STSM SCIENTIFIC REPORT

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Mitigation and monitoring of road impacts on fauna

COST MC Chair: Mr. Hans Bekker

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STSM Topic: Mitigation and monitoring of road impacts on fauna

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This report is based especially in documents and reports published by Rijkswaterstaat and contributions by: Hans Bekker, Jos Arts, Ruud Cuperus, Emilija Savanovic, Beppie van den Hengel, Peter-Jan Keyzer, Annette Piepers and Wiebe Alberts from Rijkswaterstaat and Edgar van der Grift and Rien Reijnen from Alterra – Wageningen. To all I express my gratitude for the help and contributions that made this work possible.

I also thank EP – Estradas de Portugal, EPE, Rijkswaterstaat and Cost Office for the opportunity of performing this STSM.

1. INTRODUCTION

1.1 Framing and Objectives of Short-Term Scientific Mission

The aim of a Short-Term Scientific Mission (STSM) is to contribute to the scientific objectives of a Cost Action. This STSM has started under Cost Action 350 and it concerns the methodologies and techniques to mitigate, compensate and monitor the road impacts on fauna as habitat fragmentation and mortality. The main target is to obtain some knowledge about the Netherlands procedures on Environmental Impact Assessment and mitigation/compensation measures, concerning the biodiversity conservation, as these have been already implemented in the Netherlands and were well succeeded. Portugal has recently started to implement mitigation measures as underpassages for fauna, but its efficiency is far from good. This way, it is important to learn more about the techniques and methodologies for mitigate and compensate these impacts.

The STSM was performed in Rijkswaterstaat – "Directorate General of Public Works and Water Management", that belongs to Ministerie van Verkeer en Waterstaat – "The Ministry of Transport, Public Works and Water Management", responsible for mobility policy in the Netherlands (roads, waterways, railways and airways) and for protection against floods or falling water tables as well as the water quality of rivers, lakes and the sea. Rijkswaterstaat is the executive organization for the Ministry, responsible for the good function of the road (national trunk roads – all motorways and a small part of roads with limited access) and water management.

The STSM took place from 13-03-2006 to 24-03-2006 and in sub-chapter 1.2 is presented the daily activities report.

1.2 Activity report summary

In Table 1 is presented the activities developed each day of the STSM. The present report is the result of these activities.

Table 1 – Daily activity report

Day	Place of Activity	Summary of Activities
13/03/2006	Rijkswaterstaat (RWS) - Road and Hydraulic Engineering Institute - Department of Environmental Affairs	General Introduction The author presents a communication about Portuguese Roads Institute (EP) procedures in what concerns Biodiversity: "Road Impacts on Biodiversity: EP Strategies on its Prevention, Minimization and Monitoring" Meeting with Hans Bekker in order to define the STSM program.
14/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs.	Meeting with Emilija Savanovic to discuss the procedures concerning Roads EIA in the Netherlands *vs.* in Portugal. Work at the office collecting information and writing the report.
15/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs	Meeting with Beppie van den Hengel to discuss the ditch and verge management. Work at the office collecting information and writing the report.
16/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs Fieldtrip: Highways A15 and A12	Meeting and fieldtrip with Peter-Jan Keyzer to discuss the verge management.
17/03/2006	Fieldtrip	Meeting and fieldtrip with Hans Bekker to discuss the Defragmentation measures and visit some ecoducts and adaptations of underpassages and overpassages to be used for fauna.
20/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs	Meeting with Ruud Cuperus to discuss the implementation of compensatory measures procedures in Netherlands and in Portugal. Meeting with Annette Piepers to discuss the transposition of Habitats and Birds Directives to national law (Portugal and Netherlands) and some mitigation measures features. Work at the office collecting information and writing the report.
21/03/2006	RWS - Flevoland (one of the 10 Regional Directories) Fieldtrip: A6	Meeting with Hans Bekker, Ad Blaak (Regional Directory), Kees Hund and Paul van der Hoek to discuss the possible implementation of an ecoduct on the existing A6 and under the rail way.
22/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs	Work at the office collecting information and writing the report. Meeting with Jos Arts (Head of the Department of environmental affairs)
23/03/2006	Alterra - Wageningen	Meeting with Edgar van der Grift to discuss about the program LARCH Meeting with Rien Reijnen to discuss the effect of noise on birds.
24/03/2006	RWS - Road and Hydraulic Engineering Institute - Department of Environmental Affairs	Work at the office collecting information and writing the report. Brief Meeting with Wiebe Alberts to discuss some noise affairs. Meeting with Hans Bekker to discuss the report structure and finish the STSM
25/03/2006	Fieldtrip to Zeeland.	Fieldtrip to see the water management.

1.3 Structure of the report

This report is not so much a description of the activities performed during the STSM, but more the compilation of the knowledge acquired. It intends to transmit information about the procedures studied and is organized by themes. Firstly is presented a framework of Dutch policy concerning roads, especially, the process of planning traffic and transport infrastructures. Then the report concentrates on biodiversity, being described the processes related to implementation and management of minimization and compensation measures. For its relevance, the main themes are verges and ditch management and defragmentation measures implementation. The Long-Term Defragmentation Program, and the Expert System LARCH used to find the main fragmentation problems, are also described, since Portugal could take great advantage of the application of a similar program. Following, is presented a brief description of managing and monitoring of the mitigation and compensation measures. Finally, it is presented the conclusive considerations, emphasizing the strongest and weakest points of Dutch procedures compared to Portugal ones. In annex 1 is reproduced the presentation made by the author in Rijkswaterstaat about Estradas de Portugal (EP – "Portuguese Roads Institute") procedures concerning the prevention, minimization and monitoring of roads effects on biodiversity.

2. FRAMEWORK AND ORGANIZATION

2.1 Policy

2.1.1 Political Responsibility

In the Netherlands, three ministries are responsible for the policy related to the spatial planning. These three ministries all manage related parts of the entire policy domain:

- The Ministry of Housing, Spatial Planning and the Environment is responsible for the policies related to environmental pollution, such as noise, air and soil quality, the policies regarding spatial planning and for issues concerning building and housing. In addition, this ministry is responsible for policy concerning spatial planning and the environment.
- The Ministry of Agriculture, Nature and Food Quality manages the policy domain concerned with nature. The ministry is also responsible for the policies concerning the agricultural sector and for the consequences of agricultural land use on the spatial planning of the Netherlands.
- The Ministry of Transport, Public Works and Water Management is responsible for the policies related to the national infrastructure: roads, waterways, railways and aviation, as well as for the traffic that uses this infrastructure. In addition, the Ministry of Transport, Public Works and Water Management has responsibility for protecting against flooding, an important task, as much of the

Netherlands is below sea level and therefore, must take account of the risk of flooding in its spatial planning and in managing its system of dams and dykes. The Ministry consists of a Directorate-General (DG) for Public Works and Water Management, a DG for Passenger Transport, a DG for Civil Aviation and Freight Transport, and a DG for Water Affairs.

There are strong interrelationships between the areas addressed by these three ministries and therefore they often work together. In practice, the policy domains of these ministries are sub-domains of the overall policy concerning the physical structure of the Netherlands. When issuing strategic memorandums, one minister always takes a leading role, but there will be joint responsibility. For example, important strategic memorandums have been jointly published by these three ministries in the area of mobility, environment, spatial planning, nature, defragmentation and architecture.

Ministries operate at the national level, but their work must always continue at the regional level. In the spirit of the times, the Dutch government wants to decentralize a number of governmental tasks and to delegate responsibility as close as possible to citizens. The state specifies the major policy outlines and the provinces, water boards and local authorities ensure that they are worked out in detail and implemented. In doing so, they try to take greatest advantage of the opportunities offered by a certain physical area and work together with other local authorities.

2.1.2. Directorate General of Public Works and Water Management - “Rijkswaterstaat”

“Rijkswaterstaat” – the Directorate General of Public Works and Water Management is the executive organization for the Ministry of Transport, Public Works and Water Management, being responsible for the implementation of policies for the national infrastructure of motorways and waterways, for the good function of roads (national trunk roads – all motorways and a small part of roads with limited access) and water management and for flood protection. Lower order roads are managed by the provinces, municipalities or district water boards and include some of the roads with limited access (managed by the provinces) and other paved roads located outside the built-up area.

In addition to policy implementation, the Directorate-General for Public Works and Water Management plays also an important role with respect to environmental issues together with the two other ministries, mentioned before. Regulations and policy agreements are prepared and managed within these three ministries.

The core of the work carried out by the Directorate-General is executed by 10 regional directorates that are each responsible for a specific region of the Netherlands. The head office bears overall responsibility for the planning, prioritizing and budgeting for all of the Directorate-General's activities.

For support regarding the content of the work, the head office and the regional directorates can call upon six specialist departments of the Directorate-General. These departments provide advice and carry out research in certain areas. They also perform coordinating activities for the joint regional directorates. In this way, the specialist departments ensure greater efficiency within the Directorate-General for Public Works and Water Management, through efficiencies of scale and stronger unity of action.

One of those specialist departments is the Road and Hydraulic Engineering Institute. The responsibilities of this institute include issues concerning the relationship between motorways and the environment. The Infrastructure and Environment Division, in particular, is tasked with this work. This Division consists of three clusters:

– Nature & Landscape - addresses the issues: integration of motorways into the landscape and nature-oriented integration and management of motorways, architecture and cultural history;
– Noise, Soil and Air - addresses environmental hygiene aspects;
– EIA / Transportation Centre - carries out research and provides advice on all aspects related to Environmental Impact Assessments (EIA) and the preparation of exploratory studies ("reconnaissance studies") and plan studies.

Moreover, the Division has a research coordinator and an environmental policy coordinator. These coordinators are also involved in a limited number of issues that do not fall under the three clusters mentioned: sustainable construction, environmental management and energy use.

Incidentally, the Road and Hydraulic Engineering Institute works intensively with other specialist departments and regional directorates in the area of advice and research on the environment.

2.1.3 Regulations and Policy Objectives

The protection of the environment is provided for the European and Dutch legislation and regulations. In addition to these regulations, strategic policy plans define environmental policy goals of the Dutch government. There are a number of important reasons for regulations and policy objectives in the area of motorways and the living environment: the effects of the motorway on natural environment and on health of people; the preservation of (historical) heritage; the exploitation of the possibilities of cost savings (for instance**,** energy efficient lighting).

The following is a summary of issues for which regulations and policy agreements have been made.

Regulations:

- Noise pollution: directives for background noise;
- Local air quality: directives for air quality, such as the vicinity of motorways, among other places;
- Habitat Directive and Birds Directive: protection of designated vulnerable nature areas and particular species, specified for the Netherlands in the Flora and Fauna Act, and Nature Conservation Act;
- Water: effects of physical activities on the water management;
- Environmental Impact Assessment (the appraisal of environmental effects of projects, prior to giving consent to projects);
- Strategic Environmental Assessment: the appraisal of environmental effects of strategic policies, plans and programs before their approval;
- Soil protection: directives for soil management;
- Archaeology: management of sites of archaeological interest in accordance with the Valletta Treaty;
- Compensation: the requirement to compensate the negative effects of infrastructure on nature by creating new nature areas.

For an increasing number of these issues, European regulations apply or are being prepared. These European regulations have to be implemented in Dutch law. When incorporating European regulations in the Dutch regulations, there may be added some country-specific elements.

Policy agreements:

In the Netherlands, major strategic memorandums describe the objectives the government is aiming for. These are in particular:

- Defragmentation (Memorandum “Nature for people, people for nature”, long-range program for defragmentation);
- Architecture (Third Memorandum on Architecture policy);
- Cultural history, heritage (Belvedere Memorandum);
- Ecological management of verges (memorandums of the Ministry of Agriculture, Nature Management and Food Quality since 1970);
- Sustainable construction (National Environmental Policy Plan);
- Environmental management (National Environmental Policy Plan);
- Energy use (substantiation of the Kyoto agreements).

In the Netherlands, policy objectives may be transformed into regulations over time, thereby providing more strict instruments.

