Ecological compensation of highway impacts; negotiated trade-off or no-net-loss?

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Negotiated trade-off or no-net-loss?

Ruud Cuperus

‘… In the end we will conserve only what we love,
we will love only what we understand …’

(freely adapted from: Bada Diom, Senegal)

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- the Institute of Environmental Sciences of Leiden University (*Centrum voor Milieuwetenschappen Leiden*, formerly: *Centrum voor Milieukunde Leiden*) (1995-1996), and
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Summary

The subject of this dissertation is the ecological compensation principle and its use as a means of addressing the impacts of road construction. More specifically, it offers a critical examination of how the principle has been applied in the context of the planning and construction of the Dutch ‘national’ roads, i.e. motorways and other trunk roads. The study was conducted over two periods at:

- the Institute of Environmental Sciences of Leiden University (1995-1996);
- the Road and Hydraulic Engineering Division of the Directorate-General of Public Works and Water Management (1997-2004).

The dissertation consists of three parts. Part 1 (Chapter 1) situates the basic issues and elaborates the specific research questions addressed. In Part 2 (Chapters 2 to 7) these questions are treated in detail in six articles published between 1996 and 2003 in international and Dutch journals; Chapter 8 summarizes the results of these articles. Part 3 first discusses several problematical and as yet unresolved aspects of the ecological compensation principle (Chapter 9). This discussion and the formulated general conclusions lead to a number of recommendations as to how the policy framework of the compensation principle might be refined to improve the effectiveness with which it is applied in the context of national road-building as well as possibly other development projects (Chapter 10).This chapter ends with the perspectives of the compensation principle and summarising conclusions of this dissertation.

Part 1: Introduction

Chapter 1 outlines the background of the Dutch ecological compensation principle, its consequences for the Directorate-General of Public Works and Water Management, *Rijkswaterstaat*, the government agency responsible for its practical implementation, and the problems and research questions addressed in this dissertation.

Prior to its implementation in the context of transportation infrastructure projects in 1993, the principle of ecological compensation had already been applied informally and *ad hoc* for a number of years in other policy areas in the Netherlands, notably forestry and land use. With the publication of the National Structure Plan for the Rural Areas, 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 area, principal among them the areas comprising the Ecological Main Structure. The Structure Plan sets out a phased planning and decision-making procedure involving both the initiator of the project in question and the competent authority. The first phase involves weighing up the perceived need for the project and its anticipated benefits against the projected loss of ecological values. This phase is steered by the principle of 'no unless' and culminates in a basic decision on whether or not the project may go ahead. In principle, no developments may be implemented in protected areas. If on the basis of the information emerging in this phase approval is withheld, the formal procedure is concluded. If the project is approved, given its perceived overall benefits to society, and it is anticipated that the ecology of the area concerned will suffer in any way as a result, the procedure moves into its second phase. In all cases measures must then be taken to mitigate the ensuing damage and, to the extent that such steps are inadequate, measures taken to compensate any remaining damage. The stated aim here is 'no-net-loss of ecological values'. Ecological compensation thus plays an important role in both key phases:

- in project planning and decision-making, through improved input of conservation interests;
- in implementation of projects that have received government approval.

This gives rise to a policy 'ladder' that in the course of project development seeks successively:

- to avoid ecological impacts,
- to mitigate any unavoidable impacts, i.e. reduce their severity,
- to compensate for any impacts that may then remain, aiming at a physical 'zero-sum' equation,
- financial compensation.

In the context of national road projects, avoidance of ecological damage means the road either not being granted approval after due consideration of its merits or being displaced horizontally or vertically to prevent ecological impact. Mitigating measures are provisions to reduce the road's impact; in our context here, ecoducts, fauna tunnels and fencing for wildlife, for example. Ecological compensation goes one step further and is defined here as restoration of the ecological values degraded as a result of an approved road project. Compensation measures consist of improvement of the ecological quality of the extant plant and animal habitats affected by the project and / or development of new habitats of predefined ecological quality. The compensation process encompasses acquisition (where necessary), design and long-term management of these compensation sites.

The National Structure Plan for the Rural Areas lays down the following guidelines for parties seeking to initiate a development project in the Netherlands:

- the project initiator is responsible for implementing due compensation measures;
- the necessity and benefits of the project must first have been established before attention is turned to compensation;
- wherever possible, negative impacts must first be avoided or otherwise mitigated and only compensated as a last resort;
- negative impacts 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.

Introduction of the ecological compensation principle naturally had consequences for the Ministry of Transport, Public Works and Water Management, responsible for construction, operation and maintenance of the Netherlands' national transportation infrastructure, i.e. the national road, rail and waterway grid. The same held automatically for *Rijkswaterstaat*, the agency charged with implementing ministerial policy and itself frequently acting as project principal in government-commissioned development schemes. When it came to everyday implementation of the compensation principle in ongoing road schemes, then, difficulties were anticipated right from the start. There was a clear need for a preliminary analysis of the likely problems and *Rijkswaterstaat* was eager to find solutions, one obvious reason being that it is in the transport ministry's interest to minimise delays in implementing its own infrastructure plans.

Against this background, the present dissertation – written more than a decade since the ecological compensation principle was first introduced in the Netherlands – seeks to answer three specific questions regarding use of the principle in the context of national road-building schemes:

1. What consequences has the ecological compensation principle had for planning and decision-making at *Rijkswaterstaat*?
2. How are compensation measures actually implemented and how effective are they?
3. To what extent can ecological compensation, as presently articulated for road projects, be more widely applied?
4. What are the advantages and drawbacks of the main options for science-based compensation measures?
5. What problems encountered in practice should be addressed with priority (recommendations)?

The scope of this dissertation has been consciously limited, as follows. It is concerned solely with 'national roads', i.e. motorways and other trunk roads, the infrastructure for which *Rijkswaterstaat* bears prime responsibility. Moreover, it deals exclusively with compensation of ecological values, as specified in the National Structure Plan for the Rural Areas. However, despite these restrictions the results reported here can be profitably used to improve the effectiveness of the ecological compensation principle for other kinds of infrastructure (railways and housing projects, for example), for broadening the scope of compensation (to encompass landscape and recreational aspects, for example) or for incorporating specific legislation (the European Birds and Habitats Directives, for example, with their far more stringent criteria for development project approval). These issues are treated in the discussion (Part 3, Chapter 9).

The three cited research questions were pursued in a series of articles reproduced in Part 2 of this dissertation and summarized below.

Part 2: Articulation of research questions in published articles

2. *Ecological compensation of the impacts of a road; preliminary method for the A50 road link Eindhoven-Oss (Netherlands)*

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. At this stage, however, there was no methodology yet available for deriving tangible compensation measures. This chapter describes the methodology developed and the package of mitigation and compensation measures ultimately laid down in the final A50 ecological compensation plan.

In the first step of the method, the main ecological impacts of the road project are distinguished, under three headings: habitat loss, habitat degradation and habitat isolation (including 'road kill'). In the second step, mitigation measures are drawn up for each individual impact distinguished. Although mitigation is unfeasible for habitat loss, it is for the 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 (forest, grassland, marsh, 'intimate' landscapes). 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 entails (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, the North-Brabant Regional Directorate of *Rijkswaterstaat* proceeded to draw up a draft CP for the A50. In doing so the agency refrained from adopting all the methodological premises, revising some of the compensation measures in consultation with regional experts. Regional players were then 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 developed for the Eindhoven-Oss A50 road link, 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 'intimate' 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.

3. Guidelines for ecological compensation associated with highways

This chapter describes the theoretical framework of the ecological compensation principle as applied in the context of Dutch national road projects (both construction and widening). As in the previous chapter, three kinds of ecological impact are distinguished: loss, degradation and isolation of habitats. In analogy with experience in other countries, the following basic forms of compensation are distinguished:

- in-kind vs. out-of-kind compensation, i.e. compensation in terms of, respectively, the same and different habitats, species or functions as those affected by the road;
- on-site vs. off-site compensation, i.e. compensation inside or outside the zone affected by the road.

The pros and cons of these forms of compensation were assessed for each of the three impact categories. The first conclusion was that in-kind compensation 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 need not necessarily be directed towards the impact responsible for degradation. Thus, a decline in meadow bird populations due to road noise can be compensated on-site 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 optimisation of habitat away from the road impact zone, for its part 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. Each kind of compensation has its pros and cons, and no guidelines can therefore be provided for choosing between on-site and off-site compensation, nor for in-kind versus out-of-kind compensation, and solutions of choice will have to be adopted according to the particularities of the project.

In the second place with out-of-kind compensation it is difficult to establish a suitable ecological relationship between the affected habitat and the habitat against which it is to be ‘traded off’. As a rule of thumb, trade-offs should only be made between habitats with similar ecological qualities or management requirements. The landscape features of the area should also be duly respected. The required scale and quality of out-of-kind compensation can be derived from the theoretical cost of in-kind compensation. Any form of habitat trade-off should be based on expert judgement, i.e. institutional mandate, as well as respect public input.

Being designed to supplement standing conservation policy, ecological compensation should preferably be realised in areas not covered by that policy. Practice shows that the practical modalities of compensation plan (CP) implementation are governed by three main factors: administrative considerations (consensus with provincial and local authorities), availability of land for compensation sites (in terms of supply) and the suitability of that land (in terms of hydrology and soil characteristics). The findings of this chapter led to the following conclusions and recommendations:

a) As ecological development can be forecast only approximately, CPs should be based more on processes, species groups and habitat types as representatives for the ecosystem that it is intended to develop than on single species.
b) Besides compensation targets, CPs should also specify how fulfilment of those targets is to be monitored.
c) Consequently, every CP should also include contingency measures detailing how compensation is still to be secured in the event of disappointing results.
d) Although ecological compensation need not conflict with agricultural interests, it is sometimes held that the demand for land for compensation sites is being foisted onto the farming sector. However, this is inherent in the fact that the principle of compensation is unknown in this sector.
e) In Dutch planning procedures virtually no consideration is given to the ‘replaceability’ of ecological values, even though no-net-loss is hard to guarantee beforehand in the case of values that are difficult to replace.

4. *Ecological compensation in Dutch highway planning*

This chapter evaluates practical application of the ecological compensation principle in six representative Dutch national road projects varying in length from 6.6 to 45 km, all of which were subject to the same planning procedure, viz. that laid down in the Routing Act. This phased procedure is marked by publication of the following documents:

- The Commencing Document, explaining to the local or regional community the transport bottleneck being addressed and the preferred solution, including any infrastructure alternatives and variants.
- The Routing Environmental Impact Assessment (Routing EIA), comparing the various alternatives and variants and assessing their respective environmental (including ecological) impact.
- The Preliminary Routing Decision, articulating a single alternative and leading, after any revisions, to the Routing Decision, which becomes final after the hearing of any appeals.

For each of these six road projects it was examined how ecological impacts were predicted and appropriate mitigation and compensation measure articulated in the various phases of the planning procedure. The conclusions and recommendations were as follows:

a) In deriving compensation measures, the ecological compensation principle is applied fairly uniformly. There is a marked preference for physical compensation, with very little use of financial compensation. All the projects have provisions for ex-post evaluation of ecological impacts and CP effectiveness.
b) With each new step of the procedure, compensation measures are elaborated in greater detail.
c) Compensation measures are derived specifically from two categories of impacts: habitat loss and degradation (by noise), with other impacts disregarded for lack of data and/or difficulty of quantification.
d) Estimated compensation costs for the infrastructure alternatives outlined in the Routing EIA range from 0% (no compensation) to 8.2% of the total project investment sum. For the project involving the most extensive compensation, the Routing Decision ultimately opted for an alternative having less ecological impact and compensation costs (2.3%).

e) In another project, the compensation costs in the Preliminary Routing Decision were in fact higher than in the Routing EIA (from max. 0.7% to max. 7.3%); new developments on the ground meant that land for compensation sites had to be purchased, while in the previous phase it had been assumed that management contracts could be negotiated with farmers.
f) Routing Decisions on national road projects currently embody a dual decision: first, on the envisaged benefits and perceived necessity of the project and, second, on the scale and nature of the mitigation and compensation measures required. This conflicts with the basic aim of the compensation principle, which is to address these issues in tandem.
g) The ‘benefits and necessity’ discussion should therefore take place far earlier in the planning procedure. In Routing EIAs it should also be explicitly stated how the cost and effectiveness of the various infrastructure alternatives have guided design of mitigation and compensation measures.
h) Compensation should be given legislative footing. This will move project initiators to seek consensus on compensation measures with all parties and give citizens the right of appeal in the event of the targets not being secured.

5. *Preparation and implementation of seven ecological compensation plans for Dutch highways*

Seven ecological compensation plans for national road projects were followed from the moment of their inception. These ‘first generation’ CPs, each with their own planning modalities, were evaluated in terms of:

- the processes involved in overall CP preparation and implementation;
- the methods used to derive, plan and implement individual compensation measures;
- the practical outcome of CP implementation.

In the Netherlands there is no legislative leverage for expropriating lands for the purpose of ecological compensation and compensation measures can therefore only be implemented on a voluntary basis or through negotiated agreement among all the parties concerned[1].

[1] When the article was written this was indeed the case. In 2000 the Routing Act was amended, however, creating some scope for expropriation in the Routing Decision phase as a means of ‘last resort’; see also Chapter 6 and Results (§ 8.6).

Based on evaluation of the seven ecological compensation plans, the chapter comes to the following conclusions and recommendations:

a) These first generation CPs took 5 to 10 years to prepare and implement. Initial experience was gained in acquisition of compensation sites and their transfer to conservation agencies.
b) Progress on CP implementation is hampered by the growing scarcity of land in the Netherlands and the associated rise in land prices.
c) Compensation measures can be readily incorporated in ongoing or future farmland reallotment projects, even to a substantial extent.
d) Because of the unpredictable development of targeted habitats and rising land prices in the Netherlands, actual compensation costs are difficult to forecast. This problem can be addressed by structural price-indexing of the compensation budget, to correct for unforeseen price rises.
e) Criteria need to be developed for (ex-post) evaluation of compensation measures.

6. Compensating for ecological impacts of road development: seven years' experience with Highway A50 Eindhoven-Oss (Netherlands)

This chapter describes implementation of the ecological compensation plan for the A50 Eindhoven-Oss (for preparation of this CP see Chapter 2). CP implementation and road construction run parallel, in principle, and have a timetable of nearly 10 years[2]. The main issue addressed here is whether CP targets (in terms of no-net-loss) were secured and whether the compensation measures were implemented as foreseen.

Although there were ups and downs in the acquisition of lands for compensation in the course of CP implementation, many hectares were eventually purchased. These sites have meanwhile 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. Besides 'ad hoc' land purchase, compensation was also

2 At the time of writing the CP was scheduled for completion in January 2003, but this has meanwhile been postponed to 31 December 2005 due to delays in construction of one of the road sections. In practice, then, CP project duration was in fact longer.

arranged under the terms of a farmland reallotment project. It transpired that using such land for ecological compensation may conflict with one of the subsidiary aims of such projects: implementation of the Ecological Main Structure. Over the years a number of individual farmers also expressed interest in implementing compensation measures. Generally speaking, farm-based conservation seems to be an attractive modality for compensation, because it involves no transfer of property rights. Negotiations between *Rijkswaterstaat* and farmers were broken off nonetheless: first, because there proved to be no cost advantage relative to land purchase and, second, because *Rijkswaterstaat* had doubts about the sustainability of farm-based conservation.

Because land prices doubled in the course of the project, the original CP budget proved insufficient for implementing all the compensation measures envisaged. After a complete interim review of the entire A50, the CP budget was increased. Although outlay on site acquisition, the principal cost item, is satisfactorily on schedule, expenditures on site design and management lag considerably behind. In addition, only a small fraction of the budget has been spent on mitigation, because more costly measures (such as an ecoduct) are still in the process of being implemented.

With respect to the preparation and implementation of the ecological compensation plan for the Eindhoven-Oss A50 road link, this chapter comes to the following conclusions and recommendations:

a) *Rijkswaterstaat*'s efforts on preparing and implementing this CP illustrate the agency's responsibility for putting the compensation principle into practice.

b) By the time the CP as such has been implemented, i.e. when the road is opened, the process of site acquisition will have been rounded off, or virtually so, so that in terms of area no-net-loss will have been achieved. Design, management and transfer of the compensation sites will then still be in progress, however, so that no-net-loss with respect to ecological values will require subsequent monitoring.

c) Compensation measures were not executed entirely in accordance with the CP, because precise implementation is neither predictable nor 'enforceable'. A well-defined methodology for implementing compensation measures needs to be developed.

d) Future CPs should indicate permissible deviations from targets under the constraint of no-net-loss.
e) There is now support for farm-based conservation as a modality for ecological compensation and the government should therefore develop policy thinking on this issue, specifically in the context of compensation for the ecological impacts of road infrastructure.

7. Improving ecological input in Dutch road planning

Given the extensive ecological damage that generally results from road (building and widening) projects, it is essential that ecological input to the decision-making process be of a suitably high quality. This input is of two basic kinds: specification of the (protected) plant and animal species found in the vicinity of the proposed project, and the estimated impact of the infrastructure on survival of those species. In the course of the planning procedure for 'national' road projects specified by the Dutch Routing Act, this input grows in depth and continues until the final (Routing) decision is taken on project implementation. Interim go/no-go decisions reduce project risks, such as delays associated with public participation and appeals. A different level of detail of ecological data and impact descriptions is required in each phase of decision-making, and in practice there sometimes proves to be a 'mismatch' between supply and demand. This chapter considers how a better match might best be achieved.

The statutory decision-making procedure for Dutch 'national' roads comprises three phases, embodied in the Commencing Document, Routing EIA and (Preliminary) Routing Decision (cf. Chapter 4). This process takes place against the formal, non-statutory background of:

- the Multi-Year Programme on Infrastructure and Transport (MIT), providing an annual review of transport infrastructure bottlenecks in need of urgent study;
- Reconnaissance studies, detailing the scale and nature of each bottleneck identified and outlining possible solutions.

There are three basic methods for forecasting the ecological impacts of road projects, based respectively on:

- physical area, i.e. the extent to which any protected areas are bisected; the number of habitat fragments and the area degraded are taken as yardsticks for ecological impact;
- more detailed assessment of individual impacts, with impact descriptions based on rules of thumb for each type of impact;
- population models describing exchanges between subpopulations of individual species, with ultimate survival governed by the equilibrium between disappearance and recolonisation, both influenced by the 'imperviousness' of the road.

