Deltares

How do infrastructural designs meet up to nature policy requirements?

A method to evaluate infrastructural (eco-engineering) designs in the light of nature policies

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Eco-engineering, quantification of nature, ecological value, Omgevingswijzer, nature policy

Summary
This report describes a new method which is created to evaluate a infrastructural design on how it meets up to nature policy requirements, and to compare alternative construction designs for infrastructural projects. The method does two things: it quantifies the term “nature” and it gives a value to this number, based on the evaluation for nature policy requirements. The method is developed for Rijkswaterstaat to give input to the Environmental Index Tool (in Dutch: Omgevingswijzer). The method is developed by using two case studies: the wave attenuating dike at Fort Steurgat, Werkendam and the creation of a robust road network in the Arnhem/Nijmegen area, ViA15.
The two main elements (or building blocks) of the method are the ecology that is expected in a planning area and the evaluation of this expected ecology in the light of nature policy requirements. The expected ecology is calculated based on the expected habitat in the planning area and the contribution of this habitat to surrounding areas (connectivity). Evaluation of expected ecology happens by translating nature policy requirements to criteria. The expected ecology is scored on how and if the criteria are met.
The report contains, apart from a description of the method, an evaluation of the method and suggestions for future use.

Key references

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	Oct. 2015	Sophie Vergouwen		Rick Wortelboer		Harm Aantjes	
		Sophie Moinier					
		Victor Beumer					

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Factsheet: How do infrastructural designs meet up to nature policy requirements?

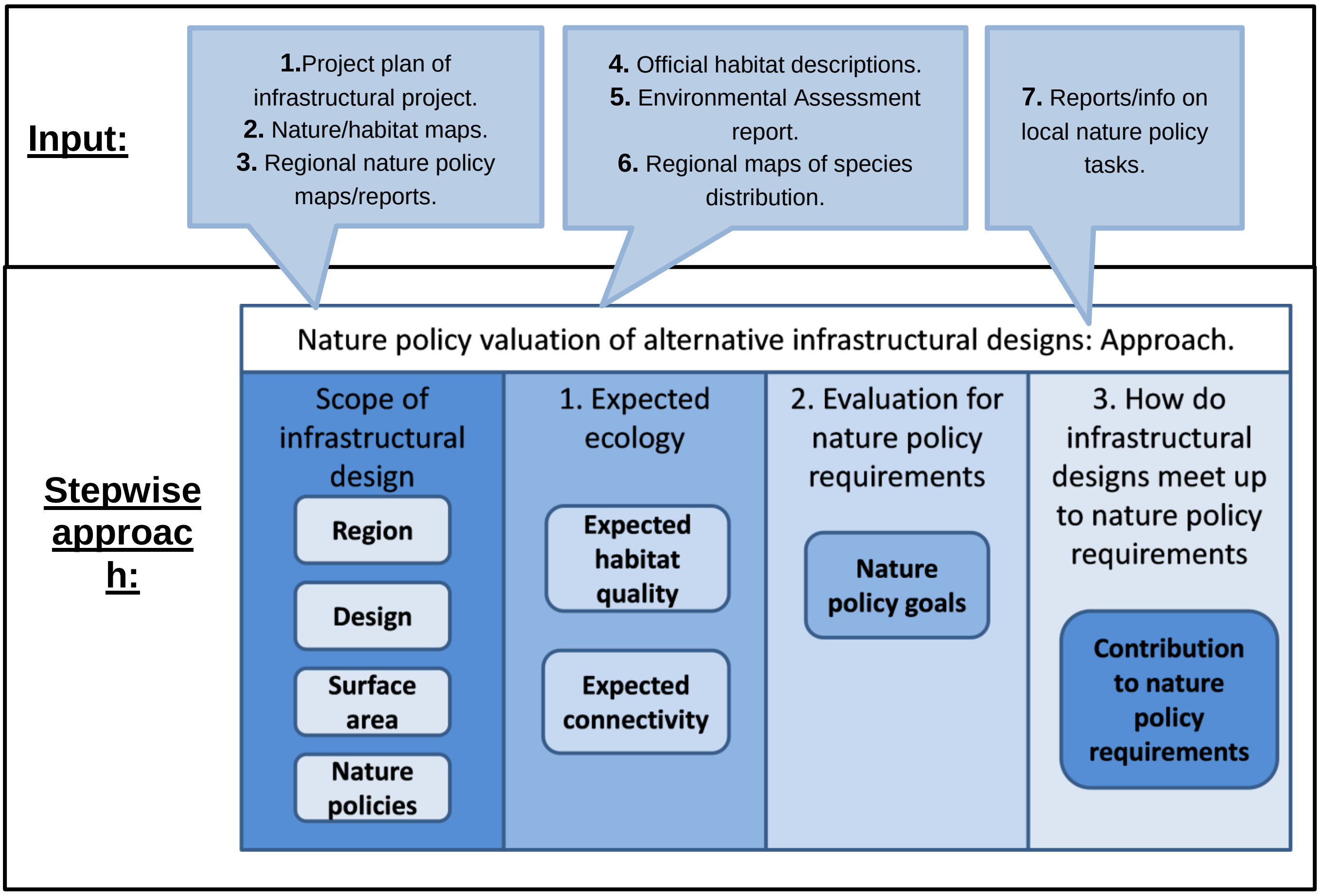
Why this tool?

1. To give input to the Environmental Index Tool (Dutch: Omgevingswijzer).
2. To compare between alternative designs of infrastructures.
3. To evaluate an infrastructural design for nature policy requirements.

Assembled from (parts of) other methods:

- Nature Management Types (Portaal Natuur and Landschap)
- Nature Points (Van Gaalen et al, 2014)
- Nature compensation method (Groenfonds, 2013)
- Handbook Robust Connections (Broekmeyer et al, 2001)

Based on the principle



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Nederlandse Samenvatting

In dit rapport wordt een nieuwe methodiek beschreven die is ontworpen voor het bepalen van de waarde van infrastructurele projecten voor natuurbeleid. De methodiek is bedoeld voor de plan-fase van een project, wanneer verschillende opties voor een infrastructureel ontwerp met elkaar worden vergeleken. De methodiek doet twee dingen: 1. Het kwantificeert het begrip “natuur”, en 2. Het geeft een waarde aan dit getal. Deze waarde wordt bepaald door de bijdrage die het project kan leveren aan het behalen van doelen die zijn vastgelegd in het natuurbeleid. De methodiek is in eerste instantie gemaakt voor Rijkswaterstaat en kan gebruikt worden in de volgende situaties: het kan opgenomen worden in de Omgevingswijzer, de MER en het kan ingezet worden bij natuurcompensatie. De methodiek bestaat uit afzonderlijke “blokken” die relatief gemakkelijk toegevoegd, verwijderd of veranderd kunnen worden. Dit biedt ruimte voor flexibel gebruik in de toekomst.

De in dit rapport beschreven methodiek is gebaseerd op een aantal andere, reeds bestaande, methodieken: Natuurbeheertypen zoals beschreven door Portaal Natuur en Landschap, de Natuurpunten methodiek (van Gaalen et al. 2014), de natuurcompensatie methodiek (Groenfonds, 2013) en het handboek robuuste verbindingen (Broekmeyer et al. 2001). Het grote verschil tussen de in dit rapport beschreven methodiek en de andere methodieken is dat de waardering van het begrip natuur gebaseerd is op de bijdrage aan natuurbeleid. Vanuit natuurbeleid is gekeken welke aspecten van “natuur” belangrijk zijn en deze zijn in de methodiek verwerkt.

De methodiek is uitgewerkt aan de hand van twee voorbeelden: Fort Steurgat – Golfremmende dijk bij de polder Noordwaard en ViA 15, het creëren van een robuuster wegennetwerk in de regio Arnhem-Nijmegen. De Fort-Steurgat-case is een relatief eenvoudige case en is gebruikt om voor het opstellen van de methodiek. De ViA 15 case is vervolgens gebruikt om de methodiek te testen.

De methodiek is (grofweg gezien) opgedeeld in 2 hoofdonderdelen: 1. De verwachte ecologie in het plangebied en 2. De evaluatie van deze verwachte ecologie in het licht van natuurbeleidsdoelen. De verwachte ecologie wordt berekend aan de hand van wat er qua habitat verwacht wordt in het plangebied en aan de hand van de verwachte bijdrage van dit habitat aan de omgeving (de connectiviteit). Voor de evaluatie van de verwachte ecologie in het plangebied worden de natuurbeleidsdoelen die gelden in het gebied vertaald naar criteria voor natuur. De verwachte ecologie wordt vervolgens gescoord op het (al dan niet) behalen van deze criteria.

In het rapport is, naast de beschrijving van de methodiek, een evaluatie opgenomen van de methodiek en er zijn opties voor (toekomstig) gebruik beschreven.

Contents

Appendices

1 Introduction

1.1 Purpose of the method

The Dutch Government plans new infrastructural projects to enhance safety, maintain waterworks and waterways and improve the usability and extend the functionality of present infrastructural projects. In the Netherlands, the Dutch Department of Waterways and Public Works of the Ministry of Infrastructure and the Environment (Rijkswaterstaat, from here on referred to with the abbreviation RWS), has the ambition to make more sustainable decisions in infrastructure solutions. In this study, a new method is proposed for the purpose of evaluating different design alternatives based on their contribution to nature policies, thus facilitating the inclusion of nature effects in the evaluation of the sustainability of infrastructural projects..

The method proposed in this study is suggested to be part of the planning phase of a project, where different options for an infrastructural design are compared and evaluated. An important tool that is used by RWS to evaluate and measure the sustainability of infrastructural projects, is the Environmental Index Tool (Omgevingswijzer in Dutch), and it is based on aspects such as Economy, Energy & Materials, Social Involvement and Ecology & Biodiversity. The method that is described in this report could also be part of this tool in the future. The purpose of the method is to quantify the extent to which alternative designs contribute to the fulfillment of nature policy requirements.

There are multiple causes for differences in contribution of infrastructural designs to the nature policy requirements:

- When natural areas are degraded due to the construction of new infrastructure, the assigned value for nature of the area and therefore the contribution to nature policy requirements is decreased;
- When the infrastructural design is an eco-engineering design (see below), this might actually benefit nature and thereby increase the contribution to nature policy requirements.

1.2 Eco-engineering in the Netherlands

In the Netherlands, eco-engineering is defined as the contribution of nature to flood protection by using ecosystem services, such as plants that dissipate wave energy and oysters that stabilize sediment. Nowadays, often a wider approach is adopted in which nature or natural processes are being applied to create cost-efficient, robust and sustainable infrastructure solutions to solve societal challenges, not being water safety purposes only. Examples of this can be found in the Building with Nature programme (Ecoshape; www.ecoshape.nl), Room for the River programme (RWS) and CIP-Eco-Engineering programme (RWS & Deltares; Reinders et al. 2013).

A second application of eco-engineering in infrastructural projects is the mitigation of negative effects of hard infrastructural constructions on the environment. Negative effects could be caused by the destruction of nature due to embedding of the infrastructural project in the surrounding area, by disturbance due to pollution and human activities and by building barriers within and between inhabited areas (van Bohemen, 2014). Examples of such mitigating eco-engineering solutions are the ecological management of highways strips, wildlife crossings and route diversions for small mammals and bats.

1.3 Structure of the report

This report will provide a detailed explanation of the method in Chapter 2. It describes the valuation of nature and explains the setup of the method in a stepwise approach. In Chapter 3 we discuss the method in detail and describe its shortcomings and strong points. Chapter 4 describes the potential of the method for future use.

Details and technical information is included in the Appendices. A-D. Appendix A gives a technical overview of the method used. Two cases have been elaborated on, a simple and a complex one. The simple case is the case of Fort Steurgat in which the management options are designed to provide additional nature value (Appendix B). The complex case deals with mitigation of negative effects on nature in the project ViA15. Management options are divided into 7 different subcases. For the purpose of testing our method we have regarded the complex case as a whole and as 7 subcases (Appendix C. and D. subsequently).

2 Description of the method

2.1 Valuation of nature

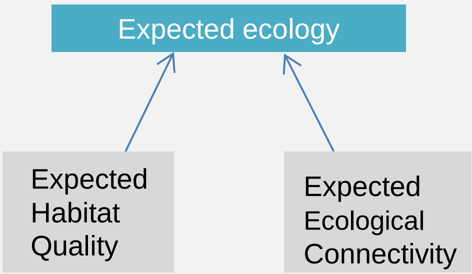
The word "value" refers to whether something is valuable or important. Nature has a certain value when it is considered to be important. Not all of nature is considered equally important and different ways exist to express this value. An important way of expressing the value of nature is through nature policies. Examples of nature policies are the European Natura 2000 (N2000) directives and the Dutch National Ecological Network (*Ecologische Hoofdstructuur* or EHS). Another way of expressing the value of nature is by looking at its intrinsic value. Intrinsic value means that something has value because it exists: for intrinsic value, there is no "higher" or "lower", or "good" or "bad". It is just "there"; everything that exists has an intrinsic value. For other ways of valuation, this is different. Such valuation systems are always subject to change. For example, economic crises may change the importance the public gives to local food production as an ecosystem service. Changes in perceptions and policies may result in changes of targets for nature, whether positive or negative.

Motives for setting nature policy goals are often a decline in the population of a certain species or a decline in the quality of certain natural areas or types of nature, which could result in the need for management of biodiversity and ecological coherence (Ministry of Economic Affairs; Natuurmonumenten, 2010). In the Natura 2000 directives, for example, nature protection areas have been identified based on a decline in quality of certain European types of nature (also called habitats). Habitats that declined in quality or decreased in surface area are valued higher than habitats that have a good quality and/or are more common. In this respect, "quality" differs from "value" in the sense that quality refers to the standard (i.e. the current) situation of an area of nature as measured against a highly desired situation (in this case: pristine state). So, in order to determine if nature policy goals are achieved in an area, the quality, connectivity and potential effects on specified goals for nature in that particular area or from that particular type needs to be analysed. One way of doing this is by using monitoring data on the biodiversity in the area.

For future situations, however, there is no monitoring data available. As a consequence, we need to estimate effects on nature in advance in order to be able to evaluate projects on their future impacts. It is possible to predict the quality that is *expected* in the area of the infrastructural project based on the construction designs and their effect on the environment, relative to the reference situation. When the expected ecological quality and connectivity (from here onwards referred to as *expected ecology)* are used to determine to what extend nature policy goals are achieved, the output of this evaluation is considered to be a relative value of the contribution to nature policy requirements.

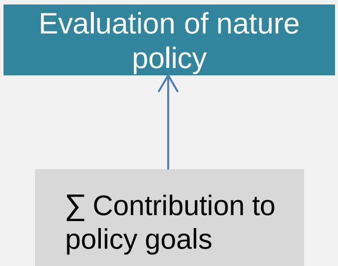
Box 1: Definition of Expected Ecology and Evaluation for nature policy

Expected Ecology
The Expected Ecology is a combination of the expected quality of habitats in the area and the expected ecological connectivity of the landscape, relative to a reference situation without a construction design. It is a value that is calculated for the construction design by comparing differences between the starting situation (with a set of abiotic conditions, management and barriers or corridors for connectivity) and the expected situation after implementation of the design. Since implementation of the design can either be positive, neutral or negative compared to the current situation, the Expected Ecology can have a positive, neutral or negative value.



The calculation of the Expected Habitat Quality and the Expected Ecological Connectivity is explained in paragraph 2.3.

Evaluation for nature policy
The evaluation for nature policy is an comparison of the expected effects of a construction design on the value of nature in an area (specifically analyzed as habitat quality and connectivity) and the requirements for an area for nature policy. Again, this value is obtained relative to the current situation without any interventions. When a construction design is expected to hinder obtaining nature policy goals compared to a situation without interventions, the evaluation can be negative. Alternatively, a positive expected effect on obtaining nature policy goals, for example by improving habitat quality or increasing connectivity, could yield a positive evaluation for nature policy. Naturally, there can be a neutral effect, in which case a neutral (0) value is obtained. The more goals there are in an area, the larger the impact can be on contributing to nature policy requirements.



The calculation of this value will be further addressed in paragraph 2.4.

2.2 Elements of the method

In the previous section, the two most important elements of the method have been briefly introduced: *expected ecology* and *evaluation for nature policy*. How they are embedded in the method is visualized in Figure 2.1:

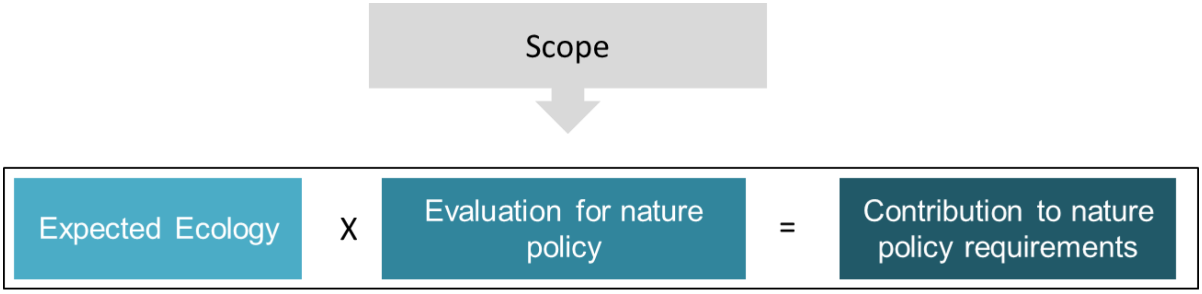


Figure 2.1: Simplified basis of the method

There are several other components that are important in this method and they set the input for the two elements (*expected ecology* and *evaluation for nature policy requirements*). First of all, the *scope* sets physical boundaries to the study by specifying the area that will be studied. Second, the *expected ecology* is determined by evaluating the *expected quality of habitats* in the area, and by evaluating to what extend these habitats could add to the *expected connectivity* in the surrounding areas. Third, the *evaluation for nature policy* is determined based on the expected contribution of a design to nature policy goals. Together, these elements make up the framework for determining the *contribution to nature policy requirements*.

The outcome of the calculation is a relative value p. This value is the outcome of a comparison between the situation without any interventions and the evaluated construction design and describes the relative contribution to nature policy requirements. The elements of the method are described below in more detail. Chapter 3 provides an example of how to calculate this number, including a step-by-step description of the method.

2.2.1 *Scope*

In the first element of the method (the *scope*) determines the boundaries of the area for which the analysis is made.

These boundaries include the spatial context of the study area (the so-called region), the study area of the analyses, a description of compared alternative designs, an overview of the (surface area of) different habitats within alternative designs and a description of relevant nature policy goals in the study area.

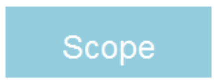
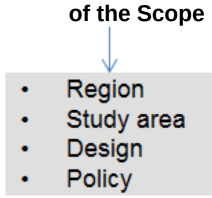


Figure 2.2: Overview of the Scope



2.2.1.1 *Region*

The region of the study area is described to provide background information about the area where alternative construction designs are planned. The extent of the region is based on the maximum value of realistic spatial dispersal scales of flora species, which is roughly 20 km (Cain et al, 2000). Since aquatic dispersal distances have been found to generally exceed terrestrial flora dispersal distances with 1 or 2 orders of magnitude (Kinlan & Gaines, 2003), the region of aquatic construction designs is set at a radius of 40 km. Dispersal distances for animals differ to a great extend per species (Reinders et al. 2013b). Furthermore, the presence of plants is considered to be very important for the quality of habitat. In order to provide a set of general rules for the extent of the region, only the dispersal distances of plants are taken into account. The region is described based on the following set of elements:

- Location of the alternative construction design;
- Important habitats;
- Characteristic species;
- Large waters;
- Important nature areas;
- An overview image of the location of the alternative construction design.

2.2.1.2 Study area

The study area sets the physical boundaries for the analysis. In order to make a comparison between alternative construction designs, a study area of equal size needs to be selected. The selection is based on the overlay of the surface areas of the different construction designs, combined with the extent of the effect of the construction designs on the surrounding area (see fig. 2.3a).
The extent to which the effect carries, depends on the nature of the effect itself. For instance the disturbance caused by noise of a road on surrounding breeding birds could for instance reach as far as at least 500 meters. Therefore, when a road is concerned, it is wise to add an extra 500 meters to the study area to include the effects on the surrounded area. Only within this study area alternative construction designs can be compared.

In some cases, fragmentation of the study area into sub-cases (or sub-areas in case of a spatial unit) could result in better understanding of separate effects of different parts of the construction designs on the *contribution to nature policy requirements.* This is usually the case when the study area gets too large and certain habitats or factors that affect those habitats occur in different parts of the total study area. For example, a habitat occurring in the east side of a total study area could be affected by other aspects of the total construction design (such as a road or a bridge) than the same habitat occurring in the west side of the total study area. Fragmentation of an area into sub-areas possibly leads to a different outcome. When the contribution to nature policy requirements is calculated for the total study area, for the calculation, all parts of the construction design have effect on all habitats present within the study area. When the study area is split up, only those habitats and aspects of the construction design that are located within a sub-area are used for the calculation of the contribution of a sub-area to nature policy requirements. When the separate calculations are added up to get a total number for the total study area, the outcome could be different since some habitats (and/or aspects of the construction design) do not occur in all sub-areas. An example of how to divide a study area into sub-areas is shown in Figure 2.3. An example of a case study which has been divided into sub-cases is shown in Appendix d.

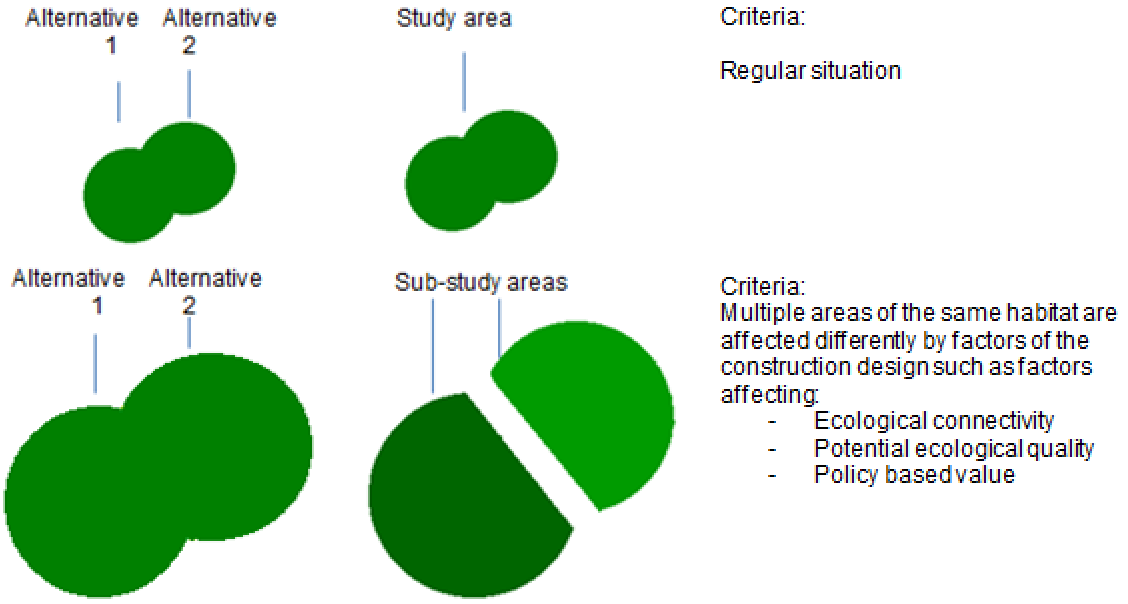


Figure 2.3 Setting boundaries to the study area in a normal situation (above) and when there are factors that affect sub-areas of the study area differently (below).

2.2.1.3 *Design*

There are two types of situations that ought to be described:

- The *reference situation* which is defined as the area without any new interventions added.
- The alternative construction designs for the area.

An important part of the design description is the inventory of all the habitats that are present in either the reference situation or after the alternative construction designs have been built. In general, habitats are described according to a standardized system for habitat characterization. In the Netherlands habitats are described according to the system Index Nature and Landscape (Portaal Natuur en Landschapsee Box 1). Only habitats in assigned protected areas for nature are included in this method, with respect to evaluation for nature policy since the contribution to policy requirements can only be calculated for areas that have policy requirements. The intrinsic value of the area outside of protected nature areas is evaluated for its expected ecology, since it could naturally contribute to the ecological quality and coherence of a site. In this method, Index Nature and Landscape is chosen as the basis for the habitat description, due to the fact that they provide a comprehensive description for management and use a qualification method for obtaining a certain quality of a habitat. Here it must be taken into account that the description of nature areas by Index Nature and Landscape is not by any means complete or as extended as some other methods such as the Natuurdoeltypen, especially when it comes to aquatic habitats. This Index is constructed to help deal with subsidizing nature management by farmers, and is therefore mainly terrestrial oriented. However, Index Nature and Landscape does suffice for a relatively rapid assessment of the effects of planned management of an area with respect to the expected ecology. For a more detailed assessment of the actual quality of a habitat a method such as Nature Points would be more accurate. A limiting factor of this method however, is the accuracy of the maps that describe nature in the area. When nature is specifically described as nature in the maps, it could be overlooked and therefore not be accounted for as a habitat according the Index Nature and Landscape which could lead to a skewed outcome.

Box 2: Determining habitats of a construction design in the Netherlands

The Dutch system Index Nature and Landscape (Portaal Natuur en Landschap), has classified nature into 17 types, with the aim of creating more alignment in description of nature and quality. Within these 17 types, a sub-division has been made between Nature Management Types, each with their own description of different factors that determine their ecological quality.
For the Dutch case studies used to develop this method, habitats have been classified under Nature Management Types.(figure 2.3). Water and environmental conditions of Nature Management Types served as the basis for determining the expected ecology of the habitat based on their description by Ommering (2010).