2.2 Planning process for traffic and transport infrastructure projects

(With the contribute of Emilija Savanovic and Jos Arts. Based on Arts, J. & Lamoen, F, 2005 and Arts, J., 2004)

The EU Directive on "Strategic Environmental Assessment" (SEA) has not yet been incorporated into Dutch legislation. Therefore, the Directorate-General for Public Works and Water Management does not yet have any concrete experience with its application. Currently, the Ministry of Housing, Spatial Planning and the Environment, the Ministry of Agriculture, Nature Management and Food Quality, and the Ministry of Transport, Public Works and Water Management are preparing some major strategic policy plans. In future, SEA for this policy plans will influence the content of policies, and thereby also the implementation of those policies by the Directorate-General for Public Works and Water Management.

The construction or extension of a highway is the end result of a long process of drawing up policy plans, project plans and formal procedures (see Figure 1).

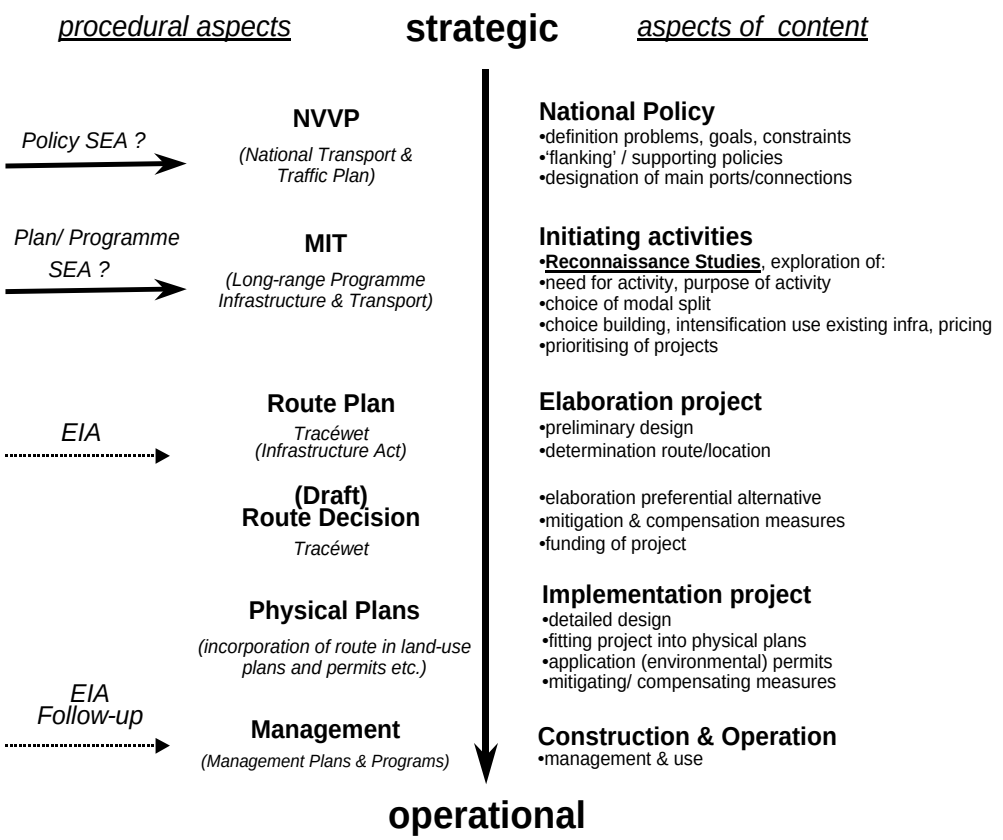


Figure1 - Planning process for traffic and transport infrastructure projects in the Netherlands (source: adapted from Arts, J. & van Lamoen, F, 2005).

The National Transport and Traffic Plan (NVVP) describes the policy guidelines related to the future development of the national Netherlands transportation system for the period 2001-2020. Policy guidelines are formulated in relation to projected transportation needs (following from socio-economic projections) and specified objectives in terms of mobility, accessibility, safety, and environmental and spatial quality. In this respect, the NVVP coordinates the policies for the transport and traffic sector with other relevant planning sectors at the national level, such as physical planning, water management, environmental management and nature conservation. The NVVP provides an overview of preferred development directions and policy options, serving as a framework for the identification and evaluation of more specific policy measures on regional and sub-regional levels. As such, the NVVP forms the top level in a transport planning hierarchy from the national to the regional and local level. All plans to be developed within this hierarchy are expected to become subject to SEA. Following the finalization of the first NVVP in 2001 the emphasis is now on the development of the regional plans, in particular the Provincial Transport and Traffic Plans (PVVP).

Every year the Ministry of Transport prepares the Long-Range Programme for Infrastructure & Transport (MIT). The MIT is an implementation programme of the NVVP policy which is updated every year and which links up with the budget of the Ministry of Transport. Like NWT, the MIT is not yet subject to a form of Strategic Environmental Assessment (SEA) — however this might change with the implementation of the European SEA-Directive.

As part of the MIT-programming, project proposals listed in the NVVP or proposed by (regional) parties may become appointed as so-called ‘Reconnaissance Studies’ (see Figure 1). In such explorative, preliminary studies, the problem and potential measures are explored by the Ministry of Transport together with other parties such as other ministries, regional authorities (provinces and municipalities) and local interest groups. In this process, the relationships with other developments planned in the area are explored as well as other problems and opportunities for the area that might be related to the traffic and transport problem at hand. Also this planning level could in future be subject to SEA.

The Provincial Transport and Traffic Plan (PVVP)

An example of a regional (provincial) plan is “The Provincial Transport and Traffic Plan (PVVP) South Holland”. The drafting of this first PVVP South-Holland is presently in progress.

South Holland is the most densely populated province of the Netherlands, located in the south-western part of the country. It contains a number of major cities such as The Hague and Rotterdam, with the port of Rotterdam as a main centre of activities for the transhipment, storage and distribution of goods. Major north-south and east-west corridors including all modes of transport (road, rail and waterways) connect

the province with major cities and industrial areas within and outside the Netherlands (in particular Germany and Belgium).

The PVVP South-Holland to be developed will contain two parts: (1) a policy document containing the specific policy views on transport planning in the province (following the directions and guidelines of the NVVP); and (2) the planning agenda which specifies the policy implementation in terms of concrete objectives and projects.

From the present perspective, some important policy views include:

- controlled accommodation of growing mobility demands;
- focus on choices and needs of traveller;
- reinforcing the coherence of national/regional transport planning;
- enhancing the regional integration of transport planning objectives and the ambitions related to physical planning and economic development.

The planning agenda would be based on a further sub-regionalisation, presumably in the form of a number of concrete corridors, based on transport relationships between or among main origin-destination centres. These would be subject to further study in order to identify the present and anticipated problems related to the performance of the transportation system and the most promising options for its improvement. In principle, such options could include a variety of projects related to the upgrading, expansion, efficiency improvement or integration of transport networks. The projects to be put on the planning agenda will not be fixed. Rather, the planning agenda will be flexible and be subject to bi-annual progress evaluation.

Given the stage of development of the PVVP planning process and the uncertainties related to the role of SEA in this process, the analysis and evaluation procedures to be applied in the drafting of the PVVP are still largely to be determined.

Reconnaissance Study

Reconnaissance studies have been part of the Netherlands transport infrastructure planning practice for quite some time. Traditionally, the identification of options to be considered in the reconnaissance phase was mainly based on an assessment of traffic and transport performance and the cost of specific unimodal options. Typically, a more detailed assessment of environmental and other impacts would then take place in the EIA procedure, after the first identification of options.

In recent years there has been a development to redefine the function and content of these reconnaissance studies. Basically, these developments aim to broaden the scope of the reconnaissance phase from the following perspectives:

- to apply the reconnaissance phase in an earlier stage of the planning process;
- to have the reconnaissance phase function as a screening and selection process involving a wide range of options rather than a converging step on a limited set of more specific options;
- to consider a wide range of impacts reflecting and involving all relevant interests and stakeholders.

Based on these views, a reconnaissance study according to the "new approach" should address the following key elements:

- a problem analysis which involves the analysis of observed and anticipated problems and the roles of responsible parties within a defined (planning) area;
- the identification and (pre)-analysis of a wide range of possible solutions;
- an inventory of all relevant parties and stakeholders and their specific involvements and interests;
- the causal relations between observed and anticipated transport problems and the spatial, social, economic and environmental characteristics and developments in the potentially affected area.

Within this broader perspective, the level of detail to be considered in the reconnaissance study should be limited. It should be considered as a first step in a planning process, (potentially) followed by more detailed assessments of more specific solutions. Obviously, such a reconnaissance study would merely apply to problem areas of a sufficiently broad nature, *i.e.* allowing for a range of different options to be considered. The typical planning level to be considered is the corridor level. This planning level will in future be subject to SEA.

One example is the reconnaissance study prepared by the Directorate-General for Public Works and Water Management for the corridor of the A27 between Breda and Utrecht (see Box 1).

Box 1
(based on Arts, J. & van Lamoen, F, 2005)

Reconnaissance study for the Corridor - A27 between Breda and Utrecht

The Directorate-General for Public Works and Water Management has prepared a reconnaissance study for the corridor of the A27 between Breda and Utrecht (approximately 80 km). The main reason for starting up this study was the congestion that occurs daily on various places along the route. It has been carried out in accordance with the new guidelines for reconnaissance studies. The study analyses the traffic and transport factors and carries out a broad inventory of spatial, economic, recreation and nature developments. On basis of the analysis of potential solutions an expert meeting was organized in order to make a first selection of possible solutions. This selection was checked and further elaborated in a workshop with regional parties. After this, it was made a first estimation of the costs and consequences of proposed solutions. In a separate study, opportunities and restrictions for integrated design – connecting the infrastructure and its surroundings – were explored.

After the completion of the reconnaissance report, the EIA centre of the Directorate-General for Public Works and Water Management carried out an evaluation of both process and results of the study.

This case-study showed that reconnaissance studies may provide a link between strategic plans (and SEA) and operational projects (EIA).

Environmental Impact Assessment: Legal Procedure

The process of Environmental Impact Assessment (EIA) for a road can be described accordingly to Figure 2. There is a first stage – Reconnaissance Study – already described, which can last one year and is not required by law (is optional).

In case it is decided to proceed with EIA, the Directorate-General for Public Works and Water Management (proponent) draws up a "notification of intent", which gives a broad outline of the proposed project. This notification is submitted to a public review, advice and consultation. The EIA Commission (a group of independent experts) issues "Advice with Guidelines" on the basis of which the competent authority (Ministers of Transport and Environment) prepares the final "Guidelines for the EIS" (EIS- Environmental Impact Statement).

Then the proponent prepares the EIS, in which the project proposal and its alternatives are assessed for their impact, and potential mitigating measures are proposed.

The law does not require the proponent to include a (draft) programme for EIA follow-up in the EIS. However, the guidelines issued by the competent authority usually ask for this. Subsequently, the competent authority checks the completed EIS prior to release for public review along with an application for the consent decision or a draft decision. The EIA Commission evaluates the quality of the EIS and submits a "Review Advice" to the competent authority. The competent authority is responsible for taking the "Consent Decision" – to grant the environmental permit or approve the plan. In doing so, it must considers the EIS, the results of the public review and the advice received, and the decision must be made public. Both the proponent and third parties may appeal against the decision in court. Finally, the competent authority must also provide a 'Programme for Ex-post Evaluation' – *i.e*. an EIA follow-up programme. This indicates the terms and manner in which the competent authority will perform the evaluation once the project commences.

In practice, most of the times this final stage – EIA follow-up – is not performed. Although there are some studies to monitor the road effects on environment, these are developed usually in a broad scale and are not directed to the segment of road developed in the EIA context nor are evaluated the mitigation or compensation measures applied in each case.