This chapter then describes how the ecological data are fed into the decision-making process and closes with the following conclusions and recommendations:

a) The legislator as well as the public at large demand want improved ecological input in the early stages of decision-making on national roads, above all in the MIT 'bottleneck identification' stage. Ecological data on protected areas and species in the area affected by projects therefore need to be available sooner than has been customary to date.
b) Based on early and explicit assessment of ecological risks, the competent authority, viz. the Ministry of Transport, should be given the power to decide whether or not a particular (national) road project requires additional study. This would prevent projects being moved forward in the planning process that are simply unfeasible from a conservation angle.
c) Given the requirement that plans for national road projects be accompanied by investment figures, there is a need to introduce indices for ecological impacts and associated mitigation and compensation measures in the earliest stages of decision-making. These indices will be governed by geographical factors and the level of protection enjoyed by areas and species.
d) Performing a 'rough-and-ready' comparison and evaluation of the infrastructure alternatives set out in the Routing EIA improves the general quality of decision-making and yields ecological benefits, as does extension of the deadline for the Preliminary Routing Decision
e) In principle, the three methods for predicting ecological impacts match the various phases of decision-making fairly well: 'area assessment' in the MIT and Reconnaissance stage, 'individual impacts' in the Routing EIA, and 'population models' in the Preliminary Routing Decision.

8. Summary of results

From the foregoing chapters a series of results are distilled, which have been grouped according to the following topics:

- planning and decision-making
- implementation
- compensation costs
- monitoring and evaluation.

The chapter closes with some conclusions on how legal aspects, public support and gaps in knowledge all influence effective implementation of the ecological compensation principle.

The main result with respect to the *planning and the decision process* is that in terms of scale, nature, location and cost, compensation measures are specified in increasing detail with each new phase of decision-making on a given project. The Routing Decision currently embodies a dual decision: on the necessity and benefits of the road project in question as well as on the required scale and nature of mitigation and compensation, while the compensation principle requires these decisions to be taken consecutively. In practice, however, this procedure provides a financial incentive for developing infrastructure alternatives having minimum impact and thus entailing lower compensation costs.

As CPs take a number of years to actually execute, there is a significant chance that *implementation* will not be entirely in accordance with targets, as compensation is essentially ‘tagged onto’ other developments (standing policy) and certain aspects of ecological development are rather unpredictable. Availability of compensation sites seems to be the principal factor determining the success of compensation plans. In the densely populated parts of the Netherlands and particularly the heavily built-up western coastal area (de ‘Randstad’), there is very little (suitable) land available owing to competition with other land use functions. This tends to lead to ‘patchy’ compensation over multiple, unconnected sites, generally reducing overall the ecological effect of a CP, with ecological values taking far longer to develop than the duration of the road project. In the Netherlands there is no form of *contingency planning*, detailing how compensation is still to be secured in the event of disappointing results.

The compensation costs associated with the CPs investigated amounted at most to 4% of the total investment sum of the road project in question. Because of the marked rise in Dutch land prices in the second half of the '90s, the targets of these CPs cannot be secured unless there is interim adjustment of the compensation budget.

In all the national road projects investigated, there was due attention to *monitoring and evaluation* of CP implementation during the various planning phases. Practice has shown, however, that there is scarcely any ex-post evaluation of decisions on specific forms of ecological compensation or the methods used for predicting ecological impacts and deriving appropriate measures. As a consequence, there is no solid basis for the *contingency planning* cited above.

With respect to *legal aspects*, in the course of this dissertation the Dutch Routing Act was amended to create (limited) scope for expropriating lands for ecological compensation at the Routing Decision phase of planning. Given the difficulty of motivating specific locations for compensation sites and the lack of jurisprudence on this point, however, in the Netherlands there still appears to be a reluctance to use this option.

Engaging interest groups in the planning and implementation of ecological compensation generally increases *public support*. Such groups have plenty of local as well as general ecological knowledge and are consequently in a good position to assess the feasibility of proposed compensation measures. Support for ecological compensation is also specifically enhanced by involving farmers in CP implementation, on the basis of management contracts, for example. However, at the same time in practice farmers are still insufficiently seen as potential 'conservationists', despite the government's growing interest in involving this sector.

Gaps in knowledge mean that certain ecological impacts are difficult if not impossible to quantify, and consequently there is scarcely any structural inclusion of these in Dutch compensation measures or CPs. Another problem with the underpinning of compensation measures is that the practical effectiveness of mitigation measures is yet to be satisfactorily reviewed. As a result, there are insufficient guarantees that no-net-loss of ecological values is indeed being achieved in the context of Dutch national road projects.

Part 3: Discussion, conclusions, recommendations and perspectives

9. Discussion: answering the questions

Proceeding from these results, this chapter returns to the specific research questions addressed in this dissertation (cf. Introduction). As to the first question, the ecological compensation principle has now indeed been largely integrated in the planning, decision-making and implementation phases of Dutch national road projects. This is reflected in the incorporation of the principle in the Routing Act procedure and the active engagement of government staff in designing and implementing ecological compensation plans. Although the concurrency of decisions on the infrastructure project and on ecological compensation is at odds with the compensation principle, this is currently the procedure at *Rijkswaterstaat*. Nonetheless, the conclusion of this dissertation is that this should remain as it is, because the financial incentive may provide powerful leverage for preventing adverse ecological impacts, as it encourages development of alternative road designs causing less ecological impact and thus requiring less ecological compensation. There are limits to such incentives, however, as some infrastructure alternatives with less ecological impact (a cutting, for example) are not necessarily cheaper.

At the same time, in answer to question 2, CP implementation at *Rijkswaterstaat* is still very much a learning process. Although the main focus in the Netherlands is still currently on acquiring suitable compensation sites, a modest start has been made on enlisting the aid of farmers, by way of management contracts, although there is some doubt as to the effectiveness of this kind of 'agri-environmental' scheme. It is up to policy-makers to support this trend. As to whether ecological compensation is indeed effective in securing no-net-loss of ecological values (the second part of question 2), this dissertation can only provide a tentative, provisional answer. Despite no compensation plans for national road projects having yet been completed or evaluated in the Netherlands, there is strong evidence that *area targets* are generally secure, despite rising land prices and the growing scarcity of suitable sites in some regions. Because ecological values at compensation sites take far longer to develop than the horizon of CP implementation, however, the achievement of *quality targets* is not always assured. It would seem sensible to set the following conditions: (a) when the road is opened, the agreed compensation acreage must already be physically secure, (b) site design and management must have been taken to hand wherever possible, and (c) any residual work on site design and management remaining after road-opening must be steered by some form of *contingency planning.* This means extending the responsibilities of the competent authority and the project initiator beyond the time horizon of the infrastructure project.

Ecological compensation, as practised for roads, can also be applied in the context of other types of development (question 3). It might, furthermore, be broadened in scope (starting from a ‘1-to-1’ approach) to encompass landscape issues, too. Although degradation of the overall physical landscape is difficult if not impossible to compensate, the situation is different for particular features, such as historical allotment patterns, for example, or local roads of recreational value. The principle might even be extended to the wider sphere of rural and regional development, mitigating and compensating a far broader range of impacts then those on ecology and the landscape. The aim would then be to improve the overall ‘quality of life’ of the local or regional community in terms of health, employment and wider issues of nature conservation. The broader the scope of (a) compensation (principle), the more public support it is likely to enjoy.

In answering question 4 it is noted that in this dissertation, derivation of compensation measures has been approached, based on descriptions of individual types of ecological impact: habitat loss, disturbance and so on. The reasons for this choice were: (a) the ecological compensation principle requires proper understanding of the ecological impacts of development projects, and that understanding is currently best provided by 1-to-1 mapping between ecological impacts and compensation, and (b) in Dutch planning procedures for development projects it has long been customary to derive individual ecological impacts; this approach enjoys greatest public support in the Netherlands. From a purely methodological angle, however, there is no inherent reason why compensation should be derived from individual types of impact rather than from some kind of aggregate impact arising as a result of possibly interrelated impacts.

In the ‘integrated’ approach, in contrast, the point of departure is that infrastructure impacts do not occur in isolation but as a coherent whole, as when population models are used. In this approach the basket of compensation measures is similarly based on coherence, with a corrective bias introduced either beforehand or concurrently with derivation of the total impact. The advantage of this approach is that it is, in principle, closer to reality. Compared with the '1-to-1' methodology of individual types of impact, however, there are two main drawbacks: it is less transparent and reproducible, and it introduces additional uncertainties, because a number of assumptions must be made in modelling interactions among individual impacts as well as in deriving an integrated compensation plan.

One logical development to have emerged from this approach is the use of (integrated) indices to establish appropriate compensation measures, a key example being the compensation ratios used in the United States ('ratio of replaced to lost area'). Use of simpler, standardised indices allows project developers to gain a reasonably accurate picture of the compensation measures associated with a road project in a fairly quick and simple manner. The principal criterion for such indices is that they be straightforward and transparent and thus likely to enjoy public support. It is certainly feasible to develop a standardised procedure for deriving compensation measures and it has already proved possible to elaborate a 'rough-and-ready' version. A 'rough and ready' version and first-pass indices are given here for the context of Dutch national roads.

Problems encountered in practice that should be addressed with priority are described in Chapter 11 (question 5) as recommendations. The chapter distinguishes recommendations on methods, procedures, implementation of compensation measures and research.

10. General conclusions, recommendations, perspectives and summarising conclusions

General conclusions **-** Based on the Results and Discussion chapters, a number of important conclusions are drawn. It is first concluded that the compensation principle is now a self-standing element of Dutch planning and decision-making on national road projects. The dual decision embodied in the Routing Decision (see Chapter 8.1) conflicts with the basic aim of the compensation principle, which is to treat these issues in tandem. At the same time, the present procedure provides a financial incentive for developers to identify infrastructure alternatives having minimal ecological impact, thereby reducing overall compensation costs. As a policy tool for addressing the ecological impact of Dutch national road projects, the compensation principle is used basically for the quantitative purpose of maintaining the overall size of target species populations.

The time horizon of a CP (several years) means that the compensation measures actually implemented will differ to a greater or lesser extent from the original CP specifications. Owing to ambiguity of definition, lack of specific ecological criteria and the absence of procedural guidelines, however, there is still no uniformity as to how the principle is implemented at *Rijkswaterstaat*. One underlying reason here are differences in how the principle is interpreted in the various echelons of government. There are more than ten issues that may hamper achievement of no-net-loss of ecological values, including gaps in knowledge about certain ecological impacts and the effectiveness of mitigation and compensation measures, lack of contingency planning as part of a CP, and competition (for land) of ecological compensation with other development projects.

Farmers seem to be in a good position to implement compensation measures to enhance ecological values in agricultural regions. However, it is unclear whether the aim of no-net-loss of ecological values and long-term preservation can be secured under current farm-based management regimes.
In addition, the following conclusions have been drawn:

- a compensation principle can only be truly effective if every single newly planned stretch of road or motorway that intersects the Ecological Main Structure (EMS) is offset by an equal stretch of motorway being demoted form the national grid or being closed elsewhere (in the EMS);
- although there are no substantive reasons why compensation measures should no longer be derived from individual types of impact, it would seems sensible from a practical perspective to develop some kind of standardised index;
- to improve public support for the compensation principle, it might be extended to encompass landscape, social and health issues.

Recommendations - Building on the Results and Discussion chapters, a series of recommendations are made concerning the following issues:

- development of an unambiguous framework for implementing ecological compensation (*use of the ecological compensation principle*);
- the concurrency of decision-making on the benefits and necessity of an infrastructure project and the associated ecological compensation, in conflict with the compensation principle (*planning and decision-making*);
- enhancing the practical scope for ecological compensation, by permitting greater flexibility in compensation plans, for example, and setting permissible deviations from original CP targets under the constraint of no-net-loss (*implementation*);
- basing ecological compensation plans on physical rather than financial targets (*compensation costs*);
- evaluation and monitoring of compensation plans to establish the extent to which no-net-loss is indeed achieved, including some form of contingency planning a part of a CP detailing how ecological quality targets are indeed to be achieved at each individual site (*evaluation and monitoring*);
- (a) formal legislative footing of the ecological compensation principle; (b) greater use of the existing legal provisions of the Routing Decision for expropriating lands for ecological compensation of road-building impacts (putting ecological compensation on the same legal footing as the road project itself) (*legal aspects*);
- (a) increasing input from interest groups, including farmers, in CP implementation; (b) development of a coherent vision on farm-based management of road project compensation sites (securing no-net-loss of ecological values with or without state acquisition of the farmland concerned, and with or without the zoning status of the sites being revised) (*public support*);
- (a) developing methods for deriving ecological impacts and measures with respect to barrier effects, road kill, roadway illumination, hydrological changes; (b) establishing knowledge about the effectiveness of mitigation and compensation measures (*gaps in knowledge*);
- developing basic rules of thumb for translating the features of major development projects such as national road schemes into a limited set of ecological impacts; developing integrated, standardised indices for deriving mitigation and compensation measures for national roads so that appropriate measures can be designed with a minimum of time and effort (*simplification)*;

- applying the compensation principle to culture and landscape issues (such as historical allotment patterns, local roads of recreational value and rural and regional development), still on a 1-to-1 impact basis (*widening scope*).

Perspectives **-** As to the future of the ecological compensation principle, it may be able to/ provide some countervailing influence on the paving-over of the Netherlands (an irreversible process, it may be added, witness developments in the country's 'Green Belt'). At the same time, new conservation opportunities may also present themselves, as with closure of a military airfield (like Valkenburg), which can then serve as a compensation bank (called a 'mitigation bank' in the US). The compensation principle makes a sharp distinction between designated 'natural areas' and other areas, protecting only the first category (no-net-loss) and permitting development schemes in the second (net-loss). Under certain circumstances, schemes may still be approved in natural areas, however, and these will therefore never be entirely free of threat. In fact, the ecological compensation principle can only be effective if it compensates impacts on a '1-to-1' impact basis, with a new stretch of national road only being approved if an equal length of national roadway is taken out of service elsewhere.

Finally, the experiences documented in this dissertation may be used in the context of compensation resulting form the European Directives, which although providing a higher level of protection are nonetheless supported by only limited legislative provisions for acquiring lands for the purpose of ecological compensation.

Summarising conclusions – From the dissertation it can be concluded that the ecological compensation principle has proved its worth as a viable planning concept that can to some extent offset the sacrifice of ecological values to economic growth. In principle, ecological compensation works well as an element and effective 'finale' of an coherent procedure and is a promising way of incorporating conservation interests in planning, decision-making and implementation vis-à-vis development projects, specifically national road projects. However, it is essential that the sequential strategy of avoidance, (then) mitigation and (only then) compensation be adhered to in addressing project impacts, that all interests be carefully balanced throughout the decision-making process, and that there be some form of contingency planning to ensure compensation plans are always fully implemented.

In the near future the ecological principle should be further refined, for example by: (a) introducing more stringent conditions ('a new stretch of national road through the EMS only being approved if an equal length of national road is taken out of service elsewhere'), (b) developing some kind of standardised index for integrated impact description, and / or (c) developing standard ratios with which to derive compensation measures, the two latter for reasons of efficiency. The principle might also be extended to encompass landscape and / or rural development issues, as a means of increasing public support for the compensation principle, now extended to the 'quality of life' of the local community.
As EU conservation rules and regulations provide no legislative leverage for expropriating land for the purpose of ecological compensation, the empirical data reported in this dissertation can be usefully employed in the context of governmental plans (programmes) and specific projects.

Natuurcompensatie bij rijkswegen:

Onderhandeling of geen-nettoverlies van natuurwaarden?

Samenvatting

Deel 1: Inleiding

Tot 1993 werd het natuurcompensatiebeginsel informeel en ad hoc toegepast in diverse sectoren, met name de landinrichting en de bosbouw. Met het verschijnen van het Structuurschema Groene Ruimte in 1993 is het compensatiebeginsel als onderdeel van nieuw rijksbeleid in werking getreden. Het is van toepassing op een aantal gebieden, met name die behoren tot de Ecologische Hoofdstructuur. Het beginsel dwingt bevoegde gezagen van ruimtelijke activiteiten tot het doorlopen van een afwegingsprocedure. De eerste stap van deze procedure betekent dat zij bij het voornemen tot het uitvoeren van een ruimtelijke activiteit een afweging moeten maken tussen enerzijds nut en noodzaak van de activiteit en anderzijds het verlies aan natuurwaarden. Deze afwegingsstap, die uitmondt in een besluit de activiteit al dan niet te laten doorgaan, laat zich leiden door het ‘nee-tenzij’-principe: in beginsel geen ruimtelijke activiteiten in beschermde gebieden. Wanneer de activiteit op basis van deze afweging niet mag doorgaan, wordt de procedure afgebroken. Wanneer echter wordt besloten tot het uitvoeren van de ruimtelijke activiteit vanwege het grote maatschappelijk belang ervan én wanneer de natuur aanwijsbare schade ondervindt als gevolg van de activiteit, volgt de tweede stap: er moeten mitigerende maatregelen en, indien deze onvoldoende zijn, ook compenserende maatregelen worden genomen. Uitgangspunt hierbij is ‘geen-nettoverlies van natuurwaarden’. Natuurcompensatie speelt daarmee in twee fasen een belangrijke rol, in de plannings- en besluitvormingsfase van ruimtelijke activiteiten via versterking van de natuurbeschermingsbelangen, en in de uitvoeringsfase van ruimtelijke activiteiten, waarvoor goedkeuring is verleend.

Het bovenstaande geldt uiteraard ook voor rijkswegen. Het voorkómen van ecologische schade betekent dat een wegenproject, na maatschappelijke afweging, niet wordt uitgevoerd of zodanig wordt ingepast dat ecologische effecten niet optreden, bijvoorbeeld door een horizontale verschuiving van het weglichaam. Mitigerende maatregelen zijn gericht op het verminderen van de optredende negatieve effecten, voor rijkswegen zijn dat bijvoorbeeld ecoducten, faunatunnels en wildkerende rasters. Natuurcompensatie gaat nog een stap verder en wordt in dit proefschrift gedefinieerd als het terugbrengen van de natuurwaarden die worden aangetast door een goedgekeurd rijkswegenproject. Fysieke compenserende maatregelen bestaan uit het verbeteren van de natuurkwaliteit van bestaande leefgebieden van planten- en diersoorten die schade ondervinden van het project en / of het ontwikkelen van nieuwe leefgebieden met een vooraf omschreven natuurkwaliteit. De compensatie wordt gerealiseerd via verwerving (indien nodig), inrichting en langdurig beheer van de daarvoor aangewezen gronden. Negatieve effecten op habitats moeten worden gecompenseerd in termen van dezelfde natuurkwaliteit, of wanneer dit onmogelijk is, in termen van vergelijkbare kwaliteit. Financiële compensatie is verplicht wanneer fysieke compensatie onmogelijk is en omvat de storting van een geldsom in het Groenfonds.