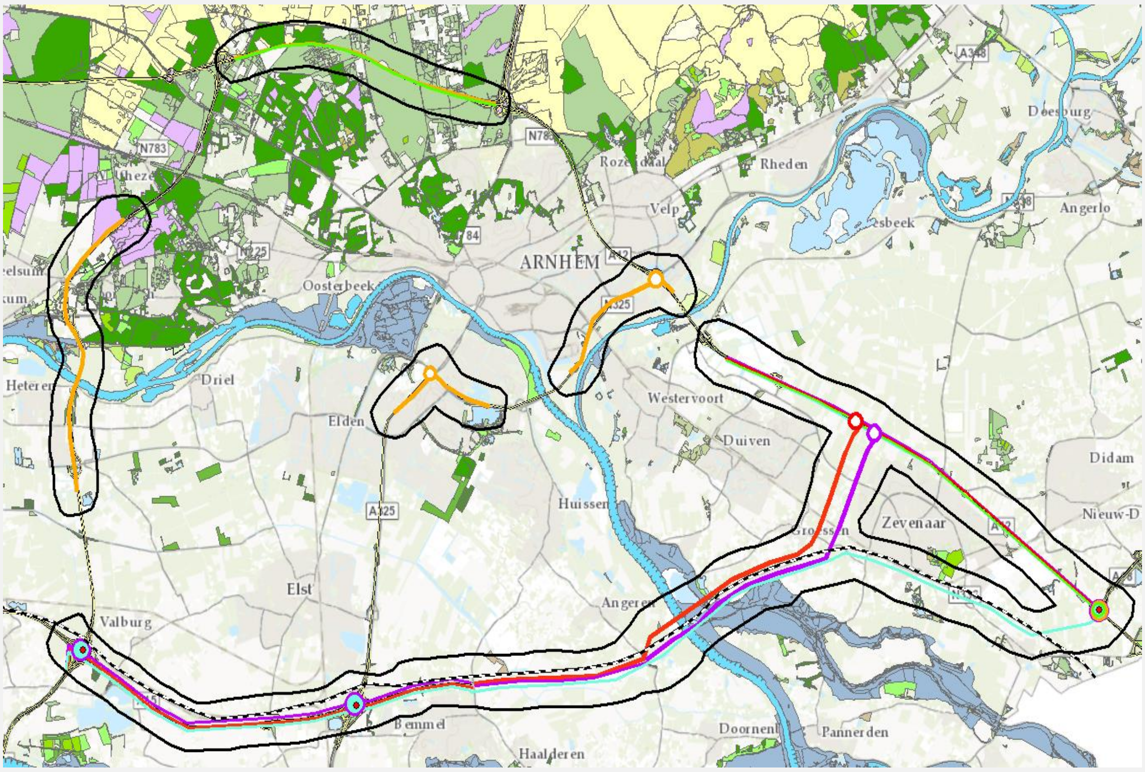


Figure 2.4 Example of a study area around different alternative construction designs of a planned road extension around the city of Arnhem (project ViA15). Natural Habitats are coloured and based on

2.2.1.4 *Nature Policy*

The evaluation of the construction design for nature policy in the area is an important component of the method. An alternative construction design can contribute to nature policy goals only, when there are relevant nature policy goals within the study area. Therefore, an important part of the scope is describing the location of the study area relative to nature policy areas. In this study, focus is only on Natura 2000 and the Dutch National Network, since clear goals have been identified for these areas.

2.3 Expected Ecology

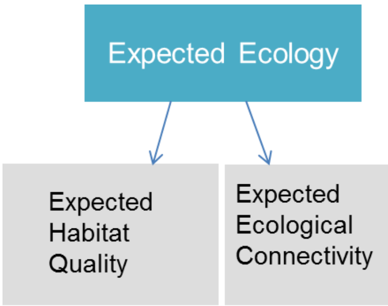


Figure 2.5 Overview of the Expected Ecology and its components

Earlier in this chapter, quality has been described as the standard of the current situation of a natural area as measured against a highly desired situation. In other words, the quality of nature is often defined by comparing a certain habitat to a predefined reference habitat, which usually resembles the same kind of habitat but then in a perfect, natural state. In other methods, habitat quality is determined by looking at specific species that are characteristic for such a habitat (Van Gaalen et al, 2014; Groenfonds, 2013). If these species are present in the habitat of which the quality needs to be determined, it is assumed that this habitat has a good quality. This method, however, focuses on the planning phase of a project, which prevents the monitoring of the presence of species and abiotic conditions after construction. In this method, habitat quality is determined by looking at the *expected* abiotic conditions and characteristic species present in the region of the alternative construction designs, since it is expected that if the abiotic conditions are suitable and the species characteristic for a certain habitat are present in the region, it is very likely that they are also present in the habitats of the construction designs.

Apart from habitat quality, there is a second form of quality that is considered in this method. This is the quality of a habitat for the surrounding areas, i.e. the extent to which a habitat adds to the ecological connectivity. Connectivity in this method is determined by looking at the closest surrounding similar habitats as defined on a map, not necessarily within the study area. In this method, this is named *expected ecological connectivity* since it is only possible to determine the extent to which the construction designs *potentially* add to ecological connectivity in the surrounding areas. In the following sections, both *expected habitat quality* and *expected ecological connectivity* are further explained.

2.3.1 Expected habitat quality

Habitat quality can be based on the actual presence of characteristic plant and animal species relative to their potential abundance (Van Gaalen et al, 2014). In this method, focus is on the potential of characteristic species to occur; this will determine which ecology is expected in the alternative construction designs. The potential of characteristic species to occur is based on two elements:

1. The suitability of the habitat for these species
2. The presence of characteristic species in the region.

Suitability of the habitat for characteristic species

The suitability of the habitat is predicted based on abiotic conditions that are expected within the alternative construction designs. Based on the abiotic requirements for each habitat, a comparison can be made between the alternative construction designs and the reference situation.

These abiotic parameters are considered in each case, in order to evaluate different habitats equally:

- Nitrogen deposition
- Groundwater level
- Nutrients
- Acidity
- Water dynamics

In addition to the abiotic requirements, the way the area is managed or potentially disturbed will result in obtaining a higher or lower suitability for characteristic species. An area with initial poor conditions for a habitat to develop could be improved by the right management. Alternatively, an area that has the potential to develop into a high quality habitat based on initial abiotic conditions could be negatively affected by vegetation management, disturbances from surroundings or pollutions.

Presence of characteristic species

For each habitat, a list can be composed of characteristic species that should occur in a habitat with a good quality. The easiest way of doing this, is by using a habitat characterization method which also defines the characteristic species for each habitat. By looking at distribution atlases (e.g. waarneming.nl; Sovon; Floron), the presence of these species in the region (i.e. the same as region as described in paragraph 2.2.2) can be determined. The more characteristic species of a certain habitat are present in the region, the higher the likelihood of these species occurring in the habitat, thus the higher the expected habitat quality of this habitat.

Box 3: Calculating *expected ecology* in the Netherlands

In the Netherlands, the Nature Management Types by Portal Nature and Landscape lie at the basis of the analysis. Nature management types have set requirements for water and environmental conditions that are required for a good habitat quality. Additionally, a list of characteristic species is provided for each habitat that can serve as the basis for analyzing the presence of characteristic species in the region.

The Nature Management Types by Portal Nature and Landscape do not require all species to be present for a habitat to be considered high quality. However, since this method does not actually monitor the presence of species but merely estimates the likelihood of them being present, by looking at their presence in the region, a higher demand for quality is set. This is an aspect of the method that requires further development since it does not specifically match the standards as set by the habitats by Portal Nature and Landscape.

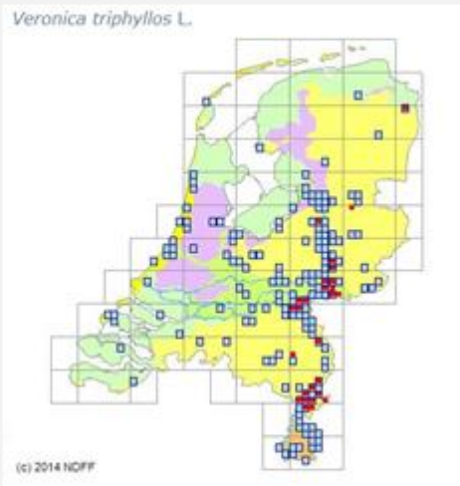
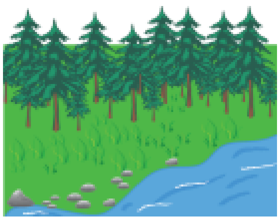
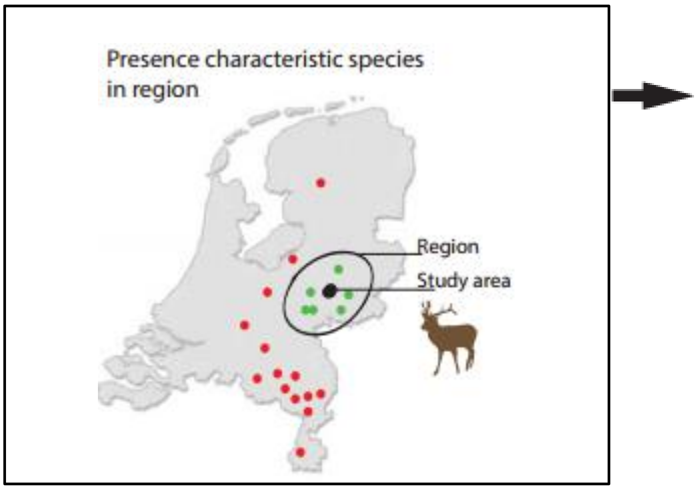


Figure 2.6 Overview of a distribution map for the species Veronica triphyllos in the Netherlands (Floron)

Abiotic conditions:
-nitrogen deposition
-groundwater level
-water dynamics
-nutrients

Management and disturbance effects:
-vegetation management
-noise
-eutrophication
-water management
-erosion





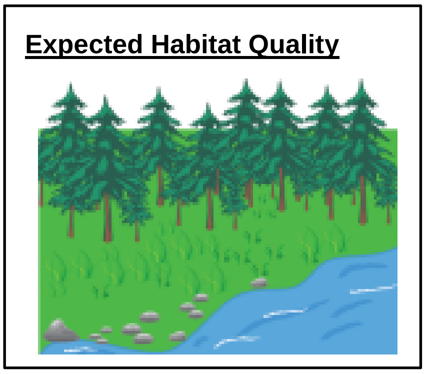


Figure 2.7 Overview of the expected habitat quality; based on the abiotic factors and water dynamics (derived from an Environmental Effects Report, based on descriptions by Ommering, 2010) + potential management and disturbance effects (based on expert judgement). These management and disturbance effects are only taken into account when relevant in the study area. and the presence of characteristic species in the region (based on distribution atlasses).

2.3.2 Expected ecological connectivity

Scientific literature proposes several ways of determining the connectivity of a landscape (Kindleman & Burel, 2008). These include factors that influence connectivity such as distance, non-habitat design (i.e. matrix), the dispersal requirements for species and the role of barriers. Other methods that calculate the value or quality of nature usually do not include ecological connectivity explicitly (Groenfonds, 2013; Van Gaalen et al 2014). However, since it is known that ecological connectivity and migration of species are factors that affect the sustainability of populations and therefore affect surrounding nature, *expected ecological connectivity* is an important factor for the *expected ecology* in this method.

Based on the definition of Tischendorf & Fahrig (2000), ecological connectivity is considered as the degree to which habitats facilitate dispersal for different groups of species, both within the study area and outside the study area. According to this definition, connectivity is a property of a landscape and not of species.

In general, areas could be of importance for surrounding nature by providing a living area, a feeding ground or a short term refuge (e.g. stepping stone or corridor). In this method, the focus lies on three ways of supporting landscape connectivity: living areas (also referred to as key areas), stepping stones and corridors. *Expected ecological connectivity* is determined by comparing habitats within the study area to habitats outside the study area. Each habitat within the study area is compared to two similar areas outside the study area. For each habitat, characteristic species are defined. In order to determine if species are able to migrate between the two areas, for each species, dispersal requirements are compared to characteristics of the landscape in between the study area and the habitats outside the study area. The degree to which the landscape facilitates connectivity per group of species is classified into three categories: 1.The landscape facilitates connectivity, 2. Barriers limit connectivity, and 3. Dispersal is limited by distance. When the landscape facilitates dispersal, this means there are no barriers and the distance between the areas is not too long for the species to migrate. For the analysis, it is assumed that all habitats have an optimal habitat quality and that the habitats can only differ in size. The reason for comparing the habitats within the study area with two areas outside the study area is to reduce the time needed to perform the analysis; it is too time consuming to analyze all the habitats in a region. Furthermore, it is reasoned that if ecological connectivity is valued as “good”, it cannot be valued higher than that; in that case there would not be a difference between using two areas or more than two areas for the analysis.

2.3.3 Data availability

The most important condition for using the method is the availability of data about the project and the study area. The first step in the scope of the method, is describing the design of alternative construction designs. Based on this design, the study area can be determined and the area can be classified into habitats. To this end, data about the design and maps of nature in the area are required to be able to use the method correctly. These maps are required to determine the expected ecological connectivity of habitats in the study area as well as determine which nature is present in the area and as such which habitats will be evaluated. In the Netherlands these maps can be obtained for nature management types (Portaal Natuur en Landschap) and a general nature map (Kramer et al 2007). Especially the addition of a general nature map will guarantee that most natural areas will be evaluated as such and none will be overlooked.

When determining the expected ecology, the element of expected habitat quality requires information on abiotic conditions in the study area. In the Netherlands, these data can be obtained from the Environmental Index Report that is written for the specific project areas. Additionally, distribution atlases of flora and fauna are required to provide information on the presence of characteristic species in the region. A number of distribution atlases in the Netherlands provide information on different species (Floron, 2014; Sovon, 2014; Vlindernet, 2014).

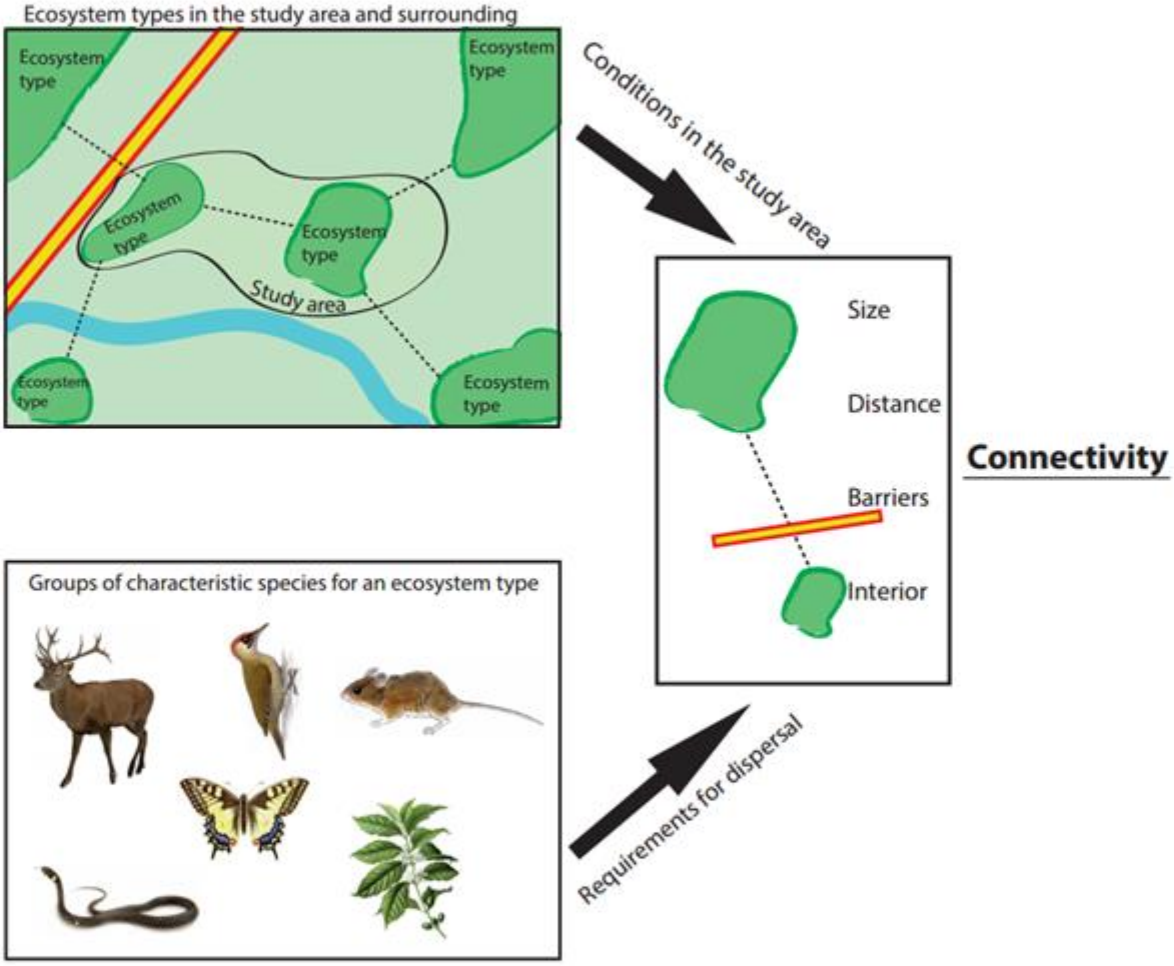


Figure 2.8 Expected ecological connectivity can be determined by looking at possible connections between ecosystem types and their traits such as distance and size. Based on these traits and requirements for dispersal of different groups of species, a measure for expected ecological connectivity can be given.

Box 4: Calculating connectivity in the Netherlands

Nature Management Types of Index Nature and Landscape (Portaal Natuur en Landschap) can readily be translated into ecosystem types (Broekmeyer et al, 2001). Additionally, Nature Management types can be selected based on ecosystem type in a map. As a result, possible connections between areas of the same ecosystem type can be defined in a map, along with possible barriers (figure 2.9). Based on dimensions of possible connections and requirements of characteristic groups of species that can disperse between areas of the same ecosystem type (Broekmeyer et al, 2001), connectivity of habitats within the study area can be calculated for each alternative construction design. These findings can be compared with the reference situation to determine whether there is an increase or a decrease in the connectivity resulting from the construction of a measure.

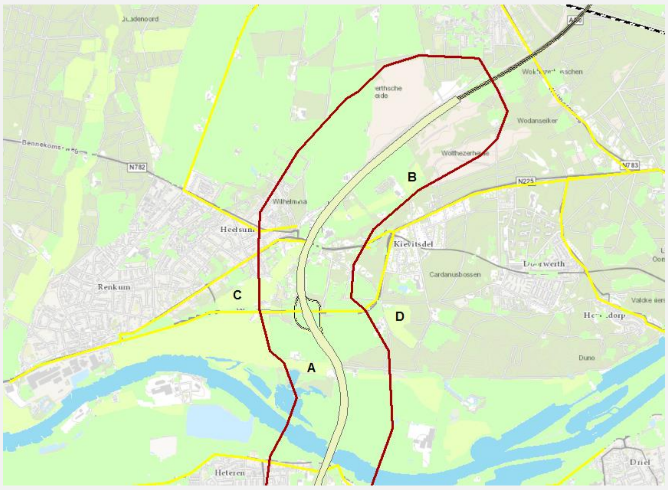


Figure 2.9 Example of a marked ecosystem type within a study area along with possible barriers and connecting areas marked with letters.

2.4 Evaluation for nature policy

2.4.1 Contribution to nature policy goals

The valuation of ecology for nature policies depends on the degree to which the construction of an alternative design possibly contributes to nature policy requirements. Naturally, different nature policy goals are composed of different elements or categories. However, when aiming to compare the effects of alternative construction designs on nature policy requirements, a uniform method is required to make an honest comparison. Therefore, nature policy goals are individually divided into categories to facilitate determining the effects.

Box 5: Calculating the evaluation for nature policy requirements in the Netherlands

In the Netherlands, Natura 2000 and the Dutch National Ecological Network have appointed as the main nature policy goals that are be evaluated with the method (Figure 2.10).

Natura 2000
Natura 2000 aims to achieve conservation goals that are based on the habitat and bird directive (Ministry of Economic Affairs). There are 4 categories of conservation goals: habitat type, habitat species, breeding bird species and bird species. Within these 4 categories, there are three sub-categories that can achieve a positive or a negative contribution: quality, surface and distribution. Furthermore, the coherence of the ecological network is a conservation goal of Natura2000. Alternative construction designs can be evaluated on their effects on these 5 categories and subcategories, relative to the reference situation. The specification of these categories is provided for each Natura2000 area, and will lie at the basis of determining the contribution to this nature policy goal.

National Ecological Network
The Dutch National Ecological Network aims to connect existing nature areas and conserve or improve the quality of the Dutch National Ecological Network. Specific goals to achieve this are specified for each province in the form of protected essential aims and values (Van de Leemkule, 2014a). Although the interpretation of specific goals differs between provinces, in general they can be classified into two categories: essential aims and essential values. A contribution of an alternative construction design to achieving the essential aims, relative to the reference situation, is valued as a positive effect. A loss or degradation of an essential value is valued as a negative effect.

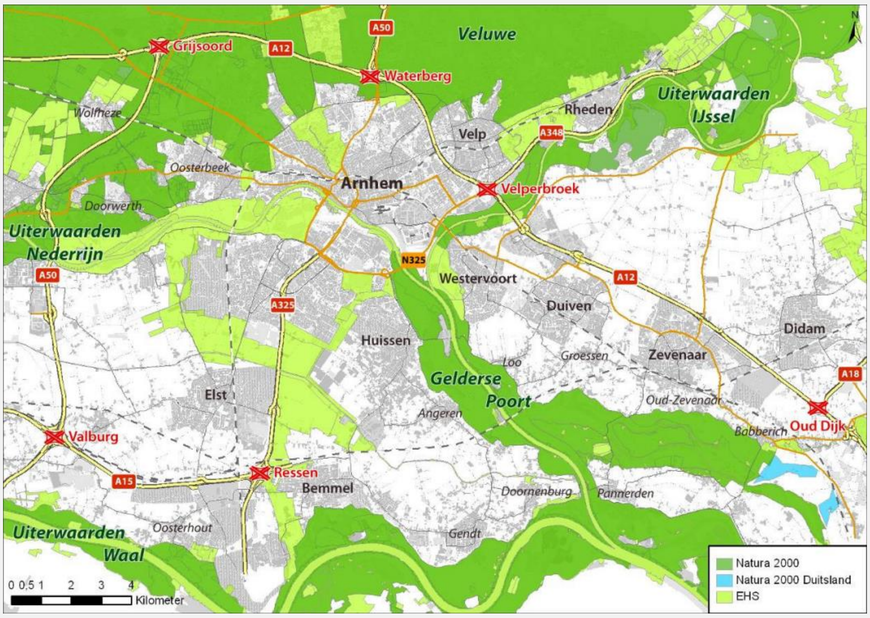


Figure 2.10 Overview of Natura 2000 areas and National Ecological Network areas (EHS) around the city of Arnhem (Projectbureau ViA15, 2011).

2.5 Contribution to nature policy requirements

In the previous sections, the elements of quantifying the contribution to nature policy requirements are described. For each separate element of the method, a number is produced as outcome of the analysis. For a detailed description on how to calculate these numbers, see the step-by-step overview in chapter 3. In Figure 2.1, the overall formula is visualized.

The ecological value for nature policy is the multiplication of the expected ecology per hectare of study area, and evaluation for nature policy (Figure 2.1). The outcome of the calculation is a relative value, because each alternative construction design is compared to the situation without interventions (i.e. the reference situation; note that this is the reference situation timed at the end of the construction period). The value gives insight in the effects of an alternative construction design on ecology. Thus, the output of the method provides the ability to make a comparison between different interventions and gives a quantitative value to nature in the context of nature policy.

Box 6: Using the contribution to nature policy requirements in the Netherlands

In order to increase sustainability of infrastructural projects, RWS has developed the Environmental Index Tool (Dutch: Omgevingswijzer) (Figure 2.11, Rijkswaterstaat, 2014). This tool is a checklist concerning several themes that are evaluated for their sustainability such as Economy, Energy & Materials and Ecology & Biodiversity. The latter theme of Ecology & Biodiversity is currently limited in its interpretation of several aspects that affect the value of ecology and biodiversity. RWS could use the method to quantify and compare the value for nature in the context of nature policy goals. The output of this method could be used to give more content to the theme of Ecology and Biodiversity.

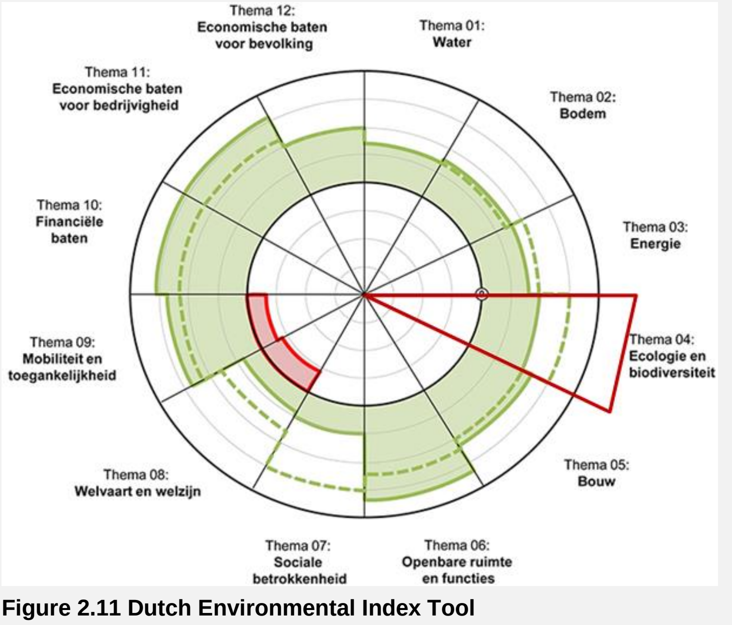


Figure 2.11 Dutch Environmental Index Tool

Box 7: the outcome of the method

The outcome of the method en and the overall contribution to nature policy requirement is shown in the table below. The table shows 5 construction designs that have been evaluated relative to the situation without any change of a case study that is described in Annex D. All designs entail an alternative enhancement of a road network in the Netherlands.
Evaluation for Nature Policy obtained a range of scores for the different designs. The output could facilitate the process of deciding on an optimal infrastructure design, within the scope of nature policy requirements. Furthermore, by evaluating which aspects of a design scored negatively in the analysis, design can be improved to mitigate expected negative effects. Overall, the outcome of the method will provide insight different aspects of nature value and effects on nature policy and could be used to construct more sustainable infrastructural designs in the future.