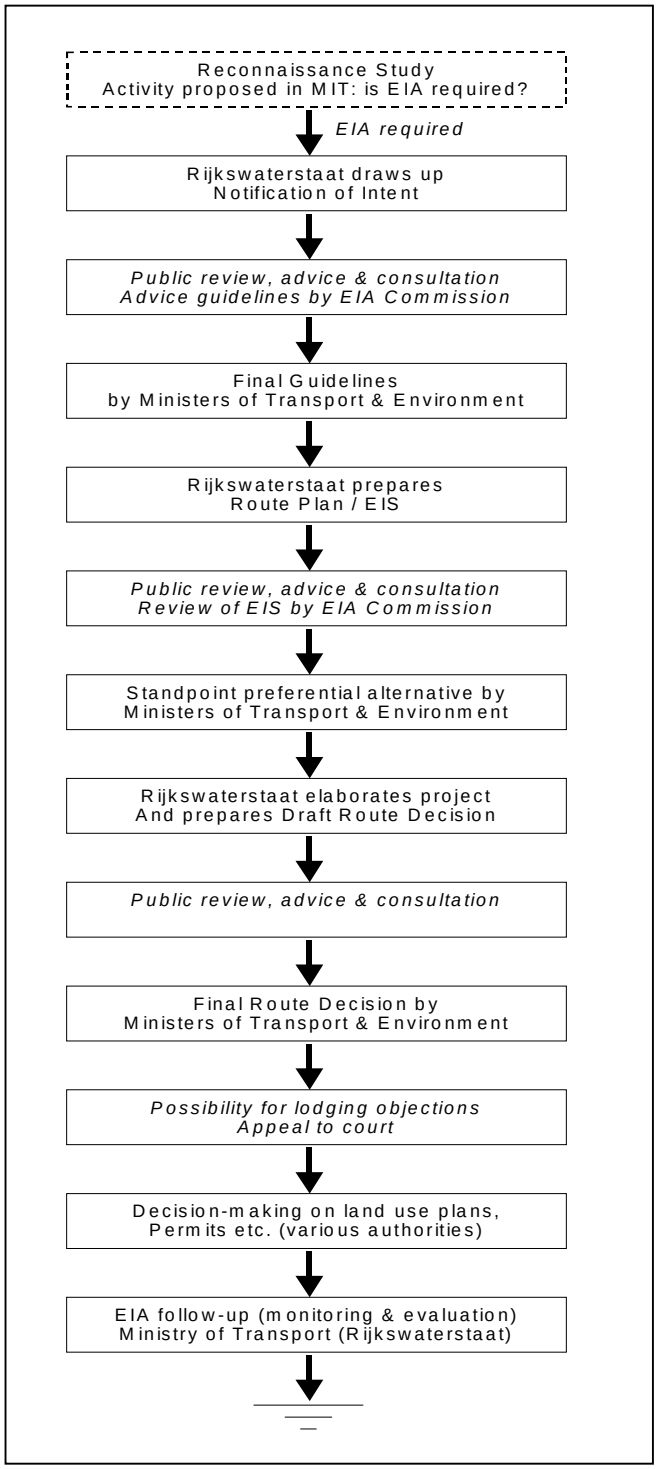


Figure 2 – EIA procedure for road projects (source: adapted from Arts, J., 2004)

Since November 2005, the projects that consist in beneficiating or altering existent roads (*e.g.* enlargement) no longer have to be submitted to the same legal process. These projects will follow only the 2nd to 3rd steps of the process and then the Directorate-General for Public Works and Water Management develops the project, which will be submitted to a public review, advice and consultation, after what the Ministers of Transport and of Environment make their decision. If there are possibility of having different choices, usually there are only two alternatives, one will be the one that the Ministry of Transports prefers, which is developed mainly with the criteria of best road performance, and the second one will be the "best possible" in terms of environment. This applies to the big infrastructures too, although there might be more alternatives: usually there is one best alternative in environmental terms and one best alternative in road design and safety terms (although avoiding the main environmental restrictions).

Although similar with the Portuguese EIA procedure, there are some differences at some points, especially in what concerns the EIA commission (in Portugal is usually the Ministry of Environment) and the EIA-follow up (in Portugal, every project is evaluated and monitored individually, but no monitoring studies are developed by the EP on a broader scale. A description of EP procedures in what concerns EIA of roads is presented in Annex 1.

3. MINIMIZATION AND COMPENSATION OF IMPACTS ON BIODIVERSITY

3.1 Introduction

In addition to its core activities in the areas of infrastructure and water management, the Directorate-General for Public Works and Water Management is responsible for other related tasks. One of these is to manage the environmental impact of these core activities. This means preserving the quality of both human and natural environment. The latter includes those parts of the natural environment constructed and managed by Directorate-General itself. Among the most important of these, in terms of dimension, are the ditches and the verges bordering the motorways and main roads in the Netherlands. It also includes the implementation of mitigation and compensation measures of the impacts. Of these, fragmentation is emphasized for its significance for animals in long-term (see Box 2).

Box 2

Effects of roads

The main effects of roads (construction, presence and operation) are destruction of habitats, disturbance, run-over and drowning of animals and the barrier effect.

Destruction of plant and animal habitats is the most direct consequence of infrastructure construction. Due to their much greater total length, lower order roads are more responsible for the destruction of habitat than national trunk roads, despite their narrower width.

Considerable research has been conducted on the impact of disturbance from national trunk roads, both caused by traffic noise and by road lighting. For example, the noise can cause a significative decrease in density of summer birds such as the black-tailed godwit (*Limosa limosa*) near the roads (this effect is extended until approximately 1000m of distance to the road).

It has been estimated than millions of vertebrates are hit on the Dutch road network each year (based on registration on part of the road network). For some relatively rare species, the number of traffic casualties constitutes a threat to their populations: the badger (*Meles meles*), the barn owl (*Tyto alba*) and amphibian species. Research has shown that this can even cause a decline in the population of common species, such as the hedgehog (*Erinaceus, europaeus*), along roads.

Based on research on several canal routes, it can be assumed that thousands of animals annually drown in canals (roads are usually constructed over dikes along canals) with steep banks (mainly hares (*Lepus europaeus*), rabbits (*Oryctolagus cuniculus*), roe deer (*Capreolus capreolus*) and *Mustelidae*).

Some research has shown that mice and ground beetles do not at any rate cross national trunk roads, provincial roads and motorways. Lower order roads are generally narrower than trunk roads and probably do not readily form an absolute barrier for fauna.

In addition to the negative impact of infrastructure on nature, it also has a positive impact. Ecological management has resulted in flowery roadside verges with a high diversity of species. More than half of the Dutch plant species grow in the roadside verges. Roadside verges can also function as a corridor between habitats, *e.g.* for ground beetles. The banks of verge ditches and along canals act as connection zones for less common species such as the grass snake (*Natrix natrix*), otter (*Lutra lutra*) and water shrew (*Neomys fodiens*).

The construction of infrastructure also has indirect effects. It increases the rate of regional economic development, which also accelerates the urbanisation process. This causes greater or lesser fragmentation of the landscape, depending on the scenario. Urbanisation along infrastructure (linear urbanisation) results in a relatively slight loss of habitats but a relatively sharp compartmentation of the landscape, which brings about the isolation of habitats.

In addition to impacts on nature, the presence of infrastructure in nature areas also effects traffic safety. This hazard is limited in the Netherlands by the installation of fences. Of the total number of fatal traffic accidents or those resulting in hospitalisation, 0,3 % were caused in 1998 by collisions with animals. This percentage is higher for two-wheeled vehicles (bicycles, mopeds and motorcycles), *e.g.* 5.6 % for motorcycles in 1997.

3.2 Verges and Ditches Management

(With the contribute of Peter-Jan Keyzer and Beppie van den Hengel)

3.2.1 Introduction

Ecological verge design and management optimizes the nature values of the verges. This approach stimulates biodiversity. When verges are managed ecologically, they are mowed less often and the mowed material is removed. The latter does not happen when verges are managed “normally”. Since

the 70's, the Directorate-General for Public Works and Water Management has been designing and managing the verges in an ecological manner. When an efficient approach is taken, the additional costs are limited. Recently, the Directorate-General has extended this working method to include ditches, which in particular means that there is improved retention of biodiversity of aquatic vegetation. For the future, the Road and Hydraulic Engineering Institute is currently investigating whether it is possible for the Directorate-General to change its methods to an approach that weighs up the costs and benefits: at the locations where the most benefit can be achieved for nature, the verges will be designed and managed ecologically. These themes are discussed in the following sub-chapters and the recommendations of the Directorate-General for Public Works and Water Management about the management of these sites are presented.

Figure 3 - Road verge. For several years, road verges have been managed to enhance their wildlife value. This involves mainly the vegetation and, to a lesser extent, the fauna. For verges with herbaceous vegetation, management generally consists of mowing at least once a year. The hay mown from these verges is removed from the site. The aim is to achieve maximum species diversity, and to retain the existing value for wildlife (photo from Beppie van den Hengel).

3.2.2. Ecological Verge Management

The verges bordering the motorways and main roads in the Netherlands cover approximately 12 000 hectares and highways verges can be 10 m or more wide. These verges are largely covered with grassy vegetation and a variety of ligneous vegetation. They have traffic and civil engineering related functions, including road safety, but also ecological and landscape-related functions.

The Netherlands has a wide variety of species of flora, some of which are rare. After 1950, there was a shift towards, on the one hand, more common flora and, on the other, rare or extinct species. This change has a number of causes, such as land allocation, fertilization, land drainage and intensive farming. The infrastructure has, however, not had a great impact on this change.

Rare species are the responsibility of conservation organizations and it is assumed that they will receive sufficient protection. So, the Directorate-General for Public Works and Water Management

devote particular attention to the plants in the middle group (species that are neither rare nor common) to ensure that they do not eventually become rare or very rare. For this point of view, roadside verges can, if correctly constructed and managed, provide a habitat for species that would otherwise be under threat of extinction (See Box 3).

It was not always seen like this. As verges were constructed to ensure the safety and stability of the road structure, they were kept short grassy and weed free, being mowed 5 to 6 times a year without collecting and removing the grass cuttings. The result was a dense grassed lawn, offering a habitat for few common plant species with poor ecological value.

Box 3

In 1982, the Road and Hydraulic Engineering Division (DWW) started a study about the effects of different management regimes, including their impact on the number of species and diversity of roadside flora. Two verges were used in the study, one with a sandy soil at Voorthuizen (on the A1) and the other with a clay soil at Tiel (on the A15). At the start of the study, both verges were already for five years mowed twice a year and the cuttings removed. Subsequently, the verges were divided into test plots and the effects of the following cutting regimes were studied over a period of ten years:

- mowing and removing cuttings twice a year;
- mowing and removing cuttings once a year in the middle of June;
- mowing and removing cuttings once a year in the middle of September;
- mowing and removing cuttings every other year in the middle of June;
- no action at all.

The best results, as far as preserving the number of species is concerned, were achieved by maintaining the original schedule of mowing and removing the cuttings twice a year. This was true to both sandy and clay verges. The study also examined the effects of the various cutting regimes at both sites where trees provided shade. In these cases, the original cutting regime of mowing and removing the cuttings twice a year also proved most successful, although the range of species in more shaded sections of the verges was very limited.

So the best option for flora is to mow and remove the cuttings twice a year. This produces the highest number of species and those in the middle group survive successfully. In areas where trees provides shade, the option of mowing and removing the cuttings twice a year also produces the best results. It is, however, debatable whether this is worth the effort since the number of species growing in the shade is very limited. Under these circumstances and taking cost into account it would be better to seek a more suitable form of vegetation, such as forest edge like vegetation. It is important in doing so, however, to take account of how this may affect other environmental factors.

The two sites selected for the study can be considered representative of most roadside verges in the Netherlands including those alongside provincial and local roads. The conclusions therefore apply to the majority of verges in the country. There are, however, other types of verge that require a different approach. These include heather verges and verges composed on very poor sands.

In certain situations, other environmental factors may be important, such as preserving the habitats of reptiles and amphibians, butterflies or other insects. In these situations, the best form of management must be sought on a case-by-case basis. Frequently the best course of action is to reduce the level of cuttings. Rijkswaterstaat has published a Handbook for Vegetation Management that provides guidance in these situations.

The Netherlands has no specific policy on verge hay disposal at national, provincial or municipal level. Generally speaking, wastes should be put to good use or recycled wherever possible, and waste production should be minimised or avoided. Provincial policy is usually to compost vegetable wastes.

Increasingly in recent years, authorities responsible for road verges and canal banks have focused on ecological restoration, maintenance and improvement of their natural value. Banks of wild flowers have now become a feature of many highway verges. But developments in verge management continue. The policy plan of the Directorate-General for Public Works and Water Management - "Strategy for the Nineties" - puts the emphasis on sustainable development. One of its goals is “sustainable verge management”.

The basic principles of sustainable verge management are:

- besides its technical purpose, vegetated areas have important environmental and nature conservation functions;
- other functions, such as timber production, are subordinate to the technical and environmental functions;
- design, layout and management determine to a great extent the environmental and nature conservation value of vegetated areas; external factors that have to be taken into account include location (proximity to a nature conservation area or agricultural land), soil type, and water management;
- the environmental and nature conservation value of a vegetated area is improved by ecologically friendly management;
- the concept of ecologically friendly management is based on the maintenance and reinforcement of ecological values; these values are determined by the diversity, rarity and "naturalness" of animal and plant species and the degree to which communities are characteristic of the site.