Het natuurcompensatiebeginsel conform het Structuurschema Groene Ruimte heeft vanzelfsprekend consequenties gehad voor het Ministerie van Verkeer en Waterstaat, dat verantwoordelijk is voor de realisatie, het beheer en het onderhoud van het Nederlandse hoofdwegennet, dit is het gehele netwerk van rijks-, spoor- en vaarwegen. Dat geldt ook voor Rijkswaterstaat als uitvoeringsorganisaties van het Ministerie. Verwacht kon worden dat bij de toepassing van het natuurcompensatiebeginsel knelpunten zouden optreden. Er was daarom grote behoefte aan een eerste analyse van de knelpunten in concrete rijkswegenprojecten en een overzicht van mogelijke oplossingen voor deze knelpunten.

Het voorliggend proefschrift, dat ruim tien jaar na de inwerkingtreding van het natuurcompensatiebeginsel verschijnt, heeft voor rijkswegen de volgende vraagstellingen:

1. Welke consequenties heeft het natuurcompensatiebeginsel voor de planning, besluitvorming en realisatie van projecten?
2. Op welke wijze worden compenserende maatregelen uitgevoerd en wat is de effectiviteit van deze maatregelen?

3. Is het natuurcompensatiebeginsel, zoals in dit proefschrift onderzocht voor rijkswegen, breder toepasbaar?
4. Wat zijn de voor- en nadelen van de belangrijkste methoden voor de afleiding van compenserende maatregelen?
5. Welke knelpunten uit de praktijk dienen met voorrang te worden opgelost?

Deel 2: Uitwerking van de vraagstellingen in de vorm van artikelen

Op basis van de internationale en nationale literatuur en van studie naar een aantal representatieve Nederlandse wegenprojecten in de planvormings- en realisatiefase worden de vraagstellingen van dit proefschrift uitgewerkt (Hoofdstukken 2-7).

Planning en besluitvorming

Het belangrijkste resultaat inzake planning en besluitvorming is dat de beschrijving van de compensatieaspecten (aard, omvang, locatie en kosten) gedetailleerder wordt naarmate de besluitvormingsprocedure vordert. Daarnaast is de praktijk niet in lijn met het natuurcompensatiebeginsel. In het Tracébesluit voor een rijksweg worden tegelijkertijd besluiten genomen over enerzijds nut, noodzaak en realisatie van het project én anderzijds de aard en omvang van de vereiste natuurcompensatie. Het beginsel eist een volgtijdelijkheid van deze besluiten. De werkwijze in de praktijk biedt echter een financiële prikkel om bij de ontwikkeling van infrastructuuralternatieven te streven naar minimale effecten en dus naar verlaging van de compensatiekosten.

Uitvoering en resultaten

Omdat een natuurcompensatieplan een looptijd van meerdere jaren heeft, is de kans groot dat de uitvoering en resultaten niet verlopen conform het plan. Enerzijds is compensatie volgend op andere ruimtelijke activiteiten (vigerend beleid), anderzijds zijn sommige compensatieaspecten niet goed voorspelbaar. De beschikbaarheid van grond lijkt de belangrijkste factor te zijn voor het slagen van een natuurcompensatieplan. Er is vooral in de dichtbevolkte delen van Nederland, met name de Randstad, zeer weinig (geschikte) grond beschikbaar vanwege concurrentie met andere ruimtevragende activiteiten. Dit leidt al gauw tot ‘postzegelcompensatie’, waarbij de compensatiegebieden binnen één natuurcompensatieplan ruimtelijk te zeer van elkaar gescheiden zijn. De ontwikkeling van natuurwaarden in daarvoor ingerichte compensatiegebieden duurt veel langer dan de looptijd van een wegenproject. *Contingency planning*, waarbij de uit-voering van natuurcompensatie - in geval van tegenvallende resultaten - op een vooraf vastgelegde wijze wordt bijgestuurd, wordt in Nederland wordt niet toegepast.

Compensatiekosten
De kosten die samenhangen met de onderzochte compensatieplannen in uitvoering bleken maximaal 4% van de investeringskosten van een rijkswegenproject te bedragen. Deze plannen zullen vanwege de landelijk sterk gestegen grondprijzen in de tweede helft van de 90-er jaren hun taakstellingen niet halen zonder tussentijdse correcties van het compensatiebudget.

Monitoring en evaluatie
Monitoring en evaluatie van de uitvoering van compenserende maatregelen krijgen goede aandacht in de planvormingsfasen van de onderzochte rijkswegenprojecten. Maar in de praktijk is er nauwelijks sprake van ex-post evaluatie van de besluiten over natuurcompensatie inclusief de aan deze besluiten ten grondslag liggende effectvoorspellingen en afleiding van de maatregelen. Hierdoor ontbreekt een basis voor een eventuele *contingency planning* (zie hierboven).

Wettelijk kader
In de looptijd van het proefschrift is de Tracéwet aangepast, waarmee nu een bredere onteigeningstitel wordt geboden om op basis van het Tracébesluit gronden voor compensatiedoeleinden te verwerven. In Nederland wordt hier echter nog met terughoudendheid mee omgegaan, met name vanwege de problematische ecologische motivering van de behoefte aan gronden op een specifiek aangeduide locatie en omdat jurisprudentie hierover nog ontbreekt.

Maatschappelijk draagvlak
Het betrekken van belangengroepen bij de planvorming en uitvoering van natuurcompensatie komt in algemene zin het maatschappelijk draagvlak ten goede. Deze groepen hebben veel gebiedskennis en daarmee inzicht in de haalbaarheid van de maatregelen, en ze kunnen daadwerkelijk maatregelen uitvoeren, bijvoorbeeld door het afsluiten van beheersovereenkomsten met

agrariërs. Tegelijkertijd worden agrariërs in de praktijk nog te weinig als natuurbeheerder gezien, ondanks de pretenties die deze groep heeft en de toegenomen beleidsmatige aandacht voor deze doelgroep.

Ontbrekende kennis
Door ontbrekende kennis zijn bepaalde effecten moeilijk of niet te kwantificeren, die daardoor in Nederlandse natuurcompensatieplannen nauwelijks bijdragen aan de afleiding van compenserende maatregelen. De onderbouwing van compensatie wordt ook nog eens belemmerd door het feit dat de effectiviteit van mitigerende maatregelen nog onvoldoende is onderzocht. Dit belemmert het zicht op het realiseren van geen-nettoverlies van natuurwaarden bij Nederlandse rijkswegenprojecten.

Deel 3: Discussie (incl. aanbevelingen), perspectieven en samenvattende conclusies

Discussie
In de discussie worden de allereerst de vraagstellingen van het proefschrift beantwoord.

Welke consequenties heeft het natuurcompensatiebeginsel voor de planning, besluitvorming en realisatie van projecten?
Het natuurcompensatiebeginsel is in hoge mate geïntegreerd in planning, besluitvorming en realisatie van rijkswegenprojecten (1e vraagstelling). In strijd met het natuurcompensatiebeginsel is het op één moment besluiten over het rijkswegenproject én de natuurcompensatie. Dit is echter wel de praktijk van Rijkswaterstaat. Het proefschrift stelt dat deze praktijk ook de voorkeur verdient, omdat het financiële aspect een krachtig instrument kan zijn om negatieve effecten te voorkómen door het ontwikkelen van alternatieve wegontwerpen met minder ecologische effecten en (daarmee) minder natuurcompensatie.

Op welke wijze voert Rijkswaterstaat compenserende maatregelen uit en wat is de effectiviteit van deze maatregelen?
De wijze waarop compenserende maatregelen worden uitgevoerd, is nog sterk in ontwikkeling (2e vraagstelling). Hoewel het accent momenteel nog steeds ligt op verwerving van gronden, is in Nederland de trend gezet voor het sluiten van

beheersovereenkomsten met agrariërs. Het is aan het beleid om deze ontwikkeling te stimuleren. Op de vraag of compenserende maatregelen daadwerkelijk tot geen-nettoverlies van natuurwaarden leiden (2^e vraagstelling), kan in het kader van dit proefschrift een eerste antwoord gegeven worden. Ondanks het feit dat nog geen compensatieplannen voor rijkswegenprojecten zijn afgerond en geëvalueerd, zijn er sterke aanwijzingen dat de oppervlaktetaakstellingen van compensatieplannen doorgaans wel worden gehaald, dit ondanks stijgende grondprijzen en de regionaal afnemende beschikbaarheid van geschikte gronden. Momenteel is, gerelateerd aan de Nederlandse rijkswegen, ca. 450 hectare grond voor natuurcompensatie aangekocht; daarvan is iets meer dan 100 ha overgedragen aan natuurbeherende organisaties. Zowel compenserende maatregelen in de vorm van beheersovereenkomsten met boeren zonder grondaankoop als financiële compensatie zijn met betrekking tot rijkswegen nog niet aan de orde geweest.

De ontwikkeling van natuurwaarden in de compensatiegebieden tot het gewenste kwaliteitsniveau vraagt daarentegen veel meer tijd dan de looptijd van een natuurcompensatieplan; dit leidt tot onzekerheden over het uiteindelijke resultaat.

Is het natuurcompensatiebeginsel, zoals in dit proefschrift onderzocht voor rijkswegen, breder toepasbaar?
De afleiding en toepassing van compenserende maatregelen kunnen voor rijkswegenprojecten en andere soorten ruimtelijke activiteiten op vergelijkbare wijze worden uitgevoerd vanwege vergelijkbare soorten effecten en vergelijkbare besluitvormingsprocedures (3^e vraagstelling). Het beginsels kan daarnaast ook in scope verbreed worden, namelijk naar bijvoorbeeld het herstel van in verval geraakte landschappelijke patronen en processen (landbouwkundige verkavelingen) en recreatieve verbindingen. Schade aan het landschap zelf is nauwelijks te compenseren. Een verdere verbreding is mogelijk naar plattelandsvernieuwing. Hierbij wordt een breder scala van effecten (dan alleen ecologische schade) gemitigeerd en gecompenseerd met als doel een regio een kwaliteitsimpuls te geven op het gebied van leefbaarheid inclusief gezondheid, werkgelegenheid en natuur. Een compensatiebeginsel met een verbrede scope kan leiden tot op een toename van het maatschappelijk draagvlak.

Wat zijn de voor- en nadelen van de belangrijkste methoden voor afleiding van compenserende maatregelen?
Bij de beantwoording van de 4e vraagstelling wordt opgemerkt dat in dit proefschrift de afleiding van compenserende maatregelen is gebaseerd op de afzonderlijke effectbeschrijvingen (vernietiging, verstoring van habitat en dergelijke).
Er zijn twee redenen voor deze keuze. De eerste reden is dat het natuurcompensatiebeginsel om inzicht vraagt in de ecologische effecten van ruimtelijke activiteiten, en dat dat inzicht op dit moment het beste geboden wordt door een 1-op-1 effectenbenadering. De tweede reden is een praktische, namelijk dat de afleiding van afzonderlijke effecten al jarenlang gangbaar is in de Nederlandse planning van ruimtelijke activiteiten, en dat deze benadering onder andere daarom in Nederland het meeste draagvlak heeft (vgl. de inspraakreacties op Trajectnota's/MER). Hiertegenover staat een benadering waarbij op basis van het totaal van de effecten één enkele index (verhoudingsgetal) wordt bepaald voor de te compenserende maatregelen. Een dergelijke benadering staat veel verder af van de analyse van de afzonderlijke effecten, maar kan in de praktijk veel makkelijker en efficiënter toepasbaar zijn. Voorwaarde is wel dat een dergelijke index simpel en begrijpelijk is, en daardoor draagvlak krijgt. Een gestandaardiseerde afleiding van compenserende maatregelen volgens de indexbenadering kan al ontwikkeld worden, en een globale, eerste opzet daartoe wordt voor Nederlandse rijkswegen gegeven.

Welke knelpunten uit de praktijk dienen met voorrang te worden opgelost?
De 5e vraagstelling leidt tot een beschrijving van *aanbevelingen* om de problemen uit de praktijk op te lossen (hoofdstuk 10). Hierbij worden aanbevelingen onderscheiden met betrekking tot methodes, procedures, uitvoering en onderzoek. In afwijking van wat het natuurcompensatiebeginsel stelt (zie inleiding, pag. 33), zouden nut en noodzaak van een project en de daarbij vereiste natuurcompensatie gelijktijdig moeten worden vastgesteld. Daarnaast zouden de realisatiemogelijkheden van natuurcompensatie moeten worden vergroot door het inbouwen van flexibiliteit in natuurcompensatieplannen en het aangeven welke afwijkingen nog haalbaar zijn binnen de randvoorwaarde van geen-nettoverlies.

Aandacht wordt aanbevolen het natuurrendement van de compenserende maatregelen te evalueren en te monitoren (inclusief het toepassen van een *contingency planning* voor het zonodig bijsturen van de compenserende maatregelen), het vergroten van de toepassing van wettelijke instrumenten om gronden voor natuurcompensatie te onteigenen, en het vergroten van de inbreng van belangengroepen bij het uitvoeren van compenserende maatregelen. Voor dit laatste punt is het noodzakelijk een visie op agrarisch natuurbeheer als vorm van natuurcompensatie te ontwikkelen (met aandacht voor het kunnen waarborgen van geen-nettoverlies op lange termijn binnen de gangbare agrarische bedrijfsvoering).

Tenslotte wordt aandacht gevraagd voor het ontwikkelen van een gestandaardiseerde index voor integrale effectbeschrijvingen, het ontwikkelen van gestandaardiseerde ratio's voor de afleiding van compenserende maatregelen (om redenen van efficiëntie), en het verbreden van de scope van het natuurcompensatiebeginsel naar landschappelijke en sociale aspecten waaronder gezondheid (om het draagvlak voor het compensatiebeginsel c.q. de leefbaarheid van de lokale gemeenschap te vergroten).

Perspectieven
De verstening van Nederland is een onomkeerbaar proces, waarvoor het natuurcompensatiebeginsel tegenwicht kan bieden.Tegelijkertijd kunnen zich kansen voor natuur voordoen, zoals bij het sluiten van militaire vliegvelden, waardoor de vrijkomende ruimte dienst kan doen als compensatiebank (hetzelfde als het Amerikaanse *mitigation banking*). Het compensatiebeginsel brengt wél een sterke scheiding aan tussen natuur- en niet-natuurgebieden, omdat het de eerste categorie expliciet beschermt (voorwaarde van geen-nettoverlies) en ontwikkelingen in de tweede categorie impliciet toestaat (geen voorwaarden aan nettoverlies). Ruimtelijke activiteiten in natuurgebieden zijn echter niet uitgesloten, en de druk op deze gebieden zal blijven bestaan. Het natuurcompensatiebeginsel zou pas volledig effectief zijn wanneer een doorkruising van de Ecologische Hoofdstructuur door een nieuw wegenproject wordt gecompenseerd door over dezelfde lengte een weg (in de EHS) aan het wegennet te onttrekken.

Samenvattende conclusies
Het natuurcompensatiebeginsel is een bruikbaar planningsconcept, dat tegenwicht biedt tegen het opofferen van natuurwaarden voor economische groei.

Natuurcompensatie als onderdeel én sluitstuk van een totale procedure blijkt in beginsel goed te werken en is een kansrijke optie om natuurbeschermingsbelangen in de planning, besluitvorming en uitvoering van ruimtelijke activiteiten i.c. rijkswegenprojecten in te brengen. Voorwaarde is wel dat gekozen wordt voor eerst voorkómen, dan mitigeren en dan pas compenseren, gecombineerd met een *contingency planning* in de uitvoeringsfase.
De resultaten van dit proefschrift kunnen ook worden gebruikt in de context van compensatie, zoals die voortvloeit uit de Europese Habitatrichtlijn en Vogelrichtlijn. Voor de uitvoering van dit type compensatie zijn net als voor de uitvoering van compenserende maatregelen conform het Structuurschema Groene Ruimte (dit proefschrift) maar in zeer beperkte mate wettelijke instrumenten voorhanden om gronden te verwerven voor compensatiedoeleinden. Verwerving, inrichting en beheer op basis van vrijwilligheid blijven de belangrijkste uitvoeringswijzen voor natuurcompensatie.

Part 1

Introduction

Chapter 1

Introduction to the ecological compensation principle and to the questions and issues addressed in this dissertation

Chapter 1

Introduction

Introduction

The subject of this dissertation is the ecological compensation principle and its use as a means of addressing the impacts of road construction. More specifically, it offers a critical examination of how the principle has been applied in the context of the planning and construction of the Dutch national road grid, comprising motorways and other trunk roads. By way of introductory background this first chapter briefly reviews a number of basic issues, as follows:

- history of the ecological compensation principle in the Netherlands (1.1)
- development and significance of the compensation principle (1.2)
- ecological compensation: the international context (1.3)
- practical issues arising during implementation in the Netherlands (1.4)
- the questions and issues addressed in this dissertation (1.5)
- the issues *not* addressed in this dissertation (1.6)
- readers' guide (1.7).

1.1 History of the ecological compensation principle in the Netherlands

Prior to its implementation in the context of transportation infrastructure projects in 1993, the principle of ecological compensation had already been applied for a number of years in other policy areas in the Netherlands, notably forestry and land use. Under the Forestry Act (Official Gazette 1961), which seeks among things to prevent further decline of the country's total forested area (natural and plantation), any developer receiving approval for forest clearance on any scale has a statutory obligation to replant the same area of forest elsewhere. There are still no formal criteria for the requisite ecological quality of the new forest stand or stands, however. In the context of land use, too, recognition of the ongoing damage to nature due to agricultural optimisation led in the 1980s to the first efforts towards ecological compensation, with 'replacement' habitats being established elsewhere. This so-called re-allotment procedure was later formalised under the terms of the Land Use Act (Official Gazette 1985, MANF 1993). One very successful re-allotment scheme implemented under this Act was the 'Eschmarke' project, in the east of the Netherlands (MTPW 1995), the ultimate outcome of government plans for two road schemes announced in the early

1990s: the A35 motorway and the Enschede bypass, both of which were seen as posing a severe threat to local amphibian and reptile populations. Besides measures to mitigate the resultant impacts, in the form of fauna passages and adapted culverts, a coherent ecological compensation plan was drawn up involving extensive exchange of land (within an overall area of 1,100 hectares of farmland) and relocation of several farmsteads. There were even interventions in the landscape itself: ponds, streams with wooded banks and other new habitat were created and linear segments planted with natural vegetation (MTPW 1995).

