and on the other hand, where degradation cannot be avoided, a requirement for compensation” (EC, 2011b). This no-net-loss approach is strongly linked to the indicators *habitat availability* and *habitat quality*. Using these indicators in defining outcome-based specifications will therefore ensure that road mitigation measures relate to the ambition of no-net-loss.
- In line with the Lisbon Treaty (EU, 2007), the EU Biodiversity Strategy aims at better integrating biodiversity concerns into other policy areas, including transport. This means that biodiversity protection requirements should be embedded and fully taken into consideration in all other sectoral policies (EC, 2011b). This includes reaching favourable conservation status for habitats and species as well as developing green infrastructure and a no-net-loss approach. This objective can be seen as strong support for referring to indicators used in the Strategy and the legal regulations it is based on in planning and designing road mitigation measures.
- The impact assessment that accompanied the Strategy explicitly states that green infrastructure would reduce fragmentation and the social and economic costs of traffic accidents caused by wildlife, including material damage, human injuries and human fatalities (EC, 2011b). Hence, it presents indicators regarding road safety, i.e. the social and economic costs of wildlife-vehicle collisions. It is also interesting to note that the proposed actions in the Strategy may have an important innovation potential. In this respect, ‘ecoducts for wildlife crossings’ are explicitly mentioned (EC, 2011b).

3.1.2 EU Green Infrastructure Strategy

The EU Green Infrastructure Strategy, adopted in 2013, elaborates on the proposed action of the EU Biodiversity Strategy to restore and promote the use of Green Infrastructure (GI) (Target 2, Action 6). GI is defined as “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. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings" (EC, 2013a). The overall aims of the GI Strategy are to ensure that natural areas remain connected, to restore the health of ecosystems and allow species to thrive across their entire natural habitat. One of the motivations for developing the strategy was the recognition that, although the Natura 2000 network already encompasses a large number of protected areas, sufficient connectivity between these areas is often lacking. Hence, the GI Strategy plays an important role in connecting all these natural areas of Natura 2000 - referred to as 'the backbone of the EU's GI' - properly and safeguarding their ecosystems and services. Consequently, the GI Strategy also addresses the objectives of Article 10 of the Habitats Directive.

Implications for defining outcome-based specifications:

- The GI Strategy is primarily about restoring landscape connectivity, which "expresses how landscapes are configured, allowing species to move" (EC, 2013b). The technical report that accompanied the Strategy explains that connectivity consists of two components: structural and functional connectivity. Structural connectivity is equal to habitat continuity. Functional connectivity is the response of the organism to the landscape elements other than its habitats (EC, 2013b). The same report explicitly refers to green bridges as 'connecting elements in GI' and provides a variety of examples of GI projects, including four projects on mitigating grey infrastructure (EC, 2013b; see also Mazza et al., 2011). Hence, the GI Strategy is most strongly linked to the indicators *actual distribution*, *habitat availability* and *wildlife movements*. Using these indicators in defining outcome-based specifications will ensure that road mitigation measures relate to the ambition of restoring landscape connectivity.

3.2 Transport policies

3.2.1 EU Sustainable Development Strategy

The EU Sustainable Development Strategy, adopted in 2006 by heads of state and governments at the European Council, aims to "identify and develop actions to enable the EU to achieve continuous improvement of quality of life both for current and for future generations through the creation of sustainable communities able to manage and use resources efficiently and to tap the ecological and social innovation potential of the economy, ensuring prosperity, environmental protection and social cohesion" (EU Council, 2006). The Strategy includes issues that relate to transport and promotes specific objectives, targets and actions regarding sustainable transport. The provided overall objective of sustainable transport is "… to ensure that our transport systems meet society's economic, social and environmental needs whilst minimising their undesirable impacts on the economy, society and the environment". Motivation for including transport issues is the notion that 'the EU transport system is currently not sustainable and in many respects moving away from sustainability rather than towards it' (EC, 2016b).

Implications for defining outcome-based specifications:

- The EU Sustainable Development Strategy does not explicitly include references to impacts on biodiversity induced by transport infrastructure. One of the targets, however, is to increase road safety through halving road transport deaths by 2010 compared to 2000 as well as reducing the number of injured. This may relate to the prevention of wildlife-vehicle collisions, and consequently road safety can be seen as a clue for defining outcome-based specifications for road mitigation.

3.3 Implications for outcome-based specifications

In our review of EU environmental and transport policies we have identified seven 'indicators', which provide clues for defining outcome-based specifications in road mitigation projects (Table 3.1).

- Two strategic policies - BS and GI - refer to indicators related to species distribution, habitat and road barriers. In addition, BS refers to indicators related to populations and wildlife-vehicle collisions.
- SDS refers to only one indicator, road safety, related to wildlife-vehicle collisions.
- Altogether, all seven indicators have also been identified in the review of EU regulations (see 2.3). We therefore refer to that section of this report to view the potential implications of these indicators for defining outcome-based specifications.

Table 3.1. Indicators extracted from EU environmental and transport policy plans that provide clues for defining outcome-based specifications in road mitigation projects.

Legend: X = indicator is mentioned in the document; - = indicator is not mentioned in the document; BS = EU Biodiversity Strategy; GI = EU Green Infrastructure Strategy; SDS = EU Sustainable Development Strategy.