Scope	Expected ecology			Evaluation for nature policy			Contribution to nature policy requirements	
Design	Potential ecological quality (ha⁻¹)	Connectivity (ha⁻¹)	Relative value ↓↓↓↓	Natura 2000 value	National Ecological Network value	↓↓↓↓	**Relative value per hectare nature ↓↓↓↓**	**Relative value ↓↓↓↓**
Regional combination 1	0,400	2,176	-0,019	-8	-2	-10	-0,241	-0,123
Regional combination 2	0,303	0,649	-0,005	-2	0	-2	0,000	-0,008
Extension North	0,439	1,468	-0,059	-12	-6	-18	-5,398	-1,716
Extension South	0,438	1,467	-0,060	-12	-6	-18	-5,543	-1,734
Joint Extension	0,430	1,467	-0,060	-12	-6	-18	-5,514	-1,739

3 Calculating the contribution to nature policy requirements

The method has been adjusted and evaluated by testing it on two case studies in the Netherlands: The wave reducing eco-dike at Fort Steurgat and the construction of a more robust road network in the region Arnhem – Nijmegen, called “ViA 15”.

The first case study (from here onwards referred to as “Fort Steurgat”) is a case with a small study area with only a few habitats located within the study area. The Fort Steurgat case has been used to set up the method; constructing the method has been an iterative process and parts of the method have been adjusted after it was tested on the Fort Steurgat case. Therefore, not all criteria that have been set for the use of the method are met in the Fort Steurgat case. A detailed description of the case study is listed in the Appendix (Appendix B).

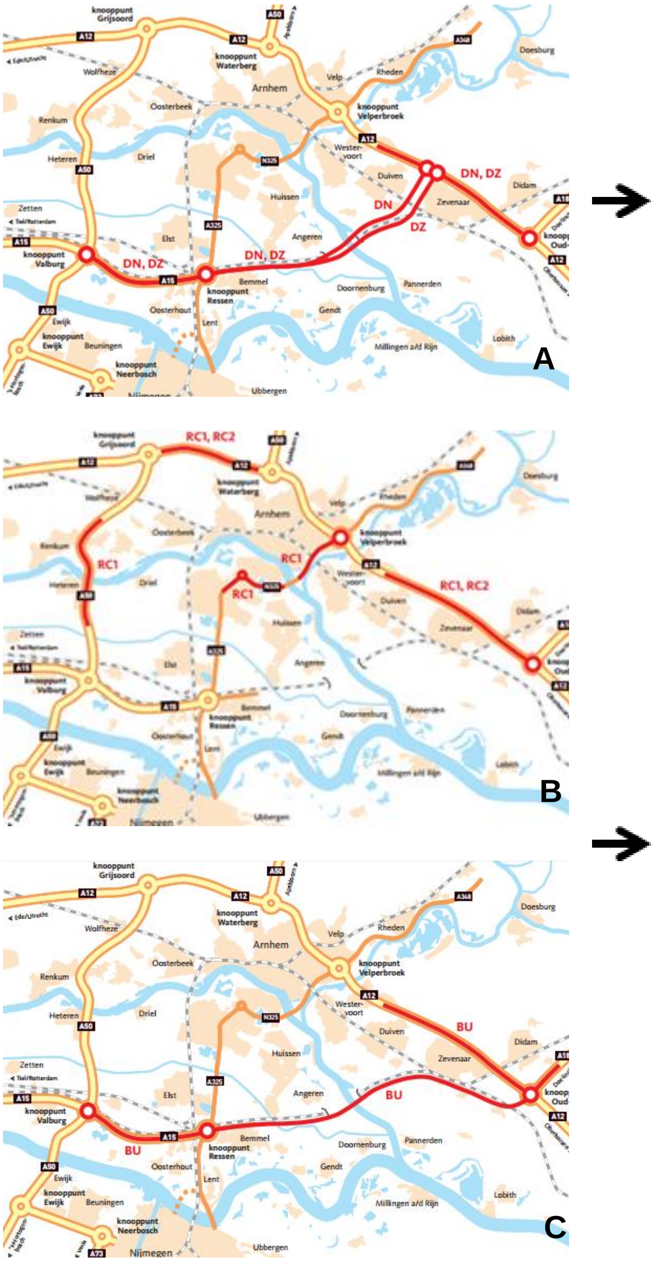
The second case study (from here onwards referred to as “ViA 15”), is more complex: the study area is much bigger, the alternative construction designs are much more complex and more different habitats are involved. The ViA 15 case study served as a test case for the method; after evaluating the method with the ViA15 case study, only minor adjustments have been made.

3.1 Case ViA15 – Step-by-step

3.1.1 General description of the case

In the region Arnhem-Nijmegen in the eastern part of the Netherlands, the road network is overloaded. This leads to negative effects for the region itself and eventually also for the entire country. Negative effects include a decline in liveability and higher risks on traffic accidents. The region Arnhem-Nijmegen, the general government and the province of Gelderland together proposed a set of measures to improve the situation. Different scenarios were designed before the final design was chosen. To test our method, all the different scenarios have been taken into account.

The different scenarios are visualized in the figure below:



Extension measures: Extension North (DN fig. A), Extension South (DZ fig. A), Joint Extension (BU fig. B)

- Extension of A15 road
- Widening of existing A15 road between Valburg and Ressen
- Widening of existing A12 between Duiven and Oud-Dijk
- Scenario's A and B differ in location/route of the extension of A15

Regional combination measures: Regional combination 1 (RC1 fig. C), Regional combination 2 (RC2 fig. C)

- Widening of roads in the area to increase carrying capacity
- Measures differ in number of roads that are widened

Figure #, Based on Projectbureau ViA15, 2011

Chapter 2 already explains that when a study area gets too large, splitting an area into sub-areas could be useful for explaining the effects of the construction designs on the surrounding nature (figure 2.3b). The ViA 15 case has been evaluated twice; once without splitting the area in sub-areas (see Appendix C) en once with splitting the study area into sub-areas.(Appendix d). Below, a description is given of one of the sub-areas of the case study to describe the steps of the method. Only one of the different scenarios is used for the description and only one habitat is described.

Table 3.1 on the following page summarizes the entire method step by step, for each of the elements of the method. The table starts (in the top area) with the first phase of the method: the scope. In the scope, the information that is used in other elements of the method is gathered. In the rest of the table (below the scope) the blue colours go from light to dark. This represents the order of the steps. First, the expected habitat quality needs to be calculated (which is part of the expected ecology), followed by the expected ecological connectivity (part of the expected ecology). Next, the evaluation for nature policy requirements (the darkest shade of blue) Is described.

Elements of the method (i.e. expected habitat quality, expected ecological connectivity and evaluation for nature policy requirements) are divided in three parts:

1. The steps that have to be taken (described in the first column of the element in the table)
2. The input that is needed to be able to perform the steps (described in the second column)
3. The quantification; i.e. how the calculations that are part of the steps need to be done. First, start with the calculation that is described in the left part of the quantification area. The next calculations are listed in the columns on the right side of this first calculation, finally leading to the value for expected ecology as a whole, which is visualised in white on the right side of the table.

Table 3.2 shows the step-by-step output of one habitat of the ViA15 case. The tables and figures to which is referred in the table are visualized in Appendix A.

Table 3.1: Step by step description of the method

	Region	Design	Study area	Policy
Scope	Gather information on: 1. Location 2. Important habitats/nature 3. Important species 4. Possible disturbances for connectivity 5. Nutrient levels/soil types 6. Nature policy goals	*For reference situation + alternative construction designs:* 1. Description of important parts of the design 2. Characterisation of habitats within design	*For reference situation + alternative construction designs:* Select the study area based on overlap of different construction designs and expected extend of the effects. Determine whether fragmentation of a large study area is required.	Short description of relevant nature policy requirements

		Steps:	Input:	Quantification:				
Expected Ecology	**Expected habitat quality**	1. Compare current conditions with predicted future conditions: →abiotic conditions →management/disturbance →presence of characteristic species in habitats in region Compare to “perfect” natural situation 2. Calculate per hectare 3. Compare to situation without interventions 4. Calculate average value for all habitats together	*Per habitat:* - Characteristic abiotic conditions (N-deposition, water level, nutrients, acidity, water dynamics) - Information on future/ideal management - List of characteristic species + their regional distributions *Overall:* - Map with habitats + surface areas in study area + region (per construction design)	**Abiotic conditions:** Preferent: 1 Sufficient: 0,5 Insufficient: 0 →	Calculate for each habitat, relative to the surface area of the habitat: Σ of the abiotic conditions and management & disturbance, maximum value is 1 →	Σ habitats: # →	Average (ha^{-1}) relative to the reference situation #	**Expected Ecology** = average of # **Expected habitat quality** + # **Expected ecological connectivity**
				Management & disturbance: Positive effect: + 0,25 Negative effect: - 0,25 →				
				Presence of characteristic species: Present: 1 Absent: 0	percentage of presence/ absence characteristic species per habitat, presented as fraction of 1. Total value range: 0-1 #	Average habitats →		
	Expected ecological connectivity	1. Define habitats within study area 2. Define characteristic species/groups of species per habitat + their requirements for dispersal 3. Determine location of habitats in and outside of study area with corresponding distance, surface area (in table) and possible barriers (in map). 4. Categorize landscape according to species requirements: →landscape facilitates dispersal →dispersal is limited by barriers →dispersal is limited by distance	- List of characteristic species/groups of species + requirements for dispersal - Map with habitats + surface areas and distances to areas that qualify as dispersal grounds for characteristic species.	**For each habitat per species/ group of species:** Landscape facilitates dispersal: 1 Dispersal is limited by barriers: 0,5 Dispersal is limited by distance: 0 →	Per habitat: # = average of species output	Calculate # per hectare	# = average of habitats	Average (ha^{-1}) relative to reference situation: #
Nature Policy		1. Define important nature policy goals 2. Define for each policy goal relevant categories 3. Determine if construction alternatives contribute either positive/negative/not at all (neutral) to the nature policy goals 4. Important: contribution to policy goals depends on difference between construction designs & situation without interventions (reference situation)	- Detailed information on nature policy goals + how to achieve them - Map with relevant policy goals in the region	**Per nature policy category:** Positive effect: 2 No effect: 0 Negative effect: -2	**#** = Σ **#** categories			**Evaluation for nature policy requirements** = Σ # **policy goals**

Contribution to nature policy requirements =
Expected Ecology x **Evaluation for nature policy requirements**

Table 3.2 step-by-step approach of the method, for a sub-area + one habitat of the ViA

Scope

Region

1. Figure 1.1. (appendix D)
2. Habitats dry and wet meadow, dry forests, fens and drift sand, grasslands, fields, swamps and open water.
3. Red deer, wild boar, large mammals
4. Betuwelijn, road network A12, A15, A50
5. Different soil types: sand, *zware klei, zware zavel, lichte zavel*
   Natura 2000 Veluwe and Rijntakken. .EHS

Design

Reference situation:

1. A12, A15, A325 (Figure 6.1)
   Largely dry forest with production, pine-, oak, and beech forest

Table 6.2 Habitats in sub-area 3 for reference situation and Regional combination

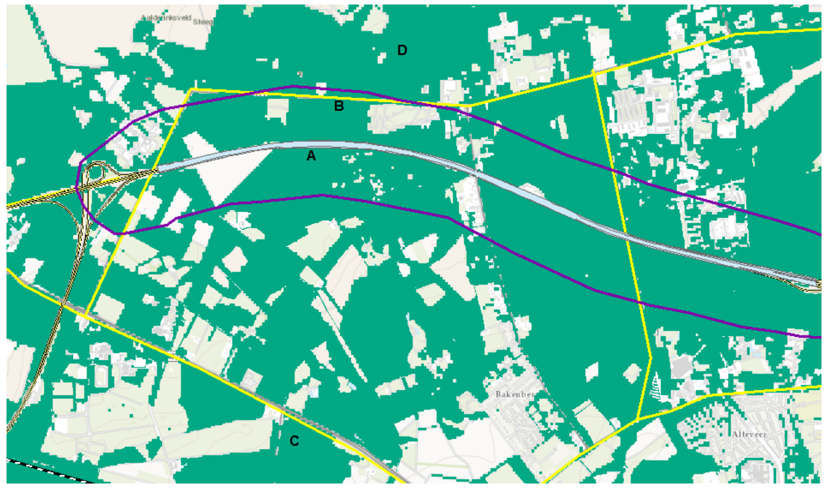


Figure 6.7 Habitat area dry forest with production (based on ecotopes and nature management type maps). Letters (A and B) illustrate largest areas in the study area and similar habitat in the region (outside of study area C and D). Yellow lines show road barriers. The purple line is the boundary of the study area.

Habitat	Nitrogen deposition boundaries			Required pH	
qualification	good	average	poor	good	average
Dry forest with production	<1420	1420-2060	>2060	-	

Table 6.3 Abiotic requirements based on Portaal Natuur en Landschap and Taakgroep Natuurkwaliteit en Monitoring SNL (2013).

Study area

For reference situation + alternative construction designs:

Surface area is based on 500 meters from planned road due to its effects on breeding birds within this distance

Policy

Natura 2000 Veluwe has specific goals described by the European Bird and Habitat directives. Overview for goals Natura 2000 (Figure 6.5)

National Ecological Network aims to connect existing nature and improve quality of network. Goals for Gelderland are specified based on core qualities and environmental conditions that need to be maintained. Specific goals for Papendal Schaarsbergen (Figure 6.6)

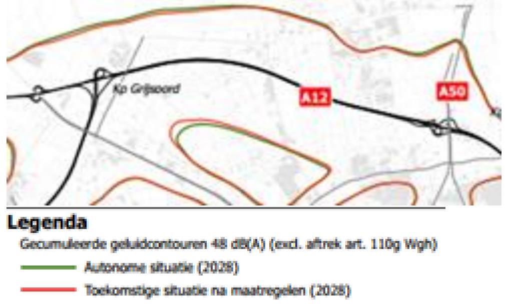


*Figure 6.8 Sound contours in 2028 with autonomous development of **Regional combination 1** without sound reducing measures(green) and with reducing measures. (modified from Projectbureau ViA15, 2011)*

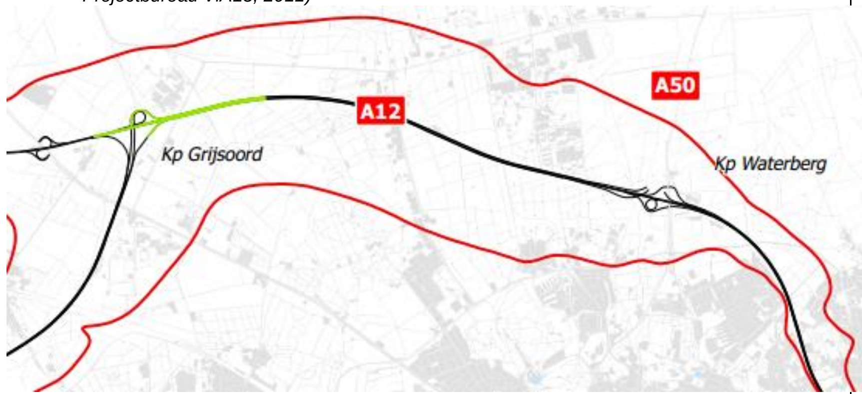


Figure 6.9 Location of sound reducing asphalt (modified from Projectbureau ViA15, 2011)

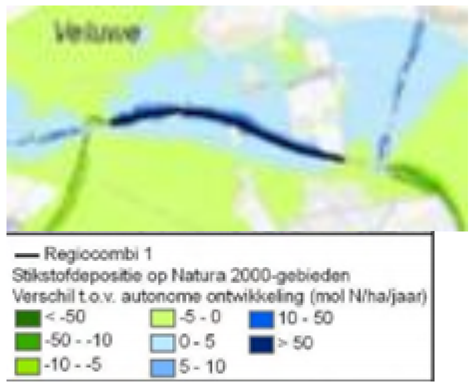


*Figure 6.10 Nitrogen deposition in **Regional combination 1 compared to the reference situation in** Natura 2000 areas (modified from Projectbureau ViA15, 2011)*

Dry forest with production (N16.01)	**Breeding birds (based on SOVON)**
	appelvink
	boomklever
	boomleeuwerik
	fluiter
	geelgors
	groene specht
	keep
	kleine bonte specht

	middelste bonte specht
	raaf
	sijs
	vuurgoudhaan
	wespendief
	wielewaal
	zwarte specht
	73.3 % -> 0.73

Table 6.4 Characteristic species of habitat Dry forest with production ((Portaal Natuur en Landschap)). Presence is judged based on observations and present data on occurrence (SOVON), green means present, grey means not present.

	Water and evironmental conditions by Taakgroep Natuurkwaliteit en Monitoring SNL (2013)				Disturbances
Condition/ factor	Nitrogen deposition			**Average**	Noise
Measure + habitats	1	0.5	0		-0.25
<u>Reference situation</u>					
Dry forest with production			X	0	-
<u>Regional combination 1</u>					
Dry forest with production			X	0	no additional

Table 6.5 calculating Expected habitat quality based on required conditions specified by Taakgroep Natuurkwaliteit en Monitoring SNL (2013) and additional disturbance or management effect in this area.

	Ecosystem type / **Habitat**	Forest of poor and rich sandy soils
N16.01	Dry forest with production	X

Table 6.6 Converting habitats (Portaal Natuur en Landschap) to ecosystem types (Broekmeyer et al, 2001) based on Index Natuur en Landschap (2009).

Ecoprofiel Forest of poor and rich sandy soils – habitat Dry forest with production.	Are a key are a (ha)	Area step ping ston e (ha)	breedt e corrido r (m)	Requiremen ts corridor	Max interr uption corrid or (m)	Dista nce key areas (km)	Barriers
Boomklever	56	5,5	-	-	-	11	-
Boommarter	300 0	300	100	Bos, struweel, houtwal	100	30	Waterweg steile randen, spoorlijnen, wegen
Bosparelmoervlin der	5	1	25	Bos, struweel, houtwal, droge ruigte	50	2	Wegen
Edelhert	300 0	300	1000	Struweel, droge ruigte, bos, heide	100	50	Waterweg steile randen, spoorlijnen, wegen
Eekhoorn	56	5,5	25	Bos	50	5	Waterweg met steile randen, wegen
Glanskop	300	30	-	-	-	11	-
Groene specht	750	75	-	-	-	20	-
Grote weerschijnvlinder	56	5,5	25	Struweel, bos, houtwal	50	2	wegen
Hazelworm	56	5,5	25	Droge ruigte, struweel, bos	50	2	Waterweg steile randen, spoorlijnen, wegen
Keizersmantel	56	5,5	-	-	-	5	Wegen
Goede verspreider planten	5	1	-	-	-	11	-
Matige verspreider planten	5	1	-	-	-	2	-
Redelijk goede verspreider planten	5	1	-	-	-	5	-
Slechte verspreider planten	5	1	100	Leefgebied	0	0,5	-

Table 6.7 List of characteristic species of Dry forest with production and their requirements for dispersal. Green coloured are requirements that are met, orange are barriers to dispersal and red are requirements that prevent dispersal in the study area. Based on (Broekmeyer

et al, 2001) and measurements in map of the study area.

	Surface (ha)	Distance to A (m)	Distance to B (
Area A	±725	-	34
Area B	+800	34	-
Area C	±200	40	-
Area D	+800	-	34

Table 6.8 Surface area of Dry forest with production and distances to habitats that qualify for dispersal (based on map of study area with habitats)

	Qualification	number of species grou
Dispersal is limited by distance or surface	0	
dispersal is limited by barriers	0,5	
dispersal is limited by distance or surface	1	
Average connectivity		

Table 6.9 Calculating connectivity based on map Figure 6.7, Table 6.8 and Table 6.7.

Regional combination 1:

1. A12 in Veluwe is widened from Waterberg to Grijsoord with 7.6 meters. (Figure 6.2)
   Largely dry forest with production, pine-, oak, and beech forest.
   Some loss of habitat

Table 6.2 Habitats in sub-area 3 for reference situation and Regional combination

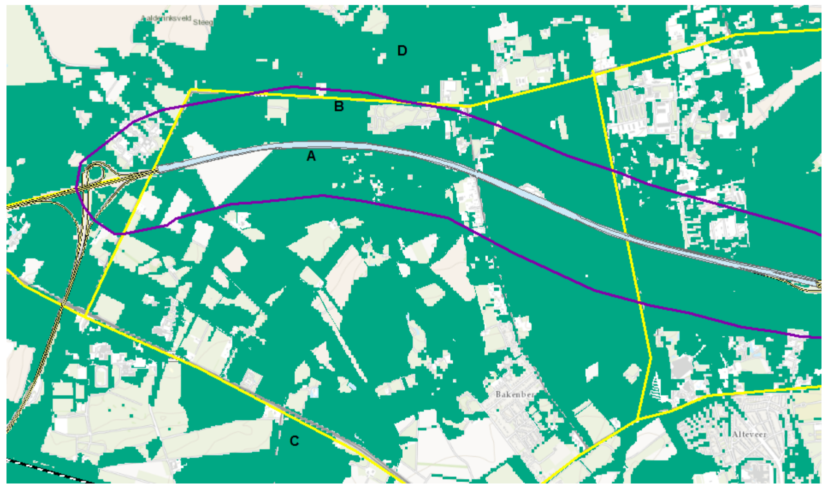


Figure 6.7 Habitat area dry forest with production (based on ecotopes and nature management type maps). Letters (A and B) illustrate largest areas in the study area and similar habitat in the region (outside of study area C and D). Yellow lines show road barriers. The purple line is the boundary of

the study area.

Habitat qualification	Nitrogen deposition boundaries			Required pH	
	good	average	poor	good	average
Dry forest with production	<1420	1420-2060	>2060	-	

Table 6.3 Abiotic requirements based on Portaal Natuur en Landschap and Taakgroep Natuurkwaliteit en Monitoring SNL (2013).

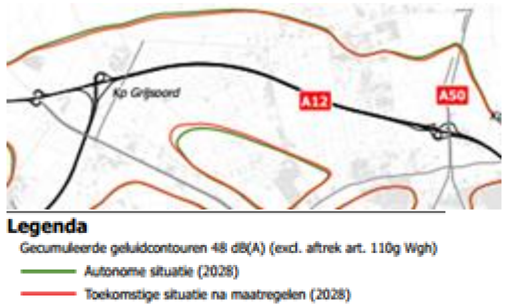


Figure 6.8 Sound contours in 2028 with autonomous development of Regional combination 1 without sound reducing measures(green) and with reducing measures. (modified from Projectbureau ViA15, 2011)

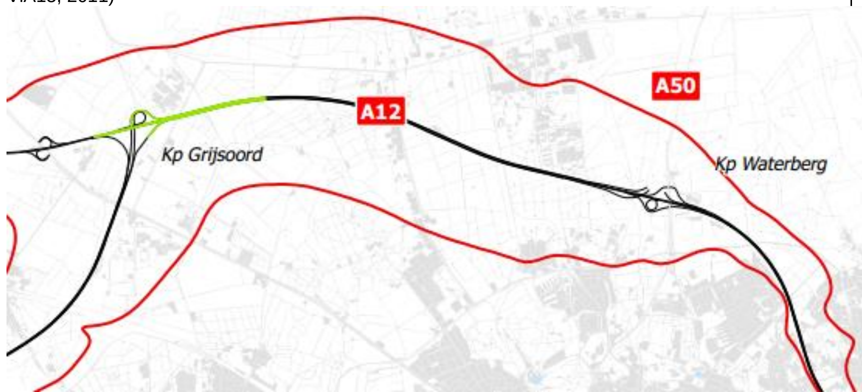


Figure 6.9 Location of sound reducing asphalt (modified from Projectbureau ViA15, 2011)

Figure 6.10 Nitrogen deposition in Regional combination 1 compared to the reference situation in Natura 2000 areas (modified from Projectbureau ViA15, 2011)

Dry forest with production (N16.01)	**Breeding birds (based on SOVON)**
	appelvink
	boomklever
	boomleeuwerik
	fluiter
	geelgors
	groene specht
	keep
	kleine bonte specht
	middelste bonte specht
	raaf
	sijs
	vuurgoudhaan
	wespendief
	wielewaal
	zwarte specht
	73.3 % -> 0.73

Table 6.4 Characteristic species of habitat Dry forest with production ((Portaal Natuur en Landschap)). Presence is judged based on observations and present data on occurrence (SOVON), green means present, grey means not present.

	Water and eivironmental conditions by Taakgroep Natuurkwaliteit en Monitoring SNL (2013)				Disturbances
Condition/ factor	Nitrogen deposition			**Average**	Noise
Measure + habitats	1	0.5	0		-0.25
Reference situation					
Dry forest with production			X	0	-
Regional combination 1					
Dry forest with production			X	0	no additional

Table 6.5 calculating Expected habitat quality based on required conditions specified by Taakgroep Natuurkwaliteit en Monitoring SNL (2013) and additional disturbance or management effect in this area.

	Ecosystem type / Habitat	Forest of poor and rich sandy soils
N16.01	Dry forest with production	x

Table 6.6 Converting habitats (Portaal Natuur en Landschap) to ecosystem types (Broekmeyer et al, 2001) based on Index Natuur en Landschap (2009).