During the same period, i.e. the 1980s and early 1990s, successive Dutch governments instigated further policies to address the ecological impact of development projects and outline appropriate conservation steps. Thus, one objective of the Second Transport Structure Plan (MTPW 1990) was ‘to reduce habitat fragmentation in the long term and prevent it in the short term’. This goal was to be pursued by means of both mitigation and compensation, i.e., measures to reduce ecological impacts or compensate for them, respectively. This approach was bolstered up by several other key government policy documents, particularly the First National Environmental Policy Plan (MHPE 1989) and the National Nature Policy Plan (MANF 1990).

Ecological compensation was first formally adopted as a policy principle in the Netherlands in 1993, with its explicit incorporation in the National Structure Plan for the Rural Areas (*Structuurschema Groene Ruimte*; MANF & MPHE 1993). Noting the rapid decline in the quality and extent of undeveloped and rural areas in the Netherlands and the importance of such areas for, *inter alia*, nature and recreation, the Structure Plan seeks to afford them better protection. As one of a basket of policies towards this objective, the ecological compensation principle was now to be implemented in all development schemes projected to have an impact on any of several categories of designated area, principal among them the areas comprising the Ecological Main Structure. The document sets out a phased planning and decision-making procedure involving both the initiator of the project in question and the ‘competent authority’, in most cases the national of provincial government. The first procedural step involves weighing up the perceived need for the project and its anticipated benefits against the projected loss of ecological values. This phase is steered by the principle of ‘no-unless’ (‘…there may be no development of protected areas unless other national (e.g.

economic) interests are deemed more urgent and important'), and culminates in a basic decision on whether or not the project may go ahead. If on the basis of the information emerging in this phase approval is withheld, the formal procedure is concluded. If the project is approved, given its perceived overall benefits to society, and it is anticipated that the ecology of the area concerned will suffer in any way as a result, the procedure moves into its second phase. In all cases measures must then be taken to mitigate the ensuing damage and, to the extent that such steps are inadequate, measures taken to compensate for any remaining damage. Ecological compensation thus plays an important role in both key phases of project development (MANF 1995):

- in project planning and decision-making, through improved input of conservation interests,
- in implementation of projects that have received government approval.

This gives rise to a policy 'ladder' that in the course of project development seeks successively:

- to avoid ecological impacts,
- to mitigate any unavoidable impacts, i.e. reduce their severity, and,
- to compensate for any impacts that may then remain, aiming at a physical 'zero-sum' equation,
- financial compensation.

In other words, the more impacts can be avoided in the planning stages, the less mitigation and/or compensation measures will be required later. Similarly, if there is maximum mitigation of impacts, only a minimum of compensation will be needed.

The government's policy on rural areas laid down in the Structure Plan has been established via the so-called Key Physical Planning Decision procedure (*Planologische Kernbeslissing*). The government has thus committed itself to implementing the ecological compensation principle before it has actually been embedded in legislation. What the government has therefore pledged is to adhere to this principle in all projects where it itself acts in the role of either competent authority or project initiator. Neither is there much leverage available under civil law for moving parties to implement measures to compensate for ecological loss, in the form of compulsory purchase orders and the like. There is consequently little alternative but to fall back on voluntary, i.e. 'amicable' land purchase and exchange, under terms freely negotiated by the respective parties. The National Structure Plan for the Rural Areas will soon be superseded by a new government policy document on Spatial Planning (MHPE *et al.* 2004), which is currently going through the final stages prior to national implementation at the moment. This Memorandum leaves unchanged the basis scope and objectives of the ecological compensation principle as described in the Structure Plan, and therefore has no great implications for the contents, conclusions and recommendations of this dissertation.

1.2 Development and significance of the ecological compensation principle

That economic progress and ecological conservation are frequently incompatible but at the same time fated to one another is now universally recognised and has been described elsewhere at length (see for the present context, e.g., Forman *et al.* 2003). The need to instigate ecological compensation in one form or another is most apparent in countries or regions where ecological values have suffered serious damage or loss as a result of economic development (Lynch-Stewart 1992, Torok *et al.* 1996). For years prior to introduction of such a principle, in the absence of effective national or federal policies and ditto environmental legislation, development projects were implemented in the absence of any proper decision-making procedure and without any serious attention being given to their likely ecological impact. One means of addressing this hiatus was by adopting ecological compensation as a formal policy principle, a process that proceeded in different ways in different countries and states (Allen & Feddema 1996, Bundesministerium für Verkehr 1996, Cowell 1996, Rundcrantz & Skärbäck 2003).

In the Netherlands the post-war period was characterised by rapid, large-scale development of residential, business and transportation infrastructure, generally accompanied by ecological damage and loss. It was not until the late 1960s that these issues were taken up the emerging environmental movement, but by the early 1970s their protests were becoming increasingly vociferous. Two of the projects singled out for particular criticism were the planned A27 road link between Utrecht and Amersfoort, scheduled to cut through a patch of woodland known as Amelisweerd, and the Leidse Baan, a provincial artery through the peat meadows between Leiden and The Hague. These protests were successful, leading to a rerouting of the A27 and reduced ecological damage, and cancellation of the Leidse Baan altogether, thus accompanied by zero ecological damage. In response to the protests of this era, the government passed legislation to improve the overall input of environmental and conservation interests in decision-making on new transport infrastructure projects. Two key items of legislation in this context were the Environmental Impact Assessment Act (*Besluit milieueffectrapportage*, Official Gazette 1987) and the Environmental Protection Act (*Wet Milieubeheer*, Official Gazette 1979), laying down among other things an obligation for project developers to identify a 'least environmentally damaging alternative' and outline measures designed to mitigate projected impacts. This was followed several years later by the Routing Act (*Tracéwet*, Official Gazette 1994), which sets out a phased planning and decision-making procedure for all major transport infrastructure projects, including national road-building schemes, complete with clear, mandatory deadlines, and enhances citizen rights by creating formal timetables for public participation and appeals. Part of the impetus for this legislation came from the European Union, it may be added, because of the duty to implement the EC Directive on Environmental Impact Assessment (EC/85/337) and other such European legislation at the national level.

Even with this new legislation in place, though, there still proved to be inadequate protection of ecological values. The populace, dismayed that at the end of the 20th century these values were still being sacrificed to economic development and seeing the substantial ecological damage often caused even after due implementation of 'mitigation' measures, continued to pressurise the government to guarantee better protection, by adopting the principle of ecological compensation, among other things. As already discussed in section 1.1, the principle was formally adopted in 1993, as one of the elements of the National Structure Plan for the Rural Areas. It is essentially an extension of the 'Polluter Pays Principle', anchored in the Environmental Protection Act and applied for many years in the context of effluent discharge permits, for example. A key feature of the compensation principle is that it is articulated according to the phases of project decision-making and explicitly identifies two actions to be pursued in tandem, as appropriate. First the envisaged benefits, perceived necessity and anticipated impacts of the project must be duly examined and weighed up. Only if planning approval is indeed granted is consideration (then) to be given to elaborating the various kinds of conservation measures, including compensation. In principle, this prevents compensation becoming just another bargaining chip on the way to successful project implementation.

Although ecological compensation has been adopted as a policy principle in the Netherlands and elsewhere, the term has never in fact been adequately defined and in this respect the cited Structure Plan for the Rural Areas is no exception. When interpreting its terms in the context of concrete development projects, questions have inevitably arisen as to the precise scope and meaning of ‘compensation’ and the kind of measures actually envisaged in the real world. As experience has grown, though, practical guidelines have been elaborated, the result of methodical study and a ‘learning-by-doing’ attitude on the part of project initiators and others parties to specific projects. One factor that has proved especially important in this context is the nature and extent of local administrators’ social networks (Glasbergen & Driessen 2002).

Based on the experience gained to date, ecological compensation can be defined as the substitution of ecological functions or qualities impaired by development projects. Such compensation aims to rehabilitate damaged areas and / or create new habitat of equivalent status, i.e., with similar ecological functions and quality attributes (Allen & Feddema 1996). This does not differ fundamentally from ‘ecological restoration’ or ‘habitat creation’ (Anderson 1995, Wyant *et al.* 1995), except that ‘ecological compensation’ specifically addresses the ecological impacts of development schemes. Dutch terminology on this point deviates from international convention, however. In the international literature ‘mitigation’ it take to signify any activity that avoids, minimises, rectifies, reduces or compensates for the effects of environmental damage (NEPA 1970, National Research Council 1992). In the Netherlands, though, and *in this dissertation* ‘avoidance’, ‘mitigation’ and ‘compensation’ are distinguished as three fundamentally different ways of addressing the impacts of development schemes. Here, then, ‘mitigation’ is a narrower concept than NEPA’s, being restricted to impact minimisation, rectification and reduction and thus standing midway between ‘avoidance’ and ‘compensation’.

The government strategy to adopt an ecological compensation principle has had two main consequences. In the first place, because some form of compensation is required in every infrastructure project there is now even greater pressure on the scarce farmland available. For decades farmers have had to provide much of the land needed for road-building schemes and other development projects and now they must do so once more in the interests of ecological compensation. In this sense the agricultural sector feels it is bearing the brunt of the government's compensation policy (Siemes 1996). Nonetheless, in the years ahead farmers are likely to be involved increasingly in the implementation of compensation measures, with individual farmers benefiting financially.

In the second place, the focus on *ecological* compensation has meant that the landscape impacts associated with development schemes have been neglected in comparison, in two respects. First, there is no parallel obligation to compensate for impacts on the structure or visual character of the landscape. Second, ecological compensation is itself a development activity that may impair the landscape in one way or another, as there is always a risk of conservation measures being implemented in a manner breaching the constraints and character of the landscape in question. However, this is intrinsic to the current policy framework of ecological compensation.

1.3 Ecological compensation: the international context

As mentioned earlier, there is already a fair amount of policy experience with the ecological compensation principle in other countries. This is now briefly reviewed, not with the aim of providing any kind of comprehensive survey but to give a representative idea of the conventions and policy umbrellas under which compensation principles have been operationalised over the past few decades.

1.3.1 International

At the international level the compensation principle has been formally adopted within the framework of two conventions: the Ramsar Convention on Wetlands (1971) and the Bonn Convention on the Conservation of Migrating Wild Animal Species (1979). The countries that have ratified these conventions have committed themselves to protecting areas deemed of major international importance, in particular key waterfowl habitats (Ramsar) and populations of designated species migrating across one or more national frontiers (Bonn). These conventions place restrictions on the kind of (economic) activities that may be undertaken in such areas and require that in cases where a project does receive approval and will lead to loss or impairment of ecological functions there is due compensation of such impacts. However, neither convention provides any precise description of what is to be understood by ‘compensation measure’.

1.3.2 North America

In the United States the principle explicitly tying development schemes to compensation measures is the ‘no–net-loss’ principle, complying with Section 404 of the US federal Clean Water Act (1972). This Act, integrated with the Fisheries Act and The Nontidal Wetlands Protection Act, obliges project initiators to compensate for losses of wetland area and functions. In the short term the no-net-loss principle aims to achieve a steady state for wetlands, i.e. with losses and gains in balance, and in the long term an expansion of total wetland area, via compensation ratios greater than unity, i.e., greater than one (Sifneos *et al.* 1992).

Specifically, developments associated with the destruction, filling and dredging of wetlands are authorised under the Act. In the 1990s projects were approved on a year-by-year basis, with no-net-loss of area or quality being sanctioned in any given year (Abbruzzese & Leibowitz 1997). Measures are usually aimed at restoring hydrological and soil characteristics, vegetative cover and wildlife use of wetlands (Brinson & Rheinhardt 1996, Wilson & Mitsch 1996). However, the authorisation process appears to give little consideration to the problems of habitat isolation and noise load resulting from infrastructure developments (Torok *et al.* 1996, Nash & Cotten 1997).

In projects receiving authorisation the goals for achieving no-net-loss are often specified as a replacement or compensation ratio, i.e. the ratio of replaced to lost area (Allen & Feddema 1996). This ratio varies from state to state according to the severity of the impacts, the succession stage of the lost wetland, as a ‘quality indicator’, and the location of the compensation site relative to the development (Lynch-Stewart 1992). The ratio usually lies between 1:1 and 4:1 (Zedler 1996).

The Canadian government has established a similar policy, specifically for impacted wetlands on federal land, which commits federal land managers to the same goal of ‘no-net-loss’ (Rubec 1994). Mitigation and compensation measures are embedded in the Canadian Environmental Assessment Act (1992). However, there are no strong legislative measures in place such as Section 404 of the US Clean Water Act and compensation may in practice be implemented under several different articles of legislation.

1.3.3 European Union

In the European Community, now the European Union, the 1979 Directive on the Conservation of Wild Birds (79/409/EEC) and the 1992 Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (92/43/EEC) together formulate a ‘no-net-loss’ principle. In the first place, these directives oblige Member States to identify protected zones (79/409/EEC) and natural habitats for species of national interest (92/43/EEC). Secondly, in cases where implementation of a high-impact develop-ment scheme is held to represent a vital and urgent public interest, they oblige states to implement compensa-tion measures to maintain the integrity of the European Ecological Network *Natura 2000*. Among the measures cited are restoration of designated habitats and creation of new habitats.

Several EU countries including Belgium, Denmark, Germany, the Netherlands, the United Kingdom and Sweden, as well as Switzerland, have adopted a regulato-ry approach to the compensation principle, encompassing similar practices to those mentioned in the two European directives. In Germany the principle was elaborated in some detail many years ago. The ‘Intervention regulation‘ (*Eingriffsregelung*), introduced in 1976 and applied within the framework of Environmen-tal Impact Assess-ment (INN 1991), is embedded in the Federal Nature Conservation Act (*Bundesnaturschutzgesetz*). It requires project initiators to follow a three-step procedure, first seeking to avoid projected impacts, then to mitigate them and subsequently to compensa-te for any remaining (i.e. unavoidable or unmitigated) impacts. Under this Act a development may be given conditional approval if suitable mitigation measures are deemed feasible. Final permission may be granted only after conservation interests (incl. compensa-tion measures) have been duly weighed up against other, wider (i.e. socio-economic) interests associated with the development (Von Kiemstedt *et al.* 1996).

After introduction of the *Eingriffsregelung* at the federal level, some fifteen implementational frameworks for compensation were elaborated in the respective German states, all fairly similar. With respect to species conservation, these procedures emphasise the impacts of habitat destruction and deterioration; with respect to habitat fragmentation, guidelines for no-net-loss are formulated in qualitative terms only (Bundesministerium für Verkehr 1996). Each year sees new projects authorised under the *Eingriffsregelung* (Bauer & Kleinschmidt 1991).

1.4 Practical issues arising during implementation in the Netherlands

As already discussed, with its National Structure Plan for the Rural Areas the Dutch government committed itself to applying the ecological compensation principle in all development projects in which it acts in the capacity of project initiator or competent authority. As soon as it was introduced in mid-1993, then, the principle at once became a key policy element for the Ministry of Transport, Public Works and Water Management, responsible for the construction, operation and maintenance of the Netherlands' national transportation infrastructure, i.e. the national road, rail and waterway grid. The same held automatically for the Directorate-General of Public Works and Water Management (*Rijkswaterstaat*), the government agency responsible for implementing ministerial policy in many key areas and itself frequently acting as project principal in government-commissioned development schemes.

The decision-making procedure in force for national infrastructure projects, including national road schemes, as defined above, is laid down in the Routing Act (*Tracéwet*, Official Gazette 1994), which came into force some six months after publication of the Structure Plan. Expectations were that application of the compensation principle in the context of national road schemes would show up immediately in the various phases of the planning and decision-making process (the first consequence of the principle). After incorporation of the principle in the Routing Act, general in scope, and the Routing Decision (*Tracébesluit*), covering the details of project implementation, it was thought that actual mitigation and compensation of the ecological impacts of national roads (the second consequence) would be guaranteed. This proved to be only part of the story, though, for introduction of the compensation principle confronted *Rijkswaterstaat* with a number of problems.

In the absence of Dutch experience or expertise in this area, ecological compensation had to be incorporated from one day to the next in a series of ongoing national road schemes. As *Rijkswaterstaat* grappled with its new task, a range of issues came into focus. With regard to the first consequence of the compensation principle, it became clear that answers must be sought to the following key questions: (a) How is the principle to be integrated in planning and decision-making on national road schemes? (b) In practice, is the ‘no-unless’ principle really effective as a means of preventing interventions in ecologically vulnerable areas? (c) How often are national roads actually rerouted in the early planning stages in order to minimise ecological impacts? (d) What issues of substance need to be studied before the ecological compensation principle can be implemented in properly scientific fashion? (e) What kinds of ecological data are required in the various phases of planning and decision-making? (f) How are the various parties – local and provincial authorities, interest groups, other organisations – likely to respond to use of the compensation principle in road schemes implemented by *Rijkswaterstaat* and how cooperative, or otherwise, are they likely to be?

When it came to the second consequence of the compensation principle, there were also questions to be answered, principal among them the following: (g) How exactly are mitigation and compensation measures to be implemented? (h) How much will they cost in practice? (i) Can such measures be implemented concurrently with realisation of the road scheme in question? (j) To what extent should compensation plan implementation and road construction be organised under one and the same procedural umbrella? (k) How can it be ensured that ecological compensation does not simply boil down to execution of standing policy, with compensation measures therefore leading to no net gains at all? (l) Does full implementation of all scheduled compensation measures necessarily guarantee that the damage they sought to address is effectively countered? (m) To what extent can the compensation principle – as presently articulated for road projects – be applied to other types of development project (e.g. railways, housing developments, plantation forests) and extended beyond ecology? (n) Where several (science-based) options are available for designating compensation measures, what are their respective advantages and drawbacks?

1.5 The questions and issues addressed in this dissertation

At *Rijkswaterstaat* there was thus an urgent need to develop unambiguous as well as practicable answers to these and related questions. At the same time, the agency's responsibility for implementing the compensation principle required a major change in organisational culture, for its brief had always been limited to the administration of (national) roads and immediately adjacent areas, including responsibility for fauna tunnels, ecoducts, fauna fencing and other such mitigation measures (Canters 1997). As compensation measures are not usually implemented in the direct vicinity of the road in question, however, the agency's traditional area of work was clearly to be extended in a very literal sense. The question, then, was how this organisational move could best be planned.