Indicator	EU Policies		
	BS	GI	SDS
Related to populations			
Population viability	X	-	-
Population size	-	-	-
Population density	-	-	-
Capacity for propagation	-	-	-
Related to species distribution			
Actual distribution	X	X	-
Historical distribution	-	-	-
Related to species abundance			
Actual abundance	-	-	-
Historical abundance	-	-	-
Related to habitat			
Habitat availability	X	X	-
Habitat quality	X	-	-
Related to road barriers			
Wildlife movements	X	X	-
Migration routes	-	-	-
Related to wildlife-vehicle collisions			
Wildlife mortality (roadkill)	X	-	-
Road safety	X	-	X

4 Use of functional specifications in procuring road mitigation measures in the Netherlands

4.1 Introduction

Over the last decades road mitigation projects in the Netherlands have seen a shift from traditional contracts to Design & Construct (D&C), Design, Build, Maintain (DBM) and Design, Build, Finance, Maintain (DBFM) contracts, particularly in projects from national and provincial road agencies. In the traditional contracts the design of the road mitigation was prepared by the road agency, after which contractors were invited to submit a bid and the project was generally granted to the party with the lowest bid. In the D&C contracts the contractor is responsible not only for the construction of the mitigation works but also for preparing the design. DBM and DBFM contracts go even a step further; in these contracts the contractor is responsible for the design, construction and maintenance of the mitigation works, and, in the case of DBFM, also for the financing. The main motivations for this shift towards D&C, DBM and DBFM contracts are to realize more value for the same investment, to better use the capacities and expertise of market parties, to shift responsibilities and risks to the party that can best control them, to better incorporate maintenance issues into the design phase, which will improve overall efficiency, and to achieve the current political objective to downsize governmental agencies.

This shift to new types of contracts demands new procurement procedures in which functional specifications increasingly replace design specifications. While the traditional contracts were based on a detailed design of the mitigation works, new types of contracts are based on a set of specifications that describe the functional requirements that should be met during the construction and maintenance phase of a road mitigation project. In this chapter we describe the Dutch approach and use of functional specifications in procuring road mitigation projects. Furthermore, we evaluate the extent to which these specifications reflect the requirements of the EU legal and policy frameworks – as described in the previous chapters – and their potential to link clear and measurable performance indicators to the required outcomes.

4.2 Functional specifications for road mitigation in the Netherlands

D&C, DBM and DBFM contracts are based on specifications that describe the functional requirements that should be met in the construction and maintenance phases. For this purpose the Dutch national road agency developed several functional specifications, each with a generic set of functional requirements, for road mitigation works that can be used as starting points for the procurement documents of individual projects (Rijkswaterstaat, 2016). Hence, these generic sets of functional requirements can be best seen as a gross list from which particular requirements can be selected that apply to the project at hand. The requirements in the gross list are related to the main functions of the work and, consequently, to the key quality requirements. Because the preparation of the gross list was risk-based, it contains several more detailed requirements to control specific risks. However, additional requirements may be needed, such as those based on the local situation or demanded by local stakeholders. Such requirements cannot be found in the generic set of specifications but need to be developed within the project itself.

The use of these functional requirements for mitigation works started roughly in 2005. In 2010, best practises were condensed into a first version of the gross list. Hence, there is still limited experience with this new form of procurement. Currently, the procurement process in

which functional specifications are used can best be described as 'learning-by-doing'; projects and procurement procedures are continuously evaluated to assess whether the functional requirements were clear, complete and in line with the overall goal of the road mitigation. This implies that the generic set of functional requirements is permanently under development: as experiences and insights into what does and does not work increase, specifications are modified, added or deleted. In this respect it is interesting to see that the current version of the gross list is less extensive than the previous one since practice has shown that contractors could deliver the required work easily with a shorter list of specifications (V. Loehr, Dutch Road Administration, pers. Communication). This conforms to the general aim of keeping the gross list as compact as possible and including only the key factors and risk-based details needed to achieve the desired outcome. The philosophy behind this approach is that one should be able to formulate the functional requirements for road mitigation measures in a few clearly written specifications and that fewer specifications lead to contractors feeling more responsible for the design that contains a great deal of their own creativity and to their having the ability to match mitigation measures with the overall design and to initiate innovations.

4.2.1 Functions for wildlife crossing structures

Roads inhibit wildlife movements and may cause wildlife road mortality due to collisions. One solution may be the construction of eco-passages that offer animals the chance to cross the road safely. The functional specifications for such eco-passages are described in the 'General Specifications Eco-passage' (Rijkswaterstaat, 2016). These eco-passages, hereafter referred to as wildlife linkages, relate to wildlife overpasses, wildlife tunnels, wildlife crosswalks, bat hop-overs, etc., but also to wildlife fences, habitat restoration and other landscaping measures that accompany the crossing structures[3]. The specifications focus on the ecological part of the design and not, for example, on the technical construction that supports the wildlife linkage, which is described in different specifications. Hence, the functional specifications for wildlife linkages can be applied to a variety of structures, both existing and future ones, such as viaducts, bridges, tunnels and culverts.

The functional specifications for wildlife linkages address the full length of the ecological corridor, i.e. from where the outer border of the road verge reaches habitat patch A at one side of the road to where the outer border of the road verge reaches habitat patch B at the other side. Consequently, there are four main functions that relate to all aspects of the linkage (Table 4.1). The last three can be seen as sub-functions of the first function.

In the procurement documents, the road agency identifies all functions that are relevant to the project. Not all functions apply to each project. The selection of a function is dependent on such factors as the size of the road corridor and the selected target species for the road mitigation. For example, species with small home ranges and dispersal capacity, such as small mammals, reptiles, amphibians and invertebrates, may not be able to cross a wide road corridor at once. They may need several days, weeks or even several generations to make it across the road. Hence, for these species the function *Offering habitat* is highly important, as these animals will have to colonize the crossing structure and its direct surroundings in order to get across the road barrier. The function *Protecting from disturbances* applies to species that have been shown to be affected by anthropogenic disturbances, such as bats or large mammals. For species that have shown little or no response to disturbances, e.g. most invertebrates, this function may not be selected for inclusion in the procurement document.

[3] Animal Detection Systems (ADS) are not included; a generic set of functional requirements for ADS may be developed in the near future.