Ecoprofiel Forest of poor and rich sandy soils – habitat Dry forest with production.	Area key area (ha)	Area stepping stone (ha)	breedte corridor (m)	Requirements corridor	Max interruption corridor (m)	Distance key areas (km)	Barriers
Boomklever	56	5,5	-	-	-	11	-
Boommarter	3000	300	100	Bos, struweel, houtwal	100	30	Waterweg steile randen, spoorlijnen, wegen
Bosparelmoervlinder	5	1	25	Bos, struweel, houtwal, droge ruigte	50	2	Wegen
Edelhert	3000	300	1000	Struweel, droge ruigte, bos, heide	100	50	Waterweg steile randen, spoorlijnen, wegen
Eekhoorn	56	5,5	25	Bos	50	5	Waterweg met steile randen, wegen
Glanskop	300	30	-	-	-	11	-
Groene specht	750	75	-	-	-	20	-
Grote weerschijnvlinder	56	5,5	25	Struweel, bos, houtwal	50	2	wegen
Hazelworm	56	5,5	25	Droge ruigte, struweel, bos	50	2	Waterweg steile randen, spoorlijnen, wegen
Keizersmantel	56	5,5	-	-	-	5	Wegen
Goede	5	1	-	-	-	11	-

verspreider planten							
Matige verspreider planten	5	1	-	-	-	2	-
Redelijk goede verspreider planten	5	1	-	-	-	5	-
Slechte verspreider planten	5	1	100	Leefgebied	0	0,5	-

Table 6.7 List of characteristic species of Dry forest with production and their requirements for dispersal. Green coloured are requirements that are met, orange are barriers to dispersal and red are requirements that prevent dispersal in the study area. Based on (Broekmeyer et al, 2001) and measurements in map of the study area.

	Surface (ha)	Distance to A (m)	Distance to B (
Area A	±725	-	34
Area B	+800	34	-
Area C	±200	40	-
Area D	+800	-	34

Table 6.8 Surface area of Dry forest with production and distances to habitats that qualify for dispersal (based on map of study area with habitats)

	Qualification	number of species grou
Dispersal is limited by distance or surface	0	
dispersal is limited by barriers	0,5	
dispersal is limited by distance or surface	1	
Average connectivity		

Table 6.9 Calculating connectivity based on map Figure 6.7, Table 6.8 and Table 6.7.

Steps:			**Input:**	**Quantification:** →				
Expected Ecology	**Expected habitat quality**	1. Compare current conditions with predicted future conditions: →increase in nitrogen deposition, no increase in sound →Sound reducing asphalt, additional public transport to reduce nitrogen deposition →No change 2. Based on water and environmental conditions by Taakgroep Natuurkwaliteit en Monitoring SNL (2013) 3. Calculate per hectare 4. Compare to situation without interventions Calculate average value for all habitats together	*Habitat Dry forest with production* Good habitat quality requires nitrogen deposition below 1420 mol N ha⁻¹ year⁻¹ (Table 6.3). Characteristic species are breeding birds (**Dry forest** | **Breeding birds (based on SOVON)**	**Abiotic conditions:** Preferent: 1 Sufficient: 0,5 Poor: 0 **Management & disturbance:** Positive effect: + 0,25 Negative effect: -	Calculate for each habitat, relative to the surface area of the habitat: Σ of the abiotic conditions and management & disturbance, maximum value is 1: *Reference* 0.365 *Regional*	Σ habitats: Reference: 0.365 Regional combination: 0.365	Average (ha^{-1}) relative to the reference situation # 0.365 + 0.73 = 0.548 For both reference situation and Regional	**Expected Ecology** = 0 **+** # **0 = 0**

				with production (N16.01) appelvink boomklever boomleeuwerik fluiter geelgors groene specht keep kleine bonte specht middelste bonte specht raaf sijs vuurgoudhaan wespendief wielewaal zwarte specht **73.3 % -> 0.73** - Table 6.4). - Reference situation: nitrogen deposition 2676 mol N ha^{-1} $year^{-1}$ (Figure 6.10 Nitrogen deposition in Regional combination 1 compared to the reference situation in Natura 2000 areas (modified from Projectbureau ViA15, 2011)(poor). Noise disturbance (Figure 6.8 Sound contours in 2028 with autonomous development of Regional combination 1 without sound reducing measures(green) and with reducing measures. (modified from Projectbureau ViA15, 2011).(Table 6.5) - Further increase nitrogen deposition (Figure 6.10) and reduction in noise pollution (figure 9). (Table 6.5) - Mitigating measures for nitrogen deposition advised. Implementation sound reducing asphalt (Figure 6.9) **Dry forest with production (N16.01)** — **Breeding birds (based on SOVON)** appelvink boomklever boomleeuwerik fluiter geelgors groene specht keep kleine bonte specht middelste bonte specht raaf sijs vuurgoudhaan wespendief wielewaal	0,25	*combination 1* 0.365		combinatio n. Relative to reference situation: 0.548 (ha^{-1}) – 0.548 (ha^{-1}) = 0	
					Presence of characteristic species: Present: 1 Absent: 0	Σ of presence/ absence per habitat	Average of habitats (both reference and Regional combination): 0.73		

			| | zwarte specht | | | **73.3 % -> 0.73** | Table 6.4. Based on SOVON: 73% of characteristic species present in region. (value:0.73)						
	Expected ecological connectivity	1. Define habitats within study area (Figure 6.7) + Nature management types (Portaal Natuur en Landschap) to ecosystem types (Broekmeyer et al, 2001) Table 6.6 2. Table 6.7 based on Broekmeyer et al, 2001 3. Determine location of habitats in and outside of study area with corresponding distance, surface area (in table) and possible barriers (in map). 4. Categorize landscape according to species requirements: →landscape facilitates dispersal →dispersal is limited by barriers →dispersal is limited by distance or surface	- Table 6.7 - Figure 6.7 + Table 6.8 Surface area of Dry forest with production and distances to habitats that qualify for dispersal (based on map of study area with habitats)	**For each habitat per species/group of species:** Landscape facilitates dispersal: 1 Dispersal is limited by barriers: 0,5 Dispersal is limited by distance: 0	Per habitat: # = 0.68 Table 6.9 (only 1 habitat in this overview)	Calculate # per hectare *Reference*: 0.68 x426.5 *Regional combination 1:* 0.68 x 419.6	# = average of 0.68 (only 1 habitat in this overview)	Calculate relative to reference situation (ha^{-1}): # No new barrier or changes in connectivity → 0	
Nature Policy		5. See scope 6. Define for each policy goal relevant categories 7. Determine if construction alternatives contribute either positive/negative/not at all (neutral) to the nature policy goals 8. Increase in nitrogen deposition compared to reference situation could potentially affect improving habitat quality (H9120, H9190, H4030 and H91E0C). Effect on species unclear. No new barriers. Core qualities of National Ecological Network likely do not reduce with Regionals combination 1. Reducing barriers is not achieved or further affected. Creating a corridor or a tunnel could potentially contribute to reducing negative effects from current and future roads.	- Figure 6.5 and Figure 6.6 - Figure 6.4	**Per nature policy category:** Positive effect: 2 No effect: 0 Negative effect: -2		-2 = Σ 6 categories			**Evaluation for nature policy requirements** = **Σ # policy goals = -2**

Contribution to nature policy requirements (relative to the reference situation) =
Expected Ecology (ha^{-1})X **Evaluation for nature policy requirements** (ha^{-1})
0 = *0* x *-2*

***** A remark to the calculation relative to the surface area of the habitat is that in this case, the surface area is not equal due to the calculation for only one habitat. Normally, the total study area is equal therefore the loss of habitat will be reflected in the final expected ecology per hectare, which is not the case in this calculation.

3.2 Lessons learned from case studies

In the following section, the most important lessons that are learned from the case studies are listed. They are sorted according to which part of the method they refer to.

3.2.1 Scope: Study area

In some cases fragmentation of the study area into sub-cases (or sub-areas) could result into more understanding in separate effects, this was tested in the ViA15 case (comparison Appendix c. en d.). This is usually the case when the study area gets too large and factors of alternative construction designs are likely to have different effects on different parts of the total study area. This was the case in the ViA15 case; the study area of this case study is very large (7569 ha). This is considered to be large, since many abiotic effects on specific habitats carry on a smaller scale. The result of dividing into sub-cases is a more specific valuation where the sub-cases significantly differ from the average valuation of the case as a whole, both in negative and positive direction.

A study area can be divided into sub-areas when there are multiple areas of the same kind of habitat located at different parts of the study area and there are factors that will have a different effect on the quality of these different habitats. A schematic overview on how to divide the study area into sub areas is shown in Figure 2.4.

3.2.2 Scope: Policy

When there are no relevant policy goals, the contribution to nature policy requirements will automatically be zero since the number for *expected ecology* is then multiplied by zero (i.e. the evaluation for nature policy). This is the case in the Fort Steurgat case study; all the areas in the region relevant for nature policies are located outside of the study area. However, the method can still provide insight in the expected ecology of different alternative construction designs without the valuation of nature policy purposes. This is shown in the case study of Fort Steurgat which is described in Appendix b.

3.2.3 Ecological connectivity

An important lesson that is learned from the ViA15 case is that it is important to set restriction to the connectivity analysis to prevent the analysis from becoming too time consuming. The first restriction is that expected ecological connectivity is measured for a maximum of two areas of the same habitat in the study area, instead of all the areas of the same habitat. Each of these areas can possibly form a connection for dispersal with surrounding areas and with each other. Setting these restrictions results in evaluations of connectivity to be performed the same way based on the same criteria independent from the number of habitats in the study area or surrounding the study area.

3.2.4 Outcome of the method

The method provides different values for the expected ecology based on the expected effects on habitat quality and connectivity. The final outcome shows different contributions to nature policy requirements. It should be mentioned that the level of detail and difference that is to be expected between construction designs, is dependent on the grid-size of the analysis. The Expected Ecology and Contribution to Nature Policy goals are evaluated per habitat, it is important to separate expected effects on a habitat. In other words, when the habitat “Dry Meadow” occurs throughout the study area, but the effects on this habitat within the study area are likely to differ (for example due to different management, barriers or nature policy

goals) it is crucial to separate the effects by creating different sub-areas. This will greatly enhance the level of detail that the method is able to provide.
For each separate analysis choices on the study area need to be made. Due to the potential effects on the outcome, it is strongly advised to argue why certain study areas are decided upon in the scope of the analysis.

4 Discussion

In this chapter, the most important points of discussion are listed. The method has been assembled by combining elements from existing methods. This is because these existing methods already had components or ideas that were highly suitable for the purpose of our method. In Appendix e, these used methods are listed together with a description on how these methods have been used.
Furthermore, calculating the contribution to nature policy requirements requires taking into account a number of conditions and assumption that are part of the method. For example, some elements of the method contain certain assumptions since a prediction of a situation in the field is used.

4.1 Data Output

The output of the method provides a relative value, since the outcomes of the analysis of the alternative construction designs are compared to the reference situation (i.e. the study area without any interventions). Therefore, values should not be seen as an absolute figure that can be interpreted on a scale. Furthermore, the analysis takes place in a predetermined fixed study area. Therefore, the contribution to nature policy requirements cannot be compared with obtained values outside of the fixed study area. Even though the contribution to nature policy requirements is calculated relative to another construction design, when the study area is too small, effects on surrounding nature can be overlooked. As such, the determining the extent of a study area is crucial, since interpretation of the relative value will be done based on the expected effects in the area.

4.2 Expected Ecology

4.2.1 Non-nature

In the case studies, habitats within a study area have been characterized based on the descriptions of Nature Management Types of Portaal Natuur and Landschap. In this Dutch system, nature has been divided into 17 Nature Management types along with requirements for optimal development and characteristic species that should occur. There are maps available for the Netherlands where nature of the country has been classified into these Nature Management Types. As a result of these descriptions, there are also areas that cannot be classified under nature and are therefore referred to as non-nature in this method. This result in these areas to not be taken into account for their expected habitat quality, since there are no characteristic species qualified and no water- and environmental conditions specified for these areas. As a consequence, these areas have no added ecological value in the context of nature policy in this method. In reality, however, this is not the case, as nature targets are set for non-nature areas as well., e.g. breeding birds in grasslands. Non-nature, however, can also contribute to ecological connectivity, for example by facilitating dispersal through an area for certain groups of species. To overcome neglect of the areas that are qualified as non-nature, in the Dutch case studies, non-nature is characterized as that of the habitat type Grassland (with small water). This habitat type is chosen based on its open character, which is mostly the character of non-nature classified areas. Although this way non-nature is taken into account as much as possible, it could still result in an under- or overestimation of its ability to facilitate dispersal since non-nature could consist of many different elements such as buildings or grasslands. This needs to be taken into account when interpreting the outcome of the analyses. By looking at the amount of ‘non-nature’ in the study area as specified in the scope of the analysis relative to the entire study area, an estimation can be made on the relative bias in the overall output. The larger the total area of non-nature relative to the defined natural areas, the larger the potential error in the overall output. However, since the final outcome is a relative value, this error will likely be within the same range for different construction designs and will therefore as such not result in a large error in the contribution to nature policy requirements.

4.2.2 *Expected habitat quality*

The expected habitat quality is a prediction of the quality of habitats in the study area, based on several quality affecting factors. Thus, the certainty that the expected habitat quality resembles the actual situation is largely dependent on these quality affecting factors such as information about the abiotic conditions. All habitats are reviewed based on the same factors, the output for expected habitat quality should be sufficient to make proper comparisons between alternative construction designs. Future monitoring of presence of characteristic species after implementation could provide more certainty on whether the habitat quality is correctly predicted and it could provide validation data on the method.

Management and disturbance factors that can improve or deteriorate the expected habitat quality have not been specified by the habitat characterization system used in the Dutch case studies. However, since this is a factor that is crucial for the final expected ecology of a habitat, this element has been added to the analysis. As a result, all management and disturbance factors have been considered to be equally important, even though it is likely that different management factors will not affect the expected habitat quality equally. This point could potentially be overcome by expert judgement for the management effects, instead of a fixed value for each effect. The management options after construction needs to be taken into account in the analysis and it is advised to use expert judgement in this step over the fixed effect values.

4.2.3 *Reliability of expected ecological connectivity*

Scientific literature proposes several methods for determining the expected ecological connectivity of the landscape. These descriptions mention factors that influence ecological connectivity such as, distance, the matrix area between dispersal grounds, requirements of dispersing species and the role of barriers. These factors could be called the building blocks for establishing ecological connectivity.

Since the expected ecological connectivity analysis in this method takes into account all building blocks that play a role in facilitation of dispersal between habitats, the evaluation of it would explain the expected situation rather well. The outcome is a value of the degree to which a habitat facilitates dispersal between ecosystem types for groups of species with different requirements for dispersal. This is a relative value compared to the reference situation as well. Research shows that any connection, such as a corridor or a stepping stone, between two isolated nature areas results in an increase in expected ecological connectivity (Heinen & Merriam, 1990). The method tries to closely determine whether a potential connection is there based on a map and as such tries to approach the real situation as much as is possible on a map. Incorporation of the effects for barriers and disturbance further increases the effects that play a role in the actual situation, since it further defines whether a potential corridor on the map actually fulfils the requirements of a corridor. As such it verifies the determined ecological connectivity of a habitat to suit a natural situation. Thus, the relative value of expected ecological connectivity is considered to be a reliable value, however is as many other aspects of the method dependent on the information that is provided on the maps and on the construction designs.

4.2.4 *Evaluation for nature policy*

The evaluation for nature policy is the sum of positive and negative contributions to nature policy goals. Whether there is a positive or negative effect on nature policy goals is straightforward, since categories of nature policy goals are classified to a degree to which the method can provide answers. For example, loss of surface of a certain habitat is factual and construction of an eco-duct increases expected ecological connectivity by removal of a barrier. As such, the potential increased connectivity by creating a corridor could be taken into account with the method for the nature areas that it would connect. Furthermore, the method would take into account the added disturbance and barrier effects from the construction of a road and would therefore not only measure the benefits of a proposed method. However, since compensation and loss of habitats are bound to strict requirements and this method is less robust since it depends on the information that is provided in the map and not the monitoring of the actual area it is advised that in these cases a more extensive research and monitoring will be performed. The method could however serve as a first step in evaluating different construction options and their potential negative or compensating effects on the surrounding nature, based on the rules that have been described in this report.

Positive and negative effects are valued in the evaluation for nature policy. When determining the evaluation for nature policy, the assumption is made that all nature policy goals are equal in value. Thus, if a nature policy has many separate goals, the total value that can be obtained for that nature policy could be higher than for a nature policy that has less goals specified. Although for policymakers, one goal could weigh more than another; this is not taken into account in the method.

The degree to which these positive or negative effects will result in the realization of a nature policy goal cannot be predicted. Therefore, it should be taken into account that the evaluation for nature policy is a degree to which an alternative construction design contributes positively or negatively to achieving nature policy goals but does not ensure achievement of these goals. To determine whether goals are actually achieved, additional monitoring will be necessary.

5 Future use

The method that is described in this report is set up in such a way that different components can be easily adjusted, used separately or be given different input, to further fit the needs in different application areas. In this chapter a number of examples are described on how the method can be used or adjusted.

5.1 Nature policy goals

In the current method, two kinds of nature policies that are relevant in the Netherlands are used: Natura 2000 and the National Ecological Network. However, there are more nature policy goals that might be relevant. Examples of other Dutch nature policies that could be relevant are the Long-term Programme on Defragmentation (MJPO) and the European Water Framework Directive. Inclusion of such goals in the method could lead to further expansion of the use of the method and could create a more general tool to calculate and compare the added ecological value for nature policy in the planning phase of different projects.

5.2 Further optimization for coastal analyses

Analysis of expected ecological connectivity is based on requirements of characteristic species for dispersal. The descriptions in the Handbook Robuuste Verbindingen are based on inland species and are not suitable for the analysis of marine and coastal habitats. As a result, the method cannot readily be used to analyse these habitats and this is a limiting factor for the application of the method in the Netherlands. It could be overcome by creating a database of coastal ecosystem types and characteristic species for dispersal and their requirements.

5.3 Design improvement

In the future, the method could be further developed in order use it for the purpose of adjusting construction designs in such a way that the added value for nature policy increases. Adding an analysis step to the method could provide insight in where the best possibilities lay to increase the contribution to nature policy requirements. For example, the construction of an eco-duct could potentially result in a higher expected ecology within an intervention that has large negative effects on ecological connectivity.

5.4 Nature compensation

Alternative construction designs can result in negative effects on nature, such as loss of valuable habitat. In the Netherlands, negative effects of alternative construction designs on nature require nature compensation (Ministerie van Infrastructuur en Milieu). Nature compensation could be achieved by improvement of habitat quality or by acquiring new areas where nature can be realized. In order to determine whether the compensation measure sufficiently compensates the nature that has been deteriorated, it is necessary to calculate the value of both the nature area that has been affected and the nature area that will be created or improved.

The expected ecology of both the affected nature and the compensation measure can be calculated by taking using only the expected ecology element of the method. In that case, the reference situation will be the nature area before the negative effects of an alternative construction design and the comparison will be made with the compensation measure.

In addition to the expected ecology, the effect of required nature compensation in the context of nature policy goals could be also be, calculated using the entire framework of the method. This way the method could provide insight both on whether the nature compensation measure is sufficient or requires additional compensation, and what the effect of nature compensation is on nature policy goals.

5.5 Reproducibility

The outcome of this method could be considered as an indication of the future ecological state of an area, based on boundary conditions that are presently known such as (possible) construction designs and information on habitats located close to the study area. The more information that is known, the better and more reliable the outcome of the calculations could be. However, since the calculations are carried out during the planning phase of a project, it is only an indication and monitoring after construction is highly recommended to determine the real contribution of an infrastructural design to the ecological state of an area and to the nature policy requirements in that area.

5.6 Environmental effects studies

An *Environmental Impact Assessment (EIA)* (English term) or MER (in Dutch) is usually carried out to give a prediction on the different effects that a main or an alternative construction design could have on various aspects of the environment, such as water, soil, air quality and nature. The aspect of nature should be included in an Environmental Effects Report when severe effects on nature are expected. The Environmental Effect Report usually focusses on the general effects for Natura2000 areas, Dutch Flora and Fauna policies, and the National Ecological Network (Committee for Environmental Effect Reporting). For these areas the boundaries are described, for Natura2000 areas conservation goals are taken into account and for the Dutch National Ecological Network core qualities and traits are taken into account. In order to give a fixed structure to the nature section of the Environmental Effects Report this method could be used, but would need to be further extended since the level of detail is limited. An important remark is that in order to supply detailed information on the species level, monitoring would be necessary since this is not provided in this method. Since the focus of this method is not on species level but on the environmental conditions of habitats in which these species could be present and connectivity, this is only an estimation.

A short description on how the method could be used to give a fixed structure to the nature section of an environmental effects report is given below. First of all, the expected ecology of construction design alternatives relative to both the reference situation and the autonomous development situation could be calculated. Since there are fixed elements in this calculation, different Environmental Effect Reports use the same method to evaluate the aspect of nature resulting in a more uniform section of the reporting. In addition to the expected ecology of all nature in the study area, the policy based value could give insight in the effects on nature policy goals. This component of the method will likely mostly resemble the interpretation of the topic nature in the current Environmental Effect Reports.

Since the evaluation of nature policy and the expected ecology are evaluated separately in this method, the method could point out whether there are areas of nature with a high expected ecology that have not been appointed with any nature policy goals. Especially in Environmental effects studies, this could point out the importance of certain nature areas that have not yet been perceived as such. Alternatively, it could provide insight in which alternative construction design has the highest or lowest added ecological value for nature policy based on fixed elements. These are factors that could be interesting to evaluate when determining the effects for the environment based on the topic nature.

When considering using this method in the nature section of an Environmental Effects Report, it should be taken into account that other sections of the report such as the effects on water, soil and air (abiotic conditions and water dynamics) serve as an input for this method. Therefore, these subjects should be evaluated before the nature section can be evaluated. On the positive hand, integration with other topics of the report could result in the measurement of a fixed set of parameters that could be measured that can directly be used in this method.

5.7 International use

This method has been developed by looking at different cases in the Netherlands (Appendix b., c., and d.). As a result, habitats of the Netherlands and their description have been taken into account in these cases. In other countries there are different habitats and (slightly) different national nature policy requirements. However, the fundamentals of the expected ecology are equal among different countries. Therefore, the component of the expected ecology can be used abroad but requires to be developed to fit the input with respect to habitat descriptions and requirements of characteristic species for dispersal in the connectivity method.

The evaluation for nature policy would require adjustment as well when the method is used internationally. Since different countries have different nature policy goals, categorization of relevant nature policy goals would be a main task in this situation.

Thus, with further development of the method to fit the input of international descriptions of ecological parameters, the method could be used to calculate the contribution to nature policy requirements on an international scale.

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A Step-by-step overview of the method

In order to give an overview of the method, the added nature value is calculated for one habitat from sub-area 2 located in the Veluwe. Regional combination 1 (equal design in this area) will be evaluated. To this purpose, Table 3.1 is be used and filled out. The result is given in table 3.2The scope, expected habitat quality, expected ecological connectivity and nature policy are all filled out in separate tables due to space required for descriptions

A.1 Scope

The tables and figures that are used for the step-by-step manual described in chapter 3 are visualized below.

Table 6.1 Scope overview table

Figure 6.1 Road network in reference situation (Projectbureau ViA15, 2011)

Figure 6.2 Road network Extension North (DN) (Projectbueau ViA15, 2011)

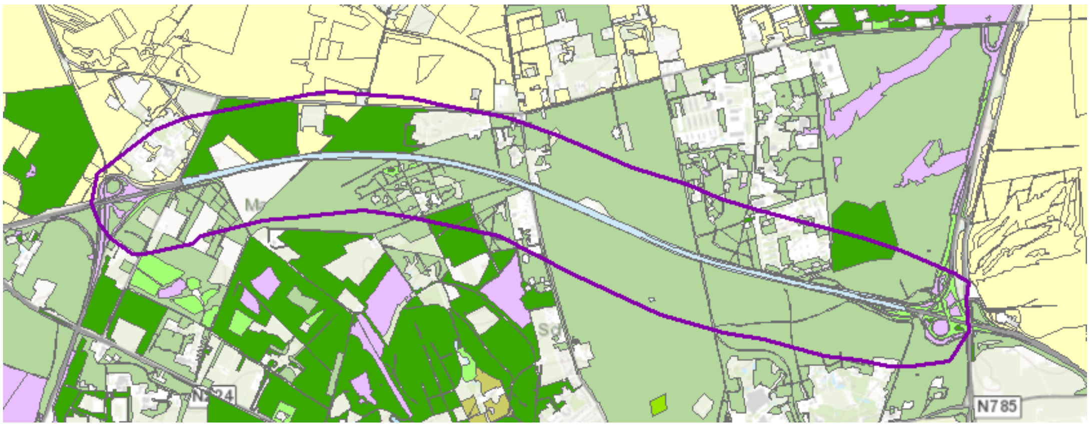

Figure 6.3 Study area (sub-area 4) with Regional combination 1 as the blue widened road and habitats according to Index NL nature management types illustrated.