When it came to everyday implementation of the compensation principle in ongoing road schemes, then, difficulties were anticipated right from the start. There was a clear need for a preliminary analysis of the anticipated problems and *Rijkswaterstaat* was eager to find solutions, one obvious reason being that it is in the transport ministry's interest to minimise delays in implementing its own infrastructure plans; smooth, scientific and effective practical elaboration of the ecological compensation principle would be a major contribution in this respect.

Against this background, the present dissertation – written more than a decade since the ecological compensation principle was introduced in the Netherlands – seeks to answer five specific questions regarding use of the principle in the context of national road-building schemes:

1. What consequences has the ecological compensation principle had for planning and decision-making at *Rijkswaterstaat*, the Directorate-General of Public Works and Water Management? (cf. questions a-f above)
2. How are compensation measures actually implemented and how effective are they? (cf. questions g-l)
3. To what extent can ecological compensation, as articulated for road projects, be more widely applied? (cf. question m)
4. What are the advantages and drawbacks of the main options for (science-based)compensation measures? (cf. question n)
5. What problems are encountered in practice and what options are available for addressing them? (cf. first half of this section).

1.6 The issues not addressed in this dissertation

This dissertation does *not* consider implementation of the European Bird Directive (79/409/EC) or Habitat Directive (92/43/EC) in the Netherlands, nor any influence these directives may have had on Dutch legislation. Although the Bird Directive was already finalised in 1979 and the Habitat Directive in 1992, it was not until the year 2000 that either were effectively implemented in the Netherlands. Areas protected under these two directives enjoy a higher status of protection than those protected under the National Structure Plan for the Rural Areas (restricted basically to the Ecological Main Structure). The key focus of this dissertation is, rather, the experience gained by *Rijkswaterstaat* in planning and implementing compensation measures in accordance with the aims and terms of this Structure Plan. However, this experience may well prove useful in any future ecological compensation schemes to emerge from the two European directives and may even provide an operational model for doing so. For even if the European directives do in principle afford designated areas greater protection, if a development is still approved after due consideration of all relevant interests, there will still be a need for mitigation and compensation measures. It may be remarked that here, too, there is very little legal leverage available in the Netherlands for realising pre-conceived compensation measures.
A second restriction of scope is that this dissertation does not address the impact of the ecological compensation principle on Dutch rail and waterway projects, even though these are now subject to the same statutory obligations. One practical reason for this is that when the compensation principle came into force in 1993 a relatively large number of road projects were already at the planning stage or midway through decision-making, making them a convenient object of study amenable to real-time monitoring. In the period during which the research for this dissertation was conducted this was not the case with rail and waterway projects.

Finally, as stated earlier, the principal focus of this dissertation is compensation of *ecological* values. No consideration is therefore given to compensation for any form of damage to landscapes, in terms of structure or visually (by restoring or enhancing ‘heritage’ features or characteristic land use patterns, for example). Although in several Dutch provinces developers are now obliged to undertake this kind of ‘landscape compensation’, no policy to this end has yet been adopted at the national level and these issues are not therefore addressed in the present study. This restriction to *ecological* compensation also means that no consideration has been given either to compensation for impairment of recreational or agricultural values, for example. Obviously, though, compensation of development-related impacts in terms of both ecological values *and* landscape integrity will always be the best option, the landscape being the abiotic substrate of those values and therefore ultimately determining the conditions available for successful development of compensation sites.

1.7 Readers' guide

Following this introductory chapter, Part 2 reproduces the various articles that have already been published in national and international journals between 1996 and 2003 as part of this ongoing dissertation project.

Chapter 2 describes the design and development of the ecological compensation plan for the A50 road link between Eindhoven and Oss. This was the very first scheme in which the compensation principle was applied and came to be the longest-running project ever, both for *Rijkswaterstaat* and for the Netherlands as such. It also set the tone and starting point for all subsequent compensation plans undertaken in the context of national road schemes. In preparing the compensation plan for the A50, two issues predominated: the methodology for deriving compensation measures and the opportunities available to the various parties for critically appraising the ensuing draft compensation plan.

Chapter 3 reviews the ecological compensation principle as it is applied in various countries around the world and sets out basic guidelines for application during the planning, decision-making and implementation phases of national road schemes. First the basic policy framework of the compensation principle is described. Then, moving on to the practicalities of compensation, the main types of choices facing project initiators are considered: 'in-kind' vs. 'out-of-kind' compensation, 'on-site' vs. 'off-site' compensation and the instruments employed to actually implement the measures.

Chapter 4 analyses and describes how the compensation principle has affected planning and decision-making for six road schemes deemed representative of the

Dutch situation. Each scheme is evaluated against four criteria: How successful was the compensation principle in preventing ecological impacts? How were descriptions of projected impacts used to derive compensation measures, with respect to both quantitative scale and ecological quality? What were the estimated costs of compensation? And what was the input of the various parties to the compensation plan?

Chapter 5 essentially repeats the exercise of the previous chapter, using the same evaluation criteria, but now for nine compensation plans established for *national* road schemes in the Netherlands.

Chapter 6 describes how implementation of the A50 ecological compensation plan discussed in Chapter 2 was proceeding seven years after initial finalisation. The main focus of this interim assessment is how actual implementation compared with the targets set in the plan, in terms of size, quality and location of the compensation sites as well as financial cost.

Chapter 7, finally, considers the kind of ecological data that is required in the various phases of the Dutch planning and decision-making procedure for national road schemes and the actual availability of such data. To this end the respective phases of the Routing Act planning process are reviewed and an appraisal made of the detail required in each with respect to basic ecological data and impact prediction. The chapter concludes with some suggestions on how mitigation and compensation measures should ideally be dovetailed into the various phases of the procedure.

Chapter 8 presents a summary of the results of this dissertation, drawn from the findings of Chapters 2-7 of Part 2.

Part 3 draws the various threads together. Chapter 9 discussed the ecological compensation principle as it is actually implemented at present and identifies a number of unresolved issues requiring further clarification. The general conclusions resulting from Part 2 and the discussion lead to recommendations as to how the ecological compensation principle might be more effectively applied in the road-building context in the Netherlands. The chapter closes with a series of summarising conclusions.

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Part 2

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Chapter 2

Ecological compensation of the impacts of a road; preliminary method for the A50 road link
(Eindhoven - Oss, the Netherlands)

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Ecological compensation of the impacts of a road; Preliminary method for the A50 road link
(Eindhoven - Oss, the Netherlands)

Abstract
After years of efforts to avoid or reduce the impact of infrastructure projects on nature, the principle of ecological compensation has been incorporated in Dutch governmental policy. Ecological compensation aims to recover those ecological functions and natural values that still remain affected after maximum effort has been made to reduce the impact of the intervention (mitigation). The accepted aim of current policy is thus no-net-loss of area and quality by means of mitigative and compensatory measures.

As part of the planning process for construction of a stretch of road in the Netherlands, viz. the A50 road link in the province of Noord-Brabant, an Ecological Compensation Plan (CP) was required to be drawn up. This work has recently been completed by the Regional Directorate of Public Works and Water Management, the initiator of the intervention. The CP, initially presented as a Draft Plan, was drawn up by the Regional Directorate using a preliminary method designed by the Centre of Environmental Science of Leiden University for deriving compensatory measures. After an opportunity for public comment, the Draft Plan was revised to form a Final CP.

This article describes, firstly, the preliminary method for deriving ecological compensatory measures. The method starts by quantifying the effects of habitat loss, habitat disturbance (by changes in noise emissions, in the water table and in outdoor recreational patterns), barrier action and fauna casualties. Following mitigation of impacts on nature, compensation for non-mitigable effects focuses successively on area size, derived from the impacts on breeding birds, and on area quality, derived from the habitat requirements of the vegetation and fauna groups affected by the road. Guidelines for identifying appropriate locations for compensation are also formulated. Secondly, the compensation method is applied to calculate the mitigative and compensatory measures for the A50 trajectory between Eindhoven and Oss. Thirdly, two comparisons are made: the Draft CP is compared with the results of the preliminary method, and the Draft and the Final

CP are compared with one another in order to identify the role of the interest groups that played a major role in commenting on the Draft Plan. Finally, realization of the compensatory measures and development of the preliminary method itself are discussed. On the basis of the experience with the A50 case study, a more robust compensation method for road projects is to be developed.

Keywords: road infrastructure, habitat loss, habitat disturbance, barrier action, fauna casualties, no-net-loss of area and quality.

1. Introduction

Roads can cause considerable damage to nature. Their physical presence hampers the exchange of plants and animals between dissected habitat areas. In addition, traffic noise decreases the quality of fauna habitats adjacent to the road, leading to lower densities of breeding birds over considerable distances (cf. Van der Zande *et al.* 1980, Reijnen & Foppen 1991). Over the last two decades, much progress has been made in preventing and diminishing the negative impact of roads on nature.
Today, the avoidance of damage to nature is generally given serious attention in Environmental Impact Assessments, in which alternative engineering designs and routing plans are evaluated and compared with one another. Increasingly today, once the design and route have been finalized, road construction is accompanied by mitigative measures such as fauna underpasses and wire fences to reduce barrier action and fauna casualties (Anonymous 1993). It is also becoming increasingly common for expensive engineering structures to be built for nature conservation purposes, such as ‘ecoducts’ (also known as ‘cerviducts’). Such structures have been introduced for example in Switzerland, France, Germany (cf. De Vries 1994) and the Netherlands (Verkaar & Bekker 1991) in order to connect the populations of large mammals, i.e. of Red deer *Cervus elaphus*, Roe deer *Capreolus capreolus* and Wild boar *Sus scrofa*, that were to be dissected by construction of roads.

While major efforts can be made to prevent and mitigate the negative impacts of infrastructure projects on nature, it is obvious that such impacts can never be fully avoided. Over the last few years there has been a growing call by interest groups to compensate for the effects remaining after mitigation. As a result, the

Dutch national government has introduced an obligation to act in compliance with the so-called compensation principle. The ‘Structure Plan for the Rural Areas in the Netherlands’ states that ‘.. when nature, forestry and/or recreational functions are to suffer demonstrable damage as a result of another important societal function, effects should be mitigated and (if such is not sufficiently possible) compensated ..’ (MANF & MHPE 1993). From the compensation principle it follows that losses of area and quality caused by interventions should be balanced out elsewhere, which is called ‘no-net-loss’ (INN 1991, Lynch-Stewart 1992). As yet, there are no underpinned and quantified guidelines available for establishing such a no-net-loss, except for wetlands (cf. Lynch-Stewart 1992).

In this article we focus - in anticipation of forthcoming guidelines from the Dutch national government - on ecological compensation. This type of compensation implies the development of habitat area that is, in terms of extent and nature quality, comparable to the lost or affected area. As no method was yet available for deriving ecological compensation, one was developed with reference to the construction of the A50 road link between Eindhoven and Oss, in the Netherlands. This article starts by describing the preliminary method, and the mitigative and compensatory measures for the A50 derived according to this method (cf. Cuperus & Canters 1994). Next, the Draft Ecological Compensation Plan (MTPW 1995a) subsequently drawn up by the North Brabant Regional Directorate of Public Works and Water Management is compared with the results of the developed method. This was necessary as the measures proposed in the Draft Plan differ on several points from those of the preliminary method. Finally, the consequences of the opportunity for public comment for the Definitive Ecological Compensation Plan (MTPW 1995b/c/d) are discussed, as well as the possibilities for implementing the compensatory measures.

2. A method to determine ecological compensation

The ecological compensation method is a step-by-step process whereby first the impacts of an infrastructure project on nature are identified (Section 2a), and then appropriate mitigative and compensatory measures are drawn up (Sections 2b and 2c, respectively). Guidelines for identifying appropriate locations for compensation are outlined in Section 2d.

2.1 General effects of road infrastructure on nature

We distinguish the following impacts of roads on nature (see also Fig. 1):
(a) *Habitat loss*: destruction of habitat area through the physical presence of the road and associated infrastructure elements;
(b) *Habitat disturbance*: deterioration of habitat quality due to traffic noise (noise effects), depressed water tables (hydrological effects) and road-induced changes in outdoor recreation patterns, resulting in sub-optimal or even marginal vegetation and fauna habitats;
(c) *Barrier action*: separation of functional areas, leading to decreases in species mobility and/or inaccessibility of functional areas;
(d) *Fauna casualties*: injury or death of fauna due to collisions with motorized traffic.
Single or combined effects on individuals can cause population effects (Fig. 1), leading in the short term to a decrease in population densities. In the long term, ecosystem characteristics may be influenced by the extinction of local or regional populations.

2.2 Mitigative and compensatory measures

For each type of effect distinguished, we describe the (range of) mitigative and compensatory measures that can be taken (see also Fig. 2). The basic point of departure is a no-net-loss of functions, implying that non-mitigable effects qualify for compensation.

2.2.1 Habitat loss
Road construction results in the loss of habitats for vegetation and fauna, and is an irreversible process. Therefore, mitigation of these effects is not possible. The area of lost habitats should be compensated by developing natural areas of equivalent size which, in the long term, will have the same qualities as the intersected area prior to intervention.

2.2.2 Habitat disturbance
Noise effects. Field research has proven the existence of a 'disturbance zone', i.e. the zone from the road axis to the point at which no effects on breeding bird densities can be demonstrated (cf. Van der Zande *et al.* 1980, Reijnen & Foppen

Intervention		Effects on species		Higher-level effects
highway construction and use	►	habitat loss habitat disturbance - noise effects - hydrological effects - changes in recreational patterns barrier action fauna casualties	►	isolation of habitat area and changes in population densities ▼ disappearance and extinction of species ▼ changes in structure of eco-systems

Fig. 1: Distinguished effects on nature of the A50 highway.

Effect		Mitigative measures (1st step)		Compensatory measures (2nd step)
Habitat loss	→		→	Obtaining land for habitat functions
Habitat disturbance				
- Noise	→	Sunken road, acoustic walls/baffle boards	→	
- Hydrological effects	→	Offset lowered ground-water table (bentonite screen, road geoliner)	→	Rising ground level (development of moist / wet vegetations)
- Changes in recreational patterns	→	Two-level crossing (underpass)	→	Creation of recreational zones elsewhere
Barrier action	→	Extended bridge sections, fauna tunnels, ecoducts	→	Closing road to motorized traffic
Fauna casualties	→	Wire fencing, 'hidden hedges'	→	In case of 'leak'

Fig 2. Effects distinguished and relationship between mitigation and compensation.

1991). Reijnen & Foppen (1991) have provided strong evidence that noise effects predominate over the other effects of motorized traffic such as air pollution and decreased visibility for fauna. According to their results the width of the disturbance zones can be derived from the combination of traffic intensity, speed limit and timber fraction in the surroundings of a road; the field research data also indicate an approximately 50% loss of the breeding bird population within the disturbance zones of the road.

The contribution to the overall noise impact of raising or sinking parts of the road can be taken into account, although underpinned relationships are not available. In the case of fine scale landscapes, grassland and marshland, elevations above grade are assumed to increase the disturbance zone (width) by 20% compared with at-grade position. In the case of woodland, no correction of the disturbance zone is necessary because of its high sound-insulating properties (adapted from Reijnen *et al.* 1992). A sunken construction is also not subjected to correction, as there appears to be only a negligible reduction of effects.

With sound-suppressing asphaltic concrete (SSAC), the width of the disturbance zone is assumed to be reduced to 80% of that without SSAC.
The effects of traffic noise disturbance on especially breeding birds can be mitigated by means of sound-suppressing structures, since these decrease the width of the disturbance zone. Noise screens 1-3 m and 3-7 m high reduce the disturbance zone width by, respectively, 50% and 80%, compared to the situation without such screens (adapted from Reijnen *et al.* 1992). To achieve the same efficiency, an acoustic wall must be 0.5 m higher than a noise screen. A correction is not applied for sound-suppressing structures when they are combined with sunken road construction and a slight verge gradient (1 in >4), as the large distance between the structure and the road means that there is little reduction of the disturbance zone. It should be noted that sunken construction makes for effective sound-proofing directly behind the acoustic walls (< 100 m) for residential quarters, while the width of the disturbance zone for breeding birds (>200 m) is left unchanged with such measures.
Any effects that still remain after mitigative measures have been taken can only be compensated for by aiming to increase the number of breeding bird territories through nature development (increasing area) and/or enhanced nature management (increasing quality).

Hydrological effects. Depressed water tables can cause disruption of moist and wet vegetation habitats. As a result these sites may disappear completely (e.g. through drying up of pools) or change in species composition (e.g. through diminished quantities of seepage water).
Effects on the water table can be reduced by hydrological isolation. If the road is sunk below grade, use of a road geoliner will in principle leave groundwater flows unchanged. In cases where geological faults are intersected, bentonite screens can be used to offset seepage water losses. Bentonite screens consist of a natural clay material and imitate the impermeability of the undisturbed clay soil prior to intersection. Elevated road construction is another way - although a rather drastic one - of avoiding hydrological effects, since roadside ditches can then be omitted and there is no drainage of surface or seepage water.
Compensation for non-mitigable hydrological effects may take the form of raising the water table elsewhere, allowing development of new moist and wet vegetations.

Road-induced changes in outdoor recreational patterns. Road construction may affect the location of recreational zones, thus disrupting vegetation habitats and reducing fauna densities (cf. Van der Zande & Verstrael 1985). In such cases mitigation should focus on adaptation of the zoning principle, for example by improving recreational facilities near the less vulnerable natural areas.
If it is anticipated that these measures will not sufficiently mitigate the negative impact, roads in the most vulnerable natural areas may be closed to motorized traffic temporarily or permanently. Closing roads locally will compensate for increased disturbance elsewhere in the planning area.

2.2.3 Barrier action
Areas that are ecologically dissected by a road can be connected by structures that diminish the barrier action. Several experiments have shown that structures such as underpasses (culverts, tunnels), overpasses (ecoducts) and extended bridge sections are used by fauna (cf. Hunt *et al.* 1987, Yanes *et al.* 1995). Although little is known about the efficiency of these structures on the scale of animal populations (cf. Nieuwenhuizen & Van Apeldoorn 1995), we assume that these structures are effective for mammals.
For amphibians and reptiles an effective way of reducing the barrier action is to oversize bridge sections so that the bank zones are not interrupted by the road

structure. Effective mitigating measures for insects such as butterflies are not well known; besides the physically absolute barrier action of the road itself, the air displacement of the traffic is also likely to make functional areas on both sides of the road inaccessible for butterflies.