Table 4.1. Main functions that relate to wildlife linkages and their direct surroundings, distinguished in the Dutch general specifications for "eco-passages" (Rijkswaterstaat, 2016).

Function	Description
Connecting ranges	To maintain or restore wildlife linkages between ranges at both sides of the road.
Offering habitat	To offer habitat in which sufficient food, cover and breeding areas occur that enable the target species to use the wildlife linkage.
Offering guiding structures	To help the target species find and use the wildlife linkage.
Protecting from disturbances	To limit anthropogenic disturbances that may prevent the use of the wildlife linkage by the target species.

Note that the point of departure for the functional specifications is that the general location and number of crossing structures as well as the target species for the road mitigation works are known. These decisions, made by the road agency in advance or by the contractor as part of the contract, determine both what generic specifications apply and what additional detailed specifications should be elaborated. For example, some generic specifications apply to only a few wildlife species (see also 4.2.3). Hence, these specifications only need to be included if these species are selected as target species. The local situation - and local stakeholders - may demand additional measures in order to deal with specific wishes or address local issues that relate to such matters as topography or current land uses. The contractor has to base the design of the crossing structures and their surroundings on all these species- and location-specific requirements.

4.2.2 Functional specifications

A functional specification has been developed for each function and each with a set of functional requirements (Table 4.2). These requirements are hierarchically ordered over three levels. Most of these requirements apply as soon as the function they belong to is selected for a road mitigation project. Some requirements, however, apply only if one or more conditions are being met. For example, the requirement that a crossing structure shall provide a visual range across the structure of at least 30 m (specification 1.1.2 in Table 4.2) only applies when ungulates are the target species. The specifications provide either universal requirements or allow for incorporating specific requirements that relate to the habitat that needs to be linked or target species that need to be addressed.

Table 4.2. Functional requirements for each function of wildlife linkages. Between [..] elements that need to be filled out in the context of the project at hand.

Function 1: Connecting ranges
1. The wildlife linkage shall connect the ranges of [target species] at both sides of the road.
1.1. The wildlife linkage shall provide a continuous link in which the abiotic and biotic conditions match the needs of [target species].
1.1.1. The upper [x] m of the soil at the wildlife linkage shall be comparable in composition and quality to the soil in the adjacent ranges. Note: [x] depends on the habitat, e.g. 1 m for forest and 0.6 m for heathland habitat.
1.1.2. The wildlife linkage shall provide [target species] a visual range across the linkage of at least 30 m. Note: Applies only to red deer, fallow deer and roe deer.
1.2. The wildlife linkage shall be composed of a set of habitats, guiding structures and screening measures suitable for frequent use by [target species].
1.2.1. Walls of tree stumps at the wildlife linkage - guiding animals and providing habitat - shall be at least 2 m wide and 2 m high.
1.2.2. The non-permeable layer in ponds - within habitats and guiding structures - shall be free of synthetic materials.
1.2.3. The dimensions of [habitats] [guiding structures] [screening measures] at the wildlife linkage shall be at least [x] by [x] by [x] m. Note: Additional requirements for the dimensions of specific features, if relevant.

Function 2: Offering habitat
2. The wildlife linkage shall provide suitable habitat for [target species].
2.1. The wildlife linkage shall provide food in such quality and quantity that it enables [target species] to pass.
2.2. The wildlife linkage shall provide suitable breeding habitat for [target species].
2.3. The wildlife linkage shall provide sufficient cover for [target species].

Function 3: Offering guiding structures

3. The wildlife linkage shall provide guiding structures that connect well with existing landscape elements and guide [target species] safely from and to their habitats on both sides of the road.
   Note: Guiding structures can be a variety of measures, such as fences, screens, hedgerows, walls of tree stumps, boulders, etc.).

3.1. Gaps in guiding structures shall be of such length that [target species] can bridge them.

3.2. The wildlife linkage shall provide guiding structures that match with the way [target species] orientate and move through the landscape.

3.2.1. Guiding structures for bats shall be at least 5 m above ground level.

3.2.2. If bats are supposed to hop over the road, guiding structures shall force them to pass at a height of at least 4 m above ground level.

3.3. The wildlife linkage shall be accompanied by fences and/or screens, tailored to be a barrier for [target species] and including one-way gates to exit the road corridor if an animal ends up on the wrong side of the fence.
Note: If the road verge is important habitat for the target species (e.g. reptiles), the desirability of a fence/screen should be considered in view of the intended exchange of individuals between verge and crossing structure.

3.3.1. Fences and/or screens shall have a minimum height of:

Target species	Structure	Minimum height	Extra features
Red deer	fence	2.2 m*	-
Roe deer	fence	1.8 m*	-
Wild boar	fence	1.0 m	0.2 m buried fence
Pine marten	fence/screen	1.8 m*	0.7 m screen upwards from 1.0 m heigth
Badger, Otter, Beaver, small mustelids	fence	1.0 m*	0.2 m buried fence; 0.3 m outriggers facing away from the road
Small mammals	screen	0.4 m	0.1 m buried fence
Amphibians and reptiles	screen	0.4 m	0.1 m buried fence

* If the fence is positioned on a slope, fence height shall be increased by the tangent line of the slope angle.

3.3.2. Fences and/or screens shall have at each side of the crossing structure a minimum length of:

Target species	Minimum length
Red deer	500 m
Roe deer	500 m
Wild boar	500 m
Pine marten	50 m
Badger, Otter, Beaver, small mustelids	50 m
Small mammals	50 m
Amphibians and reptiles	15 m

Function 4: Protection from disturbances

4. The wildlife linkage shall reduce disturbances from anthropogenic sources (e.g. movement, light, noise) to such an extent that [target species] are enabled to pass.