Figure 6.4 National ecological Network (Papendal Schaarsbergen) and Natura 2000 area Veluwe in the study area (modified from Van de Leemkule, 2014)

Directive	Dutch name	Code	Goal
Habitat types	Meren met krabbenscheer en fonteinkruiden	H3159	Spread (=), Surf. (+), Quality (+)
	Beken en rivieren met waterplanten (grote fonteinkruiden)	H3260 (B)	Spread (=), Surf. (+), Quality (=)
	Slikkige rivieroevers	H3270	Spread (=), Surf. (+), Quality (+)
	Stroomdalgraslanden	H6120	Spread (=), Surf. (+), Quality (+)
	Ruigten en zomen (moerasspirea) (Droge bosranden)	H6430(A)(C)	Spread (=), Surf. (+), Quality (+)
	Glanshaver- en vossenstaarthooilanden (glanshaver) (grote vossenstaart)	H6510 (A)(B)	Spread (=), Surf. (+), Quality (+)
	Vochtige alluviale bossen (zachthoutooibossen) (essen-iepenbossen)	H91E0(A)(B)	Spread (=), Surf. (=), Quality (+)
	Droge hardhoutooibossen	H91F0	Spread (=), Surf. (+), Quality (+)
Habitat species	Zeeprik	H1095	Spread (=), Surf. (+), Quality (+)
	Rivierprik	H1099	Spread (=), Surf. (+), Quality (+)
	Elft	H1102	Spread (=), Surf. (=), Quality (=)
	Zalm	H1106	Spread (=), Surf. (=), Quality (=)
	Bittervoorn	H1134	Spread (=), Surf. (=), Quality (=)
	Grote modderkruiper	G1145	Spread (+), Surf. (+), Quality (+)
	Kleine modderkruiper	H1149	Spread (=), Surf. (=), Quality (=)
	Rivierdonderpad	H1163	Spread (=), Surf. (=), Quality (=)
	Kamsalamander	H1166	Spread (+), Surf. (+), Quality (+)
	Meervleermuis	H1218	Spread (=), Surf. (=), Quality (=)
	Bever	H1337	Spread (=), Surf. (=), Quality (+)
Bird species	Dodaars	A004	Spread (=), Surf. (=), Quality (=)
	Aalscholver	A017	Spread (=), Surf. (=), Quality (=)
	Roerdomp	A021	Surf. (+), Quality (+)
	Woudaap	A022	Surf. (+), Quality (+)
	Porseleinhoen	A0119	Surf. (+), Quality (+)
	Kwartelkoning	A122	Surf. (+), Quality (+)
	Kleine zwaan	A037	Surf. (=), Quality (=)
	Watersnip	A153	Surf. (=), Quality (=)
	Zwarte stern	A197	Surf. (+), Quality (+)
	Wilde zwaan	A038	Surf. (=), Quality (=)
	Brandgans	A045	Surf. (=), Quality (=)
	Nonnetje	A068	Surf. (=), Quality (=)
	Goudplevier	A140	Surf. (=), Quality (=)
	Kemphaan	A151	Surf. (=), Quality (=)
	Ijsvogel	A229	Surf. (=), Quality (=)
	Blauwborst	A272	Surf. (=), Quality (=)
	Dodaars	A004	Surf. (=), Quality (=)
	Fuut	A005	Surf. (=), Quality (=)
	Aalscholver	A017	Surf. (=), Quality (=)
	Toendrarietgans	A039	Surf. (=), Quality (=)
	Kolgans	A041	Surf. (=), Quality (=)
	Grauwe gans	A043	Surf. (=), Quality (=)
	Bergeend	A048	Surf. (=), Quality (=)
	Smient	A050	Surf. (=), Quality (=)
	Krakeend	A051	Surf. (=), Quality (=)
	Wintertaling	A052	Surf. (=), Quality (=)
	Wilde eend	A053	Surf. (=), Quality (=)
	Pijlstaart	A054	Surf. (=), Quality (=)
	Slobeend	A056	Surf. (=), Quality (=)
	Tafeleend	A059	Surf. (=), Quality (=)
	Kuifeend	A061	Surf. (=), Quality (=)
	Merkoet	A125	Surf. (=), Quality (=)
	Scholekster	A130	Surf. (=), Quality (=)
	Kievit	A142	Surf. (=), Quality (=)
	Grutto	A156	Surf. (=), Quality (=)
	Wulp	A160	Surf. (=), Quality (=)
	Tureluur	A162	Surf. (=), Quality (=)
	Oeverzwaluw	A249	Surf. (=), Quality (=)
	Grote karekiet	A298	Surf. (+), Quality (+)

Figure 6.5 Natura 2000 goals Veluwe. Surf. stands for surface. '=' means keep the same, '+' means an increase is required, '-' means is a decrease is required (modified from Ministry of Economics).

Gebiedsnaam	Papendal - Schaarsbergen
kernkwaliteiten deelgebied natuur en landschap	• Bos en heideontginningen in de stadsrand van Arnhem en Oosterbeek met allerlei instellingen van klooster tot kazerne, en doorsneden door snelwegen en andere infrastructuur • onderdeel van Nationaal Landschap Veluwe • gave geomorfologie van het vanggebied van de Wolfhezer Beek: droogdal achter de stuwwal van Arnhem • leefgebied das • cultuurhistorische waarden van de landgoederen, oude ontginningen en kavelpatronen, hakhout, houtwallen, singels, sprengen en beken en boerderijen • abiotiek: aardkundige waarden, kwel, bodem, grondwaterreservoir • ecosysteemdiensten: recreatie, drinkwater
aardkundige waarden	+: Stuwwal van Zuidoost-Veluwe; Sandr van Wolfheze; Heelsumse Beek
waardevol open gebied of verkaveling	-
parel	-
natte landnatuur	-
ontwikkelingsdoelen natuur en landschap GNN (omvorming, natuurontwikkeling)	• ontwikkeling en handhaven bos- en natuurrijk karakter en samenhang, waar onder heiderestanten • vermindering barrièrewerking A12, A50, N224, N310, N311, N783, N785, N803 en spoorlijn • ontwikkeling bosranden en overgangen naar cultuurgronden • ontwikkeling biotopen voor vlinders, reptielen en amfibieën • ontwikkeling landgoederen en hun cultuurhistorische patronen • ontwikkeling overige cultuurhistorische patronen en beheersvormen
ontwikkelingsdoelen natuur en landschap Groene Ontwikkelingszone	• ontwikkeling en handhaven bos- en natuurrijk karakter en samenhang in het bijzonder van de ontginningen: singels, ruigteranden en bosranden en -zomen • vermindering barrièrewerking A12, A50, N224, N310, N311, N783, N785, N803 en spoorlijn • ontwikkeling bosranden en overgangen naar cultuurgronden • ontwikkeling biotopen voor vlinders, reptielen en amfibieën • ontwikkeling landgoederen en hun cultuurhistorische patronen • ontwikkeling overige cultuurhistorische patronen en beheersvormen

Figure 6.6 Area specific goals for National Ecological Network Papendal Schaardsbergen

Habitat	**Current situation**	**Regional combination 1**
	Surface (ha)	Surface (ha)
Non-nature	157,7	167,9
Dry forest with production	426,5	419,6
Pine-, Oak, and Beech forest	78,6	78,1
Dry meadow	12,2	12,2
Herb- and fauna rich grassland	47,9	45,1
Sand and limestone landscape	27,7	27,7

Table 6.2 Habitats in sub-area 3 for reference situation and Regional combination

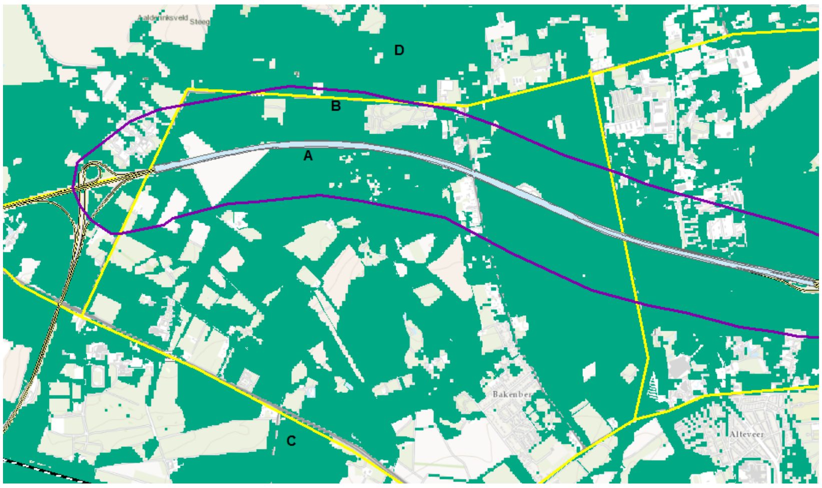

Figure 6.7 Habitat area dry forest with production (based on ecotopes and nature management type maps). Letters (A and B) illustrate largest areas in the study area and similar habitat in the region (outside of study area C and D). Yellow lines show road barriers. The purple line is the boundary of the study area.

Habitat	Nitrogen deposition boundaries			Required pH			Required groundwater level			Required nutrient level		
qualification	good	average	poor	good	average	poor	good	average	poor	good	average	poor
Dry forest with production	<1420	1420-2060	>2060	-			-			-	-	-

Table 6.3 Abiotic requirements based on Portaal Natuur en Landschap and Taakgroep Natuurkwaliteit en Monitoring SNL (2013).

Figure 6.8 Sound contours in 2028 with autonomous development of Regional combination 1 without sound reducing measures(green) and with reducing measures. (modified from Projectbureau ViA15, 2011)

Figure 6.9 Location of sound reducing asphalt (modified from Projectbureau ViA15, 2011)

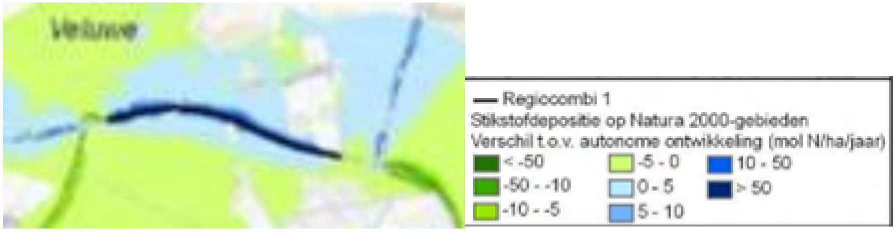

Figure 6.10 Nitrogen deposition in Regional combination 1 compared to the reference situation in Natura 2000 areas (modified from Projectbureau ViA15, 2011)

Dry forest with production (N16.01)	**Breeding birds (based on SOVON)**
	appelvink
	boomklever
	boomleeuwerik
	fluiter
	geelgors
	groene specht
	keep
	kleine bonte specht
	middelste bonte specht
	raaf
	sijs
	vuurgoudhaan
	wespendief
	wielewaal
	zwarte specht
	73.3 % -> 0.73

Table 6.4 Characteristic species of habitat Dry forest with production ((Portaal Natuur en Landschap)). Presence is judged based on observations and present data on occurrence (SOVON), green means present, grey means not present.

	Water and evironmental conditions by Taakgroep Natuurkwaliteit en Monitoring SNL (2013)				Disturbances and management effects			Expected habitat quality
Condition/ factor	Nitrogen deposition			**Average**	Noise	Pollution	**Total**	
Measure + habitats	1	0.5	0		-0.25	-0.25	**min 0 max 1**	
Reference situation								
Dry forest with production			X	0	-		-0.25	0
Regional combination 1								
Dry forest with production			X	0	no additional		0	0

Table 6.5 calculating Expected habitat quality based on required conditions specified by Taakgroep Natuurkwaliteit en Monitoring SNL (2013) and additional disturbance or management effect in this area.

	Ecosystem type / **Habitat**	Forest of poor and rich sandy soils
N16.01	Dry forest with production	x

Table 6.6 Converting habitats (Portaal Natuur en Landschap) to ecosystem types (Broekmeyer et al, 2001) based on Index Natuur en Landschap (2009).

Ecoprofiel Forest of poor and rich sandy soils – habitat Dry forest with production.	Area key area (ha)	Area stepping stone (ha)	breedte corridor (m)	Requirements corridor	Max interruption corridor (m)	Distance key areas (km)	Barriers
Boomklever	56	5,5	-	-	-	11	-
Boommarter	3000	300	100	Bos, struweel, houtwal	100	30	Waterweg steile randen, spoorlijnen, wegen
Bosparelmoervlinder	5	1	25	Bos, struweel, houtwal, droge ruigte	50	2	Wegen
Edelhert	3000	300	1000	Struweel, droge ruigte, bos, heide	100	50	Waterweg steile randen, spoorlijnen, wegen
Eekhoorn	56	5,5	25	Bos	50	5	Waterweg met steile randen, wegen
Glanskop	300	30	-	-	-	11	-
Groene specht	750	75	-	-	-	20	-
Grote weerschijnvlinder	56	5,5	25	Struweel, bos, houtwal	50	2	wegen
Hazelworm	56	5,5	25	Droge ruigte, struweel, bos	50	2	Waterweg steile randen, spoorlijnen, wegen
Keizersmantel	56	5,5	-	-	-	5	Wegen
Goede verspreider planten	5	1	-	-	-	11	-
Matige verspreider planten	5	1	-	-	-	2	-
Redelijk goede verspreider planten	5	1	-	-	-	5	-
Slechte verspreider planten	5	1	100	Leefgebied	0	0,5	-

Table 6.7 List of characteristic species of Dry forest with production and their requirements for dispersal. Green coloured are requirements that are met, orange are barriers to dispersal and red are requirements that prevent dispersal in the study area. Based on (Broekmeyer et al, 2001) and measurements in map of the study area.

	Surface (ha)	Distance to A (m)	Distance to B (m)	Distance to C (m)	Distance to D (m)
Area A	±725	-	34	40	
Area B	+800	34	-	-	34
Area C	±200	40	-	-	
Area D	+800	-	34	-	-

Table 6.8 Surface area of Dry forest with production and distances to habitats that qualify for dispersal (based on map of study area with habitats)

	Qualification	number of species groups	Overall
Dispersal is limited by distance or surface	0	1	0
dispersal is limited by barriers	0,5	7	3,5
dispersal is limited by distance or surface	1	6	6
Average connectivity			0,68

Table 6.9 Calculating connectivity based on map Figure 6.7, Table 6.8 and Table 6.7.

Natura 2000 area	Natura 2000 category	Regional combination 1 and 2 effect	National Ecological Network area	Core qualities and goals National Ecological Network	Regional combination 1 and 2 effect
Veluwe	Habitat types	-2	Papendal schaarsbergen	n.a.	n.a.
	Habitat species	0			
	Breeding birds	0			
	Non-breeding birds	0			
	Ecological coherence	0			
Total value Natura 2000		-2	Total value National Ecological Network		0

Table 6.10 Overview of nature policy goals with categories for qualification and potential effects based on detailed goal requirements Figure 6.6 and Figure 6.5 and expected habitat quality and connectivity effects from previous steps.

B Case study Fort Steurgat

B.1 Scope Fort Steurgat

B.1.1 Region

Fort Steurgat is situated in the North-West of the province Brabant, West of the town Werkendam. The location of the planned dike measures to protect Fort Steurgat against high water levels, lays North-East of the area the Noordwaard. The project area is part of the New Dutch Waterline (Nieuwe Hollandse Waterlinie) and borders with the area Noordwaard, the river Nieuwe Merwede and a creek that connects the fort with the nature area Biesbosch (Figure 1.2). Other large waters in the area are Hollands diep, the Waal and the Bergse Maas.

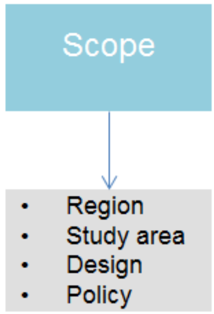

Figure 1.1 Overview of the Scope and its components

The project area is surrounded by large the Natura2000 area the Biesbosch and surrounding waters are part of the National Ecological (Ministry of Economic Affairs). Important habitats for this area are humid alluvial forests, muddy riverbanks and brushwood and hems.

Important species that have been specified for the area are for example the beaver Castor fiber and the vole Microtus oeconomus. Additionally, the area is important for many breeding birds and birds that rely on the presence of water (Ministry of Economic Affairs).

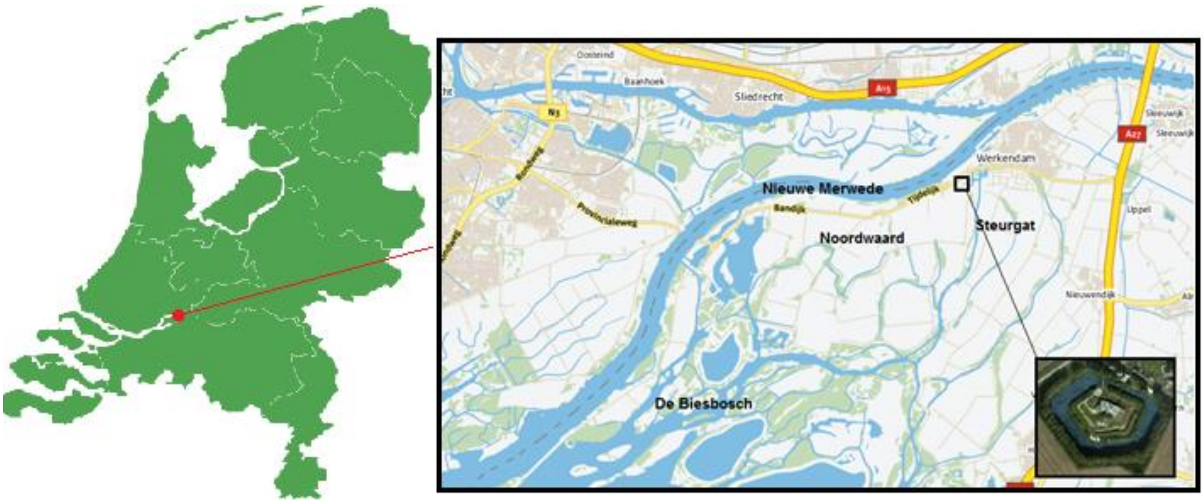

Figure 1.2 Overview of the location of the project area in the Netherlands and the exact location of Fort Steurgat in the region.

B.2 Design

Habitats have been classified according to the Dutch system Index Nature Landscape (Portaal Natuur en Landschap).

B.2.1 Reference situation: situation without interventions

The reference situation without interventions is described as the situation before the depoldering of the Noordwaard area when no dike was necessary. The new dike will be placed around the little wall of trees that is currently placed around the canal surrounding Fort Steurgat. In the current situation there is agricultural landscape at the location of the planned dike (expert judgement) (figure 1.3). Since agricultural land cannot be classified as nature according to Portaal Natuur en Landschap, the land is classified as 'non-nature'.

Figure 2.1 Overview of the current situation of Fort Steurgat
(Source: E. Noteboom from De Vries & Dekker, 2009).

B.2.2 Construction alternative 1: conventional measure

The conventional measure is the construction of a solid dike with a height of 5.5 meter above Amsterdam Ordnance Datum (Dutch: Normaal Amsterdams Peil). Inside of the dike there will be a mild slope that will look like ascending grassland to the inhabitants of the fort. Outside of the dike will be a regular steep slope with grass (figure 1.4) (De Vries & Dekker, 2009). The dike will be built with a core of sand followed by an erosion resistant clay layer of 1 meter. It will be coated with a grass layer and a large footpath of asphalt will be placed on top. The grass dike could be grazed by sheep or could be maintained as a hay land. Habitats of the dike are grassland (4.8 ha) and stone grounds (1 ha) (De Vries & Dekker, 2009). The asphalt road will be referred to as non-nature. The grassland will be classified as Flower Dike (Portaal Natuur en Landschap).

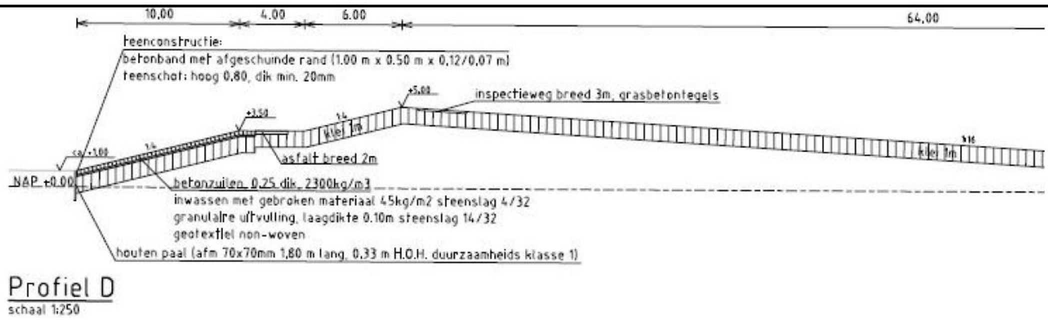

Figure 2.2 Schematic cross-section of a conventional measure (De Vries & Dekker, 2009).

B.2.3 Construction alternative 2: Eco-engineering measure

The construction of a lower the dike has been suggested (De Vries & Dekker, 2009). The dike has a planned height of 4.5 meter above Amsterdam Ordnance Datum (figure 1.5). Inside of the dike there will be a mild slope of ascending grassland. The dike will be grazed by cattle. Outside of the dike there will be a small trench, followed by an increased level (+1.5 meter above Amsterdam Ordnance Datum) with a strip of willow forest consisting of *Salix alba* and *Salix viminalis*. This willow forest will be 80 meters wide at the widest point and 60 meters wide at the smallest point (figure 1.5). 70 meters has been set as the average width of the willow forest. The surface of this willow forest will be approximately 5 ha of quite densely vegetated willow forest. The forest will be mowed every 2 years (De Vries & Dekker, 2009).
The habitat of the willow forest belongs to the Nature Management Type River- and brook accompanying forest (Portaal Natuur en Landschap). The grassland on the dike is classified as the Nature Management type Flower Dike (Portaal Natuur en Landschap).

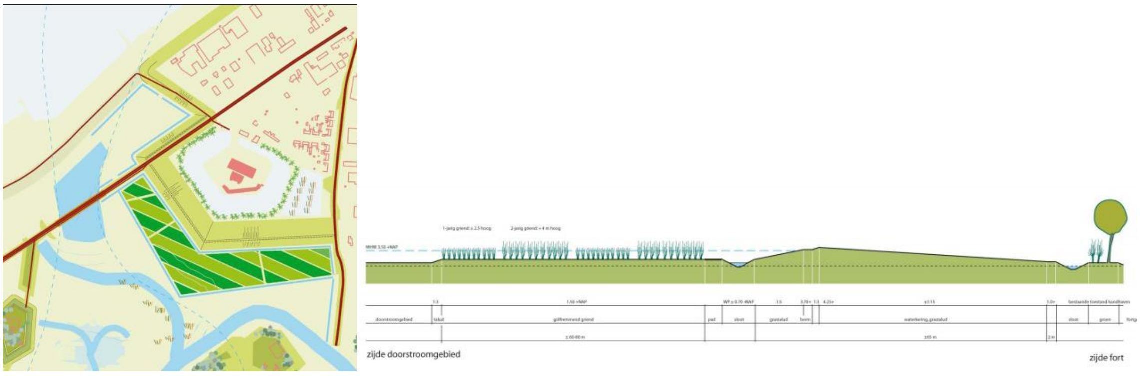

Figure 2.3 On the left, an overview of the location of the eco-engineering measure at Fort Steurgat. The striped block represents the willow forest; the light green strip represents the dike. On the right, a schematic cross-section of the eco-engineering measure (De Vries & Dekker, 2009).

B.3 Study area

There are no diffusing effects of any of the measures; the study area is therefore based on the largest extent of a measure: the eco-engineering measure. An overview of the different measures and their corresponding habitats and surface area is illustrated in table 1.1. An overview of the region and the study area is given in figure 1.6.

Measure	Habitat	Surface (ha)
reference situation	Non-nature	9.0
Conventional dam	Herb- and fauna rich grassland	2.7
	Flower dike	4.8
	Non-nature	1.5
Eco-engineering solution	River- and brook accompanying forest	4.0
	Flower dike	5.0

Table 3.1 Description of the study area for different measures around Fort Steurgat with their corresponding habitats and surface area.

Figure 3.1 Overview of the region with its Habitats and the study area in the North West, outlined in black. The interior of the study area has been drawn; however this is classified as non-nature in the current situation.

B.4 Policy

The study area is not part of National Ecological Network areas (figure 1.7) or Natura 2000 area (figure 1.8).

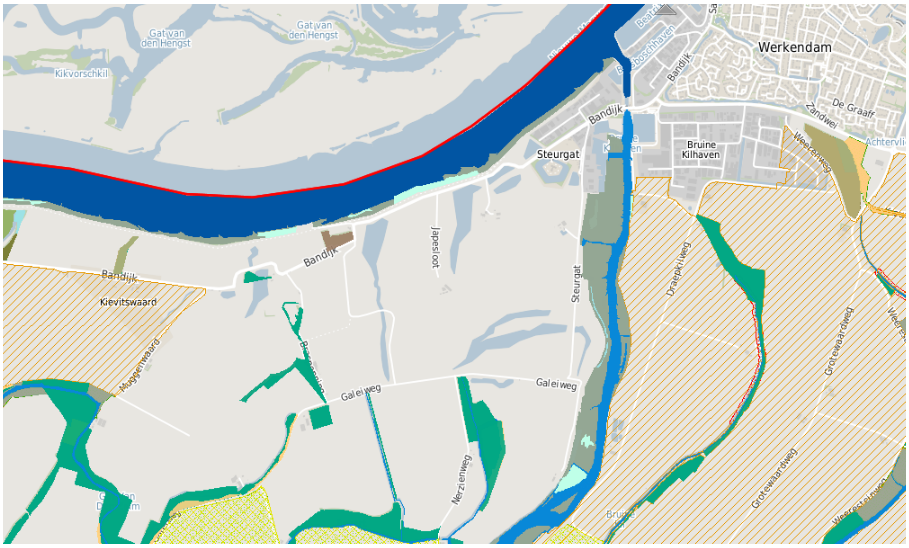

Figure 4.1 Areas belonging to the National Ecological Network around the study area and striped ambition areas Provincie Noord-Brabant, 2014).

Figure 4.2 Overview of Natura2000 areas in the region, and Fort Steurgat in the centre (Ministry of Economic Affairs, 2013).

B.5 Expected ecology

The output of the expected ecology is shown in table 2.1. Chapter 2.1 and chapter 2.2 give more insight in how these values have been established.