A possible approach to compensating for non-mitigable barrier effects is to close (some of) the roads of the underlying road grid to motorized traffic (as already mentioned above for recreational effects). The aim of closing secondary roads is to improve the quality of nature in the vicinity of a planned road. Compensation must be applied if there is evidence that mitigating measures will be inadequate.

2.2.4 Fauna casualties

Intersection of core areas of fauna may result in casualties. Landscape transitions such as the edges of woods, hedgerows and brook basins, in particular, are often used by animals as routes to foraging or dispersal grounds that may lie on the other side of the road.

In such cases wire fences can reduce the number of fauna casualties, especially for mammals. ‘Hidden hedges’ (a dry ditch along the road with a very steep bank at the roadside, so that the road itself forms the ‘hedge’) are visually compatible in open landscapes.

Non-mitigable effects, resulting mainly from ‘leaks’ in fences and ‘hidden hedges’ in complex situations such as cloverleaves, qualify for compensation.

2.3 Compensation of the non-mitigative effects based on selected breeding bird species (area size) and the requirements of the vegetation and other fauna groups

Compensation for balancing non-mitigable effects focuses first on area effects (following from the effects of habitat loss and habitat disturbance by noise) and second on quality effects (following from the other types of effects).

2.3.1 Compensation for area effects

For each type of effect of roads on nature, species groups should be selected for use as indicators in the compensation method (see Table 1). Selection is to be based, firstly, on the availability of spatially comprehensive information about the distribution and abundance of plant and animal species and, secondly, on the

Table 1: Types of effects of roads related to types of compensation and species groups that are used as indicators of impacts on nature.

Type of effect	Compensation for area or quality effects	Species groups
Habitat loss	area	breeding birds
Habitat disturbance		
Noise	area	breeding birds
Changes in recreational patterns	quality	vegetation
Hydrological effects	quality	vegetation, fauna
Barrier action	quality	mammals, amphibians and reptiles, butterflies
Fauna casualties	quality	mammals

available knowledge of dose-effect relationships. As both criteria often apply to breeding birds, these can be taken to represent the (overall) effects of habitat loss and disturbance by noise. An additional argument for this choice is that breeding birds of different landscape types are, to a large extent, mutually exclusive in their distribution (cf. Kwak *et al.* 1988).
After mitigation of the effects of habitat disturbance, the compensation area is calculated by multiplying the number of lost and non-mitigated disturbed territories of the selected species by their (estimated) territory size. The territory sizes are specified in terms of a minimum and maximum area, leading to a compensation area range. The minimum territory size is used if the nature quality in the compensation area is expected to be high to very high, i.e. little or no disturbance by human activities, high abiotic potential for nature quality and/or linkage with large natural areas. The maximum territory size is used if the nature quality in the compensation area is expected to be moderate (also in the long term), i.e. moderate disturbance by human activities through urbanization or intensive farming, moderate abiotic potential for nature quality and/or a more or less isolated location.

2.3.2 Compensation for quality effects

Quality compensation is used as an additional tool in cases where particular effects on groups of organisms cannot be quantified. This means that compensation for effects on vegetation and on faunal groups other than breeding birds can be established by appropriate rearrangement measures and nature management in the compensation areas for breeding birds or by closing roads in the vicinity of a planned road. In principle, therefore, qualitatively described impacts do not contribute to area compensation.

2.4 Guidelines for identifying appropriate locations for compensation

The areas that come into consideration for implementing compensatory measures ('search areas') should preferably link up spatially with larger existing natural areas, for two reasons. First, large natural areas contain more species in higher densities than small areas (cf. Spellerberg 1991); and second, management of large natural areas will be more cost-effective than management of small, isolated compensation areas. Furthermore, compensation areas ensuing from deterioration of the habitat quality should be located near the intervention area but outside the disturbance zones of the road, so that natural values can develop undisturbed by the intervention.
From the strategic point of view compensation areas should not to be located in nature areas for which a development strategy is laid down by the government. This accounts at the least for the Dutch National Ecological Network, a coherent configuration of areas in which natural and landscape values are to be conserved, recovered or developed in a sustainable manner (MANF 1990).

3. Application of the method to the A50 road link

3.1 Road plan, planning area and acceptance of the A50

For many years the regional road grid between Eindhoven and Oss (in the centre of the province of Noord-Brabant, S. Netherlands) has been overloaded and has now reached its maximum capacity. The traffic congestion in the rural areas and the city centres has led to a plan for adapting the existing road grid. An Environmental Impact Assessment was drawn up for the new A50 road link scheduled for the region (MTPW 1991, see also Fig. 3 and 4). In 1993 the Minister of Transport and Public Works decreed that the link should be constructed as a dual carriageway (2x2 traffic lanes, divided by a central band). Much of the link is to be constructed by widening the present main road between

Fig 3. Location of the new A50 road link in the province of North Brabant, The Netherlands.

Eindhoven and Oss, although several re-routings are to be established. As planned, the road includes twenty-five overpass junctions. Traffic intensity on the A50 is estimated to be 40-50,000 vehicles per 24 hours (MTPW 1993). From south to north, the following four stretches are distinguished: Son-Nijnsel (S2/N2), Koevering (K), Veghel (V1) and Uden-Oss (U1).

The road is planned in an area of sandy soil. The higher -mainly dry- soils are afforested, with vegetation dominated by more or less aggregated pine, deciduous and mixed woodland. The lower sandy soils and brook basins are surrounded by marshes and mainly wet grassland. In between, there is a variegated, dispersed landscape in which small copses, hedgerows, areas of grassland and arable farmland alternate. The road will intersect these landscapes over a distance of more than 30 kilometres. Moreover, the road is to cross two canals (Wilhelminakanaal and Zuid-Willemsvaart), four brooks (Leijgraaf, Aa, Dommel and Venloop) including their basins, a disused goods railway line and two

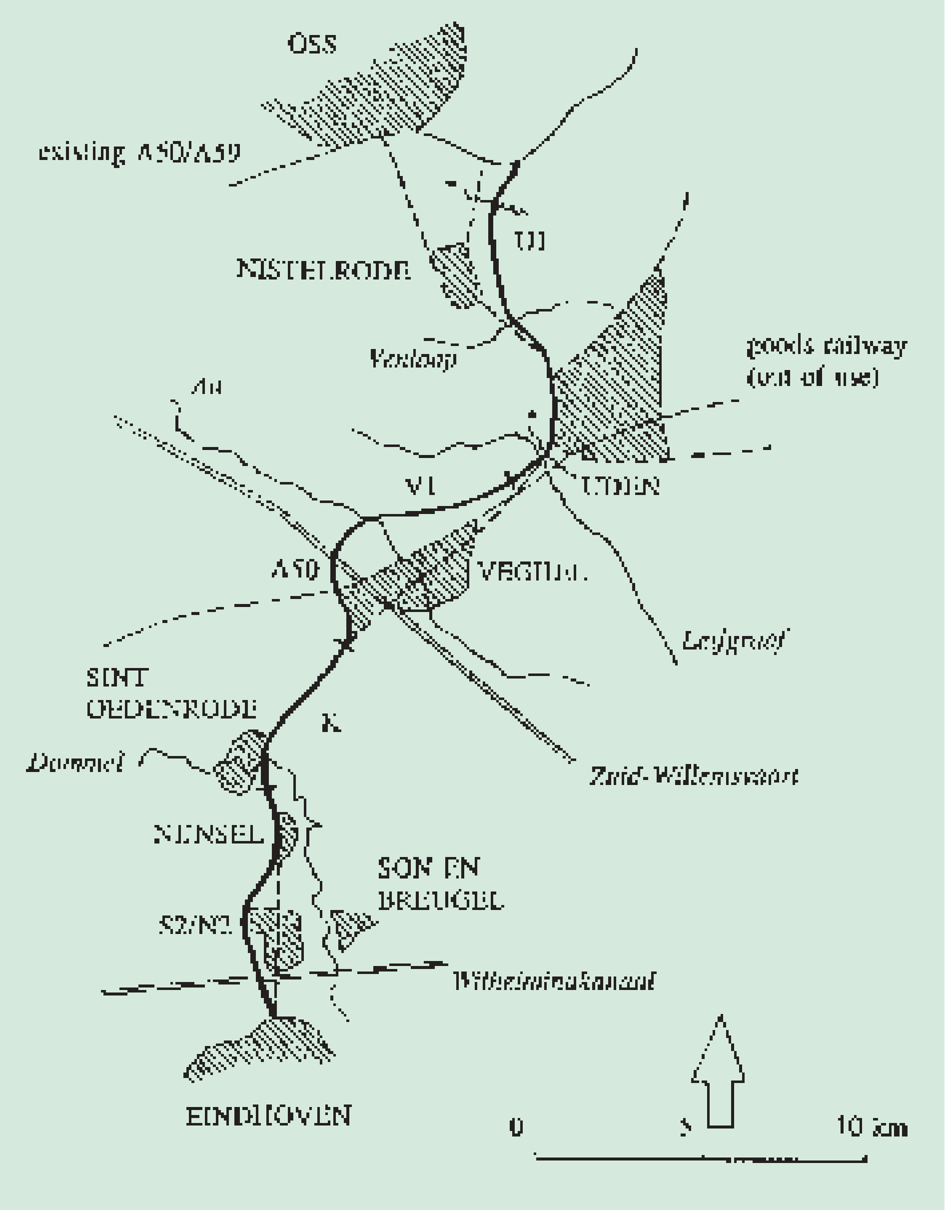

Fig. 4: Route of the A50 road link. Stretches: S2/N2 Son-Nijnsel, K Koevering, V1 Veghel, U1 Uden-Oss (acronyms correspond with the alternatives in the EIA (MTPW 1991)). * : geological fault; --- : links in present situations.

geological faults (see Fig. 4). These linear elements are assumed to have (landscape) ecological corridor functions for vegetation and fauna. In the rural areas habitation is scattered and consists of mainly farm-houses.

The road is to be constructed mainly with a standard profile, viz. a width of approx. 45 m, including verges, although in some situations slightly different profiles have been chosen for safety and landscape reasons. To reduce the visibility and noise nuisance of the A50 for a residential quarter of the town of Son en Breugel, over a length of approx. 2,000 m the road is to be semi-sunken, i.e. sunk less than three metres below grade, and shielded with acoustic walls. Between Veghel and Uden 3,300 m of road is to be raised six to seven metres above grade, to overpass the Zuid-Willemsvaart canal and the disused railway line. One side-effect of this elevated construction is to minimize the hydrological effects resulting from dissection of the geological faults.

The road construction plan was received with mixed feelings by the various municipal authorities. On the one hand, re-routing of the A50 relieves two town centres (Veghel and Son en Breugel) of high traffic intensities and the road is therefore strongly supported by these two local authorities. In addition, lateral re-routing will open up industrial zones, thus giving a new impulse to local economic activities. On the other hand, as re-routing is not possible near two other towns (Nijnsel and Sint-Oedenrode), the A50 is expected to have a substantial negative impact on the human environment there. The authorities of these two towns have requested radical measures to offset noise nuisance.
From the outset a number of environmental groups were seriously concerned about the traffic congestion in their region. In the Environmental Impact Assessment they agreed to a ‘zero-plus alternative’ in which the major bottlenecks affecting the quality of life along the road were to be solved by optimizing the existing infrastructure. In this alternative two local re-routings were inevitable, however: near Son en Breugel and between Veghel and Uden. More so than the other options, the zero-plus alternative focused on restricting the growth of motorized traffic in the planning area and strongly supported improvement of public transport facilities (MTPW 1991). The ultimate decision for the 4-lane alternative led to great disappointment among the environmental groups: serious damage to ecosystems and the landscape implies that the ‘quality of life’ objectives will not be achieved.

The government's 'Explanatory Statement' to the road construction decree contained a requirement to draw up an Ecological Compensation Plan (MTPW 1993). As a preliminary to this Plan, an exploratory study was undertaken to prepare a coherent programme of possible compensatory measures (Cuperus & Canters 1994). The preliminary method used in that study is described below. For the distribution of plant and animal species in the planning area of the A50 road link the data reported by Kleijberg & Klooker (1991) were used, with no additional field research being undertaken.

3.2 Quantification of the effects on nature

Information on the civil engineering aspects of the road link were obtained from the A50 Environmental Impact Assessment (MTPW 1991). Engineering aspects relevant to 'dose' parameters were: the geographic location of the road, including associated infrastructure elements (amenities, sliproads, roadsides and ditches), road height relative to grade level, road width, junctions with the existing road grid and expected traffic intensity.

Because of the limited knowledge of breeding bird distributions in the planning area, it was necessary to select some characteristic species for each of the four types of landscape distinguished (cf. Table 2). To avoid dependency on the occurrence of one single species, two species were chosen for each type of landscape. Of each species pair the one that eventually leads -later on in the method- to the highest degree of compensation, i.e. by territory area, is chosen to represent the most unfavourable impact (i.e. worst-case approach).
The impacts of changes in hydrological and recreational patterns, barrier action and fauna casualties are described qualitatively, due to the lack of detailed inventories in the planning area of the A50 (cf. Kleijberg & Klooker 1991).

The disturbance zone along the A50 road was estimated to be 500 m wide for woodland bird species and 1,500 m wide for species of fine scale landscapes, grassland and marshland. The effects of habitat loss and disturbance by noise are quantified in Table 3A. The data show that the effects of habitat loss are restricted to the selected species of fine scale landscapes. Along the S2/N2 and K stretches the selected species of the four landscapes are disturbed by noise to roughly the same extent, while along the V1 and U1 stretches effects on the

Table 2: Selected species and their territory size, based on data from the Netherlands and - if not available - from comparable habitat types in Europe (Cramp et al. 1983, Glutz von Blotzheim 1973-1993).

Type of landscape	Selected species	[a] Territory size (in hectares)
woodland	Golden oriole *Oriolus oriolus*	5-10
	Green woodpecker *Picus viridus*	5-10
fine scale landscape	Partridge *Perdix perdix*	[b] 10-20
	Whitethroat *Sylvia communis*	[b] 2-4
grass-land	Black-tailed godwit *Limosa limosa*	2-4
	Snipe *Gallinago gallinago*	2-4
marshland	Reed warbler *Acrocephalus scirpaceus*	2-4
	Water rail *Rallus aquaticus*	2-4

[a]: The territory sizes of 2-4, 5-10 and 10-20 hectares correspond with circular territories with a radius of 80-115, 125-180 and 180-250 metres, respectively.

[b]: Includes the area of linear elements (wooded belts, hedgerows).

species of woodland and fine scale landscapes predominate. The data show, furthermore, that along the K stretch the effects of habitat disturbance on the selected species of fine scale landscapes are minor; despite the presence of the Dommel brook there is only moderate disturbance of the grassland and marsh species.

The qualitatively described effects occur mainly on the S2/N2 and U1 stretches (cf. Table 3B). As no hydrological research has been undertaken in the planning area, it was not possible to estimate the extent of such effects. groundwater-dependent vegetations were considered to be affected within 500 m of the road (i.e. worst-case approach). The hydrological changes resulting from construction of the A50 link are expected to affect a pool in the woods of Sonse Heide (at a distance of 400 m from the S2/N2 stretch) and the immediate neighbourhood of the two dissected geological faults (U1). The road is furthermore expected to affect the recreational zoning as established in the Maashorst National Park (approx. 4,000 ha) along the U1 stretch. The National Park is visited by 8-900,000 people annually and the A50 intervention will lead to shifts in recreational activities towards areas which are now already extensively used.

Table 3. Quantitative (3A) and qualitative (3B) description of the effects of the A50 highway and the effectiveness of the proposed mitigative measures.

3A. Effects of the A50 highway: habitat loss ('loss') and disturbance by noise ('disturb'), expressed as number of territories of the selected species lost, summarized per habitat type and stretch (s). Remaining and/or non-mitigable effects (r) are indicated after application of sound-suppressing asphaltic concrete (SSAC) and acoustic walls according to the preliminary method (cf. Table 4).

Landscape/species	**Stretch**							
	Son-Nijnsel (*S2/N2*)		Koevering (*K*)		Veghel (*V1*)		Uden-Oss (*U1*)	
	loss s/r	disturb s/r	loss s/r	disturb s/r	loss s/r	disturb s/r	loss s/r	disturb s/r
- woodland								
Golden oriole	0/0	2/0	0/0	1/1	0/0	5/1	0/0	4/1
Green woodpecker	0/0	2/0	0/0	2/2	0/0	4/1	0/0	4/1
- fine scale landscape								
Partridge	0/0	6/5	0/0	3/2	2/2	14/11	2/2	11/9
Whitethroat	1/1	25/20	0/0	9/7	2/2	74/59	9/9	43/32
- grassland								
Black-tailed godwit	0/0	5/4	0/0	8/6	0/0	3/2	0/0	0/0
Snipe	0/0	2/2	0/0	0/0	0/0	1/1	0/0	1/1
- marshland								
Reed warbler	0/0	3/0	0/0	1/1	0/0	1/1	0/0	0/0
Water rail	0/0	0/0	0/0	1/1	0/0	1/1	0/0	0/0

3B. Assessment of the magnitude of effects per stretch (s). Remaining and/or non-mitigable effects (r) are assessed after application of the proposed fauna and/or recreation underpasses, 'hidden hedges'/wire fences, bentonite screens and extended bridge sections according to the preliminary method (cf. Table 4).

Effect	**Stretch**			
	Son-Nijnsel (*S2/N2*) s/r	Koevering (*K*) s/r	Veghel (*V1*) s/r	Uden-Oss (*U1*) s/r
hydrological effects	--/o	o/o	o/o	--/o
changes in recreational patterns	o/o	o/o	o/o	--/o
barrier action				
Badger	o/o	o/o	o/o	--/-
other mammals	--/-	o/o	--/o	--/o
amphibians & reptiles	--/-	--/o	--/o	--/o
butterflies	--/--	-/-	-/-	-/-
fauna casualties	-/o	o/o	o/o	-/-

Assessment of effects: o = absent to minor; - = moderate; -- = (very) serious.