This means that verges should be designed, laid-out and managed in such a way that they fulfil a function for the many plants and animals found in the wild. This function can consist of providing a suitable permanent habitat for plants and animals, or just a temporary refuge. A third function is that of a linear connection or corridor between different nature reserves. The aims of ecological management are therefore: continuity; diversity; reduction of the level of plant nutrients in the soil; and avoidance of non-native elements (See Box 4).

Box 4

Continuity
Continuity is a pre-requisite for ensuring stability in the ecosystem. This can be achieved by drawing up a verge management plan for a particular site. This should prescribe the management measures, their frequency and scope to keep disturbance to a minimum.
In this way, verge management can be adapted to the local flora and fauna - by mowing when spring flowers have finished blooming, or once certain insect species are in a position to complete their life cycle, for example. At nesting sites, mowing should only be done after the middle of June. It is important, however, that mowing or clearing takes place every year at roughly the same time of year on a particular site.

Diversity
Variety in the structure of the vegetation is the best way of achieving a rich diversity of plant and animal species. This is possible by differential mowing - leaving certain sections unmown or mowing and clearing less often. These sections can provide overwintering and breeding sites for many animals.

Reduction of excess nutrients
The Netherlands has relatively few ecosystems that are nutrient-poor, undisturbed and species-rich. Therefore, ecological management should be aimed at reducing excesses of nutrients in water and soil. This can be achieved by good design, eliminating for example the use of fertilisers and humus-rich soil. This should only be used where it is really necessary, to provide stability on steep slopes, for instance. Other measures include removal of grass cuttings and ditch weed, and not disturbing the soil by compaction, etc.

Non-native elements
Indigenous species are recommended when selecting plants for landscaping. Chemical pesticides are non-native, and should therefore be avoided.

Management of herbaceous vegetation

The roadsides are large and often flat. The wide outer verges are more interesting ecologically than central reservations or the narrow verges where road signs are placed. Here there may be problems of soil compaction, waterlogging, salt, intensive maintenance, vehicle emissions, and acoustic and visual pollution from traffic. The Directorate-General for Public Works and Water Management recommends that these sites be only mowed as often as safety dictates. Further away from the road, these factors have less effect, and the verge has greater ecological potential. These parts of the verge are best mown once or twice a year, using a par mower or rotary cutter. If mowing is done once a year, it is better done in the autumn.

The hay should be removed after a few days and processed by composting or using for animal fodder (see Box 5). Leaving the hay on the ground for several days allows seeds to fall. Likewise, animals, particularly insects, can then seek a habitat in the areas left unmown. To provide a varied structure, the management plan should incorporate sections that are mown less frequently than others (for example, by mowing in strips or leaving some places unmown). In this way, a fifth to a tenth of the herbaceous vegetation can be left unmown on each mowing. Nesting and overwintering sites are preserved, and plants have a chance to produce seed.

Another possibility, depending on the width of the verge, is to leave sections unmown in a strip of grassy verge adjacent to a wooded area. This produces the woodland edge conditions favoured by many insects and other animals. Transitions - from dry to wet, from low elevation to high - should also be assessed for their wildlife value, to enable a balanced management to develop.

Bare or stony ground and small differences in verge elevation are important for wildlife. Some insects prefer these sites for laying their eggs, and reptiles use the reflected heat to warm up. Such sites should only be seeded, removed or levelled when the technical demands of the traffic require it, or if it poses real difficulties for verge maintenance.

Box 5

The chemical quality of verge grass in the Netherlands

The usual destinations for the cuttings are farms, composting plants and landfill sites. However, according to the policy on waste substances laid down in the National Environmental Policy Plan, which aims at waste prevention and recycling, dumping is not a desirable solution. The practice should therefore be reduced, especially where products are reusable, as is the case with verge grass.

However, one obstacle to reusing verge grass on a wider scale is its negative image in terms of pollution, especially from vehicle exhaust fumes and fragments of tyres and brake linings. The main pollutants are heavy metals and polycyclic aromatic hydrocarbons (PAHs). These substances may be carried onto the verge by rainwater runoff or by the wind and turbulence caused by passing vehicles.

The Road and Hydraulic Engineering Division has conducted a detailed study of the degree to which verge grass is really polluted. This way, it was assessed the “acceptability” of verge grass to various potential uses by the knowledge of it chemical quality. As far as using it as fodder and for making compost is concerned, specific environmental limit values have been set, but often only for a limited number of substances. The main objective of the study was therefore to obtain information on pollution levels and to compare them with the limit values.

Grass samples were taken along seven different highways. This was done on both sides of the road to allow for the possible influence of the wind. Traffic intensity and road type were taken into account when selecting locations. In each location, a reference sample was taken about 200 m from the road. To ensure that the locations could be compared, sites were sought where:

1. there were no obstacles in the vicinity, so there was no protection from the wind;
2. the verge was at least 12 m wide, so that the relationship between pollution level and distance from the road could be determined;
3. the vegetation was typical of that found on verges;
4. the road lay at ground level in a flat terrain.

The measurements for zinc and the other heavy metals and for PAHs show that, in general, a relationship exists between pollution level and distance from the road. The levels are highest in the direct vicinity of the road. No direct relationship was found between pollution level and traffic intensity.

The study shows that the levels of lead, cadmium, chromium, nickel and arsenic in verge grass satisfy the limit values for fodder and for very clean compost. The zinc levels are far below the limit value for fodder and easily satisfy the limit value for materials used for making clean compost, but not all of them satisfy the limit value for very clean compost. The copper levels satisfy the limit values for fodder and very clean compost. Sheep are more sensitive to copper than other animals, and a more stringent limit value of 17 mg/kg dry matter has therefore been set for copper in sheep feed. Levels above this value were measured in very few cases.

No standards have yet been set for PAHs in fodder, but the measured values of 0,2 to 0,7 mg/kg dry matter do not seem to give cause for concern, since levels of up to 0,4 mg/kg dry matter have been found in green vegetables for human consumption and the level of PAHs 200 m from the road - outside the road's immediate sphere of influence - is also 0,2 mg/kg dry matter.

Similarly, no limit values have been set for PAHs in materials used for making compost. During the composting process, PAHs decompose, which means that PAH levels in verge grass cannot be compared with levels in compost. To protect the multifunctional quality of the soil, *i.e*. to ensure that the soil continues to perform all its current functions for humans, animals and plants, reference values have been laid down in the Soil Protection Guidelines. For PAHs this value - a value for clean soil - is 1 mg/kg dry matter. The average PAH level in the verge grass is below this reference value at all the locations where measurements were made.

The above results showed that verge grass can be used as fodder without any problems. Nor are there any objections to using it to make clean compost. However, if it is to be used for making very clean compost, the zinc level must be checked to ensure that it satisfies the relevant limit value.

The first one and a half metres beside the road, known as the "signpost strip", tend to be mown more frequently than the rest of the verge for safety reasons. A flail mower is often used on this strip, so that the grass is left lying on the ground. Sometimes, however, other equipment is used, and the cuttings are not left on the ground and have to be disposed of. The grass in this strip is the most polluted. In general, this is no objection to using it as fodder or to make clean compost. However, the grass is not suitable for making very clean compost. If the signpost strip and the rest of the verge are mown separately, the cuttings from the rest of the verge can be used as fodder and to make very clean compost.

In addition to chemical pollutants, refuse and other waste such as tyre fragments may be found on verges. It is advisable to remove as much of this waste as possible just before the verge is mown. Any waste that remains can be removed using screens after composting, but its use as fodder is likely to be less acceptable to customers.

Management of woodland vegetation

Rather than planting, each site should be considered on its merits and a scheme for spontaneous woodland development. Tree-planting often requires intensive maintenance and the discrete planting pattern often makes a poor habitat for wildlife.

If woodland planting is undertaken, only indigenous species that are characteristic of the site should be used. The road will then blend in better with the surrounding landscape. The planting can also fulfil a function for fauna (as a shelter belt or corridor).

Periodic removal of saplings can be useful to stem unwanted thicket growth. The young felled trees can be left in the site, without being chipped.

3.2.3 Ditch Management

While recent years have seen an increase in the wildlife value of verges, this appears not always true for watercourses and ponds. Pollution by domestic, industrial and agricultural wastes has led to eutrophication and the impoverishment of flora and fauna.

Traditional watercourse management also has consequences for flora and fauna. To improve wildlife value, the Directorate-General for Public Works and Water Management is starting to implement the following measures:

- Maintaining adequate water levels all year for aquatic fauna (fish, frogs etc.). Current practice is to keep levels low in winter and high in the summer, and many fish, amphibians and other aquatic organisms die in the winter and spring;
- Clear ditches once or twice a year, and if possible less frequently. In consultation with the water authority responsible for land drainage a less rigorous ditch-clearing schedule is often possible. Watercourses not subject to water authority inspection should be cleaned as little as possible, depending on function. The mower should be fitted with a basket;
- Ditch and pond banks are best cut with a par mower or horizontal rotary mower. In nutrient-rich sites, this can be done twice a year, in May/June (July in species-rich and bird-nesting sites) and late in the autumn. A single annual mowing should be done in the autumn. The grass cuttings should be removed;
- Waterside banks should also be differentially mown, and ditches cleared at staggered times, for the same reasons as other verges.

Usually animals are not fazed by water, but if the banks are too steep they cannot climb out of the water and will drown. This is prevented by installing banks with natural sloping transition between water and land at regular intervals or by installing fauna exits – structures a couple of meters wide, which provide a gentle slope for animals to climb on.

Large-scale maintenance activities can often provide opportunities for redesigning a waterside bank. These include oversizing, varying the depth of ditches and the batter slope, and replacing rip-rap with environmentally-friendly banks. Maintenance access need only be provided on one side, and other design features should allow for the retention of polluted water, and minimizing runoff from agricultural land.

Figure 4 - The waterside of this ditch along the highway is being reconstructed in order to become less steep. This has the double effect of preventing animals from drowning and promoting more flora diversity and abundance.

3.2.4 Biodiversity in ecologically managed verges and ditches

For five years the flora and vegetation in verges was studied extensively. It were found 796 plant species, which corresponds to 50% of all plant species in the Netherlands. Among these, various rare species were discovered. Of all species, approximately 160 (10% of Dutch flora) are mainly found there since few, if any, suitable habitats are available elsewhere.

A richer array of plants and wider variation in vegetation structure also benefited the fauna in verges. 50% of Dutch butterflies (80 species) are common in highway verges. It is estimated that 22 species can actually survive during all life cycle in the verges, including some threatened species. Many other insects, small mammals and some birds can find viable living conditions. Verges have also acquired a connective function, being used for many animals to move from one location to another. Further improvements are achieved by creating nature-friendly (verge) ditches and adopting a ditch management system focusing on their potential for nature. This turns verges into important arteries through a landscape low in natural elements, contributes to an improvement in the quality of the natural environment and prevents further decline because of fragmentation.

It is possible to conclude that the ecologically management of verges represents a history of success that can be even improved when this kind of management is extended to all roads.

3.3 Defragmentation Measures

(With the contribution of Hans Bekker and based on Piepers, A.A.G. (Ed.), 2001)

Mitigation measures are defined as those that reduce or alleviate the negative impact of infrastructure construction and use on ecological processes and nature values in an area. For this, a distinction is made between source-oriented and effect-oriented measures. Source-oriented measures focus on the infrastructure itself or on traffic, *e.g.* reduction of the maximum speed limit or laying of ZOAB (porous asphalt), which is currently used, is a standard procedure on national trunk roads in order to reduce noise pollution. Effect-oriented measures specifically concentrate on particular animal groups or ecosystems. Fences and fauna passages are in this category.

Defragmentation measures are required to re-connect nature areas that are fragmented by the main infrastructure. Examples of defragmentation measures are ecoducts and badger tunnels (Figure 9). These are needed to achieve the required scale and accessibility of the natural habitat and they promote the local survival of species. Moreover, these measures prevent animals crossing the motorway, something threatening to both road user and animal.