Scope	Expected ecology (ha^{-1})				
Measure	Expected habitat quality (ha^{-1})	Expected ecological connectivity (ha^{-1})	Relative value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Absolute value ↓↓↓↓
Conventional measure	0.33	0.48	0.2	0.25	0.51
Eco-engineering measure	0.39	0.40	0.19	0.19	0.40

Table 5.1 Overview of the expected ecology of both measures relative to the reference situation, based on expected habitat quality and expected ecological connectivity

B.5.1 Expected habitat quality

The output of the expected habitat quality is shown in table 5.3.

B.5.1.1 Abiotic conditions

For each habitat in the area, the expected habitat quality is determined based on the requirements of water- and environmental conditions for optimal quality, as described by Ommering (2010). Planbureau Noordwaard has performed and Environmental Effects Study on the current abiotic conditions in the area of the Noordwaard (Planbureau Noordwaard, 2010). Furthermore, certain assumptions on water dynamics must be made since these are not explicitly stated in the Environmental Effects Report. Assumptions need to be verified with expert judgement in order to give a proper qualification for the expected habitat quality of the habitat.

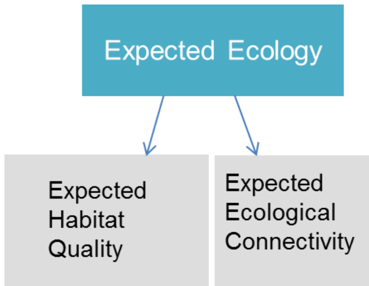

Figure 5.1 Overview of the Expected ecology with its components

In the reference situation there is only non-nature in the area (table 1.1). This area cannot obtain an expected ecology higher than 0. A summary of the expected ecology of each habitat based on the effects of different measures on abiotic conditions and water dynamics plus disturbances and management effects is summarized in table 2.2.

		Abiotic conditions and water dynamics													Disturbances and management effects			
Measure	Condtion	Nitrogen deposition			Groundwater level			Water dynamics			Nutrient level			Average	Nutrients/ fertilization	Grazing/ mowing	Vegetation management	Total
	Factor	1	0.5	0	1	0.5	0	1	0.5	0	1	0.5	0		0.25		0.25	
Conventional measure	Flower dike		?			?			?			?		0.5	-	-		0
	Herb- and fauna rich grassland		?			?			?			?		0.5			+/- ?	0.5
Eco-engineering measure	Flower dike		?			?			?			?		0.5	-	-		0
	River- and brook accompanying forest	x			x?			x			x			1.0		-	-	0.5

Table 5.2 Expected ecology of habitats of different alternative construction designs based on Abiotic conditions and water management, and effects of disturbances and management

B.5.1.2 *Presence of characteristic species*

The presence of characteristic species in the region is determined by looking at distribution atlases (Floron, 2014; Vlindernet, 2014, Sovon. Based on these atlases and described characteristic species for each habitat by Ommering (2010).

Scope	Expected habitat quality (ha^{-1})				
Measure	Abiotic conditions, management and disturbance (ha^{-1})	Presence of characteristic species in the region (ha^{-1})	Relative value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Absolute value ↓↓↓↓
Conventional measure	0.15	0.52	0.33	0.40	0.33
Eco-engineering measure	0.22	0.55	0.39	0.39	0.39

Table 5.3 Expected habitat quality of different measures relative to the reference situation

B.6 Expected ecological connectivity

An overview of ecosystem types to which habitats of different measures belong, is provided in table 2.4. Ecosystem types have been illustrated in maps created in ArcGis. Maps of Nature Management Types and a general map of nature in the Netherlands (CBS et al, 2013; Kramer et al, 2007) have been used. For each measure, expected ecological connectivity is analyzed based on dispersal requirements of groups of species belonging to the ecosystem type (Broekmeyer et al, 2001). The output of expected ecological connectivity is shown in table 2.5.

Measure	Habitat	Surface (ha)	Ecosystem type	
			Forest, thicket and border vegetation on clay (with large water)	Grassland (with small water)
Reference situation	Non-nature	9.0	-	x
Conventional measure	Herb- and fauna rich grassland	2.7	-	x
	Flower Dike	4.8	-	x
	Non-nature	1.5	-	-
Eco-engineering measure	River- and brook accompanying forest	4.0	x	-
	Flower Dike	5.0	-	x

Table 6.1 Overview of ecosystem types to which the habitats of different measures belong

Measure	Expected ecological connectivity (ha^{-1})		
	Relative value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Absolute value ↓↓↓↓
Conventional measure	0.09	0.09	0.51
Eco-engineering measure	-0.02	-0.02	0.40

Table 6.2 Expected ecological connectivity in different measures relative to the reference situation and the absolute value.

B.7 Nature policy goals

There are no nature policy goals in the study area, as was described in chapter 1.4. Thus, the different measures do not contribute to nature policy goals either positively or negatively.
The policy based value is therefore zero.

Scope	Policy based value (∑)		
Measure	Natura 2000 value	National Ecological Network value	↓↓↓↓
Conservative measure	0	0	0
Eco-engineering measure	0	0	0

Table 7.1: Policy based value

B.8 Added ecological value for nature policy

The added ecological value for nature policy is calculated with the formula displayed in figure 4.1. An overview of the values of different components, leading to the calculation of the policy based value is shown in table 4.1. There is no overview of the relative value based in hectares of nature or the absolute value, since they are all zero due to the lack of policy based value.

Expected Ecology X Evaluation for nature policy = Constribution to nature policy requirements

Figure 8.1 Formula to calculate the added ecological value for nature policy

Scope	Expected ecology (ha^{-1})			Evaluation for nature policy (∑)			Added ecological value for nature policy (ha^{-1})
Measure	Expected Habitat Quality (ha^{-1})	Expected ecological connectivity (ha^{-1})	Relative value ↓↓↓↓	National Ecological Network	Natura 2000	Relative value ↓↓↓↓	
Conservative measure	0.33	0.48	0.2	0	0	0	0,00
Eco-engineering measure	0.39	0.40	0.19	0	0	0	0,00

Table 8.1 Overview of the Added ecological value for nature policy relative to the current measure.

C Complex case ViA15

C.1 Scope ViA 15

C.1.1 Region

The study area is situated in the province of Gelderland, in the region Arnhem – Nijmegen (figure 1.1). The road network A12, A15 and A50 surround the cities of Arnhem, Zevenaar, Valburg, Ressen and Duiven. The study area is crossed by the railway route ‘Betuwelijn’.
Large waterways in the region are the Neder-Rijn, the Waal and the Pannerdensch Channel. Significant nature areas lie in the study area, such as National Park and Natura2000 area the Veluwe and Natura 2000 area Rijntakken. Furthermore, parts of the study area belong to the the National Ecological Network. Habitats of the Veluwe include dry and wet meadow, dry forests, fens and drift-sand. The Veluwe offers a habitat for several large mammals such as red deer and wild boar (Ministry of Economic Affairs). Natura2000 area the Rijntakken consists of 4 parts, 3 of which are included in the study area: Gelderse Poort, Uiterwaarden Ijssel and Uiterwaarden Rijn. The Gelderse Poort continues all the way across the German border. Grasslands, fields, swamps and open water are among important habitats. The Pannerdensch Channel waterway is situated central in the Gelderse Poort (Ministry of Economic Affairs).

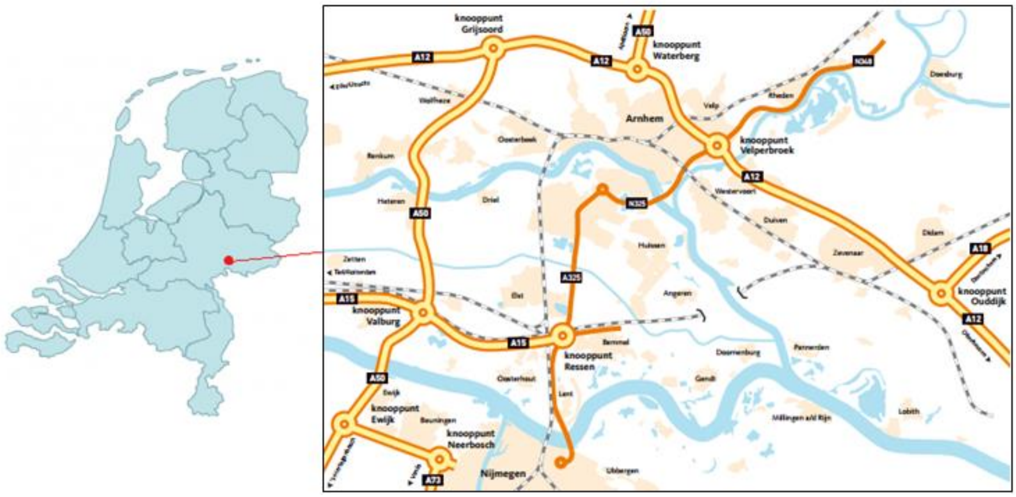

Figure 1.1 Overview of the location of the measures in the Netherlands (modified from: Projectbureau ViA15, 2011)

C.1.2 Design

Habitats will be classified according to the Dutch system Index Nature Landscape (Portaal Natuur en Landschap). Interventions that have been planned to improve the design of different measures such as the placement of noise and fine particles reducing asphalt or sound screens have been taken into account. They will not further be described in the report and further information on the type of interventions and locations can be found in Environmental effect reports of the ViA15 project (Projectbureau ViA15, 2011).

C.1.2.1 *Reference situation: situation without interventions*

The reference situation of the road network surrounding Arnhem is illustrated in figure 1.2. Natura2000 area the Veluwe is currently crossed by the road A12 and A15. Furthermore, the roads A12 and A325 cross the National Ecological Network at several locations. In the reference situation, the railroad Betuweroute crosses the area and the Pannerdensch Channel.

An overview of all habitats of the different measures and the current situation are illustrated in table 1.1. Furthermore, the study area consists of large areas that are other than nature which are classified as non-nature.

Figure 1.2 Overview of the reference situation (Projectbureau ViA15, 2011)

C.1.2.2 *Extension measures: Extension North, Extension South, Joint Extension*

In these measures, the A15 will be extended in different ways (figure 1.2). Furthermore, the existing highway A15 between Valburg and Ressen will be widened at both sides of the current road. Additionally the A12 will be widened between Duiven and Oud-Dijk. Dimensions and locations of the road have been taken into account and are based on descriptions by Projectbureau ViA15 (2011).

In Extension North, the extension of the A15 will cross the railroad Betuweroute around Bemmel and continues to the North of this road. All extension measures will cross the Pannerdensch Channel with a bridge. Extension South resembles Extension North. However, it differs in the fact that the route will follow the railway route Betuweroute on the Southern side. The Joint extension differs from Extension North and South in the tracing from Bemmel until the A12. It will cross the Pannerdensch Channel with a bridge like in Extension North. However, the tracing will follow join the current route of the railway route Betuwelijn until Babberich. After Babberich it extends towards the A12 at Oud-Dijk.

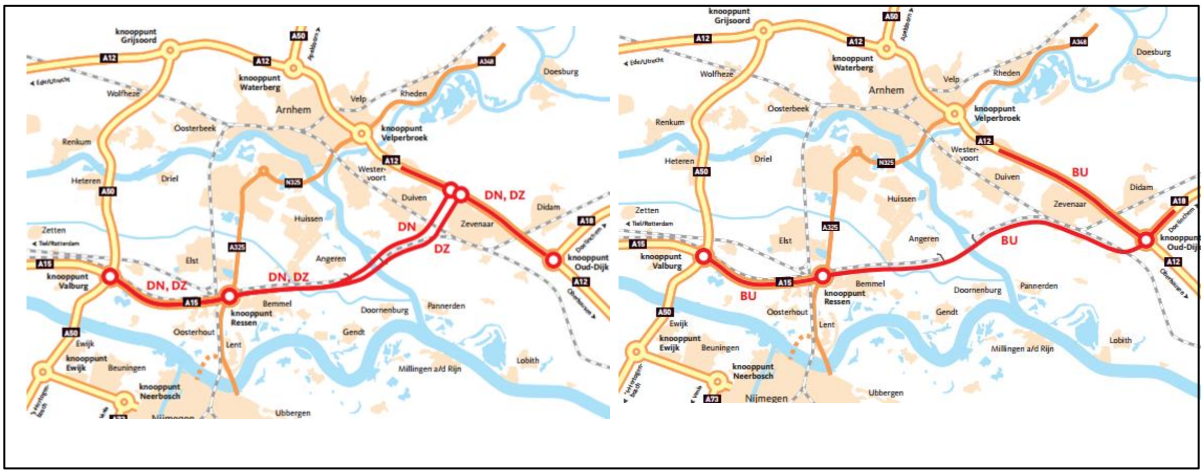

Figure 1.3 The location of Extension North (DN) and Extension South (DZ) on the left. Location of the Joint Extension (BU) is shown on the right (Projectbureau ViA15, 2011).

C.1.2.3 *Regional combination measures: Regional combination 1 and Regional combination 2*

These measures do not include an extension of the current A15 (figure 1.3). Instead there will be a widening of a number of current roads of the network to increase carrying capacity. The Regional combination 1 is a more extensive measure than Regional combination 2.

In both measures for the current A12 between Grijsoord and Waterberg a lane will be added in both directions. Similar to the extension measures, there will be a widening of the A12 between Duiven and Oud-Dijk.

For only Regional combination 1 there will be additional measures at the A50 between Heteren and Renkum in the form of widening of the current highway.

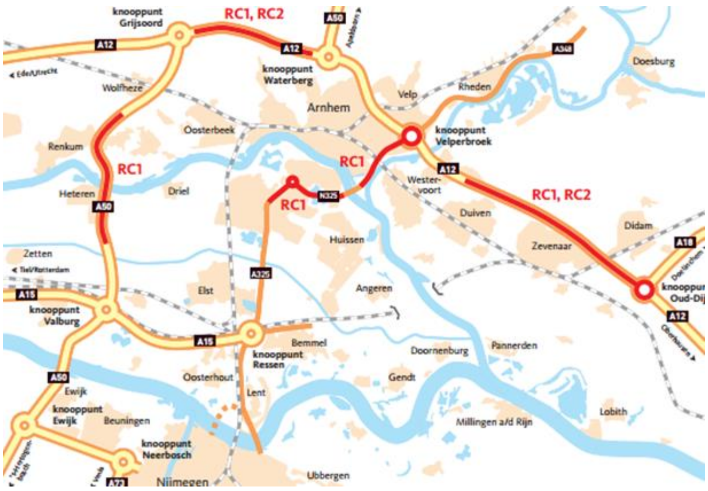

Figure 1.3 The location of Regional combination 1 and Regional combination 2. (Projectbureau ViA15, 2011).

Additionally, levels will be added to the Pleiroute N325, which does not affect the surface area of the study area.

Figure 1.3 Locations of the Regional combination measures. RC1 stands for Regional combination 1, RC2 stands for Regional combination 2 (Projectbureau ViA15, 2011).

C.1.3 Study area

The study area has been defined within a distance of 500 meters from the planned road alteration sections, due to known effects on breeding birds within this distance (Reijnen et al, 1997). The entire study area consists of 7569 ha, of which 1242 ha is defined as habitat in the current situation. Habitats of different measures are shown in table 1.1.

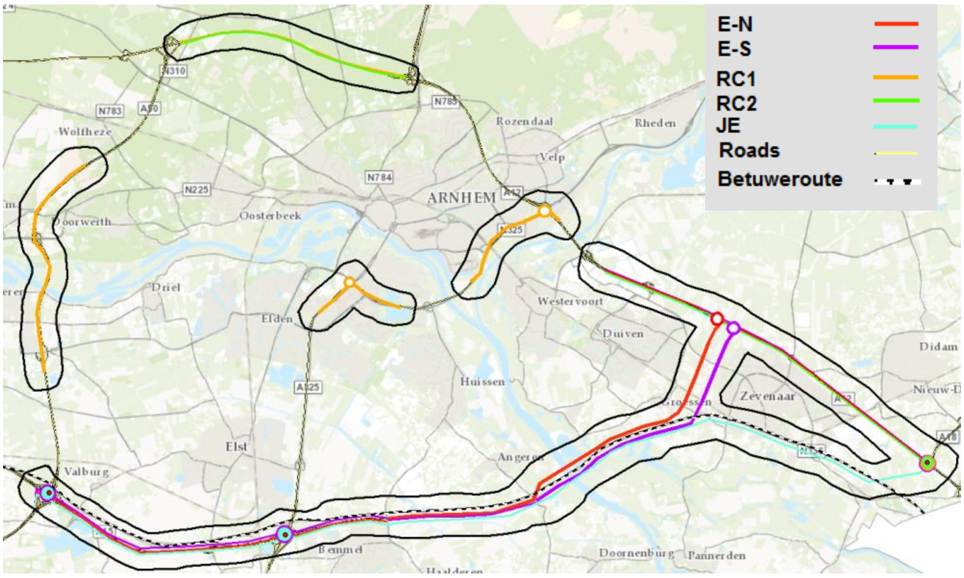

Figure 1.4 Overview of the study area. Measures are illustrated with different colours. 500 meter distance from the location of the measure has been chosen as the effect distance of the study area.

Habitat	**Current situation**	**Extension North and South**	**Joint extension**	**Region combination 1**	**Region combination 2**
	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)
Non-nature	6327	6329	6328	6369	6357
Dry forest with production	495	494	495	470	473
River and swamp landscape	207	207	207	207	207
Dry meadow	111	111	111	106	111
Pine-, Oak, and Beech forest	110	110	110	105	108
River	78	78	78	78	78
Fresh water lake	50	50	50	50	50
Herb- and fauna rich grassland	41	41	41	34	35
River- and brook accompanying forest	35	35	35	35	35
Sand and limestone landscape	32	32	32	32	32
Glanshaverhooiland	25	25	25	25	25
Hornbeam and Ash forest	20	19	19	20	20
Swamp	13	13	13	13	13
Humid forest with production	8	8	8	8	8
Herbs and fauna rich field	7	7	7	7	7
Wet arid land	6	6	6	6	6
Saline- and overflowing grassland	2	2	2	2	2
Park- en stinzen forest	2	2	2	2	2

Table 1.1 Overview of classification of different habitats and their total surface area in each measure

C.1.4 Policy

The measure will interact with several Natura 2000 and National Ecological Network locations. An overview of Natura 2000 and the National Ecological Network boundaries is given in figure 1.5.

Figure 1.5 Overview of the study area with boundaries of the Natura2000 area and the National Ecological Network (defined as EHS in the map). National Ecological Network areas are Gelderse Poort Noord, Overbetuwe, Papendal Schaarsbergen and Uiterwaarden Neder-Rijn Uiterwaarden Neder-Rijn Arnhem – Heteren (blue). Natura2000 areas are the Veluwe and Gelderse Poort (black). (Projectbureau ViA15, 2011a; Van de Leemkule, 2014)

C.1.4.1 *National ecological Network*

There are several areas of the National Ecological Network in the study area: Overbetuwe, Uiterwaarden Neder-Rijn Arnhem – Heteren, Gelderse Poort Noord and Papendal Schaarsbergen (figure 1.5) (Van de Leemkule, 2014). National goals of the National Ecological Network are connecting existing nature and improving quality of the network. Goals for the National Ecological Network are defined in the policy goals of the province of Gelderland and will be further discussed in chapter 3.

C.1.4.2 *Natura 2000*

Natura2000 area the Veluwe is located North of Arnhem (figure 1.5). Furthermore, as a part of the Natura2000 area, the Gelderse Poort lies centered in the study area and the Uiterwaarden Ijssel and and Uiterwaarden Neder-Rijn are located in the edges of the study area. Specific goals are described by the European Bird and Habitat directives (Ministry of Economic Affairs), and will be further discussed in chapter 3.

C.2 Expected ecology

he output of the expected ecology is shown in table 2.1. A further description of the components that make up this value is provided in chapter 2.1 and 2.2.

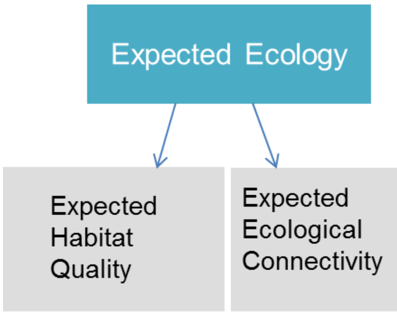

Figure 2.1 Overview of the Expected ecology with its components

Table 2.1 Overview of the expected ecology (ha^{-1}), relative to the reference situation and based on the components shown in figure 2.1.

Scope	Expected ecology (ha^{-1})				
Measure	Expected habitat quality (ha^{-1})	Expected ecological connectivity (ha^{-1})	Absolute value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Relative value ↓↓↓↓
Extension North	0,073	0,47	0,271	-0,043	-0,001
Extension South	0,073	0,47	0,271	-0,043	-0,001
Joint Extension	0,073	0,47	0,271	-0,044	-0,001
Regional combination 1	0,062	0,47	0,266	0,020	-0,006
Regional combination 2	0,067	0,47	0,269	0,015	-0,003

C.2.1 Expected habitat quality

The output of the expected habitat quality is shown in table 2.3. Calculation of the elements is described shortly in 2.1.1 and 2.1.2.

C.2.1.1 Abiotic conditions

For each habitat in the area, the expected habitat quality is determined based on the requirements of water- and environmental conditions for optimal quality, as described by Ommering (2010). Data on abiotic conditions and water dynamics are based on the Environmental Effect Reports (Projectbureau ViA15, 2011). The analysis of all different habitats in the area is not described in this report due to the multitude of the habitats and the size of the area. However, an overview of the outcome is provided in table 2.2.

C.2.1.2 Presence of characteristic species in the region

In this method, the presence of characteristic species in the region is determined by looking at distribution atlases (Floron, 2014; Vlindernet, 2014, Sovon, 2014) and characteristic species described for each habitat by Ommering (2010). An overview of the output is shown in table 2

Tabel 2.2 Overview of the calculations per habitat per measure woth their corresponding surface area

Habitat	Current situation			Extension North/South			Joint Extension			Regional combination 1			Regional combination 2		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
Non-nature	6327	0	-	6329	0	-	6328	0	-	6369	0	-	6357	0	-
Dry forest with production	495	0	0,73	494	0,25	0,73	495	0,25	0,73	470	0	0,73	473	0	0,73
River and swamp landscape	207	0,25	0,47	207	0	0,47	207	0	0,47	207	0,25	0,47	207	0,25	0,47
Dry meadow	111	0,25	0,60	111	0,25	0,60	111	0,25	0,60	106	0	0,60	111	0,25	0,60
Pine-, Oak, and Beech forest	110	0	0,68	110	0	0,68	110	0	0,68	105	0	0,68	108	0	0,68
River	78	0,5	0,77	78	0,25	0,77	78	0,25	0,77	78	0,25	0,77	78	0,5	0,77
Fresh water lake	50	0,5	0,81	50	0,5	0,81	50	0,5	0,81	50	0,5	0,81	50	0,5	0,81
Herb- and fauna rich grassland	41	0,5	0,89	41	0,5	0,89	41	0,5	0,89	34	0,5	0,89	35	0,5	0,89
River- and brook accompanying forest	35	0,25	0,71	35	0,25	0,71	35	0,25	0,71	35	0	0,71	35	0,25	0,71
Sand and limestone landscape	32	0	0,51	32	0	0,51	32	0	0,51	32	0	0,51	32	0	0,51
Glanshaverhooiland	25	0,5	0,93	25	0,5	0,93	25	0,5	0,93	25	0,25	0,93	25	0,25	0,93
Hornbeam and Ash forest	20	0	0,74	19	0	0,74	19	0	0,74	20	0	0,74	20	0	0,74
Swamp	13	1	0,57	13	1	0,57	13	1	0,57	13	0,5	0,57	13	1	0,57
Humid forest with production	8	0,25	0,88	8	0,25	0,88	8	0,25	0,88	8	0,25	0,88	8	0,25	0,88
Herbs and fauna rich field	7	0,75	0,74	7	0,5	0,74	7	0,5	0,74	7	0,75	0,74	7	0,75	0,74
Wet arid land	6	0	0,5	6	0	0,5	6	0	0,5	6	0	0,5	6	0	0,5
Saline- and overflowing grassland	2	0,5	0,56	2	0,5	0,56	2	0,5	0,56	2	0,25	0,56	2	0,5	0,56
Park- en stinzen forest	2	0,5	0,90	2	0,5	0,90	2	0,5	0,90	2	0,5	0,90	2	0,5	0,90
Average per aspect (ha^{-1})		0,027	0,111		0,034	0,111		0,034	0,111		0,018	0,107		0,026	0,108
Average potential ecological quality per measure (ha^{-1})		0,069			0,073			0,073			0,062			0,067	

Table 2.3 Overview of the expected habitat quality relative to the reference situation

Scope	Expected habitat quality (ha^{-1})				
Measure	Water- and environmental conditions (ha^{-1})	Presence of characteristic species in the region (ha^{-1})	Absolute value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Relative value ↓↓↓↓
Extension North	0,040	0,111	0,073	0,020	0,003
Extension South	0,040	0,111	0,073	-0,043	0,073
Joint Extension	0,038	0,111	0,073	0,020	0,000
Regional combination 1	0,025	0,107	0,062	-0,042	-0,007
Regional combination 2	0,030	0,108	0,067	-0,003	-0,002

C.2.2 Expected ecological connectivity

An overview of ecosystem types to which habitats of different measures belong, is provided in table 2.4. Ecosystem types have been illustrated in maps created in ArcGis. Maps of Nature Management Types and a general map of nature in the Netherlands (Kramer et al, 2007) have been used. For each measure, expected ecological connectivity is analyzed based on dispersal requirements of groups of species belonging to the ecosystem type (Broekmeyer et al, 2001). The output of expected ecological connectivity for separate habitats per measure is shown in table 2.5. The overall expected ecological connectivity relative to the reference situation is shown in figure 2.6.