3.3 Derivation of mitigative measures

The preliminary method proposes mitigative measures for specific species as well as for groups of organisms. The frequency of mitigative measures depends on the number of bottlenecks for the fauna along the road. Fauna underpasses (tunnels) with a cross-section of 2.5*1.75 m are proposed at locations where the dispersal or foraging routes of larger mammals, in particular Roe deer for the A50 planning area, are intersected. Smaller mammals, e.g. the Mustelidae: Stoat *Mustela ermina*, Weasel *Mustela nevalis* and Polecat *Mustela putorius*, will also benefit from these underpasses. In cases where the habitat of medium-sized mammals such as the Red fox *Vulpes vulpes* and Badger *Meles meles* is intersected, fauna tunnels with an entrance diameter of 0.50 m are proposed. In Badger habitats these tunnels should be spaced 250 m apart on average, and 125 m apart if setts are located less than 200 m from the road. For species other than the Badger the suggested average spacing of the tunnels (of the same diameter) is 200 m (cf. Van Nierop 1988). Fauna tunnels should be shielded from high groundwater levels so that animal passage is guaranteed.

The use of acoustic walls combined with planted elements and wire fences is restricted to woods and fine scale landscapes. Application of acoustic walls in open landscapes would mean a deterioration in the appearance of the landscape for characteristic species; meadow bird species, for example, profit from the openness of grassland and arable land habitats. ‘Hidden hedge’ constructions can be applied in all types of landscape, however, as they are not anticipated to have any negative impact on the fauna.

The mitigative measures derived from the effects (cf. Tables 3A,B) are presented in Table 4A. Wire fences are proposed behind the acoustic walls in woodland (total length 25 km) to facilitate combined application with fauna underpasses. Two larger underpasses (2.5*1.75 m), in the U1 stretch, are designed to improve the permeability of the road to Roe deer, Badger and Red fox in the Maashorst National Park. The twenty smaller underpasses (∅ 0.50 m) are concentrated in the V1 and U1 stretches, where the road intersects Wijboschbroek and Maashorst, respectively, two core areas for Mustelidae. Since underpasses cannot be built along the sunken S2/N2 stretch, a viaduct is proposed, combined with a fauna

Table 4: Summary of mitigative and compensatory measures in the A50 highway planning area according to the preliminary method. Sound-suppressing asphaltic concrete (SSAC) is used over the full length of the road link.

4A. Mitigative measures	**length/number**
Acoustic walls (height >3.5 m)	[a] 25 km
Wire fencing (height >1 m)	[a] 25 km
'Hidden hedge' (height >1 m)	[a] 6.5 km
Road foliation	2 km
Bentonite screen	2 x
Fauna underpass (tunnel ∅ 0.50 m)	20 x
Fauna underpass (tunnel 2.5*1.75 m)	2 x
Recreation underpass (width 8 m) [b]	1 x
Extended bridge sections; brooks (2xΔ10 m)	4 x
Extended bridge sections; canals (2xΔ10 m)	2 x
Extended viaduct over sunken A50; fauna overpass	1 x
4B. Compensatory measures	**number/area**
Acquisition, design and management of [c]:	
- woodland	30-60 ha
- fine scale landscape	[d] 345-665 ha
- grassland	26-52 ha
- marshland	4-8 ha
Closing roads to motorized traffic (1-2.5 km)	3 x

[a] Total length of double-sided application.

[b] Also designed for use by fauna.

[c] Total area of 405-785 ha, dependent on the location and expected nature quality of the compensation area, should be obtained by acquisition, design and management.

[d] I.e. 320-640 ha compensation for effects on breeding birds and 25 ha compensation for loss of Badger habitat.

overpass, i.e. a strip of vegetation 2 m wide providing an ecological link between the two halves of the dissected woodland.

Bridges are proposed at six locations, to be extended by 10 m on both sides to avoid interruption of bank zones. Use of road geoliners over a distance of approx. 2,000 m (S2/N2) and two bentonite screens (V1, U1) is proposed, to offset depression of the water table. A recreation underpass is proposed to restore the recreational zoning of the National Park. The underpass can be designed for use by fauna at the same time.

Due to the qualitative descriptions, impacts on water table, recreational patterns and fauna casualties, are not considered further in deriving compensatory measures.

3.4 Derivation of compensatory measures

3.4.1 Compensation for area effects

Those territories of the selected species lost as a result of the new road and those still disturbed by noise (after mitigation) qualify for compensation. The non-mitigable disturbance effects are indicated in Table 3A, in terms of territory numbers. The table shows that, although the use of acoustic walls is restricted to woods, fine scale landscapes also benefit from soundproofing as they alternate with or are adjacent to wooded areas. This is also the case for the marsh species Reed warbler *Acrocephalus scirpaceus* along the S2/N2 stretch. Use of sound-suppressing asphaltic concrete (SSAC) appears to mitigate disturbance of the grassland species Black-tailed godwit *Limosa limosa* and Snipe *Gallinago gallinago* to a limited extent only. In addition, also twenty-five hectares of Badger habitat, not covered by territories of the bird species, will become unsuitable for habitation because of the extensive cloverleaf situation connecting the A50 with the existing road near Oss. In spite of ‘hidden hedges’ and wire fences, leaks will remain. This lost Badger habitat should be compensated for.

3.4.2 Compensation for quality effects

The contribution of quality compensation is relatively limited (cf. Table 3B). All the effects are assumed to be mitigated except for the barrier effects on the Badger (along U1), on ‘other mammals’ (along S2/N2, mainly Mustelidae), on amphibians and reptiles (along S2/N2; eight species, i.e. Pool Frog *Rana lessonae*, Viviparous Lizard *Lacerta vivipara* and Alpine Newt *Triturus alpestris*) and on butterflies (along all stretches; approx. 40 species of various habitat types). Barrier effects on these species must be compensated for in the compensation area for breeding birds.

3.4.3 Summary of compensatory measures

Application of the described method to the A50 road link yields the measures summarized in Table 4B. The range in the size of the compensation area, 405-785 ha, follows from uncertainties about the anticipated long-term quality of habitats. The net compensation area includes 25 ha of lost Badger habitat (cf. Table 4B: ‘fine scale landscape’). Twelve search areas for compensation are indicated along the stretches S2/N2 (4x), K (2x), V1 (3x) and U1 (3x). The net search area is highly oversized (i.e. two to three times the required area), thus giving ample scope for determining the exact locations of the compensation areas through negotiations with municipal authorities and other interested parties. The compensation areas should be designed and managed making due allowance for the barrier effects of the road, as indicated above.

3.5 Location of the compensation areas

The search area locations for compensation follow directly from three provincial spatial plans relevant to the A50 planning area (Province of Noord-Brabant 1993). Under the terms of the Green Network provincial planning policy excludes further establishment or expansion of industry, and aims to improve extensive agriculture. The Provincial Ecological Network provides the backbone of natural functions in North Brabant. By means of this network, nature quality and diversity are to be improved according to well-defined ‘target types for nature’. Under the terms of the Agricultural Structure zoning policy, intensive farming operations are to be optimized within the existing environmental context. There is a considerable overlap between the (Provincial) Ecological Network and the Green Network, while the Agricultural Structure is spatially distinct from these two networks.

Search areas for compensation must be situated outside the Agricultural Structure area, since present farming management may not be affected. The compensatory

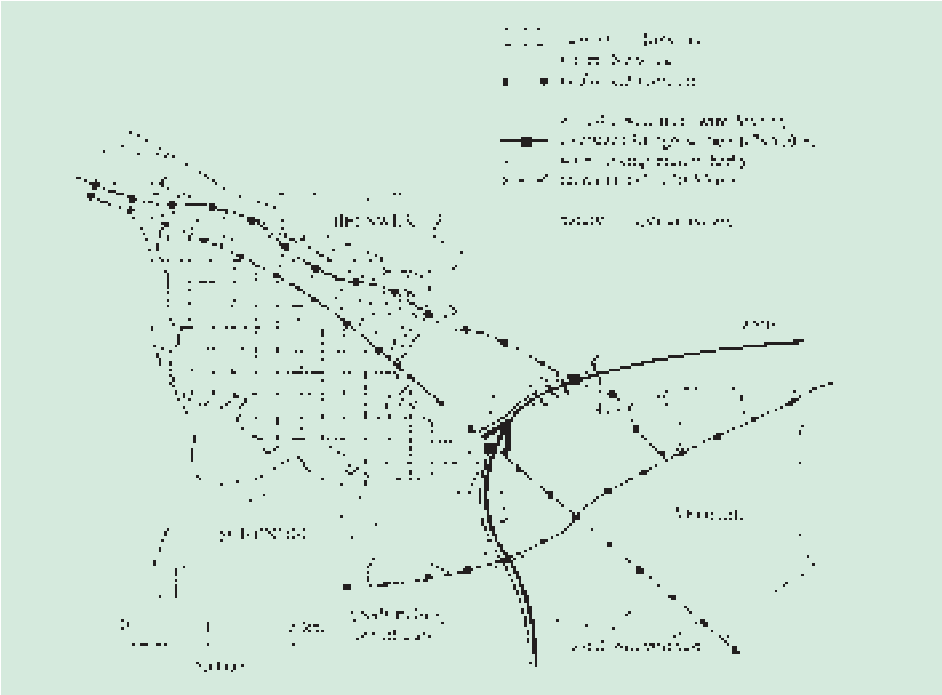

Fig. 5: Survey of mitigative measures and the search area for ecological compensation along the Veghel stretch (V1). The search area is oversized in comparison with the calculated compensation area (150-300 ha).

measures should also preferably not been implemented in the Ecological Network, as current provincial policy aims to protect or develop this Network and land is available for compensation purposes outside the Network. Thus, the potential area for compensatory measures, i.e. for establishing ecological functions and/or improving nature quality, is that part of the Green Network not overlapping the Ecological Network.

Although in conflict with one of the basis points of departure, it proved impossible to avoid location of some of the search areas in Agricultural Structure zones. This was true of the K stretch, in particular, where one of the compensation options is to connect the two divided Dommel brook basin areas through extension of the natural values adjacent to the A50 bridge span, an area in use as farmland. Three other search areas have also been located in Agricultural Structure zones, as implementation there would enhance the natural values in nature development areas. These areas are: an agricultural area adjacent to woods (S2/N2), an extensive part of the Aa brook basin adjacent to Wijboschbroek (V1, see Fig. 5) and an agricultural enclave in Maashorst (U1).

The minor effect of barrier-weakening measures along the S2/N2 stretch (i.e. an extended viaduct over the sunken part of the road) makes compensation necessary in the form of closing one road (length approx. 1.2 km) of the underlying road grid to motorized traffic. Two other roads (lengths approx. 2 and 2.5 km) near the U1 stretch are also eligible for closing, to overcome uncertainties in assessing the barrier action of the A50. These roads would become alternative, 'short-cut' routes after realization of the A50; their closure will relieve the badger population along the U1 stretch, in particular.

4. Towards the Final Ecological Compensation Plan

4.1 The Draft Compensation Plan

The Draft CP, drawn up by the Regional Directorate of Public Works and Water Management of the province of Noord-Brabant (MTPW 1995a), follows from the results of Cuperus & Canters (1994). Compared with the preliminary version, the Draft CP was modified in the following respects (compare Table 5A with Table 4A):

(a) In the Draft Plan acoustic walls are no longer applied. Their efficiency, i.e. the reduction of the number of disturbed territories of species of woodland and fine scale landscapes (cf. Table 3A) in relation to the costs, is considered to be too small. Noise effects are compensated directly.

(b) Wire fencing to prevent fauna casualties are assumed to be just as effective as 'hidden hedges'. 'Hidden hedges' are therefore not included in the Draft CP, but replaced by fences.

(c) As the compensation areas will be realized by developing optimal natural areas, the Regional Directorate has made use of the minimum territory sizes of the selected species of woodland, grassland and marshland (cf. Table 1). For the species of fine scale landscapes a different approach was followed, as these are now considered - contrary to the preliminary method - to be compatible with agricultural management. 'Condensing' of agricultural land, by increasing the figure of 4,000 m of wooded belts, hedgerows and/or wildflower margins per 100 ha in the basic design (existing situation) to 8,000 m in the optimal design, is expected to lead to increased densities of Partridge *Perdix perdix* and Whitethroat *Sylvia communis*. This step is assumed to have no deleterious impact on farm management. Mitigative and compensatory measures for impacts on fine scale landscapes are derived as follows. Each lost Partridge or Whitethroat territory is compensated for by the development of 4 and 2 ha shrubland, respectively. For each disturbed Partridge and Whitethroat territory, the compensatory measures take the form of creating 160 m (i.e. 0.16 ha) of wildflower margins or 80 m (i.e. 0.08 ha) of wooded belts and hedgerows, respectively, within the 1,500 m disturbance zone (mitigation) as well as outside the disturbance zone (compensation).

(d) The fauna overpass combined with a viaduct (S2/N2) was considered to be pointless.

(e) Planting linear landscape elements within the disturbance zone over 298 ha of grassland and arable land is applied as a mitigative measure for the impact of traffic noise, which implies the planting of 12 ha of linear elements in the Agricultural Structure zone.

(f) As a final step, the Draft CP adds a surplus to the calculated compensation area for some landscape categories because of the interim period during which the lost quality standard will not be achieved in the compensation area. This quality surplus is determined as a function of the replaceability of the lost qualities and amounts to 1/3 of the compensation area for grassland and fine scale landscapes and 2/3 of the compensation area for woodland and marshland. This means that lost and disturbed territories of the selected species of grassland/fine scale landscapes and woodland/marshland are compensated for area and quality losses by applying factors of, respectively, $1^{1/3}$ and $1^{2/3}$.

The resultant compensation area according to the Draft CP is summarized in Table 5B. The area to be used for compensation purposes is seen to be 25-50% the size of that according to the preliminary method (cf. Table 4B), despite omission of the acoustic walls and introduction of the quality surplus in the Draft Plan. This reduction in size is due to use of the minimum size of the selected species' territories and particularly to the 'condensation' of agricultural land

Table 5: Summary of mitigative and compensatory measures in A50 highway planning area according to the Draft Ecological Compensation Plan (MTPW 1995a). SSAC is used over the full length of the A50.

(5A) Mitigative measures	**Length / number / area**
Wire fencing (height >1 m)	31,5 km
Road geoliners	[a]2 km
Bentonite screen	2x
Fauna underpass (tunnel ∅ 0.50 m)	20x
Fauna underpass (tunnel 2.5*1.75 m)	2x
Recreation/fauna underpass (width 8 m)	1x
Extended bridge sections; brooks (2xΔ10 m)	4x
Extended bridge sections; canals (2xΔ10 m)	2x
Optimal design fine scale landscape [b]	12 ha
(5B) Compensatory measures	**Area (ha)**
Acquisition, design and management of [c]:	
- woodland	109
- fine scale landscape [d]	12
- shrubland	25
- grassland/marshland	56

[a] Total length of double-sided application.
[b] Mitigative measures, i.e. plantation of 12 ha linear elements, applied to 298 ha of agricultural land *within* the disturbance zone.
[c] Total area: 202 ha.
[d] Compensatory measures, i.e. plantation of 12 ha linear elements, applied to 298 ha of agricultural land *outside* the disturbance zone.

through the planting of linear elements in the Agricultural Structure zone outside the disturbance zone. These ‘condensation’ activities imply prior agreement being reached with the agricultural interest groups. In comparison with the results of the preliminary method the Draft CP yields a greater amount of woodland, owing to the quality surplus for this type of habitat.

In interim negotiations with the parties concerned, five search areas identified in the preliminary method proved to be unsuitable, for administrative reasons. At the same time, new search areas revealed more convenient locations for compensation (five areas were added). In the Draft Plan six search areas proposed in the preliminary method have been enlarged by adjusting and/or moving their boundaries. One search area was adopted without modification (cf. MTPW 1995a).

4.2 The Final Compensation Plan

Although not laid down by law, the Draft CP was sent to interested parties in the region to give the public an opportunity to give their comments. In the four-week period provided - the month of March 1995 - 41 comments were received by the Regional Directorate of Public Works and Water Management (cf. MTPW 1995b). The principal areas of comment on the Draft Plan were as follows:

(a) The environmental groups emphasized the uncertainties in the compensation methodology, e.g. indications of territory size, and the risk of underestimating the impacts on other groups of organisms besides breeding birds. Furthermore, the underpinning of the choice of species representing habitat loss and disturbance effects was considered disputable. Although the Regional Directorate considered the species to be representative of the landscape types in question and sensitive to infrastructural interventions, the Directorate expected a certain amount of overlap of the habitats of the various groups of organisms. However, the Directorate did not consider it necessary to adapt the size of the compensation areas for reasons of representativeness or sensitivity.

(b) The impact of habitat loss on birds and amphibians was considered to be under-estimated. It was brought forward that a large area of woodland that will be lost to the road was not covered by territories of the selected species nor by amphibian habitat. To offset the underestimation of the impact of habitat loss on birds, in the Draft Plan 36 ha of woodland and 6 ha of grassland/arable land have now been added to the compensation area. For amphibians additional measures, such as the creation of toad pools, will be realized in the compensation areas (viz. in the ‘condensed’ agricultural landscapes).

(c) The fauna underpasses are held to be insufficiently linked, ecologically, with the landscape in the Draft Plan. To overcome this problem, the fine scale landscapes that are to be developed will be located, where possible, around these underpasses in order to intensify ecological connections.

(d) Several new search areas were suggested during participation by the public. As a result, in the Definitive Plan four new areas have been added to the list of search areas.
(e) The agricultural interest groups agree, in principle, with the plantation of linear elements along farm lots. In their view, though, there is too much emphasis on the voluntary willingness of farmers to cope with the 'condensing' objectives.

In June 1995 the Definitive Plan (MTPW 1995d) was approved by the Minister of Transport, Public Works and Water Management. Besides the proposed measures along the A50 (Table 5A) the Definitive Plan consists of the development of 145 ha of woodland, 24 ha of shrubland, 62 ha of grassland/marshland and the 'condensation' of approx. 600 ha of agricultural land (50% inside and 50% outside the A50 disturbance zone; cf. Table 5B). The precise nature of the compensation plan is to be established before the year 2003. The Regional Directorate has already started acquiring land for compensation purposes.

4.3 Implementation and realization of ecological compensation

The Regional Directorate has practical experience with the envisaged mitigative measures. However, realization of the compensatory measures will be hampered by the current lack of a legal basis for the compensation principle. Policy-making is in progress for scheduled areas of special governmental interest, such as the Ecological Network. Until this process has been completed, the present policy instruments must be used, particularly those applicable to land use and land consolidation activities. Compensation areas can still be designated by the exchange and purchase of land in the 'Sint Oedenrode' reallotment scheme which has recently been set in progress in the centre of the A50 planning area. Another possibility is to make use of the scope for so-called 'land adaptation', within the framework of the Land Use Act. This act enables the negative impact of infrastructural works on their surroundings to be mitigated or compensated (MANF 1993). A potential area for a 'land adaptation' approach can be found west of the line of towns Veghel-Uden-Nistelrode.