4.1. At the edges of green bridges lightproof screens shall be present that are at least 2 m above ground level.

Note that the current set of specifications consists of functional requirements supplemented by several design specifications (see for example specification 1.1.1, 1.2.1, 1.2.3, 3.3.1, 3.3.2 and 4.1). These design specifications were added to control risks encountered in actual projects. For example, contractors may have strong incentives for reducing the use of high quality soil (1.1.1), and fences that are too low may cause serious road accidents (3.3.1). In contracts without a maintenance phase (e.g., D&C), the road agency may add a year of completion, which offers the contractor better chances to verify that the intended functions have been achieved. However, it usually takes several years for many wildlife linkages to be colonized by the target species. The road agency may also add requirements that relate to

the availability of the wildlife linkage. For example, a requirement can be included that demands that the crossing structure is available for use by the target species during all periods that the species is active, including times of extreme rainfall, wind or drought. Known pitfalls in the design of wildlife linkages may result in additional requirements, such as that small wildlife tunnels shall never be flooded. Other examples of additional requirements that can be added are related to traffic safety.

4.2.3 Quality management

The use of functional specifications and new contract forms calls for a different approach from the parties concerned. Contractors have different tasks and responsibilities and have to adapt. The same applies to the road agencies using such specifications, where a shift takes place from executing to directing projects. In this respect the national road agency has implemented a new system for contract management, which is primarily based on the principle that contractors have to work in accordance with a certified quality management system, such as ISO 9001. In each phase of a project the contractor has to be able to prove that the work meets all of the quality standards. The road agency frequently audits the contractor to verify whether this is the case and will redirect the contractor if necessary.

Note that in both the procurement and contract phases of a road mitigation project, the road agency does not merely provide the functional specifications. During the different stages of procurement and project execution, a variety of activities and services provide contractors with a clear view of what is expected, such as (1) results of surveys of flora and fauna in the project area, (2) a presentation on ecology at formal information meetings during the tendering process, (3) informal meetings between ecologists of both the road agency and contractors and (4) the provision of a comprehensive handbook on road mitigation measures, including many examples of wildlife crossing structures (Wansink et al., 2013).

4.2.4 Method of verification

In addition to audits and checks in quality management-based contract enforcement, some projects use qualitative assessments to verify whether specifications are being met. In these assessments the proposed design is evaluated by experts to determine whether or not ecological functionality can be expected. For example, known habitat requirements of wildlife species are used to assess whether the proposed design is expected to sufficiently facilitate target species that are supposed to colonize the wildlife linkage. Similarly, known responses of wildlife species to linkages are used to assess whether the proposed design includes structure dimensions that will fit the target species. If specifications with lower design limits apply, quantitative assessments are used to determine whether the prescribed limits are being met. In some cases specific verification methods are provided in the contract that, for example, force contractors to conduct analyses that prove that their solution works.

4.3 The Dutch approach and EU legal and policy frameworks

Here we evaluate the extent to which the Dutch approach, and more explicitly the generic set of functional specifications, corresponds with the requirements or ambitions of the EU legal and policy frameworks described in the previous chapters. The central question is: What indicators, identified in the review of regulations and policies, are reflected in the current set of functional specifications?

- The Dutch specifications strongly relate to restoring landscape connectivity, and thus clearly reflect the indicators *habitat availability* (see e.g. specification 1, 1.1), *habitat quality* (see e.g. specification 2, 2.1, 2.2, 2.3, 4) and *wildlife movements* (see e.g. specification 1.2, 3, 3.2). The emphasis is on restoring range and habitat connections

that allow species to move through the landscape in their natural way. The indicators *species distribution* and *migration routes* are thus also implicitly addressed.

- Noteworthy is that the Dutch specifications show no reference to any of the indicators that relate to populations. Restoring or maintaining population viability can be seen as one of the end targets of road mitigation, so linking functional specifications to this indicator will more likely ensure that populations can be preserved. A possible explanation for this lack of references to populations - e.g. their viability, size, density, etc. - may be that the use of population-related requirements may seem difficult in practice. It may also be the result of the fact that the Dutch specifications are designed to address a single mitigation structure - the number of structures and where to situate them are usually already known - while population-related requirements usually exceed the level of one crossing structure and correspond to the full set of mitigation works aimed for in a road project. A complicating factor here may be that the responsibility for nature conservation, including the protection of populations and the preservation of biodiversity, lies with a ministry other than the ministry responsible for mitigating road impacts for wildlife.
- Although there are clear requirements for fences and screens, no explicit reference is made to any of the indicators associated with wildlife-vehicle collisions. This clearly illustrates that the Dutch specifications are mostly so formulated that the emphasis is on the solutions ('what measure needs to be taken') and not on the impacts ('what impact needs to be mitigated and to what extent'). This approach may seem to allow the road agency to better direct potential contractors during procurement, but it does not necessarily ensure that the road impacts the mitigation works should address will be fully mitigated.
- Most of the functional requirements - not referring to the requirements that can be categorized as design specifications (see 4.2.2) - are qualitative descriptions. An exception is requirement 1.2, which states that 'the crossing structure shall be ….. suitable for *frequent* use by [target species]'. However, there is no definition of what is meant by 'frequent'. In addition, the specifications provide no references to baseline conditions or reference standards. The lack of both quantitative requirements and clear reference standards may inhibit the ability to judge whether or not the aimed for functions are being sufficiently met.

4.4 The Dutch approach and measurable performance indicators

As described above, the use of functional specifications in road mitigation projects demands more attention to clear and measurable performance indicators. After all, the specifications no longer prescribe a specific structure or dimension, but rather a general outcome that should be achieved. Here we briefly evaluate the potential to link the Dutch set of functional specifications to such performance indicators.