Together with the Ministry of Agriculture, Nature Management and Food Quality, the provinces and the local authorities, the Directorate-General for Public Works and Water Management has drawn up a list of problem areas related to fragmentation. The intention is to implement the Ecological Main Structure, a nature network, in the Netherlands until 2018. By then the three ministries mentioned want to have solved the problem areas related to the main infrastructure.

Many fauna passages have been constructed in recent years for new and existing infrastructure. Four ecoducts and at least 250 small-fauna tunnels were constructed over and under national trunk roads, and at least 80 existing structures (viaducts, bridges, culverts) were rendered passable to animals (*e.g.*: Figures 5, 6 and 11).

In 1988, the first two ecoducts were built at the same time as the construction of the new motorway - the A50 (Figure 8). Both were built in places where the motorway crosses the migration routes of red deer. In 1992, the third ecoduct was built over the new section of the A1 near the Boerskotten country estate. The fourth was completed at the end of 1998. It was built over the existing section of the A1 near Kootwijk (Figure 7). Similarly to the first two ecoducts, it links two parts of the Veluwe, one of the largest nature reserves in the Netherlands, that are situated on opposite sides of the motorway.

In the 90s, a large number of existing engineering structures such as viaducts, bridges and culverts were remodelled so they could function as fauna passageways. Gangplanks and gangways have been placed in culverts, canal banks have been extended under bridges and rows of tree-stumps have been placed under and on viaducts.

Figure 5 - An adaptation made to an existing water passage under a highway. This lateral ledge was constructed after the road construction.

Figure 6 - Viaduct over A28. It were made some adaptations in order to be used by fauna: wall of tree-stumps and net to hide the cars.

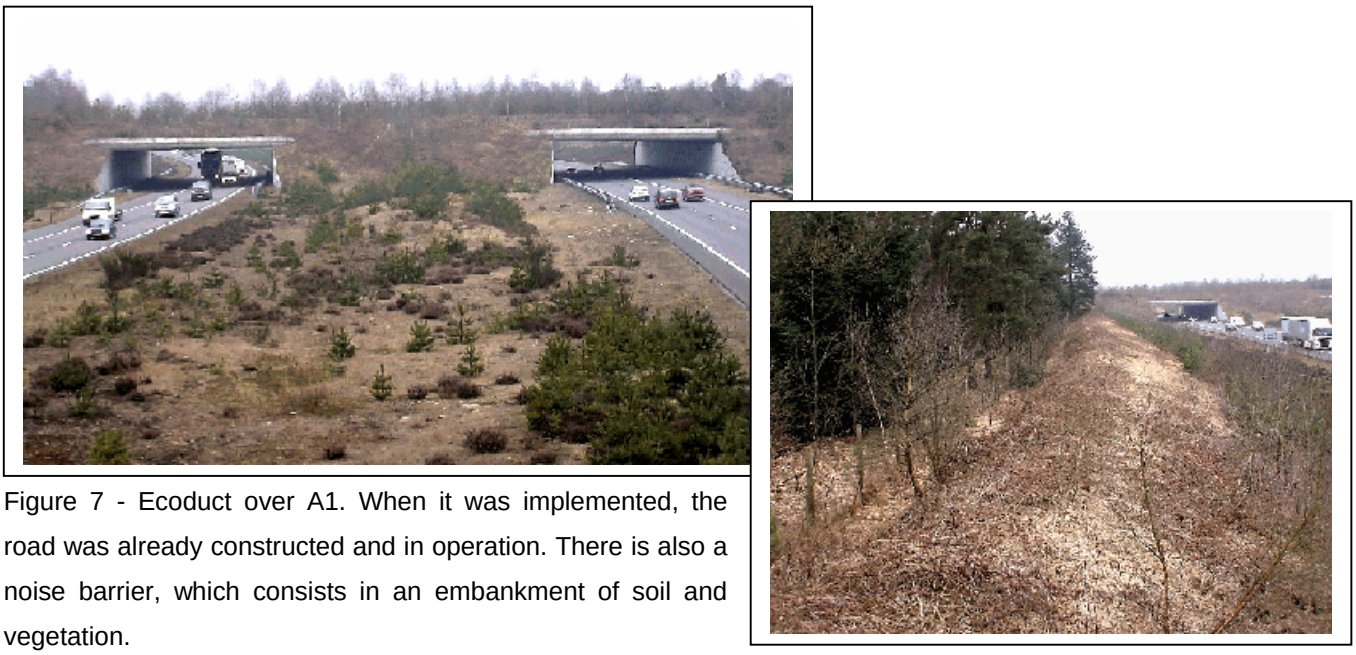


Figure 7 - Ecoduct over A1. When it was implemented, the road was already constructed and in operation. There is also a noise barrier, which consists in an embankment of soil and vegetation.

Figure 8 - Ecoduct over A50. It was the second one to be constructed in the Netherlands in 1988.

Nearly 80 tunnels for amphibians were installed in lower order roads. Almost 40 facilities were constructed along the railway infrastructure, including dry culvers, wet-dry passages and small-fauna tunnels.

By the 80's, the construction of badger tunnels became a normal part of building practices. Since 1990, building badger tunnels has also been a standard feature in the planning and design of new motorways. This applies to both areas in which badgers are actually found and areas where it is known that they have lived in the past. This specie population, which had decreased intensively in the past, has doubled over the last 15 years due to a package of conservation measures including these tunnels.

Figure 9 - Badger tunnel, installed on an existing road. The tracks on the ground show that it has been used frequently by badgers.

More measures will be taken to optimise transport capacity by improving road utilisation, remaining within the bounds of the existing infrastructure, *i.e*. without the construction or widening of roads. In addition, approximately 100 km of motorway will be constructed and several hundred kilometres of the main road network will be widened. Many fauna passages under and over national trunk roads are planned for the near future, including approximately 260 small-fauna tunnels, approximately 20 ecoducts and nearly 100 adaptations of existing structures.

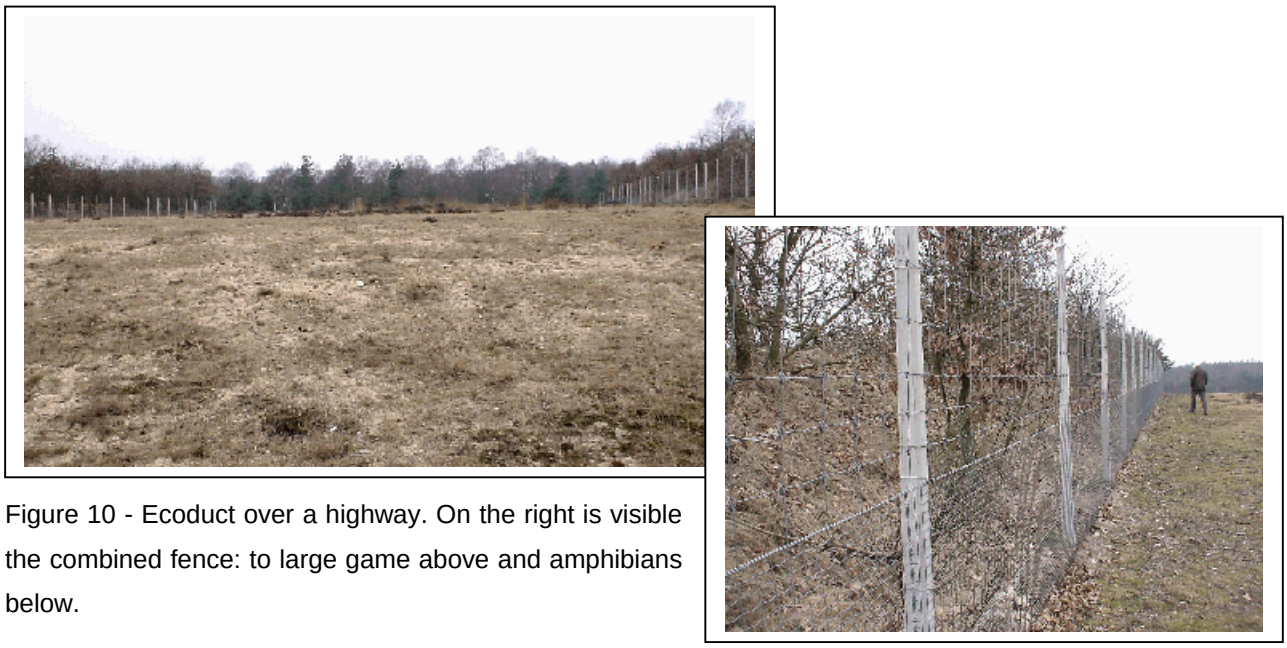


Figure 10 - Ecoduct over a highway. On the right is visible the combined fence: to large game above and amphibians below.

The costs of fauna passages construction in national trunk roads vary considerably and mainly depend on the type of facility. Constructing fauna passages under and over existing roads is much more expensive than installing them during the construction of new roads. This is partly due to the fact that traffic measures have to be taken for existing roads. Other factors that affect the cost are aspects like the quantity of earth to be moved, the area of an ecoduct, the length of the required fences and whether the groundwater has to be taken into account. Defragmentation of national trunk roads is financed by the Ministry of Transport, Public Works and Water Management.

The expense of defragmentation measures implementation has to be related to their advantages for the natural environment, but this analysis is just beginning.

Figure 11 - Adaptation of an information structure over a highway in order to allow squirrel and pine marten to cross to the other side. This is an experience to see if this kind of structures will be used by these species.

3.4 Compensation measures

(With the contribution of Ruud Cuperus)

Compensatory measures are defined as measures that promote the ecological functions and nature values in an area to replace the functions and values that have been reduced or lost due to the construction and use of infrastructure. The compensation process encompasses acquisition (where necessary), design and long-term management of the compensation sites.

With the publication of the National Structure Plan for the Rural Areas (see Box 7), in 1993, the ecological compensation principle was formally introduced as an element of national policy. It is to be

applied in relation to several categories of designated nature areas, especially, areas comprising the Ecological Main Structure.

This Plan declare that:

- The project initiator is responsible for implementing due compensation measures;
- If not possible to avoid or minimize the negative impacts, these must be compensated on sites of the same ecological quality or, where unfeasible, sites of comparable quality;
- If physical compensation is unfeasible, financial compensation must be paid.

The Directorate-General for Public Works and Water Management, as the major road manager, is responsible for the implementation of compensation plans of road projects. In doing so, the Directorate-General wishes to make use of the opportunities that nature compensation offers.

Since the compensation principle has taken effect, approximately 25 planning papers/EIAs, which incorporate compensatory measures, have been issued or are in preparation for national trunk roads. For projects developed before the compensation principle take effect, a compensation plan has later been formulated for the selected alternative. In several provinces compensation is currently being applied or is in preparation for road construction or reconstruction.

In Box 6 is presented the first methodology to develop a compensation plan used in the A50 road link Eindhoven-Oss.

Box 6
(Source: Cuperus, R. 2004)

Ecological compensations of the impacts of a road; preliminary method for the A50 road link Eindhoven-Oss

The A50 link between Eindhoven and Oss was the first national road scheme in the Netherlands in which the ecological compensation principle was implemented; indeed, the Routing Decision for the link virtually coincided with its statutory introduction. This document stated that an ecological compensation plan would be prepared. As, there was no methodology yet available for deriving tangible compensation measures at this stage, it was developed a methodology that is useful for most projects:

In the first step, the main ecological impacts of the road project are quantified, under three headings: habitat loss, habitat degradation (disturbance by noise, changes in water table, etc.) and habitat isolation (barrier effect and fauna casualties). In the second step, mitigation measures are drawn up. Although mitigation is unfeasible for habitat loss, it is for other impacts, for example by installing baffle boards (noise impacts), fauna tunnels (barrier action) and/or wildlife fencing (road mortality). Although a rough indication of the required mitigation measures had already been included in the so-called Routing Environmental Impact Assessment study (Routing EIA) for the A50, these were still to be articulated for the ecological compensation plan (CP). The third and final step is to derive suitable compensation measures for the unmitigated impacts. To this end, suitable indicator species are selected for assessing impacts on a number of categories of landscape. In the case of the A50 link, the compensation area was derived directly from the quantitative impacts of habitat loss and degradation (by noise) due to the road, the aim being to develop an area of breeding bird habitat offsetting the reduction in indicator species numbers, based on the average territory size of the breeding bird species in the habitats below and along the A50. The quality of the compensation sites was derived from the impacts of habitat isolation on

indicator species (mammals, amphibians, reptiles and butterflies) and involves (further) improvement of the ecological quality of the compensation sites to a degree designed to offset these impacts.