Tabel: 2.4 Overview of habitats belonging to ecosystem types

Habitat / Ecosystem type	Forest of poor and rich sandy soils	Dry meadow	Forest, thicket and border vegetation on clay with large water	Swamp, thicket and large water	Ticket and border vegetation on sandy soils with small water	Grasland (with small water)	Humid meadow with fens
Dry forest with production	X						
River and swamp landscape	X		X	X		X	
Dry meadow		X			X		
Pine-, Oak, and Beech forrest	X						
River			X	X		X	
Fresh water lake			X			X	
Herb- and fauna rich grassland						X	
River- and brook accompanying forest	X		X				
Sand and limestone landscape	X	X	X		X	X	
Glanshaverhooiland						X	
Hornbeam and Ash forest	X		X				
Swamp				X			
Humid forest with production	X		X				
Wet arid land						X	X
Saline- and overflowing grassland						X	
Park- en stinzen forrest					X		
Non-nature						X	

Table 6.11 Overview of expected ecological connectivity of different measures relative to the reference situation

Scope	Expected ecological connectivity (ha^{-1})	
Measure	Absolute value ↓↓↓↓	Relative value ↓↓↓↓
Extension North	0,467	-0,01
Extension South	0,467	-0,01
Joint Extension	0,467	-0,01
Regional combination 1	0,472	0,00
Regional combination 2	0,473	0,00

Habitat	Reference situation		Extension North/South		Joint Extension		Regional combination 1		Regional combination 2	
	Surface (ha)	Expected ecological connectivity (ha^{-1})	Surface (ha)	Expected ecological connectivity (ha^{-1})	Surface (ha)	Expected ecological connectivity (ha^{-1})	Surface (ha)	Expected ecological connectivity (ha^{-1})	Surface (ha)	Expected ecological connectivity (ha^{-1})
Non-nature	6327	0,33	6329	0,33	6328	0,33	6369	0,33	6357	0,33
Dry forest with production	495	0,68	494	0,68	495	0,68	470	0,68	473	0,68
River and swamp landscape	207	2,73	207	2,58	207	2,58	207	2,73	207	2,73
Dry meadow	111	0,85	111	0,85	111	0,85	106	0,85	111	0,85
Pine-, Oak, and Beech forest	110	0,68	110	0,68	110	0,68	105	0,68	108	0,68
River	78	2,05	78	1,90	78	1,90	78	2,05	78	2,05
Fresh water lake	50	1,08	50	1,01	50	1,01	50	1,08	50	1,08
Herb- and fauna rich grassland	41	0,33	41	0,33	41	0,33	34	0,33	35	0,33
River- and brook accompanying forest	35	1,43	35	1,36	35	1,36	35	1,43	35	1,43
Sand and limestone landscape	32	2,61	32	2,54	32	2,54	32	2,61	32	2,61
Glanshaverhooiland	25	0,33	25	0,33	25	0,33	25	0,33	25	0,33
Hornbeam and Ash forest	20	1,43	19	1,36	19	1,36	20	1,43	20	1,43
Swamp	13	0,97	13	0,89	13	0,89	13	0,97	13	0,97
Humid forest with production	8	1,43	8	1,36	8	1,36	8	1,43	8	1,43
Herbs and fauna rich field	7	0,33	7	0,33	7	0,33	7	0,33	7	0,33
Wet arid land	6	0,53	6	0,53	6	0,53	6	0,53	6	0,53

Saline- and overflowing grassland	2	0,33	2	0,33	2	0,33	2	0,33	2	0,33
Park- en stinzen forest	2	0,52	2	0,52	2	0,52	2	0,52	2	0,52
Average expected ecological connectivity per alternative measure (ha^{-1})	0,47		0,47		0,47		0,47		0,47	

Table 2.5 Overview of the expected ecological connectivity of different measures per habitat, the value is a sum of each contribution of all ecosystem types, values are

C.3 Evaluation for nature policy

There are several nature policy areas that intersect with the study area. The effects of the alternative construction designs of each of the nature policy goals and ambitions in the study area are determined for Natura 2000 areas and National Ecological Network areas, compared to the reference situation. The output of the overall policy based value is shown in table 3.1.

Table 3.1 Policy based value of different alternative construction designs

Scope	Evaluation for nature policy (∑)		
Measure	Natura 2000 value	National Ecological Network value	↓↓↓↓
Extension North	-12	-6	-18
Extension South	-12	-6	-18
Joint Extension	-12	-6	-18
Regional combination 1	-8	-2	-10
Regional combination 2	-4	0	-4

C.3.1 Nature 2000

Natura 2000 has conservation goals that are based on the habitat and bird directive (Ministry of Economic Affairs). There are 4 categories of conservation goals: habitat type, habitat species, breeding bird species and bird species. Furthermore, the coherence of the ecological network is a conservation goal. Measures are scored on their effect of these 5 categories. A distinction has been made between the effects on Natura 2000 conservation goals of the extension measures (3.1.1) and the Regional combination measures (3.1.1.2). An overview is provided in table 3.2.

C.3.1.1 Extension measures: Extension North, Extension South and Joint extension

Habitat types

With the extension of the A15, there is a loss of habitat surface and quality in the Gelderse Poort, due to increased nitrogen deposition and construction on a highway and bridge. This has a negative effect on conservation of habitat surface. Furthermore, the effects of noise and light pollution have a negative effect on habitat quality.

Habitat species

The construction of a bridge and the extension of a highway increases noise and light pollution in the area. This could negatively affect the pond bat (*Myotis dasycneme,* H1218). Noise pollution could negatively affect the beaver (H1337) (Projectbureau ViA15, 2011e). There is therefore a general negative effect on habitat species.

Breeding birds

The construction of the bridge across the Pannerdensch Channel results in an increase in noise pollution which could negatively affect breeding birds (Reijnen et al, 1997). Especially

the Little grebe (A004) and the Sand martin (A249) and the Kingfisher (A229) are expected to experience negative effects, due to their habitat along the Pannerdensch Channel.
Beside the area around the extension of the A15, the area around the Pleijroute contains
Therefore, there is a general negative effect on breeding birds.

Non-breeding birds
Similar to breeding birds, construction of a bridge across the Pannerdensch Channel will result in a loss of habitat. Furthermore, the noise from the current road negatively affects the habitat quality of the breeding birds. The area around the Pannerdensch Channel is an important stop-over site for migratory birds, increase in noise and light pollution and loss of habitat due to construction of a bridge could negatively affect the habitat for migratory birds. Construction of the bridge therefore has a general negative effect on non-breeding birds (Projectbureau ViA15, 2011e).

Ecological coherence
Extension of the A15 creates a direct barrier for land dispersing species. Chapter 2.2 has shown reduction of expected ecological connectivity is limited. However, for species dispersing over longer distances the road could definitely induce a barrier. Although the land was already split up by the Betuweroute the ecological coherence is negatively affected by the extension of the A15.

C.3.1.2 Regional combination measures: Regional combination 1 –and 2

Habitat types
The border of the Natura2000 area the Veluwe lies at a distance of 13 meters from the present road. A widening of the current road does therefore not result in loss of Natura2000 habitat surface (Projectbureau ViA15, 2011e). Nitrogen deposition values in the Veluwe area were already high. A further increase of these values decreases the likelihood of habitat quality improving over a short time. However, the reason for high nitrogen depositions mostly results from high background deposition values. The widening of the A50 takes place in Natura2000 area which could therefore negatively affect the habitat surface that is available for habitat types of Natura 2000 area Rijntakken or the Veluwe.
Based on the increase in nitrogen deposition a negative effect of both measures is expected on habitat quality, of two Natura 2000 areas. Based on the widening of the current A50, an additional negative effect is expected on the habitat surface in Regional combination 1.

Habitat species
The habitat species Brook lamprey (H1096) occurs in the River close to the A50. However, since this is an area of high water quality that will be conserved with the widening of the current A50 (Projectbureau ViA15, 2011e) no negative effects on water quality is expected.

Breeding birds
The effects of noise pollution are large around the widening of the A50. This would result in a negative effect on breeding birds that reside in the Natura 2000 around the A50. No negative effects are expected around the Pannerdensch Channel from these measures.

Non-breeding birds
There are limited habitats for non-breeding birds in the area where widening of the current highways is planned (Projectbureau ViA15, 2011e). Therefore, there is no positive or negative effect expected on habitat species in Regional combination 1 and 2.

Ecological coherence
There are no new barriers resulting from the implementation of Regional combination 1, and -2. Therefore, there is no effect on the ecological coherence.

Table 3.2 Overview on the sum of effects of the alternative construction designs on Natura 2000 goals in the study area.

Natura 2000 category	Extension North effect	Extension South effect	Joint Extension effect	Regional combination 1 effect	Regional combination 2 effect
Habitat types	-4	-4	-4	-6	-2
Habitat species	-2	-2	-2	0	0
Breeding birds	-2	-2	-2	-2	-2
Non-breeding birds	-2	-2	-2	0	0
Ecological coherence	-2	-2	-2	0	0
Total value Natura 2000	-12	-12	-12	-8	-4

C.3.2 National Ecological Network

The general goal on the National Ecological Network is connecting existing nature areas and conserving or improving the quality of the National Ecological Network. Specific goals are specified for each province (Van de Leemkule, 2014a). Categories of these specifications for each province form the basis for scoring whether a measure contributes to these goals in a positive or negative manner.

The province of Gelderland has defined core qualities and environmental conditions for areas belonging to the National Ecological Network (Van de Leemkule, 2014b). There is a loss of National Ecological Network values when there is a negative effect on core qualities of an area. Each core quality is a category of its own that can be affected. Furthermore, area specific development goals have been specified. When a measure contributes to realizing a development goal, a positive contribution can be obtained. Core qualities that are not affected or the effects are unknown will not be described.

For the National Ecological Network, the core qualities of the areas shown in chapter 1.4 are analyzed, relative to the reference situation. The exact location of these areas is shown in figure 1.5. The extension measures and the Regional combination measures are described separately in 3.2.1 and 3.2.2 respectively. An overview of the effects of the alternative construction designs on the National Ecological Network policy goals is provided in table 3.3.

C.3.2.1 Extension North and South and Joint extension

National Ecological Network area Papendal – Schaarsbergen has several core qualities. Since the measures do not cross the area Papendal – Schaarsbergen, the effects of the core qualities are neutral.

The area Uiterwaarden Neder-Rijn Arhnhem – Heteren experiences no effects on its core qualities, since the measures do not lie in the area. The extension of the A15 is planned in the area Gelderse Poort Noord. Uncultivated land is one of the core qualities, which is affected negatively by the construction of a highway and bridge. Another core quality is maintenance of quietness, darkness and space. It is likely that a bridge and a highway will negatively affect these core qualities. This will be negatively affected by the construction of a bridge and a highway. Several species are mentioned as core qualities, for example beavers and fish. Due to the increase noise and light effects due to increased traffic, negative effects of beavers and birds could be expected. Possibly vibrations from the bridge could negatively affect the fish. Therefore this core quality is negatively affected.

The area the Overbetuwe does not experience any effects on their core qualities.

C.3.2.2 Regional combination 1 and 2

National Ecological Network area Papendal – Schaarsbergen has several core qualities. Since the measures do not cross the area Papendal – Schaarsbergen, the effects of the core qualities are neutral.
The area Uiterwaarden Neder-Rijn Arnhem – Heteren will likely experience a negative effect on the core qualities of quietness, space and darkness due to the widening of the A50 and the mentioned increase in noise pollution (-1). This will only be the case for Regional combination 1, since the widening of the A50 will result in increased noise pollution. No new barriers arise from the Regional combination 1 and 2 which leaves habitats of species with specified core qualities intact.
The Gelderse Poort Noord and the Overbetuwe are not affected by the Regional combination 1 and 2.

Table 3.3 National Ecological Network based value of different measures based on core qualities and goals of different areas.

National Ecological Network area	Core qualities and goals National Ecological Network	Extension North effect	Extension South effect	Joint Extension effect	Regional combination 1 effect	Regional combination 2 effect
Gelderse Poort Noord	Uncultivated land	-2	-2	-2	0	0
Uiterwaarden Neder-Rijn Arnhem – Heteren	Quiteness, darkness and space	0	0	0	-2	0
Gelderse Poort Noord	Quiteness, darkness and space	-2	-2	-2	0	0
Gelderse Poort Noord	Meadowbirds, water- and swampbirds, bats, amphibians, fish, ringsnakes and beavers	-2	-2	-2	0	0
Total value Natura 2000		-6	-6	-6	-2	0

C.4 Added ecological value for nature policy

The added ecological value for nature policy is calculated with the formula displayed in figure 4.1. An overview of the values of different components, leading to the calculation of the policy based value is shown in table 4.1. The expected ecology is taken as an absolute value in the equation due to the fact that it is a negative value. The extension measure have the lowest added ecological value for nature policy relative to the reference situation. This is largely due to the large negative effects on nature policy goals in the area.

Expected Ecology X Valuation for nature policy = Added ecological value for nature policy

Figure 4.1 Formula to calculate the added ecological value for nature policy

Table 4.1 Overview of the Added ecological value for nature policy and its components for different measures of the ViA15 project, relative to the current situation.

Scope	Expected ecology (ha^{-1})			Policy based value (∑)			Added ecological value for nature policy (ha^{-1})	
Measure	Expected Habitat Quality (ha^{-1})	Expected ecological connectivity (ha^{-1})	Relative value ↓↓↓↓	National Ecological Network	Natura 2000	Relative value ↓↓↓↓	Relative value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓
Extension North	0,073	0,47	-0,001	-12	-6	-18	-0,018	-0,77755
Extension South	0,073	0,47	-0,001	-12	-6	-18	-0,018	-0,77755
Joint Extension	0,073	0,47	-0,001	-12	-6	-18	-0,018	-0,78458
Regional combination 1	0,062	0,47	-0,006	-8	-2	-10	-0,06	-0,19802
Regional combination 2	0,067	0,47	-0,003	-4	0	-4	-0,012	-0,05918

D Via15 with sub-cases

The case that is described in Appendix C could be evaluated in more detail when the area is divided into sub-cases, based on different effects as described in chapter 2.2.3. Since large part of the method do not change when the study area changes, outcomes that overlap with the description in Appendix C are not described in this case.

D.1 Scope Via15 with sub-cases

D.1.1 Region

See description in Appendix C.

D.1.2 Design

See description in Appendix C.

D.1.3 Study area

There are 7 locations in the overall road network where different measures take place. The study area is divided into sub-areas based on these locations (figure 1.1), since there will likely be different effects for each measure and location. For each area an overview of the habitats and measures in the areas is provided. The location of different areas is shown in figure 1.1.

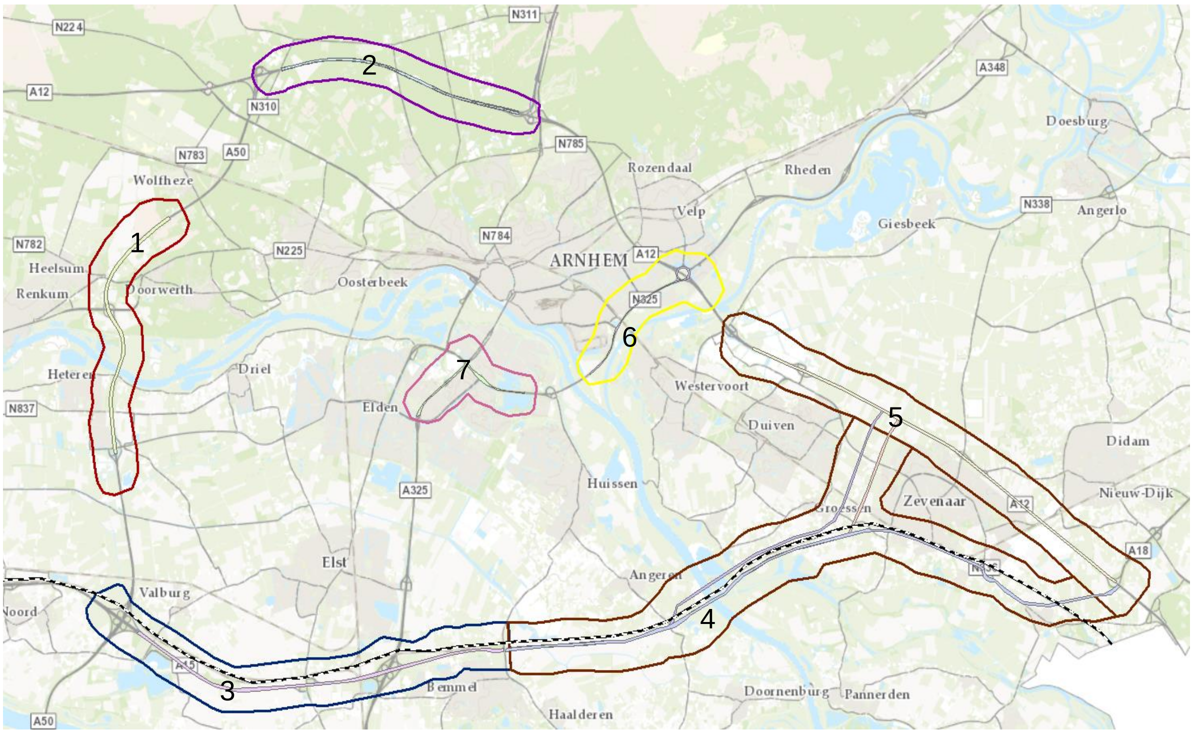

Figure 1.1 Overview of the entire study area with 7 sub-areas based on locations of alternative construction designs. Sub-areas are illustrated with different colours and areas are numbered.

D.1.3.1 Area 1

In area 1 only Regional combination 1 takes place. The overview of different habitats in area 1 is illustrated in table 4.1.

Table 4.1 Overview of habitats in study area 1 in the reference situation and relevant measures

Habitat	Reference situation	Region combination 1
	Surface (ha)	Surface (ha)
Non-nature	578,5	588,4
Dry meadow	98,0	96,1
Pine-, Oak, and Beech forest	36,7	34,5
Dry forest with production	30,2	29,1
River	23,4	22,5
Herb- and fauna rich grassland	14,9	12,3
Glanshaverhooiland	13,0	12,8
Fresh water lake	7,7	7,6
River and swamp landscape	7,2	6,5
Hornbeam and Ash forest	6,8	6,4
River- and brook accompanying forest	6,8	6,8
Wet arid land	5,9	5,9
Swamp	2,9	2,9
Saline- and overflowing grassland	1,9	1,9
Dry arid grassland	0,7	0,7
Dry coppice	0,4	0,4
Creek- and source	0,3	0,3

D.1.3.2 Area 2

In study area 2 the A12 in the Veluwe area is widened from junction Waterberg to Grijsoord with 7.6 meters, in both alternative construction designs 1 and 2. The overview of different habitats in area 2 is illustrated in table 4.2.

Table 4.2 Overview of habitats in study area 2 in the reference situation and relevant measures

Habitat	Reference situation	Region combination 1 and 2
	Surface (ha)	Surface (ha)
Non-nature	157,7	167,9
Dry forest with production	426,5	419,6
Pine-, Oak, and Beech forest	78,6	78,1
Dry meadow	12,2	12,2
Herb- and fauna rich grassland	47,9	45,1
Sand and limestone landscape	27,7	27,7

D.1.3.3 Area 2

In study area 3 the A15 between Valburg and Ressen is widened in three extension measures: Extension North, Extension South and the Joint Extension. The overview of different habitats in area 3 is illustrated in table 4.3.

D.1.3.4 Area 4

In study area 4 the extension of the A15 is planned for Extension North, Extension South and the Joint Extension. The overview of different habitats in area 4 is illustrated in table 4.4.

Table 4.3 Overview of habitats in study area 3 in the reference situation and relevant measures

Habitat	Reference situation	Extension North, Extension South, Joint Extension
	Surface (ha)	Surface (ha)
Non-nature	1231,7	1235,6
Dry forest with production	24,3	23,3
Pine-, Oak, and Beech forest	1,0	1,0
Hornbeam and Ash forest	13,4	10,7
Humid forest with production	7,5	7,5

Table 4.4 Overview of habitats in study area 4 in the reference situation and relevant measures

Habitat	Reference situation	Joint extension	Extension North	Extension South
	Surface (ha)	Surface (ha)	Surface (ha)	Surface (ha)
No nature	2138,4	2146,1	2144,4	2145,1
River and swamp landscape	179,0	173,3	174,7	173,2
River	35,6	35,6	35,6	35,6
Creek- and source	5,3	5,2	5,3	5,3
Fresh water lake	11,2	10,6	10,9	10,6
Swamp	7,9	7,9	7,9	7,9
Herb- and fauna rich grassland	13,3	13,3	12,4	13,3
Glanshaverhooiland	1,0	1,0	1,0	1,0
Herb- and faun rich field	6,6	6,6	6,6	6,6
River- and brook accompanying forest	2,8	1,8	2,8	2,8
Hornbeam and Ash forest	0,2	0,2	0,2	0,2
Pine-, Oak, and Beech forest	1,0	1,0	1,0	1,0
Dry forest with production	2,8	2,5	2,4	2,6
Humid forest with production	1,1	1,1	1,1	1,1
Park- en stinzen forest	2,4	2,4	2,4	2,4

D.1.3.5 Area 5

Study area 5 is equal in all measures and will be altered in all measures. The overview of different habitats in area 5 is illustrated in table 4.5.

Table 4.5 Overview of habitats in study area 5 in the reference situation and relevant measures

Habitat	Reference situation	All measures
	Surface (ha)	Surface (ha)
No nature	1427,3	1430,0
Fresh water lake	1,8	1,8
River- and brook accompanying forest	23,1	20,4
Dry forest with production	1,2	1,1

D.1.3.6 Area 6

In study area 6 different levels are added to the current intersections to increase the flow of traffic in Regional combination 1. The overview of different habitats in area 6 is illustrated in tabel 4.6.

D.1.3.7 *Area 7*

In study area 7 different levels are added to the current intersections to increase the flow of traffic in Regional combination 1. The overview of different habitats in area 7 is illustrated in table 4.7.

Table 4.6 Overview of habitats in study area 6 in the reference situation and relevant measures

Habitat	Reference situation	Region combination 1
	Surface (ha)	Surface (ha)
Non-nature	449,5	449,5
River	17,7	17,7
River and swamp landscape	13,5	13,5
Glanshaverhooiland	10,0	10,0
Dry forest with production	1,6	1,6
Hornbeam and Ash forest	1,4	1,4
Flower dam	0,1	0,1

Table 4.7 Overview of habitats in study area 7 in the reference situation and relevant measures

Habitat	Reference situation	Region combination 1
	Surface (ha)	Surface (ha)
Non-nature	381,0	381,0
Swamp	0,0	0,0
Herb- and fauna rich grassland	4,3	4,3
Humid forest with production	0,5	0,5
Dry forest with production	13,2	13,2
Fresh water lake	1,0	1,0

D.1.4 Policy

See description in Appendix C.

D.2 Expected ecology

The output of the expected ecology is shown for each area separately in table 2.1 up until 2.7. A further description of the components that make up this value is provided in chapter 2.1 and 2.2.

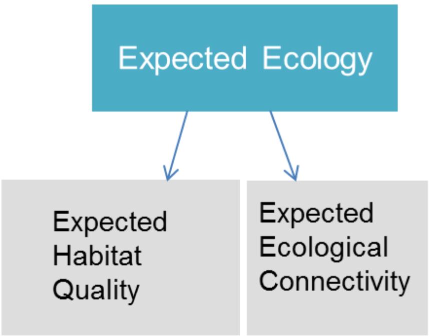

Figure 2.1 Overview of the Expected ecology with its components

Scope		Expected ecology (ha^{-1})				
Study area	Measure	Expected Habitat Quality (ha^{-1})	Expected Ecological Connectivity (ha^{-1})	Absolute value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Relative value ↓↓↓↓
Area 1	Regional combination 1	0,030	0,425	0,271	-0,030	-0,014
Area 2	Regional combination 1	0,295	0,644	0,470	0,000	-0,004
	Regional combination 2	0,295	0,644	0,470	0,000	-0,004
	Extension North	0,377	0,646	0,512	0,048	0,038
	Extension South	0,377	0,646	0,512	0,048	0,038
	Joint Extension	0,377	0,646	0,512	0,048	0,038
Area 3	Extension North	0,015	0,008	0,011	0,001	-0,001
	Extension South	0,015	0,008	0,011	0,001	-0,001
	Joint Extension	0,015	0,008	0,011	0,001	-0,001
Area 4	Extension North	0,039	0,810	0,424	-0,300	-0,095
	Extension South	0,038	0,808	0,423	-0,308	-0,096
	Joint Extension	0,038	0,808	0,423	-0,306	-0,097
Area 5	All measures	0,008	0,005	0,006	0,000	-0,001
Area 6	Regional combination 1	0,043	0,850	0,446	0,000	0,000
Area 7	Regional combination 1	0,024	0,256	0,140	0,000	0,000

Table 2.1 Overview of the expected ecology (ha^{-1}) for each study area and its relevant measures, relative to the reference situation and based on the elements show in figure 2.1.The outcome is shown for each area to illustrate the different effects of sub-designs of the measures.

D.2.1 Expected habitat quality

See description in Appendix C. An overview of the outcome of different areas is shown in table 2.2.

D.2.1.1 Abiotic conditions and water dynamics

See description in Appendix C. An overview of the outcome of different areas is shown in table 2.3 t/m 2.10.

D.2.1.2 Presence of characteristic species in the region

See description in Appendix C. An overview of the outcome of different areas is shown in table 2.3 t/m 2.9.