- The current Dutch set of functional specifications put little emphasis on quantification and measurability other than the requirements in which clear references are made to design features and dimensions (see e.g. 1.2.1, 3.1.1). This is reflected in the qualitative assessments currently used to verify if specifications are being met. Consequently, the potential to link the specifications to performance indicators is often but not always limited. For example, several specifications provide specific requirements for habitat development or guiding structures and include the phrase 'that it enables [target species] to pass'. In this respect a variety of performance indicators can be used, i.e. crossing rate, successful-unsuccessful crossings ratio or abundance if the wildlife linkage is supposed to be permanently inhabited by the species.

- It should be noted, however, that the proper use of such performance indicators requires a baseline condition ('how many animals were passing when the road was not there yet') or reference standard ('what is the quantified aim in terms of structure use') that should be met. After all, although one passing animal of the target species theoretically meets the functional requirement to enable a species to pass, this does not adequately achieve the ambitions to allow the target species to 'move through the landscape' and restore habitat connectivity. The requirement 'suitable for frequent use by [target species]' (specification 1.2) takes a first step towards the use of reference standards, although in practice it may be of limited value as 'frequent' is not defined. The same applies to, for example, a phrase like 'sufficient cover'. The lack of references to baseline conditions is likely a consequence of the focus on solutions rather than impacts (see also 4.3). Performance indicators for mitigation works, however, essentially focus on the extent to which the measured or expected impacts are mitigated. Hence, a shift to functional specifications in which impacts are addressed may increase the feasibility of linking the specifications to clear and concrete performance indicators.

5 Guidelines for defining outcome-based specifications

5.1 Introduction

It is clearly impractical to develop a static set of technical rules for road mitigation works that must always be applied regardless of the actual conditions. Local and regional deviations from the rules may be necessary and render such a static system of design specifications ineffective. Instead, it may be more efficient to define general properties or qualities that should be created to produce an outcome that meets with the overall goals for mitigation as well as the requirements from environmental legislation and policies. However, what should such outcome-based specifications look like? How can such specifications ensure that the end goals are being met? And can we avoid the set of specifications becoming too extensive, which may reduce its practical application? In this chapter we provide a small set of guidelines that aims to help define clear outcome-based specifications for road mitigation projects. These guidelines are based on the observations made in the reviews of regulations (chapter 2) and policies (chapter 3), the analyses of the current Dutch approach (chapter 4) and existing guidelines for the evaluation of road mitigation effectiveness (see Van der Grift et al., 2013).

5.2 Guidelines

We have identified a set of eight guidelines for defining outcome-based specifications:

1. Link the specifications directly to the goals for mitigation
No procurement of road mitigation works should be started until the goals for mitigation have been clearly described. This goes beyond the listing of target species as it should include a clear description of what road impacts need to be addressed and to what extent these impacts should be mitigated (Van der Grift et al., 2013). A direct link with such goals for mitigation, including clear aims as to what extent impacts should be mitigated (see also the next guideline), allows for a better understanding of what the mitigation measures are meant for and may consequently result in a higher probability of achieving the desired outcomes. It will also provide a more direct link to potential performance indicators, which are needed to verify whether all requirements are being met.

2. Specify whether or not no-net-loss is the aim
Goals for road mitigation have two potential targets (Van der Grift et al. 2013): (1) no-net-loss and (2) limited-net-loss. No-net-loss implies that road impacts will be entirely mitigated, i.e. the post-mitigation situation for the targeted species is identical to the pre-road construction situation. Limited-net-loss implies that a limited road impact will be accepted. If not already done during the assessment of mitigation goals, the target level should be specified in procurement. The decision of a target level will depend on the local situation, including the local conservation status of a species, but may also be suggested by legislation. For example, the Habitats Directive permits the incidental killing of wildlife in traffic as long as such incidental killing does not have a significant negative impact on the species concerned. Hence, this may support a target level of limited-net-loss for some species.

3. Use the SMART-approach to develop clear and objective specifications
In outcome-based contracts it is fundamental that the required ‘outcome’ can be measured. This implies that, for successful outcome-based procurement arrangements, performance indicators need to be set out at an early stage. To do so, the specifications are preferably SMART, i.e. Specific, Measurable, Achievable, Realistic and Time-framed. Road mitigation goals, and consequently the specifications for mitigation works, should ideally specify what

road impact(s) is/are addressed, quantify the targeted reduction in road impact(s), be agreed upon by all stakeholders, match available resources and specify the time span over which the reductions in road impact(s) have to be achieved (Van der Grift et al., 2013). Vague specifications or a lack of relevant performance indicators are often cited as one of the primary pitfalls of implementing a successful outcome-based contract (North, 2014).

4. Make use of baseline conditions or reference standards
Road mitigation measures can only be properly evaluated if there is a clear definition of success. Such a definition is already necessary in the design phase of the project. It will not be sufficient to only list the road impacts that should be reduced, but also to state how much this reduction should be. For this purpose the specifications should preferably make use of either baseline conditions or reference standards. Baseline conditions refer to the local conditions before mitigation. This may be the pre-road construction situation for mitigation of new roads or the post-road construction situation for mitigation of existing roads. Pre-road construction conditions may be a valuable baseline for wildlife movement, for example, or population indicators. Post-road construction conditions may be a valuable baseline for indicators such as those related to wildlife-vehicle conditions. Reference standards may refer, for example, to the conditions at reference sites, standards generated by model simulations or standards that have been derived from regulations or policies. Reference standards may replace baseline conditions if such conditions are lacking or if they can be a valuable addition to baseline conditions, for example, if they are based on model simulations of future population development.

5. Link the specifications directly to the indicators used in regulations and policies
Unlike the more conventional contract forms, outcome-based contracts articulate requirements in the form of end goals without specifying exactly how these are to be achieved. The overall end goal of road mitigation is in line with the end goals of EU regulations and policies i.e. preserving or restoring biodiversity, ecosystems and ecosystem services. In this respect it makes sense to link road mitigation specifications to the indicators derived from these regulations and policy plans. After all, this will ensure that road mitigation projects correspond with the overall environmental objectives and will allow for better evaluations of whether road mitigation enforces the implementation of such objectives. The same applies to national regulations and policies, although these are outside the scope of this study.