"Search areas" were established within which suitable compensation sites were to be sought, and based on the basket of measures described above, it was drawn up a draft CP for the A50. Some of the compensation measures were revised in consultation with regional experts and regional planners were also given an opportunity to respond to the plan, leading to a few final changes, including an extension of the search area. The final ecological compensation plan for the A50 was drawn up in 1995.

With respect to the (provisional) compensation methodology, the following conclusions were drawn and recommendations made:

a) Breeding birds play a key role in the derivation of compensation measures, because of the relative abundance of distribution data and dose-effect relationships for habitat loss and degradation (by noise). Impacts on other species groups need to be better incorporated.

b) This lack of data on other species groups may lead to underestimation of the necessary scale of compensation. To achieve no-net-loss of ecological values, the compensation area should therefore be greater than that indicated solely by dose-effect relationships for birds.

c) Further study is required on the scope for '"condensing" the landscape as a means of compensation, that is, creating wooded belts, hedgerows and wildflower margins in "open" agricultural landscapes to compensate for impacts in close landscapes.

d) There was local input to the A50 ecological compensation plan by various interest groups (potential search areas for compensation sites, for example), which increased support for the plan.

e) The particular choice of indicator species is debatable, as is use of an average figure for territory size, which may vary substantially from region to region. A more robust method therefore needs to be developed that is independent of regional characteristics.

According to Cuperus (2004), in-kind compensation (compensation in terms of the same habitats, species or functions as those affected by the road) is generally the most preferable option, giving the best guarantees for achieving the aim of no-net-loss of ecological values. In the case of habitat loss, this involves developing an equal area of habitat of the same ecological quality. In-kind compensation for habitat degradation, means restoring the original densities of the species affected by the road. Here, measures do not need necessarily to be directed towards the impact responsible for degradation. Thus, a decline in meadow bird populations due to road noise can be compensated on-site (inside the zone affected) by raising the water table in the overall impact zone to improve habitat conditions for these species.

The advantage of on-site compensation is that the abiotic conditions are already in place. Off-site compensation, *i.e*. development or optimization of habitat away from the road impact zone, has the advantage that such sites are unaffected by the road infrastructure. Compensation for habitat isolation may entail development of new habitat combined with improvements to existing habitat and restoration of the connectivity of isolated habitats (for fauna). One example of this kind of combined action is closure of a minor road, in compensation for road-building elsewhere, as a means of improving both habitat quality and connectivity. On-site compensation is generally a reasonable option if this improves habitat connectivity on both sides of the road and/or the effectiveness of mitigation measures.

The efficiency of compensation projects can sometimes be improved by planning at a level that transcends individual projects. The Road and Hydraulic Engineering Institute is currently investigating new possibilities in this area. This means that nature compensation can sometimes occur in another location than in the direct vicinity of the new infrastructure. In the majority of cases, the Directorate-General purchases land to be used for nature compensation. The acquisition of land (set of instruments, quantity of available land) is one of the most significant problems for compensation.

In the Netherlands there was no legislative leverage for expropriating lands for the purpose of ecological compensation and compensation measures could therefore only be implemented on a voluntary basis or through negotiated agreement among all the parties concerned, similarly to what happens still in Portugal. But in 2000 the Routing Act was amended, creating some scope for expropriation in the routing decision phase as a means of “last resort”.

In recent years, a new possibility emerged: agricultural nature management. In this approach the land remains the property of the farmer, who receives a budget from the Directorate-General for the creation and management of nature areas.

In the EIA reports it is estimated that the cost of compensation vary approximately 1% to 8,2% of the total projects costs. For two compensation plans that are currently operative the relative costs of compensation are respectively 3,6% (A50), 2,0 - 2,7% (N37/34) and 0,1% (N57).

In the A50 road link Eindhoven-Oss, many hectares were purchased and have been transferred to conservation agencies for further management, under contracts specifying aspects of design (as necessary), management, costs, regional information campaigns and long-term physical planning guarantees.

4. LONG-TERM DEFRAGMENTATION PROGRAM (MJPO)

(With the contribution of Hans Bekker and Edgar van der Grift)

4.1 Framework

The Netherlands has a dense road network. Over the last twenty years it has grown to a total length of approximately 125 000 km. In many places, important natural areas, and connection zones between them, are dissected by roads.

Policy was adopted in the 90’s in order to prevent further decline in the natural environment due to fragmentation and to promote recovery. On the one hand this was based on Nature Policy Plan (with the National Ecological Network - NEN) and Structure Plan for the Rural Areas, and on the other hand

by the Second Structure Scheme for Traffic and Transport and The Third and Fourth Policy Document on Water Management (see box 7).

Box 7

Second Structure Scheme for Traffic and Transport (SVVII)

The Second Structure Scheme for Traffic and Transport (Ministry of Transport, Public Works and Water Management, 1990) is the policy document concerning transport and infrastructure (see chapter 2.2). In this Plan, target situations are expressed, which are intended to prevent the fragmentation of the natural environment and landscape in the short term and reduce it in the long term. The short-term perspective is particularly geared to the development of new infrastructure and the long-term perspective to the existing infrastructure. A new policy document has been issued on this topic: the National Traffic and Transport Plan.

National Traffic and Transport Plan (NVVP)

The National Traffic and Transport Plan (Ministry of Transport, Public Works and Water Management, 2000) is the follow-up to the SVVII and contains the main outlines of the proposed policy in terms of traffic and transport for the period up to 2020 (see chapter 2.2). The fragmentation policy is strenuously continued. It receives a more area-specific approach, and the Ministry of Agriculture, Nature Management and Fisheries, the Ministry of Transport, Public Works and Water Management, and the Ministry of Housing, Spatial Planning and the Environment are developing a joint long-term defragmentation programme. The policy is to focus on the main infrastructure as well as provincial and municipal roads. A broader approach should be the result.

Nature Policy Plan (1990)

The Nature Policy Plan (Ministry of Agriculture, Nature Management and Fisheries, 1990) focuses on the conservation and development of ecosystems by building up a spatial network – the National Ecological Network (NEN). The NEN concept strives for a cohesive network of ecosystems and is made up of existing natural land (the core areas), planned natural land and the connecting zones between them.

In 1999, the effectiveness of the proposed NEN was re-estimated: Habitat modelling showed that many nature reserves would still be too small and spatial cohesion of habitats insufficient to protect a large portion of the NEN's target species. Therefore, "robust connections" were introduced: these are considerably larger than the linkage zones already part of the NEN, enabling migration not only of mobile species but also of species with low dispersal capacity by offering them habitat in which their entire life-cycle can take place. In 2000, 9 robust connections were roughly mapped in the updated Nature Policy Plan – "People for Nature, Nature for People".

Structure Plan for Rural Areas

The spatial interpretation of nature policy is expressed in the Structure Plan for Rural Areas (Ministry of Agriculture, Nature Management and Fisheries, 1993). It introduces the "no-unless" principle: areas designated for nature and/or woodland and/or recreation may not be altered unless the initiator can prove that there is a vital social requirement involved. If any changes are made, mitigation measures should be taken. It also introduces the principle of compensation, which states that compensation must take place for damage to nature resulting from construction and reconstruction of infrastructure, which cannot be prevented or mitigated. The scope of this principle includes NEN areas. In 2000, the nature policy was reformulated in the document "Nature for People, People for Nature" (Ministry of Agriculture, Nature Management and Fisheries), which gives specific attention to the establishment of ecological connection zones. At national level, strong connections between larger units have priority. Just as in the NVVP, this document also states that the first long-term defragmentation programme will be formulated in 2001.

Third and Fourth Policy Document on Water Management

Policy geared towards boosting the ecological value of waters was first laid down in the Third Policy Document on Water Management (Ministry of Transport, Public Works and Water Management, 1990) and then reinforced and extended, with a slight shift in the theme, in the Fourth Policy Document on Water Management

(Ministry of Transport, Public Works and Water Management, Ministry of Housing, Spatial Planning and the Environment and Ministry of Agriculture, Nature Management and Fisheries, 1998). The latter document discusses resilient ecosystems. In addition to good quality water and beds, the construction of nature-friendly banks is part of this. Banks with vertical sheet piling are replaced wherever possible by broader slope protection and, when not possible, by fauna exits.

The large number of animals – such as toads, hedgehogs, and badgers killed on Dutch roads caused nature conservation groups and governmental agencies to start addressing habitat fragmentation about thirty years ago. The first wildlife passage was built in 1974.

Since then, a variety of wildlife passages have been constructed: tunnels for amphibians, eco-culverts for (semi-)aquatic animals, small and large underpasses for various mammals, and wildlife exits from canalised waterways. Also, bridges and viaducts have been modified to facilitate co-use by animals. A milestone was reached with two “ecoducts” (wildlife overpasses) over a new highway in 1988, which were designed for a multitude of species. By now, over 800 wildlife passages have been built at national trunk roads, and a similar number at railroads, provincial, and municipal roads. Nowadays, wildlife passages are standard procedure in highway and railroad (re)construction in the Netherlands.

The initiatives in the 70’s and 80’s can be characterised as *ad hoc* attempts to prevent road kills or isolation of populations. Only in 1990, the coordinated national defragmentation plan (the National Ecological Network - NEN) was initiated.

Following the introduction of the NEN, various studies identified, often independently, a multitude of “bottle-necks”, *i.e*., spots where defragmentation measures at transport corridors are most urgent to reach NEN objectives. Because the studies varied widely in research approach and scale, an overall prioritisation of defragmentation spots was impossible. The ecological benefit of individual measures also was not always clear.

Therefore, the government started developing a “Long-Term Defragmentation Program” in 2001. It aims at identifying problem spots in a standardised way, developing solutions, and prioritising actions.

The Long-term Defragmentation Program (MJPO) has been launched in June 2004 and has been approved by the Dutch Parliament in March 2005. Three ministries (Ministry of Agriculture, Nature and Food Quality, Ministry of Transport, Public Works and Water Management and the Ministry of Housing, Spatial Planning and Environment) have given their commitment to the Program. This includes providing work schemes and money for counteracting the fragmentation of natural habitats due to national infrastructure (motorways, canals and rail). The MJPO is implemented in three long-term policies: Mobility Program, Nature Program and the Program for Spatial Planning.

In the MJPO the three ministries commit themselves to solve the problems, concerning fragmentation, in the ecological main structure, including the so-called robust zones. The approach in this long-term program is area oriented, integrated and based at co-operation between involved parties in the region.

The goals are focused at reaching spatial coherence and a higher environmental quality of the ecological main structure.

To find the main fragmentation problems due to linear infrastructures, it was used the LARCH model developed by Alterra – Green World Research Institute in Wageningen, witch is presented in the next section.

High priority fragmentation problem locations are identified. Each of the problem points is being first analysed and worked out to location specific solutions. The measures will be the result of all interests of the involved institutes at the regional and national level. Based at this measures an estimation of the budget will be made, following already accepted procedures and methods.

The first evaluation of the whole MJPO will be in 2008. This evaluation will focus at the update of missing problem points and at results of the implementation rate of the MJPO.

4.2 Expert System LARCH

(With the contribution of Edgar van der Grift and based on Van der Grift, E., 2003 and Van der Grift, E., 2005).

Introduction

LARCH (Landscape Ecological Analysis and Rules for the Configuration of Habitat) is an expert system that assesses the sustainability of habitat networks for a variety of species. It does a multi-species analysis with of high-priority locations to restore habitat connectivity across main roads in the Netherlands. Input for the assessment is a habitat map. For each habitat patch, the carrying capacity for the species concerned is calculated, based on size and habitat quality of the patch. Then LARCH analyses the configuration of the population, *i.e.*, what habitat patches are occupied by individuals of the same local population and which local populations belong to the same metapopulation, using rules for maximum distances between local populations and metapopulations. Total carrying capacity of a metapopulation is compared with thresholds for a minimum viable metapopulation (MVMP) in order to determine whether a metapopulation is expected to be viable or not. Thresholds differ, dependent on the configuration of the metapopulation. When the metapopulation includes a key population, *i.e.*, a relative large local population that is viable under the condition of one immigrant per generation, the threshold for a MVP can be considerably lower than in the case where no key population is present.