Table 2.2 Overview of the expected habitat quality relative to the reference situation of all separate study areas

Scope		Expected habitat quality (ha^{-1})				
Study area	Measure	Abiotic conditions (ha^{-1})	Presence of characteristic species in the region (ha^{-1})	Absolute value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Relative value ↓↓↓↓
Area 1	Regional combination 1	0,030	0,201	0,116	-0,062	-0,023
Area 2	Regional combination 1	0,030	0,561	0,295	-0,001	-0,006
	Regional combination 2	0,030	0,561	0,295	-0,001	-0,006
	Extension North	0,183	0,571	0,377	0,096	0,076
	Extension South	0,183	0,571	0,377	0,096	0,076
	Joint Extension	0,183	0,571	0,377	0,096	0,076
Area 3	Extension North	0,005	0,025	0,015	0,004	-0,001
	Extension South	0,005	0,025	0,015	0,004	-0,001
	Joint Extension	0,005	0,025	0,015	0,004	-0,001
Area 4	Extension North	0,016	0,062	0,039	-0,313	-0,021
	Extension South	0,014	0,062	0,038	-0,320	-0,022
	Joint Extension	0,014	0,061	0,038	-0,321	-0,022
Area 5	All measures	0,004	0,012	0,008	0,000	-0,001
Area 6	Regional combination 1	0,022	0,064	0,043	0,000	0,000
Area 7	Regional combination 1	0,012	0,037	0,024	0,000	0,000

Habitat	Reference situation			Extension North/South/Joint Extension/ Regional combination 2			Regional combination 1		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
Non-nature	578,5	0	0	578,5	0	0	588,4	0,00	0,00
Dry meadow	98,0	0,25	0,60	98,0	0,25	0,60	96,1	0	0,60
Pine-, Oak, and Beech forest	36,7	0	0,68	36,7	0	0,68	34,5	0	0,68
Dry forest with production	30,2	0	0,73	30,2	0	0,73	29,1	0	0,73
River	23,4	0,5	0,77	23,4	0,5	0,77	22,5	0,25	0,77
Herb- and fauna rich grassland	14,9	0,5	0,89	14,9	0,5	0,89	12,3	0,5	0,89
Glanshaverhooiland	13,0	0,25	0,93	13,0	0,25	0,93	12,8	0,25	0,93
Fresh water lake	7,7	0,5	0,81	7,7	0,5	0,81	7,6	0,5	0,81
River and swamp landscape	7,2	0,25	0,47	7,2	0,25	0,47	6,5	0,25	0,47
Hornbeam and Ash forest	6,8	0	0,74	6,8	0	0,74	6,4	0	0,74
River- and brook accompanying forest	6,8	0,25	0,71	6,8	0,25	0,71	6,8	0,25	0,71
Wet arid land	5,9	0	0,5	5,9	0	0,5	5,9	0	0,50
Swamp	2,9	0,75	0,57	2,9	0,75	0,57	2,9	0,75	0,57
Saline- and overflowing grassland	1,9	0,25	0,56	1,9	0,25	0,56	1,9	0	0,56
Dry arid grassland	0,7	0,5	0,56	0,7	0,5	0,56	0,7	0,5	0,56
Dry coppice	0,4	0	0,83	0,4	0	0,83	0,4	0	0,83

Creek- and source	0,3	0,5	0,62	0,3	0,5	0,62	0,3	0,5	0,62
Average expected habitat quality per measure (ha^{-1})	0,139			0,139			0,116		

Table 2.3 Overview of the expected habitat quality in area 1

Table 2.4 Overview of the expected habitat quality in area 2

Habitat	Reference situation			Extension North/South/Joint Extension			Regional combination 1 and -2		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
Non-nature	157,7	0	0	157,7	0,00	0,00	167,9	0,00	0,00
Dry forest with production	426,5	0,00	0,73	426,5	0,25	0,73	419,6	0,00	0,73
Pine-, Oak, and Beech forest	78,6	0,00	0,68	78,6	0,00	0,68	78,1	0,00	0,68
Dry meadow	12,2	0,00	0,60	12,2	0,00	0,60	12,2	0,00	0,60
Herb- and fauna rich grassland	47,9	0,50	0,89	47,9	0,50	0,89	45,1	0,50	0,89
Sand and limestone landscape	27,7	0,00	0,51	27,7	0,25	0,51	27,7	0,00	0,51
Average expected habitat quality per measure (ha^{-1})	0,302			0,377			0,295		

Table 2.5 Overview of the expected habitat quality in area 3

Habitat	Reference situation			Extension North/South/Joint Extension			Regional combination 1 and -2		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
Non-nature	1231,7	0	0	1235,6	0,00	0,00	1231,7	0	0
Dry forest with production	24,3	0,25	0,73	23,3	0,25	0,73	24,3	0,25	0,73
Pine-, Oak, and Beech forest	1,0	0,25	0,68	1,0	0,25	0,68	1,0	0,25	0,68
Hornbeam and Ash forest	13,4	0,00	0,74	10,7	0,00	0,74	13,4	0,00	0,74
Humid forest with production	7,5	0,00	0,88	7,5	0,00	0,88	7,5	0,00	0,88
Average expected habitat quality per measure (ha⁻¹)	0,016			0,015			0,016		

Table 2.6 Overview of the expected habitat quality in area 4

Habitat	Reference situation			Extension North			Extension South			Joint Extension		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
No nature	2138,4	0	0,00	2144,4	0	0,00	2145,06	0	0,00	2146,10	0	0,00

River and swamp landscape	178,97	0, 5	0,47	174,69	0	0,47	173,22	0	0,47	173,34	0	0,47
River	35,62	0,5	0,77	35,62	0,5	0,77	35,62	0,5	0,77	35,62	0,5	0,77
Creek- and source	5,32	0,5	0,62	5,26	0,25	0,62	5,26	0,25	0,62	5,23	0,25	0,62
Fresh water lake	11,20	0,5	0,81	10,93	0,25	0,81	10,58	0,25	0,81	10,59	0,25	0,81
Swamp	7,92	0,75	0,57	7,92	0,5	0,57	7,92	0,5	0,57	7,92	0,5	0,57
Herb- and fauna rich grassland	13,29	0,5	0,89	12,42	0,25	0,89	13,29	0,25	0,89	13,29	0,25	0,89
Glanshaverhooiland	0,98	0,5	0,93	0,98	0,25	0,93	0,98	0,25	0,93	0,98	0,25	0,93
Herb- and faun rich field	6,61	0,5	0,74	6,61	0,5	0,74	6,61	0,25	0,74	6,61	0,25	0,74
River- and brook accompanying forest	2,84	1	0,71	2,77	1	0,71	2,84	0,5	0,71	1,79	0,5	0,71
Hornbeam and Ash forest	0,19	0,5	0,74	0,19	0,25	0,74	0,19	0,25	0,74	0,19	0,25	0,74
Pine-, Oak, and Beech forest	0,97	0	0,68	0,97	0	0,68	0,97	0	0,68	0,97	0	0,68
Dry forest with production	2,79	0,5	0,73	2,38	0,5	0,73	2,61	0,25	0,73	2,51	0,25	0,73
Humid forest with production	1,13	0,5	0,88	1,13	0,25	0,88	1,13	0,25	0,88	1,13	0,25	0,88
Park- en stinzen forest	2,41	0,5	0,90	2,41	0,5	0,90	2,41	0,25	0,90	2,41	0,25	0,90
Average expected habitat quality per measure (ha^{-1})	0,06			0,04			0,04			0,04		

Table 2.7 Overview of the expected habitat quality in area 5

Habitat	Current situation			All measures		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
No nature	2138,4	0	0	2144,4	0	0
Fresh water lake	178,97	0.25	0,81	174,69	0.25	0,81
River- and brook accompanying forest	35,62	0.25	0,71	35,62	0.25	0,71
Dry forest with production	5,32	0	0,73	5,26	0	0,73
Average expected habitat quality per measure (ha^{-1})	0,009			0,008		

Habitat	Current situation			Regional combination 1		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
Non-nature	449,5	0	0	449,5	0	0
River	17,7	0,25	0,77	17,7	0,25	0,77
River and swamp landscape	13,5	0,25	0,47	13,5	0,25	0,47
Glanshaverhooiland	10,0	0,25	0,93	10,0	0,25	0,93
Dry forest with production	1,6	0,25	0,73	1,6	0,25	0,73
Hornbeam and Ash forest	1,4	0	0,74	1,4	0	0,74
Flower dam	0,1	0,25	0,83	0,1	0,25	0,83
Average expected habitat quality per measure (ha^{-1})	0,082			0,082		

Table 2.8 Overview of the expected habitat quality in area 6

Habitat	Current situation			Regional combination 1		
	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region	Surface (ha)	Water- and environmental conditions	Presence of characteristic species in region
non nature	381	0	0	381	0	0
Herb- and fauna rich grassland	4,3	0,25	0,89	4,3	0,25	0,89
Humid forest with production	0,5	0,25	0,88	0,5	0,25	0,88
Dry forest with production	13,2	0,25	0,73	13,2	0,25	0,73
Fresh water lake	1,0	0,25	0,81	1,0	0,25	0,81
Average expected habitat quality per measure (ha^{-1})	0,024			0,024		

Table 2.9 Overview of the expected habitat quality in area 7

D.2.2 Expected ecological connectivity

For description see Appendix C. An overview of the ecosystem types belonging to habitats per area is shown in table 2.10. An overview of the expected ecological connectivity of different areas and their measures is shown in table 2.11.

	Ecosystem type / Habitat	Forest of poor and rich sandy soils	Dry meadow	Forest, thicket and border vegetation on clay with large water	Swamp, thicket and large water	Ticket and border vegetation on sandy soils with small water	Grasland (with small water)	Humid meadow with fens	Creeks and creek valley forest
Area 1	Dry meadow		x			x			
	Pine-, Oak, and Beech forest								
	Dry forest with production	x							
	River			x	x				
	Herb- and fauna rich grassland						x		
	Glanshaverhooiland						x		
	Fresh water lake			x	x				
	River and swamp landscape	x		x	x		x		
	Hornbeam and Ash forest	x		x		x			
	River- and brook accompanying forest	x		x					
	Wet arid land						x	x	
	Swamp				x				
	Saline- and overflowing grassland						x		
	Dry arid grassland			x		x	x		
	Dry coppice					x			
	Creek- and source								x
Area 2	Dry forest with production	x							
	Pine-, Oak, and Beech forrest	x							
	Dry meadow		x			x			
	Herb- and fauna rich grassland						x		
	Sand and limestone landscape		x	x		x	x		
Area 3	Dry forest with production	x							
	Pine-, Oak, and Beech forrest	x							
	Hornbeam and Ash forest	x		x		x			
	Humid forest with production			x					
Area 4	River and swamp landscape	x		x	x		x		
	River			x	x				
	Creek- and source								x
	Fresh water lake			x	x				
	Swamp				x				
	Herb- and fauna rich grassland						x		
	Glanshaverhooiland						x		
	Herb- and fauna rich field						x		
	River- and brook accompanying forest	x		x					
	Hornbeam and Ash forest	x		x		x			
	Pine-, Oak, and Beech forest								
	Dry forest with production	x							
	Humid forest with production			x					
	Park- en stinzen forrest					x			
Area 5	Fresh water lake			x	x				
	River- and brook accompanying forest								
	Dry forest with production	x							
Area 6	River								
	River- and brook accompanying forest	x		x					
	Glanshaverhooiland						x		
	Dry forest with production	x							
	Hornbeam and Ash forest	x		x		x			
	Flower dam						x		
Area 7	Herb- and fauna rich grassland						x		
	Humid forest with production			x					
	Dry forest with production	x							
	Fresh water lake			x	x				

Table 2.10 Overview of areas with their habitats and corresponding ecosystem types

Scope		Expected ecological connectivity (ha^{-1})	
Study area	Measure	Absolute value ↓↓↓↓	Relative value ↓↓↓↓
Area 1	Regional combination 1	0,425	-0,006
Area 2	Regional combination 1	0,644	-0,002
	Regional combination 2	0,644	-0,002
	Extension North	0,646	0,000
	Extension South	0,646	0,000
	Joint Extension	0,646	0,000
Area 3	Extension North	0,008	-0,001
	Extension South	0,008	-0,001
	Joint Extension	0,008	-0,001
Area 4	Extension North	0,810	-0,169
	Extension South	0,808	-0,171
	Joint Extension	0,808	-0,171
Area 5	All measures	0,005	-0,001
Area 6	Regional combination 1	0,850	0,000
Area 7	Regional combination 1	0,256	0,000

Table 2.11 Overview of the expected ecological connectivity per area per measure

D.3 Policy based value

Relevant policy goals have been determined for each area. The overall output of the policy based value is shown in table 3.1. For each area a description is provided below.

Scope		Policy based value (∑)		
Study area	Measure	Natura 2000 value	National Ecological Network value	↓↓↓↓
Area 1	Regional combination 1	-6	-2	-8
Area 2	Regional combination 1	-2	0	-2
	Regional combination 2	-2	0	-2
	Extension North	0	0	0
	Extension South	0	0	0
	Joint Extension	0	0	0
Area 3	Extension North	0	0	0
	Extension South	0	0	0
	Joint Extension	0	0	0
Area 4	Extension North	-12	-6	-18
	Extension South	-12	-6	-18
	Joint Extension	-12	-6	-18
Area 5	All measures	0	0	0
Area 6	Regional combination 1	0	0	0
Area 7	Regional combination 1	0	0	0

Table 3.1 Policy based value of alternative construction designs

D.3.1 Area 1: Regional combination 1

An overview of the contribution to nature policy goals is shown in table 3.2.

D.3.1.1 Natura 2000

Habitat

15.02 Pine-, oak and beech forest is mostly affected by the increase in noise pollution. In this area the habitat types Beech and oak forest with holly (H9120) and Old oak forest (H9190) could occur (Ommering, 2010). Both are sensitive to nitrogen deposition. Their surface area and quality should increase based on conservation goals. Increase in nitrogen deposition and noise pollution, likely results in a decrease of habitat quality. A further increase in nitrogen deposition will negatively affect habitat types. Furthermore, habitat around the A50 is lost due to widening. This nature lies within Natura 2000 borders and therefore could reduce Natura 2000 habitat surface.

Habitat species

The area around the A50 is brook lamprey (H1096) living area, not certain if it occurs. There is likely no significant increase in negative effects on its living area. Pollution from runoff is limited to conserve water quality.

Breeding birds
On both sides of the A50 there is living area for breeding birds such as the stonechat (A276) , the honey buzzard (A072), the Woodlark (A246) and the black woodpecker (A236) (Projectbureau ViA15, 2011e). Due to an increase in noise pollution, especially east of the A50, there will likely be a reduction in habitat quality for breeding birds, whereas the conservation goal is for the habitat quality of these species to remain equal.

Non breeding birds
All birds specified are breeding birds.

Ecological coherence
No new road, therefore there is no new effect.

D.3.1.2 National ecological Network
For the area Uiterwaarden Neder-Rijn Arnhem – Heteren the core quality that will likely be most affected is that of quietness, darkness and space. Expected increase in noise (Projectbureau ViA15, 2011e) will negatively affect this quality (-1).

Natura 2000 area	Natura 2000 category	Regional combination 1 effect	National Ecological Network area	Core qualities and goals National Ecological Network	Regional combination 1 effect
Rijn-takken	Habitat types	-4	Uiterwaarden Neder-Rijn Arnhem – Heteren	Quietness, darkness and space	-2
	Habitat species	0			
	Breeding birds	-2			
	Non-breeding birds	0			
	Ecological coherence	0			
Total value Natura 2000		-6	Total value National Ecological Network		-2

Table 3.3 Overview of the contribution to nature policy goals in area 1 compared to the reference situation.

D.3.2 Area 2: Regional combination 1 and 2
An overview of the contribution to nature policy goals is shown in table 3.3.

D.3.2.1 Natura 2000
Habitat type
Habitat types that could be located in this area are Beech and oak forest with holly (H9120), Old Oak forests (H9190), Dry meadow (H4030) and some humid alluvial forests (H91E0C).
Although habitat quality of these habitats is likely limited in the current situation due to high nitrogen depositions and noise pollution from the current A12, nitrogen depositions will increase relative to the autonomous situation. This will further prevent achieving conservation goals of increased quality in this area. Surface area of habitats is not reduced since it lies at a distance from the highway (Projectbureau ViA15, 2011e).

Habitat species
The effect of the widening on habitat species is unclear.

Breeding birds
Since the noise is not expected to increase further, breeding birds will not be negatively affected due to widening.

Non breeding birds
There are no non breeding birds specified for the Veluwe.

Ecological coherence
There are no new barriers.

D.3.2.2 National Ecological Network

Core qualities are not affected. However, the widening of the road is a negative contribution to the development goal of reduction of the barrier of the road. Creating a corridor or a tunnel for species to migrate would increase expected ecological connectivity and could increase the positive contribution to achieving development goals

Natura 2000 area	Natura 2000 category	Regional combination 1 and 2 effect	National Ecological Network area	Core qualities and goals National Ecological Network	Regional combination 1 and 2 effect
Veluwe	Habitat types	-2	Papendal schaarsbergen	n.a.	n.a.
	Habitat species	0			
	Breeding birds	0			
	Non-breeding birds	0			
	Ecological coherence	0			
Total value Natura 2000		-2	Total value National Ecological Network		0

Table 3.4 Overview of the contribution to nature policy goals in area 2 compared to the reference situation

D.3.3 Area 3

Area 3 is not situated in Natura 2000 or National Ecological Network area; therefore the policy based value is 0.

D.3.4 Area 4: Extension measures

An overview of the contribution to nature policy goals is shown in table 3.4.

D.3.4.1 Natura2000

Habitat type
The bridge through Natura2000 area is seen as habitat space taken in due to the creation of shadow and the placement of pillars that hold the bridge up (Projectbureau ViA15, 2011e). Therefore, Natura 2000 surface area is more or less decreased which is a negative effect on conservation goals. Negative effects from the presence of a highway will affect habitat quality. Especially softwood alluvial forests (H91E0A) will lose in quality (Projectbureau ViA15, 2011e), where there conservation goal is increase in quality.
Habitat species

Habitat species of this Natura 2000 area all live along or in the water. Due to the bridge, there is no barrier for these species and their living space is therefore not affected. However the increase in sound could negatively affect the beaver (H1337) and light could negatively affect the pond bat (*Myotis dasycneme,* H1218).

Breeding birds
The area where the bridge is planned is a breeding bird area. The Sand martin (A249), little grebe (A004) and the kingfisher (A229) might be negatively affected in habitat quality due to the increase in noise pollution.

Non breeding birds
The area where the bridge is located is suitable as a habitat for non-breeding birds. It is an important area for many migratory birds (Projectbureau ViA15, 2011e). This will be affected by the building of the bridge, since surface is indirectly lost.

Ecological cohesiveness
Due to the bridge there is a barrier that negatively affects the cohesiveness of the Natura2000 area Gelderse Poort.

D.3.4.2 National Ecological Network

There are several core qualities of the Gelderse Poort Noord that are negatively affected. First of all the core quality silence, space and darkness is negatively affected by the extension of the A15. Second, meadow birds, water- and swamp birds, bats, amphibians, fish, ring snakes and beavers are valued. Some of these species will be negatively affected due to noise and light pollution and possibly vibrations for the fish. Third, a core quality is uncultivated land. The construction of a highway would negatively affect that quality due to taking up uncultivated surface. Furthermore, two development goals will be hindered. First of all the goal to develop alluvial forests is hindered by the extension due to increased nitrogen depositions, shadow and runoff.

Table 3.5 Overview of the contribution to nature policy goals in area 4 compared to the reference situation

Natura 2000 area	Natura 2000 category	Extension North, - South, Joint Extension	National Ecological Network area	Core qualities and goals National Ecological Network	Extension North, - South, Joint Extension
Gelderse Poort	Habitat types	-4	Gelderse Poort Noord	Uncultivated land	-2
	Habitat species	-2		Quiteness, darkness and space	-2
	Breeding birds	-2			
	Non-breeding birds	-2		Meadowbirds, water- and swampbirds, bats, amphibians, fish, ringsnakes and beavers	-2
	Ecological coherence	-2			
Total value Natura 2000		-12	Total value National Ecological Network		-6

D.3.5 Area 5
Area 5 is not situated in Natura 2000 area of National Ecological Network area; therefore the policy based value is 0.

D.3.6 Area 6
There is only Natura2000 area Rijntakken here but no further negative effects on its conservation goals are expected; therefore the policy based value is 0.

D.3.7 Area 7
Area 7 does not contribute to nature policy goals in a positive or negative way; therefore the policy based value is 0.

D.4 Added ecological value for nature policy

The added ecological value for nature policy is calculated with the formula displayed in figure 4.1. An overview of the values of different components, leading to the calculation of the policy based value is shown in table 4.1. The expected ecology is taken as an absolute value in the equation due to the fact that it is a negative value. The negative effects are largest in area 1 and 2 for Regional combination 1 and to less extent Regional combination 2. The most negative added ecological value for nature policy is obtained in area 4 due to the many negative effects to nature policy goals and the relatively large effects on the expected ecology.

Figure 4.1 Formula to calculate the added ecological value for nature policy

Scope		Expected ecology (ha^{-1})			Policy based value (∑)			Added ecological value for nature policy (ha^{-1})	
Study area	Measure	Expected habitat quality (ha^{-1})	Expected ecological connectivity (ha^{-1})	Relative value ↓↓↓↓	Natura 2000 value	National Ecological Network value	Relative value ↓↓↓↓	Relative value per hectare nature ↓↓↓↓	Relative value ↓↓↓↓
Area 1	Regional combination 1	0,030	0,425	-0,014	-6	-2	-8	-0,241	-0,115
Area 2	Regional combination 1	0,295	0,644	-0,004	-2	0	-2	0,000	-0,008
	Regional combination 2	0,295	0,644	-0,004	-2	0	-2	0,000	-0,008
	Extension North	0,377	0,646	0,038	0	0	0	0,000	0,000
	Extension South	0,377	0,646	0,038	0	0	0	0,000	0,000
	Joint Extension	0,377	0,646	0,038	0	0	0	0,000	0,000
Area 3	Extension North	0,015	0,008	-0,001	0	0	0	0,000	0,000
	Extension South	0,015	0,008	-0,001	0	0	0	0,000	0,000
	Joint Extension	0,015	0,008	-0,001	0	0	0	0,000	0,000
Area 4	Extension North	0,039	0,810	-0,095	-12	-6	-18	-5,398	-1,716
	Extension South	0,038	0,808	-0,096	-12	-6	-18	-5,543	-1,734
	Joint Extension	0,038	0,808	-0,097	-12	-6	-18	-5,514	-1,739
Area 5	All measures	0,008	0,005	-0,001	0	0	0	0,000	0,000
Area 6	Regional combination 1	0,043	0,850	0,000	0	0	0	0,000	0,000
Area	Regional	0,024	0,256	0,000	0	0	0	0,000	0,000

7	combination 1								

Table 4.1 Overview of the added ecological value for nature policy and its components for different measures of the ViA15 project for each analysed sub-are,a relative to the reference situation

Scope	Expected ecology			Evaluation for nature policy			Contribution to nature policy requirements	
Design	Potential ecological quality (ha⁻¹)	Connectivity (ha⁻¹)	Relative value ↓↓↓↓	Natura 2000 value	National Ecological Network value	↓↓↓↓	**Relative value per hectare nature ↓↓↓↓**	**Relative value ↓↓↓↓**
Regional combination 1	0,400	2,176	-0,019	-8	-2	-10	-0,241	-0,123
Regional combination 2	0,303	0,649	-0,005	-2	0	-2	0,000	-0,008
Extension North	0,439	1,468	-0,059	-12	-6	-18	-5,398	-1,716
Extension South	0,438	1,467	-0,060	-12	-6	-18	-5,543	-1,734
Joint Extension	0,430	1,467	-0,060	-12	-6	-18	-5,514	-1,739

Table 4.2 Overview of the added ecological value for nature policy and its components for as summed up for each construction design, relative to the reference situation

E Overview of the assembly of the method from elements of existing method

from other methods	Element of the method					
	Design	**Study area**	**Abiotic conditions**	**Presence of characteristic species**	**Expected ecological connectivity**	**Value for nature policy**
Original method	Portaal Natuur and Landschap	Nature Points (Van Gaalen, 2014)	Portaal Natuur and Landschap	Nature Points (Van Gaalen, 2014)	Broekmeyer et al (2001)	Nature Points (Van Gaalen, 2014) and Groenfonds (2013)
Description	Classification of nature into Nature Management types	Setting boundaries to the area that is being affected. Normalisation for the area that is being analysed by multiplication with surface area.	Description of required Water- and Environmental conditions and a qualification of good average and poor values for several factors.	In the Nature Points method the ecological quality of habitats is analysed based on monitoring the presence of characteristic species	Description of building blocks required for groups of species to form an ecological connection with another ecosystem type.	In the Nature points nature is valued based on international importance, trend and rareness of species. In the method by Groenfonds this is taken into account as well in adition to the time it takes for a habitat to develop
Modification	Nature management types lay at the basis of classifying habitats in the method	Normalisation for the area that is being analysed by calculation per hecater of fixed study area	Factors have been put into criteria in the method and qualifications of good, average and poor have been valued as 1, 0.5 and 0. Unknown factors have been valued as average 0.	In the planning phase monitoring is no option. A percentage of (of 1) the characteristic species of a habitat present in the region has been analysed as a measure of the possibility that these species could occur in the habitat.	Use of the specified conditions for dispersal of groups of species. Descriptions of ecosystem types. Translation of habitats into ecosystem types.	RWS required policy based value based on Natura2000 and National Ecological Network goals. The contribution to these goals is analysed to the detail level of the method.

Input in the method	Descriptions of habitats and nature maps by Portaal Natuur and Landschap. These descriptions lie at the basis of further analyses	Description of the alternative construction designs and nature and topography maps	Descriptions by Portaal Natuur and Landschap and descriptions of the area in the Environmental Effects Report	Lists of characteristic species of Nature Management types by Portaal Nature and Landscape. Distribution atlases (waarneming.nl, Vlindermet, Sovon, Floron, Zoogdierenvereniging)	Dispersal requirements of groups of species and description of ecosystem types (Broekmeyer et al, 2001). Translation table Portaal Natuur and Landschap to ecosystem types, nature and topography maps (Portaal Natuur en Landschap, Kramer, 2007; Esri Nederland)	Natura 2000 conservation goals (Ministry of Economic Affairs). National Ecological Network goals and ambitions specified per province (Van de Leemkule, 2014) and nature policy plans and maps of the relevant province.