6. Link the specifications to multiple indicators whenever possible and relevant
Outcome-based specifications will gain in strength if multiple indicators are addressed. For example, if the road mitigation aims to reduce roadkill as well as increase the road permeability of a vulnerable wildlife population, the specifications should preferably include requirements that relate to wildlife-vehicle collisions, road barrier effect and population viability. If, in this case, the specifications focus only on roadkill and all requirements are met, population survival may however still be in jeopardy, for example, as a result of insufficient wildlife movements.

7. Link the specifications to the road section to be mitigated and not to a single structure
The number and placement of crossing structures are preferably not decided upon in advance but are part of the procurement arrangement. Both number and placement strongly affect the performance of mitigation works; if these structures are determined in advance, potential contractors will have less room for innovations and designs may be less differential. In fact, linking specifications to indicators that relate to populations or species distribution may become impossible as the number and spatial distribution of structures are key factors for achieving the pre-set goals for such indicators.

8. Keep the use of technical specifications to a minimum
Although technical - or design - specifications can be included, their use should be kept to a minimum as they do not stimulate innovations. Technical specifications may be used for structures or structural features that are considered 'non-negotiable'. For example, specific dimensions for a structure can be included if there is a comprehensive body of proof that a structure of such dimensions is functional. Hence, such prescriptive technical specifications should only be included if they are well supported by studies that have evaluated the effectiveness of structures or structural features. Nevertheless, a regular check is needed to determine if the technical specifications used are still state-of-the-art.

5.3 The guidelines applied: examples

We illustrate the use of these guidelines with two hypothetical examples of road mitigation projects. The examples refer to the mitigation of existing roads. For the mitigation of new roads, however, the same approach can be used. The first case addresses the mitigation of a road where large numbers of toads are killed during spring migrations, thus putting the survival of the local toad population at stake. The second case addresses the mitigation of a road on which moose are frequently killed, thus jeopardizing road safety.

5.3.1 Case 1: Toad on the road
A local road crosses toad habitat and separates their land habitat from their breeding ponds. Hence, the toads have to cross the road twice a year: during spring migration and when they return to their land habitat after breeding. Each year, especially in spring, many toads are killed on a 1-km road stretch due to traffic. The population is still considerable, but shows a negative trend. To prevent the death of toads on the road and a further decrease of population numbers, the road agency initiates a road mitigation project involving a number of crossing structures that will bring the toads safely across the road and keep the population healthy.

We propose that the following set of specifications should be met:
1. The mitigation measures will allow at least 90% of the migrating toads to get across safely.
2. The mitigation measures will ensure that no more than 5% of the migrating toads will be killed in traffic.
3. The mitigation measures will ensure that the survival probability of the toad population is >99%, calculated over a 100-year period.
4. The mitigation measures will be in effect in spring, summer and autumn.
5. The mitigation measures meet the requirements of specification 1 to 4 in the first year after installation.
6. The mitigation measures and population will be monitored for a period of 5 years to determine whether specifications 1 to 4 are being met.

The specifications link directly to the goals for mitigation (guideline 1), i.e. survival of the toad population. They also link directly to indicators used in regulations and policies (guideline 5 and 6), i.e. wildlife movement, roadkill and population viability. The specifications for movement and roadkill make clear that limited-net-loss is the target level for mitigation (guideline 2), while the specification on population survival stipulates that no-net-loss is the aim, i.e. >99% survival probability. The specifications comply with the SMART approach (guideline 3). They are specific in what road impacts need to be addressed and clearly set out what needs to be achieved. They are measurable as they include clear thresholds for each road impact that needs to be addressed. They are achievable and realistic since the aim is not to avoid all roadkill or get all migrating animals across as from experience we know that a success score of 100% is rare. Finally, a clear time frame is included for both the

availability of the mitigation works and the time period over which the performance should be assessed to decide whether the specifications are being met. One specification is included with a reference standard (>99% survival probability) (guideline 4). The specifications relate to the road barrier as a whole and decisions on the type, number and spacing of crossing structures or type and length of fences are part of the design phase (guideline 7). Furthermore, no technical specifications are included (guideline 8).

Note that the specifications are somewhat flexible due to the phrases 'at least' (specification 1) and 'no more than' (specification 2). This is necessary as the variables of these first two specifications - i.e. number of successful crossings and number of roadkill - will affect population survival probability, which is set out in specification 3. Depending on the size of the population, it may be necessary to reduce roadkill to a value below 5% in order to achieve >99% survival probability in case 90% of the migrating animals get safely across. On the other hand, it may be necessary to increase the percentage of successful crossings above 90% in order to achieve >99% survival probability in case of 5% roadkill. Hence, potential contractors have flexibility in whether they try to further optimize road permeability (e.g. more crossing structures) or reduce road mortality (e.g. longer or better fences). Precise target values in relation to the survival probability of the population can be calculated for the local situation with the help of population models or web tools such as the Road Mitigation Calculator (see www.roadmitigationcalculator.eu).

5.3.2 Case 2: Moose on the loose

A highway crosses moose habitat. Suitable feeding areas occur on both sides of the highway and hence moose cross the road frequently. Over the last five years an average of ten moose-vehicle collisions occurred annually at a 4-km stretch of the highway - hereafter referred to as a 'collision hotspot'. Most of these collisions resulted in the death of the animals involved and some caused human injuries. The populations on both sides of the road are sufficiently large and not affected by the number of traffic-related mortality. Moose movements across the highway also occur elsewhere, but they rarely result in accidents outside of the collision hotspot due to differences in road design and lower speed limits. To increase road safety, the road administration initiates a mitigation project. The ambition is to take measures that will keep the moose off the road and avoid human injury.