LARCH is able to include the barrier effect of roads in the analyses. The presence of roads may result in a decreased probability that an animal reaches a neighboring local population, and consequently in the split up of (meta)populations. The extent to which the road is a barrier is species-specific and can be gradually adjusted in the model, differing from no barrier at all to an absolute barrier.

LARCH has been used in a large number of studies, such as environmental impact assessments, the development of national and regional plans for spatial development, the design of ecological networks or corridors, mitigation and compensation projects in relation to habitat fragmentation by transportation corridors, plans for habitat development and habitat restoration, demarcation proposals for protected nature areas or landscapes, species protection plans, nature management plans, urban ecology plans and evaluations of the efficacy of nature policy.

Assessing Priority Locations for Defragmentation

In the Netherlands, population density is on average 470 people/km^2 and paved road density is 3,4 km/km^2, which is one of the highest in the world. Consequently habitat fragmentation is a widespread problem. Roads frequently intersect ecological corridors and core natural areas, as well as, planned habitat restoration areas or ecological linkages, such as the Robust Ecological Corridors, which may affect proper functioning of these measures to improve wildlife viability.

In the last decade many bottleneck analyses have been carried out to assess the locations where roads impact ecological networks within the Netherlands. The methods used in these assessments often differed, as well as the method to set priorities in solving the fragmentation problems. Some studies determined bottleneck locations by means of comparing the road network with existing or proposed ecological networks. Others used data on wildlife mortality due to collisions with cars to assess defragmentation locations, or mitigation sites were based on the ecology (*e.g*., migration routes) of certain species, such as otter, badger, roe deer or red deer *(Cervus elaphus*). In other studies a combination of methods was used. This resulted in a variety of maps with bottleneck locations and proposed mitigation sites, which partly overlap and partly are complementary to each other.

It was the desire of the Ministry of Agriculture, Nature Management and Fisheries, the Ministry of Transport, Public Works and Water Management and the Ministry of Housing, Spatial Planning and the Environment to produce a complete overview of mitigation sites, determined by means of an assessment of changes in population viability due to the presence of roads. Furthermore, setting priorities was needed, based on the ecological profit of defragmentation measures.

The model LARCH was used to assess potential habitat configuration and network population viability for ten focal species in the situation with and without roads (see Box 8). The latter can be interpreted as the situation in which all fragmentation effects by roads are mitigated. Each focal species represents a group of species, sensitive to roads as barriers, with similar habitat requirements and dispersal capacity. The selected focal species represent the different main habitat types in the Netherlands: forests, heartland and dunes, wetlands, and lowland creek tributaries. By comparing the population viability analyses with and without roads, defragmentation locations were identified for each species' group.

Defragmentation locations were distinguished at road transects where network population viability shifted either from non-viable (extinction probability >5% in 100 years) towards viable (extinction probability 1-5% in 100 years) or highly viable (extinction probability <1% in 100 years), or from viable to highly viable, solely due to the removal of road barriers.

Priorities were set by calculating the increase in population viability as a result of defragmentation. High-priority locations were defined as locations where the increase in carrying capacity exceed the threshold for a sustainable habitat network with a key patch, *i.e*., a habitat network that sustains a minimum viable metapopulation in configurations with a key population.

For national trunk roads, provincial roads, railroads and canalised waterways, a total of 1126 defragmentation spots were identified. For main roads were identified and mapped a total of 840 defragmentation locations. At about 75 % of the locations, the model predicts an immediate increase in population viability due to mitigation measures. At other locations, success depends on prior mitigation of other bottle-neck spots. About 23 % of the spots are a bottle-neck for two or more (in rare cases up to five) focal species.

If all defragmentation spots are successfully addressed, the model predicts an increase in population viability for one or more focal species in more than 60 % of the NEN area.

About 24 % of the identified defragmentation locations were labeled high-priority for the construction of wildlife passages and restoring habitat connectivity.

Box 8

(Source: Van der Grift, E. & R. Pouwels, 2003.Towards sustainable networks. Setting priorities in restoring habitat connectivity across transportation infrastructure. Presented at IENE Conference 2003.)

ASSESSMENT OF LOCATIONS WHERE WILDLIFE CROSSING STRUCTURES CAUSE A SHIFT IN POPULATION VIABILITY

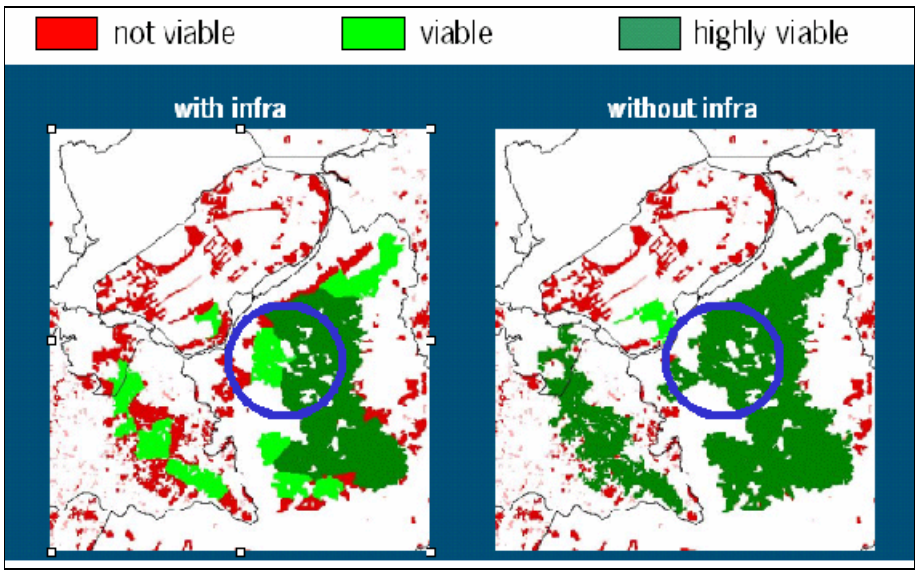
RESEARCH QUESTIONS:

1. At what locations do roads, railroads or waterways significantly affect population viability?
2. Which of these locations should be mitigated first?

APPROACH:

1. Population viability analysis in situation with infrastructure and population viability analysis in situation without infrastructure
2. Comparison of both situations ⇒ identification of locations
3. Quantification of ecological profit ⇒ setting priorities

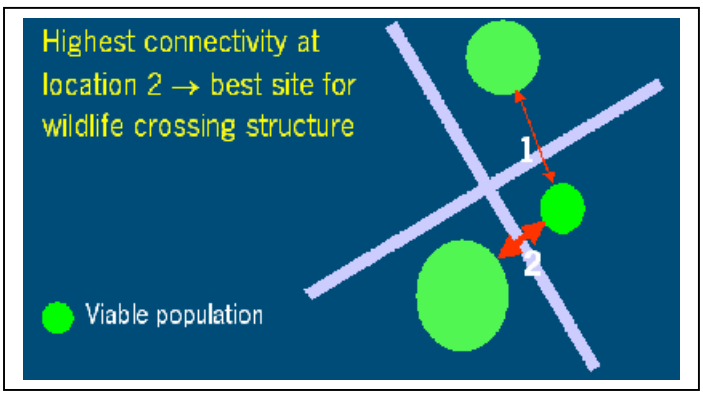
Example: model species - “slow worm”.



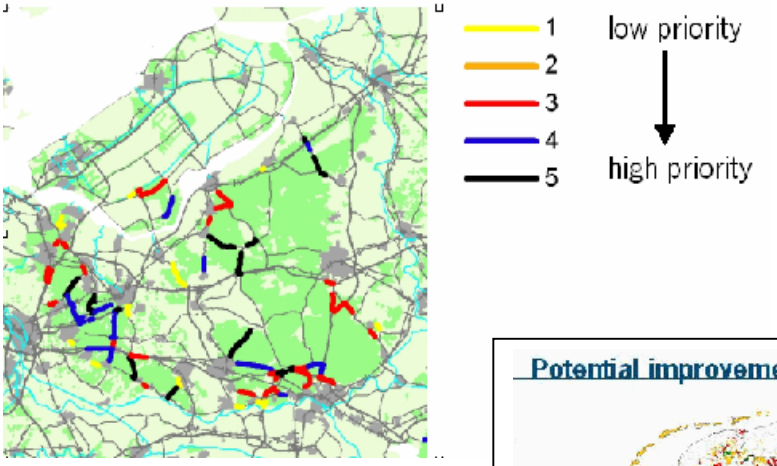
Identifying Defragmentation Locations

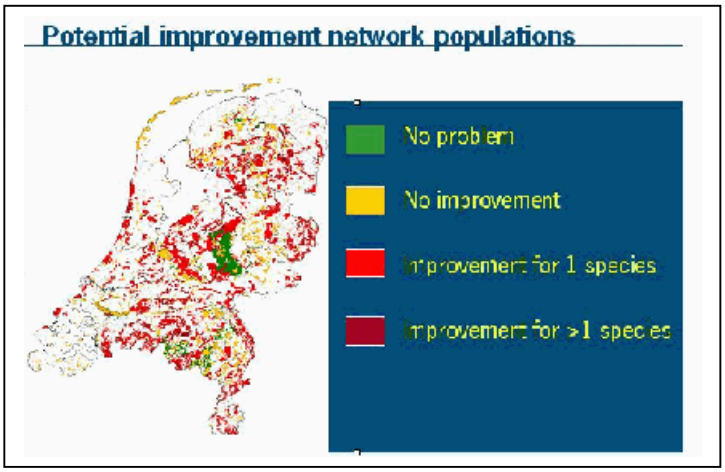
Connectivity will be determined by:

- size source population
- distance
- resistence intermediate landscape
  - land use, infrastructural barriers
  - mitigation measures



Example: Defragmentation locations “slow worm”



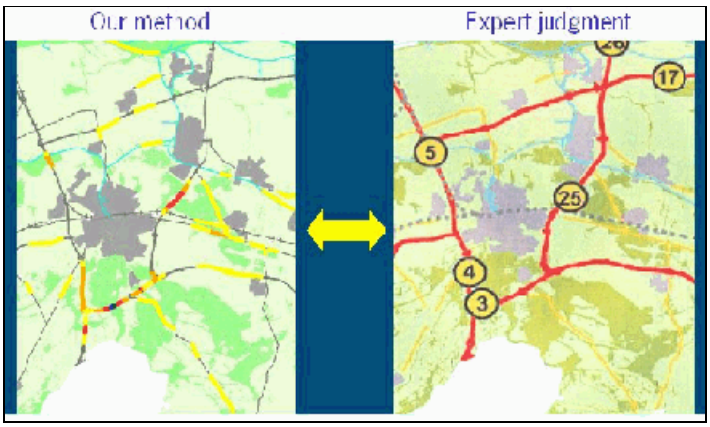


Setting priorities

Criteria:

1. Direct or secondary change in habitat sustainability
2. Ecological profit: extent of improvement of population viability

Comparison with expert judgement



Where to construct wildlife crossing structures?

1. Use population viability analysis as starting point
2. Specify locations by:
   – Road kill information
   – Location animal migration paths
   – Landscape features
   – Other relevant aspects

4.3 Implementation of Long-Term Defragmentation Program

(With the contribution of Edgar van der Grift and Hans Bekker and based on “Van der Grift, E., 2005)

The Long-Term Defragmentation Programme prioritised actions along three criteria:

– spots where defragmentation measures achieve relatively greater improvement of population viability based on model results;

– spots pointed out in workshops by regional administrations and nature conservation groups, based on knowledge of the field situation;

– spots situated in priority areas for sustainable regional development.

According to the first criterion, 74 out of the 1126 sites identified by model analyses were labelled as high-priority spots. In the workshops, the participants identified 87 priority spots of which 34 corresponded with high-priority spots identified by the model.

14 of these 34 spots are located within the priority areas for sustainable regional development and received the highest priority: mitigation measures at these locations will be constructed by 2010. All other spots should be addressed by 2018.

In addition to the aforementioned 1126 defragmentation spots within the NEN, 1482 defragmentation sites were identified within the robust connections. Of this number, 43 sites were selected as priority spots in the Long-Term Defragmentation Programme. First mitigation measures are being taken still in 2006.

For instance, is being studied the implementation of an ecoduct over the A6 near a nature reserve. As the road already existed some problems are being discussed, as the best location for the ecoduct, the changes that will have to be made to the road (it has to be raised or lowered if it is decided respectively to make a tunnel or an overpassage), and the changes to the vicinity landscape in order to create a corridor that lead animals to the “robust connections” that are being implemented. In Figure 12 is presented one of the possible alternatives that are being studied to this project.

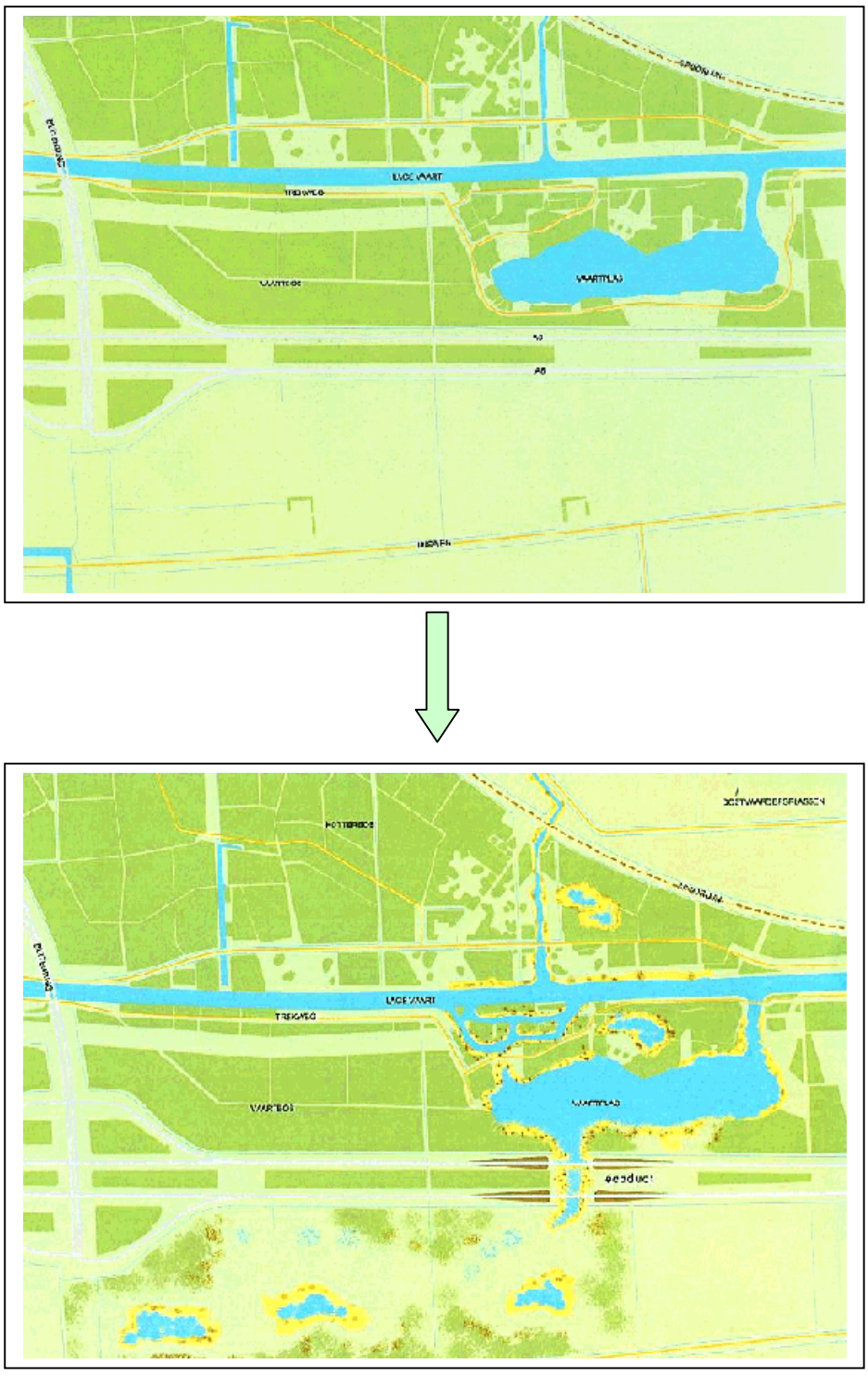


Figure 12 - One of the alternatives in study for the implementation of an ecoduct on A6. The first image represents the actual situation. It is interesting to notice the landscape changes that are being planned in order to assure the efficiency of the corridor.

5. MANAGING AND MONITORING OF MITIGATION AND COMPENSATION MEASURES

The Directorate-General for Public Works and Water Management bases the management of green areas along the national trunk road network on ecological principles.

Ecological roadside verge management reinforces the function of the verge as a corridor and habitat for plant and animal species. Design and management is used to increase the effectiveness of fauna passages by optimising the route in roadside verges to and from the passage for the animals for which the passage is intended.

In what concerns the four ecoducts, the management is shared. The Directorate-General for Public Works and Water Management is responsible for the management of the structures (civil engineering), while a nature conservation organisation is responsible for managing the green spaces and immediate vicinity. Management of compensation areas are also being transferred to nature conservation organisations. In most provinces, the provincial road maintenance authority maintains the fauna facilities on provincial roads. Several provinces are currently developing a specific maintenance plan for completed fauna facilities.

The use of fauna passages under and over trunk roads is regularly monitored. Monitoring the establishment of intended plant and animal species in the compensation areas still takes place only marginally. In half of the provinces, there is not (as yet) any monitoring of installed fauna facilities. In the other half, (Friesland, Utrecht, Drenthe, North Holland, South Holland, Limburg), monitoring takes place on an *ad-hoc* basis. Local organisations do this in two provinces, not the provinces themselves.

Monitoring has showed that wildlife passages are usually soon accepted and frequently used by red deer*,* wild boar *(Sus scrofa),* fallow deer *(Cervus dama),* roe deer*,* badger*,* red fox *(Vulpes vulpes),* rodents, amphibians, and possibly vipers. Recently built wildlife overpasses are also used by pine marten *(Martes martes),* polecat *(Mustela putorius),* hedgehog*,* hare *(Lepus europaeus),* and rabbit *(Oryctolagus cuniculus*). *Mustelidae* use all types of passages such as ecoducts, large-game tunnels, badger tunnels, extended banks and walkways under bridges and in culverts, and tree-stump walls under viaducts and amphibians use walkways under bridges and in culverts.

Indicators and models are being used to assess the fragmenting impact of infrastructure construction and utilisation, in order to enable judgements to be made now and in the future. They are used at local, regional and national levels.

A great deal of research is required in order to bridge gaps in knowledge with regard to fragmentation and defragmentation. The Directorate-General for Public Works and Water Management is currently conducting research on the use of facilities.

Monitoring the efficacy of measures on population levels has also begun. The limited availability of necessary data is a major problem, and consequently insight into this point will only be gained in stages.

The Dutch Railways Infrastructure Management Board has set up an extensive defragmentation research project, which includes quantification of effects, monitoring and evaluation of measures and development of forecasting methods.

Research institutes, universities and nature conservation organisations will also conduct research, partly commissioned by infrastructure management authorities.

6. CONCLUSIONS

The Dutch policy organization is similar to the Portuguese one. EP – Estradas de Portugal, EPE (Portuguese Roads Institute) can be compared to the Directorate-General of Public Works and Water Management, although only in what concerns roads. EP is responsible for planning, construction and operation of all roads (with the exception of municipal roads which are responsibility of municipal authorities). EP has a National Road Plan approved in 1998, which was not subjected to SEA. It is expected that, with the future implementation of SEA Directive in Portugal, its revision (in 2008) will be submitted to SEA.

In what concerns the environment, EP has an Environmental Department that plays an important role in preventing and minimizing the impacts, since the earliest stages of road studies – “Previous Study”. The first stage of the so-called Previous Studies, which are briefly explained in Annex 1, can be compared to the Dutch “reconnaissance study”. This stage – “Corridors Viability Study” - implies a critical analysis of the corridors at 1:25000 scale considering the diagnosis and evaluation of impacts on the main legal and territorial restrictions. Once this is done, the Previous Study continues with the “Road Alignment Viability Study”, that analyses the road alignment at 1:5000 scale, in technical and environmental terms, in order to optimise and stabilize it to the development of the Previous Study and the EIA report.

The EIA is reviewed by an EIA Commission that in Portugal is not independent being usually composed by various experts from the Environmental Ministry. The EIA is also submitted to a public review and consultation, after what the EIA Commission makes a decision based on its review together with public review. Then, the approved alternative will be object of a more detailed study and projected taking in consideration the “Advices” formulated by the EIA Commission (which have an obligatory character).

In Portuguese procedure, at the moment, is being made a big effort to find the best solution between the road and environment needs and restrictions. Sometimes, it even happens that one of the alternatives become the only one possible since the others cannot achieve this best combination (it doesn't mean there are no impacts, but the main ones were avoided unless they can't be avoided at all in any scenario). In other cases a choice must be made between alternatives that will have different kinds of environmental or social impacts, and in that case the choice will be made by the EIA Commission. In any case all the alternatives in study are viable from the road point of view or wouldn't be studied at all.

This way, in Portugal, the environmental matters are already being taken into account in early stages of the corridor study and having good results. But the mitigation measures implementation is still very ineffective, probably due to the incorrect design/construction. At the moment, to most road projects, is required the implementation of adaptations to common culverts in order to be used by animals. Some fauna passages were constructed but do not seem to be effective (see Annex 1). A lot of work has still to be done in this field. With these STSM was possible to learn some more techniques that can be applied to Portuguese roads, including to the existing roads, as in the Netherlands, the mitigation measures are being implemented for a long time now and are showing good results.

One important difference between the two countries is that these measures in the Netherlands are planned in regional or national scales while in Portugal are implemented case by case (to each segment of road, independently). This is a big limitation in Portugal, since, for instance, there is not a logical net of defragmentation measures: a fauna passage can lead to a barrier of a second road. In this sense, it would be very interesting to use a program as LARCH to identify the fragmentation problems and elaborate a national defragmentation plan, as it has been done in the Netherlands.

In what concerns the verges, in Portugal the case is quite different from the Netherlands and if there is enough rain, there will be diversity of spontaneous flora. During the construction, grass is sowed and some plants or tree are planted, accordingly to a Landscape Recovery Plan. The main problems in Portugal are the lack of water and fauna casualties. Although fences are obligatory in all main roads, the net allows small mammals, amphibians and reptiles to cross the road and be killed.

Compensation measures are a big problem to EP at the moment, since there is no legal support that allows EP to expropriate land that is not for the road itself. Like as happened in the Netherlands, it will be necessary to make an emend to the actual law. Due to this restriction, very few compensation measures have been applied by EP, specially if it implies land acquisition. Even so, in some cases it may be possible to establish agreements with landowners to recover some areas that will be then managed by institutions of the Environmental Ministry, but in practice this has not occurred yet. Only in the case of concessions (the infrastructure is entrusted to a third party to build and manage it at its

own cost and risk whilst enjoying the revenue deriving from the relative economic use and with the obligation to return the asset at the end of the period of concession) compensation measures will be able to be applied as the private companies can acquire land if the owners want to sell it (which will depend much on the value offered).

Concerning the EIA-follow up, in Portugal, every project is evaluated and monitored individually, but no monitoring studies are developed by the EP on a broader scale, like it is in the Netherlands. On the other hand, in the Netherlands, in most of the cases is not performed an EIA follow-up of each project as it is required by the Directive.

Both kinds of studies are necessary. Monitoring the effectiveness of mitigation measures for each road will allow their improvement and the correction of problems. But if these studies are taken independently, there may not be possible to compare results of different roads/locals and is impossible to understand the effects of roads on a larger scale. In order to solve this gap, EP is now promoting research studies in a broad scale, as it is explained in the Annex 1.

Road planning more and more requires the assessment of impacts on nature and the environment. Although impacts on individual animals have to be addressed (*e.g.* expected road kill rates) more emphasis should be put on the impacts of road construction and road use on the viability of populations.

Models and expert systems may be helpful tools to assess population viability. These tools give the possibility to predict changes in viability, or even threats to the (local) survival of a species, before road construction is started and thus may play a key role in comparing scenarios and in decision making. Impacts of roads can be best analyzed with spatially explicit (meta)population models. However, these models require extended information about the biology and ecology of a species, which in Portugal is not available in most cases. Expert systems may be a practical alternative, facilitating rather easy, rule-based analyses of population viability for a variety of species.

The implementation in Portugal of these expert systems and the improvement of mitigation measures conception must be EP´s next step in order to minimize the impacts caused by roads on fauna diversity.

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