We propose that the following set of specifications should be met:

1. The mitigation measures will reduce the number of moose-vehicle collisions at the collision hotspot by at least 80% compared to the mean number of collisions at that spot over the past 5 years.
2. The mitigation measures at the hotspot will not cause an increase in the number of moose-vehicle collisions on adjacent highway stretches without mitigation compared to the mean number of collisions at these stretches over the past 5 years.
3. The mitigation measures will be in effect year-round.
4. The mitigation measures meet the requirements of specification 1 to 3 in the first year after installation.
5. The mitigation measures will be monitored for a period of 5 years to determine whether specifications 1 to 3 are being met.

The specifications link directly to the goals for mitigation (guideline 1), i.e. increasing road safety. They also link directly to indicators used in regulations and policies (guideline 5 and 6), i.e. roadkill and road safety, including wildlife-related human injuries. The first specification makes clear that limited-net-loss is the target level for mitigation (guideline 2) as the aim is not to prevent all moose-vehicle collisions. The specifications comply with the SMART approach (guideline 3). They specify what road impact - moose-vehicle collisions - needs to be addressed and clearly set out what needs to be achieved. They are measurable as they include a clear threshold for the road impact that needs to be addressed. They are

achievable and realistic since, for example, the aim is not to avoid all collisions as a 100% chance of preventing collisions is unlikely. Finally, a clear time frame is included for both the availability of the mitigation works and the time period over which the performance should be assessed to decide whether the specifications are being met. The first two specifications make use of a baseline condition: the mean number of collisions over the past five years (guideline 4). The specifications relate to the road barrier as a whole and decisions on the type of mitigation or road length over which measures should be taken are part of the design phase (guideline 7). Furthermore, no technical specifications are included (guideline 8).

Note that, in reality, additional specifications may be needed, such as specifications that address the local situation or national regulations. For example, in Sweden wildlife fences aiming to keep moose off the road should always be accompanied by a structure that allows the animals to cross the road safely if the fences are more than 6 km long. Hence, more generic specifications can be combined with tailor-made ones that address specific needs or requirements.

5.4 Potential benefits to stakeholders

Well-defined outcome-based specifications may have great value for policymakers, road agencies and other stakeholders involved, such as NGOs:

- Outcome-based specifications based on these guidelines may better ensure that the overall objective - either related to wildlife conservation or road safety - is being met. This concerns both the initiator of the mitigation project, usually the road agency, and the contractor. After all, technical specifications do not automatically ensure that, for example, populations are healthy or road safety is sufficiently increased. Hence, the use of outcome-based specifications may force a shift from resource-induced decisions on what can be installed towards end-goal-induced decisions on what should be installed.
- Outcome-based specifications based on these guidelines may significantly increase our knowledge base as such specifications will force all involved to gain more knowledge of what does and does not work. Currently, there are few or no incentives to evaluate the effectiveness of road mitigation measures. A project is considered to have been finished successfully if all proposed mitigation measures are in place and meet the technical requirements. Whether or not end goals are being met is usually not addressed; hence a ‘successful’ road mitigation project may still result in the extinction of a population or animal-vehicle collision numbers that turn out to be higher than average. If the guidelines presented here are used, knowledge is a key factor for success and acquiring new knowledge becomes an integrated part of road mitigation projects.
- Outcome-based specifications based on these guidelines may guarantee a strong link with national and international regulations and policies. They immediately clarify what regulations or policies are addressed and how the obligations and ambitions are being met. This may help to bring road mitigation efforts out of the realm of ‘costly and unnecessary projects’, a criticism frequently posed by opponents of road mitigation, and place them in a strong framework of legislation and agreed-upon policies. As use of the guidelines may also lead to a more fact-based approach (see previous bullet point), political and/or societal discussions on the need for and usefulness of road mitigation may also be better supported.
- An outcome-based approach provides room for adaptive management. If road mitigation works, designed and constructed on the basis of the best available knowledge, are not sufficient to reach the desired outcome, corrective measures can be taken. Such adaptive management may address a more fundamental concern of environmental agencies and conservation groups as recent case law points out that the best available

mitigation will suffice, irrespective of population effects (see Helldin et al., 2016). The use of outcome-based specifications may ensure that agreed-upon end goals will always be met, eventually with additional measures if the original mitigation plan appears to be insufficient.

5.5 Potential disadvantages and risks

The use of outcome-based specifications in procuring road mitigation may have certain disadvantages and risks if compared with the more traditional procurement approaches:

- Outcome-based specifications require better knowledge of mitigation measures and their effects than what we may have today. This implies that a trial and error phase is needed when shifting to an outcome-based approach in procurement during which it may not be possible to hold contractors fully responsible for a failure and/or the costs of mitigation works may increase as risks have to be covered.
- Costs may also increase due to the need for studies to assess baseline conditions or reference standards. An important notion in this respect is that such studies usually need to start (long) before the start of the mitigation project. This implies that a strategic vision is needed on how and where to study baseline conditions and reference standards, and this demands the pro-active programming and budgeting of monitoring and research efforts.
- Outcome-based specifications for road mitigation measures should be accompanied by a prescribed time span in which the outcomes should be evaluated. Lack of knowledge of appropriate time spans for such evaluation studies may result in either too long or too short monitoring periods. In the first case, financial resources may be wasted, and in the latter, road mitigation effects may not be well estimated and conclusions on whether the measures are successful or not may be wrong.
- If not well-regulated and safeguarded, knowledge of road mitigation effectiveness becomes an asset of private contractors rather than being freely available to all stakeholders. Hence, full access to data and research reports should be well arranged in the contracts for evaluation studies. If such arrangements are lacking, we run the risks of the wheel being invented over and over again, knowledge being scattered over numerous actors and improvements in road mitigation being impeded. Implementing control mechanisms that ensure that knowledge becomes public is indispensable to the success of an outcome-based approach in procurement. An important first step in this respect is selecting different contractors for the design/construction and evaluation of the mitigation works respectively.
- An outcome-based approach in road mitigation procurement requires a new judicial framework in which the responsibilities of both the road agency and contractors are clearly stipulated. Who is responsible for what? How will the success of the outcome be evaluated? What should be done if the desired outcome has not been reached within the prescribed time period? What should be done if the contractor that designed and built the mitigation works questions the findings of the evaluation executed by another contractor or the road agency? A strong judicial basis is indispensable to prevent financial and time-consuming disputes on who is responsible for what.
- The shift in mindset needed for an outcome-based approach to work may take considerable time. This may result in a phase in which a ‘mixed approach’ is used in which functional specifications are complemented by an abundance of design specifications. The risk of such a mixed approach is that innovations will be slowed down and the strength of control mechanisms will decrease. After all, if prescribed outcomes

are not reached it will be difficult to point out the specific cause for the failure in the design. Is it the result of applying the prescribed design specifications or the result of decisions on the design made by the contractor? For example, if outcome-based specifications address population-level end goals but the number of wildlife crossing structures and/or length of wildlife fences are prescribed by the road agency, the contractor may argue that goals were not met due to these prescriptions.

5.6 Recommendations for implementation

Obviously, using outcome-based specifications means that a considerable shift in mindset is needed for all involved in the procurement process. Instead of detailed technical and process specifications that are mostly prescriptive, a relatively small set of functional requirements should be presented that correspond to a strong set of performance indicators and a transparent method to judge whether the intended functions have been achieved. Here we provide a few recommendations for road administrations on how to implement the use of outcome-based specifications in the procurement process.

- Make sure that environmental authorities are closely involved in the procurement process in order to ensure that environmental objectives are adequately reflected in the contract. Make use of existing environmental expertise to write specifications that are as specific as possible and properly address the overall end goals.
- Develop a generic set of functional specifications, as illustrated by the Dutch approach, which can be easily adapted to the situation and ambitions of the project at hand. For each driver of road mitigation - e.g. wildlife conservation or road safety – it is likely that a limited set of potential specifications apply in which only limit values or time periods may differ between projects or target species. A well thought-out set of specifications will considerably facilitate their use in practice.
- Write outcome-based specifications in a language style similar to that of technical specifications. Make sure the wording of the specifications is specific and unambiguous. If quantitative requirements or thresholds are used in the specifications, make sure the metrics to be used are clear. If any terminology is included, it should be well explained.
- Develop a clear set of performance indicators that accompany the outcome-based specifications. Sound performance indicators are critical to ensuring a successful outcome-based procurement arrangement. If the required ‘outcome’ cannot be measured, performance cannot be managed nor can a project be properly evaluated on the basis of performance.
- Contract an independent contractor to evaluate the road mitigation works on the basis of the performance indicators provided. We do not recommend putting both the designing/constructing and evaluating of the mitigation measures in one contract. Besides possible conflicts of interests, this approach allows for selecting a contractor for the evaluations based solely on their ecological knowledge and experience. If designing/constructing and evaluating the mitigation works are put in one contract, ecological knowledge and experience may play a much smaller role in the contractor selection as the evaluation activities are usually only a small percentage of the total budget and hence relatively little weight is given to ecological expertise.
- Develop a strategy to systematically assess baseline conditions and reference standards. Baseline conditions should be known at the start of procurement, and this also applies to certain reference standards that the road agency may want to prescribe. This implies that a new way of working should be adopted as such systematic assessments are currently often lacking at the start of procurement.

- Develop an open access database on road mitigation evaluations so that future projects will be able to learn from previous ones. As the use of outcome-based specifications demands proper evaluations of the realization of end goals, new knowledge will be quickly acquired. Such knowledge should be made easily available to all stakeholders.
- Evaluate the use of outcome-based specifications in road mitigation procurement as compared to the use of design specifications and gather empirical evidence on the possible benefits and/or disadvantages of the approach.
- Test whether this relatively small set of guidelines for developing outcome-based specifications is practical and effective.

6 Conclusions

EU regulations and policies provide a variety of requirements and ambitions that are of concern for road projects and may help define sound road mitigation outcomes. We have identified fourteen indicators, all of which provide clues for defining outcome-based specifications to be used in road mitigation procurement. Besides identifying these indicators, our review pointed out the importance of the measurability of effects, both from activities that damage the environment and activities that aim to mitigate such damage, as the importance of using baseline conditions or reference standards that allow for quantitative evaluations. Using indicators that directly relate to regulations and policies, adopting a quantitative approach and incorporating clear baseline conditions or reference standards in defining outcome-based specifications will inevitably improve the ability to judge whether or not performance requirements are being met.

Although still in development, the outcome-based approach currently used in the Netherlands is an illustrative case that may help others to move from detailed technical prescriptions towards more generic descriptions of functions. The Dutch specifications clearly reflect some of the key requirements and ambitions of the EU legal and policy frameworks; however, there is room for improvements, such as including indicators that relate to populations. Other improvements may be to (i) emphasize the impacts that need to be mitigated, (ii) quantify requirements and (iii) use baseline conditions or reference standards. Such improvements will inevitably allow the specifications to link to clear performance indicators.

We have presented a relatively small set of guidelines to help define clear outcome-based specifications for road mitigation projects. We recommend carefully testing these guidelines in practice and creating a generic set of functional specifications that can be derived from them. If deemed appropriate after testing, the guidelines should be modified to optimize their application in road mitigation projects throughout the EU.

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