As the Definitive Ecological Compensation Plan has recently been approved, agreements on the extent and location of the compensation areas should be forthcoming in negotiations between the parties involved (i.e. municipal authorities, nature conservation organizations and environmental groups). After agreement has been reached, the compensation locations must be incorporated in the zoning plans by the local authorities with properties along the road. A promising perspective in the negotiation process is the increasing contribution of agricultural interest groups to possible realization of nature conservation objectives. This is a lucky circumstance in a country where every hectare of land is usually claimed by more than one societal function.

An important aspect of realizing the compensation objectives is the announcement that progress is to be monitored in the form of annual reports. Such monitoring may result in adjustment of the measures in cases where the compensation objectives are not fully achieved.

5. Conclusions and discussion

5.1 Comments on the preliminary method

As there was no method available for determining the extent and type of ecological compensation, a preliminary method was developed for the A50 road link. Breeding birds play an important role in the method and are used to quantify the impacts of habitat loss and habitat disturbance by traffic noise. The dominant role of breeding birds is based on the following facts:

(a) compared to other species groups, spatially comprehensive information on breeding birds was, although limited, the best available (cf. Kleijberg & Klooker 1991);
(b) breeding birds are assumed to be useful indicators for the presence of different types of landscape (Kwak *et al.* 1988);
(c) the dose-effect relations for disturbance by noise are relatively well-underpinned for breeding birds (Reijnen & Foppen 1991, Reijnen *et al.* 1992);
(d) breeding birds are disturbed by traffic noise over a relatively long distance (Van der Zande *et al.* 1980).

Nevertheless, several critical remarks should be made. Firstly, by assessing the territories of the selected characteristic breeding birds that are to be dissected by

the A50, lost habitat sites not covered by any of these territories are neglected. This follows from the implicit focus of the method on actual habitat sites, with potential ecological values not being taken into consideration. Although 'no selected species territory present' may suggest 'the absence of corresponding habitat quality', we assume that this problem is of relatively minor importance. Argument for this is that a lost territory is bigger than the area strictly destroyed by the road and, consequently, that the totalized surplus will balance the total extent of habitat not covered by any territory.
Secondly, the lack of detailed information, leading to qualitative descriptions, has resulted in underestimating the extent of compensatory measures. Effects on hydrology, recreational patterns and fauna casualties were not considered in determining the size of the compensation area. So, a no-net-loss situation will not be reached completely when significant knowledge is lacking. This can be used as an argument to compensate more for quantitative effects than the compensation that follows from the corresponding dose-effect relations (i.e. by so-called overcompensation).

5.2 The Ecological Compensation Plan versus the results of the preliminary method

As initiator of the A50 road construction project, the North Brabant Regional Directorate of Public Works and Water Management has drawn up an Ecological Compensation Plan for the road link, using the results of the preliminary method and the opportunity for public comment. In the process of formulating the CP, the Regional Directorate has demonstrated its serious intention to compensate for impacts on nature. Still, several uncertainties in the compensation methodology have to be solved.
Two major new aspects of the Final CP proved to result in considerable differences in measures compared with the preliminary method: introduction of the 'condensing' objective in the Agricultural Structure and omission of acoustic walls. It is clear that both of these will have to be critically discussed during further development of the compensation method.
The role of interest groups appeared to be of great importance for the Final CP. On the one hand interest groups can bring forward extensive knowledge of natural values in the planning area (i.e. the introduction of alternative search areas for compensation in the Plan). On the other hand, the implementation of

their comments in the Final CP will promote the public support for the intervention, which will work out positively especially when interest groups participate in designing and managing the future compensation areas (i.e. individual farmers and nature trust organisations).

5.3 Further developments

The Final CP is rooted in the preliminary method. Experience with the A50 road link and other case studies will lead to elaboration of a more robust compensation method for road projects. As mentioned above, the method will be adjusted for the aspects of landscape ‘condensing’ and direct compensation through omission of mitigative measures such as acoustic walls.
Furthermore, consideration might be given to incorporating losses of bird communities rather than specific bird species in the method. The choice of characteristic species for the various types of landscape and the estimation of their territory sizes are two aspects that are open to question, being subject to regional differences. Working at the community level makes the method less dependent on maximum and minimum territory sizes, so that a more robust method can be obtained. It should be noted that new dose-effect relations for the different aspects of communities are to be established. At the same time, efforts should be made to offset the underestimation of qualitatively described impacts on vegetation and groups of organisms other than birds in the preliminary method. This offset must enable us to reach a no-net-loss situation for area and quality.
The implications of the lack of certain relevant information will also be evaluated, to adjust the method and thus make it a useful tool for future road projects. An important aspect in this context will be the search for compatibility with the government’s Structure Plan for the Rural Areas in the Netherlands (MANF & MHPE 1993), which sets out legislation and other regulations relating to ecological compensation programmes.

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Chapter 3

Guidelines for ecological compensation associated with highways

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Guidelines for ecological compensation associated with highways

Abstract
Avoidance, mitigation and compensation are three planning concepts designed to counteract the adverse impacts of infrastructure on nature. To promote the compensation principle introduced in the Netherlands, this article proposes guidelines for its implementation in the context of highway development. To this end, a coherent framework has been developed comprising: (a) impacts on nature, (b) concepts for use in planning ecological compensation, and (c) ecological, spatial-planning and financial instruments for realizing such compensation. Finally, Dutch experience is discussed within the international context. Recommendations are made for improving the implementation of compensation. These stress the importance of creating 'win-win' situations to increase public support, of dealing with impacts that cannot be predicted, and of developing criteria for evaluating compensation plans. There are still several priority problems to be dealt with: the effects of habitat isolation caused by highway projects, the effectiveness of compensation measures and compensation ratios (viz. ratios of replaced to lost area) greater than one, the real costs associated with replacing habitats, the feasibility of compensation for ecological values that are difficult to replace, and the strategy to exchange impacted and substitute habitats.

Keywords: policy, planning, realization, legislation, instruments, costs.

1. Introduction

The construction and use of highways imply the loss, degradation and fragmentation of habitats (Andrews 1990, Bennett 1991, Atkin-son & Cairns 1992, Forman & Hersperger 1996, Canters 1997). Increased awareness of environmental problems caused by infrastructure has moved civil engineers, ecologists and policy-makers to develop planning concepts to deal with the impacts on nature and landscape, as embodied, for example, in the US National Environmental Policy Act (NEPA) regulations (1969). The first, and most fundamental approach is to avoid adverse impacts. Avoidance can be achieved by simply not pursuing a certain development, by generating an alternative for the development or by limiting the intensity or magnitude of the development. If avoidance is not feasible, mitigation measures can be undertaken as a second planning concept. Such measures are designed to reduce or sometimes even eliminate the impacts of a given development on nature. Today, it is common practice worldwide to back up highway projects with mitigation measures, such as ecological management of roadside verges (Way 1977), fauna tunnels (Hunt *et al.* 1987, Bekker & Canters 1997), adapted culverts (Yanes *et al.* 1995) and ecoducts (Friedman 1995, Pfister & Keller 1995) for wildlife movements.

Recently, a third concept has been developed. Based on the experience that impacts may still persist after mitigation, several states and countries have adopted a compensation principle, envisaged as counterbalancing the adverse impacts of developments on nature. Examples of such a principle are: the German *Eingriffsregelung* (functioning since 1976, cf. Meier 1987), the US no-net-loss policy for wetlands (since 1986, cf. Section 404 of the Clean Water Act), and the Dutch compensation principle for spatial protected areas (since 1993, cf. MANF & MHPE 1993). This concept explicitly incorporates nature conservation interests in decision-making on spatial developments. The initial consequences of the compensation principle for Dutch highways have been discussed by Van Bohemen (1995). However, the principle has raised urgent questions about the basis for its implementation.

This article proposes guidelines for implementing the compensation principle in the context of highway development. After defining the setting of ecological compensation (section 2), the impacts of highways on nature (3) are briefly described. Subsequently, concepts for use in planning ecological compensation measures (4) and instruments for their practical realization (5) are presented. The article concludes with a discussion of evolving Dutch experience in the international context and identifies problems that are still to be solved (6).

2. The setting of ecological compensation

Ecological compensation is defined here as the substitution of ecological functions or qualities that are impaired by (highway) development (Cuperus *et al.* 1996). Such compensation aims either to improve damaged areas or to create new

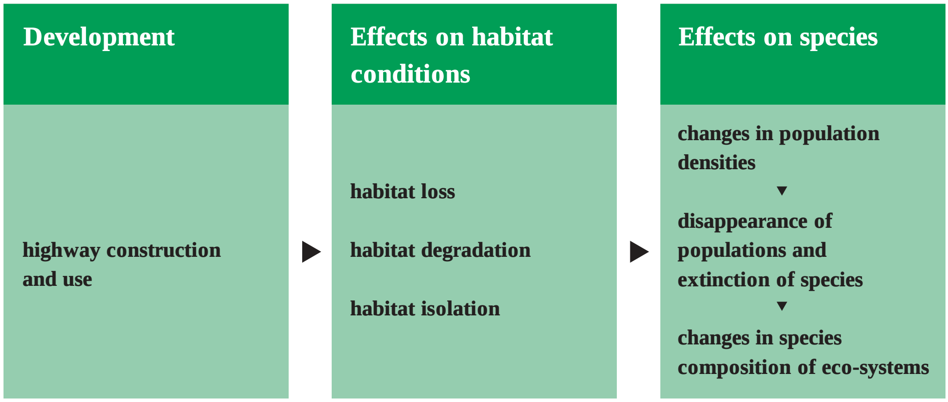

Fig. 1: Distinguished effects of highways on nature (adapted from: Cuperus et al. 1996).

habitat with ecological functions and quality attributes (Allen & Feddema 1996). Fundamentally, this does not differ from ecological restoration or habitat creation (Anderson 1995, Wyant *et al.* 1995), except that it is associated with adverse impacts on nature due to development. Moreover, in contrast to mitigation measures, ecological compensation is generally undertaken outside the highway management area.

The distinction made between the three planning concepts employed here — avoidance, mitigation, compensation — deviates from current international terminology. This describes ‘mitigation’ as any activity that avoids, minimizes, rectifies, reduces or compensates for the effects of environmental damage (NEPA 1970, National Research Council 1992). However, our concepts stress the three fundamen-tally different approaches to counteracting the impacts of a development. Within this framework, ‘mitigation’ contracts the NEPA interpreta-tion to ‘minimizing, rectifying and reducing’ effects. The terms ‘avoidance’ and ‘compensation’ are thus taken to refer to two specific issues, and to bypass the compound term ‘compensatory mitigation’ (cf. Bedford 1996). This article focuses on the problems and solutions associated with compensation measures in the stricter sense defined above.

3. Effects of highways on nature

Developments generally affect ecological values by modifying (abiotic) habitat conditions, which in turn influence the abundance and distribution of plant and animal species in the impacted areas. Ecological compensation may require no-net-loss of habitat conditions (cf. Adamus *et al.* 1987), of habitat types (U.S. Fish and Wildlife Service 1980), of species populations (Nilsson & Grelsson 1995), of populations of species groups (e.g. ecotopes for vegetation: Runhaar & Udo de Haes 1994), or of ecological functions (Brinson & Reinhardt 1996), all to the extent that they have ecological significance or characterize a specific ecological site. Before considering the planning and realization of compensation measures (see sections 4 and 5), we distinguish three primary effects of highways on nature in terms of changed habitat conditions, viz. the loss, degradation and isolation of habitat (Fig. 1).

3.1 Habitat loss

There is strong evidence that habitat loss is a problem for species in many habitats, implying serious threats to local and regional populations (cf. Reed 1995, Thomas 1995). Between the mid-1970s and mid-1980s annual wetland losses in the USA due to infrastructure amounted to about 1,050 km^2 (Mitchell 1992), i.e. 0.02% of rural land in the USA. Over the period 1980-1993 construction of Dutch rural metalled roads (including verges and road ditches) caused about 180 km^2 of habitat loss, an annual loss of 0.04% of rural land in the Netherlands (Central Statistical Office 1996).

3.2 Habitat degradation

Although habitat patches remain physically accessible to species, the construction and use of highways may lead to a decline in habitat quality in zones adjacent to the infrastructure. This decline may be due to noise, visual disturbance (e.g. illumination), changes in water table and microclimate, and the spread of toxic substances mainly by air and water pollution. These qualitative effects may result in decreased densities of species sensitive to the development, as is the case, for example, with woodland and meadow-bird populations exposed to the noise of car traffic (Reijnen *et al.* 1995, 1996).

3.3 Habitat isolation

Infrastructure may lead to a reduced exchange of species between populations, as a result of increased landscape resistance through barrier effects, and higher mortality rates through fauna casualties (cf. Andrews 1990, Saunders *et al.* 1991). Habitat isolation undermines the persistence of stable (meta)populations, in which local extinction and recolonization are well-balanced.

As metapopulation dynamics are complex, it is still scarcely feasible to make a quantitative assessment of the habitat isolation effects of infrastructure. Extinction thresholds and minimal viabilities of (meta)populations of single species have been demonstrated in theoretical models (Bascompte & Solé 1996, Hanski *et al.* 1996), but appear difficult to prove quantitatively in realistic situations (Opdam *et al.* 1994). This makes it all the more logical to adopt multiple-species approaches. Initial attempts at quantitative assessment are currently in progress in the context of introducing infrastructure-related compensation measures in single-species metapopulation models (cf. Van Apeldoorn 1997).

Secondary effects of highways, i.e. on species (cf. Fig. 1), are dependent on both species and landscape characteristics. The role of species characteristics is illustrated by (a) barrier effects decreasing and mortality effects increasing with increasing mammal size (Verboom 1996), and (b) specialist species being more vulnerable to development than generalists (Andrén 1994) or species with a restricted range (Simberloff 1994). On the other hand, landscape characteristics also determine the stability of populations: as more habitats are fragmented, the persistence of populations becomes increasingly dependent on the spatial arrangement and decreasingly dependent on the total number of suitable habitats (Andrén 1994).

4. Planning principles behind ecological compensation in the Netherlands

Recent experiences in Dutch highway projects provide opportunities for developing a new approach in which the different types of ecological compensation can be better combined with highway planning. The type of ecological compensation to be adopted depends on two aspects (e.g. Brinson &

Reinhardt 1996): (a) the degree of equivalency of habitats or species (in-kind versus out-of-kind compensation), and (b) the location of the compensation site relative to the development site (on-site vs. off-site compensation). In-kind compensation involves replacement with the same habitats, species or functions; out-of-kind compensation involves replacement with alternative habitats, species or functions. On-site and off-site compensation are defined here as being within and outside the effect zone of the highway, respectively. The width of this zone depends on the cause of habitat degradation (e.g. noise load, change of water table, etc.).

4.1 In-kind compensation measures

4.1.1 Habitat loss

The method used to reverse the effects of habitat loss is creation of habitat patches of the same size and quality via (on-site or off-site) in-kind compensation (Fig. 2). Upgrading existing habitat may also be effective as a secondary approach. Generally, the longer time required for the habitat to develop, the more difficult it will be to compensate for impacts. Long established and ancient habitats can scarcely be replaced, if at all (Anderson 1994).

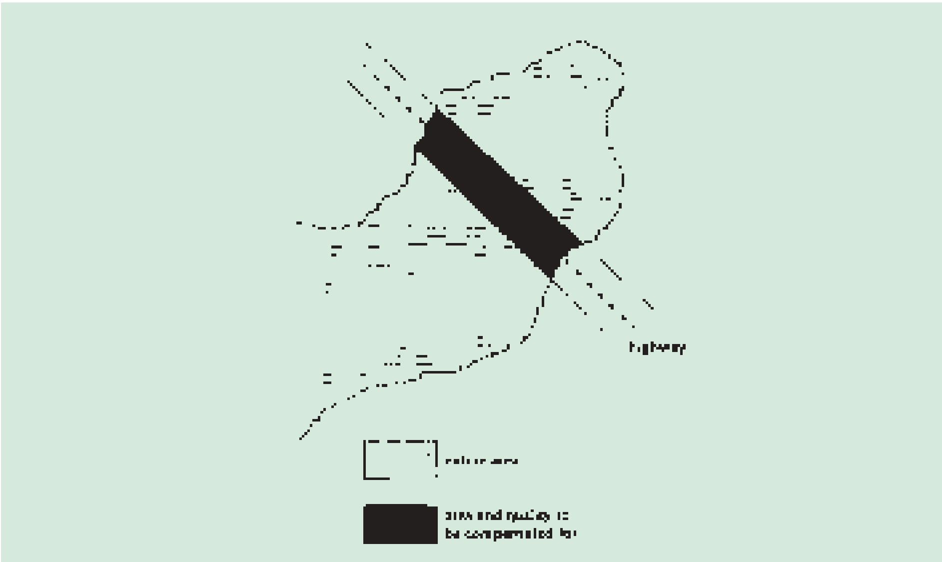

Fig. 2: Compensation for impacts of habitat loss.

4.1.2 Habitat degradation

No-net-loss of habitat degradation is preferably achieved by upgrading habitats. In-kind compensation measures should aim at restoring the ecosystem, expressed in terms of the densities of (selected) species prior to the development (Fig. 3A). Depressed water tables may be compensated for by raising groundwater levels off-site, providing suitable conditions for groundwater-dependent vegetation. On-site (in-kind) compensation for the impact of elevated noise loads can only be achieved by intervening in other habitat conditions, as habitat quality is determined by a multiple set of habitat conditions. Decreased meadow-bird densities in suboptimal habitat patches due to traffic noise may be compensated for basically within the effect zone either by raising the water table or by introducing a new management regime to render the affected habitat more attractive to meadow birds (cf. De Jong 1977, Fig. 3B). For highly sensitive species such measures are more effective off-site, as these species will probably persist in avoiding the impacted zones.

4.1.3 Habitat isolation

Compensation for isolation effects should aim to offset decreased dispersal rates and increased mortality rates. Appropriate measures are (a combination of) enlarging and upgrading habitats or increasing the connectivity of isolated habitat patches. An example of such a combination of measures associated with highway construction is concurrent closure of the ‘lower-level’ road network (e.g. trunk roads) to motorized traffic. This measure aims to achieve not only a decrease in the overall noise load of habitats and numbers of fauna casualties, but also continuity of suitable habitat patches. New patches may be developed and attached spatially to or located within existing nature areas, thus forming larger units with a potentially greater number of species and individuals. Alternatively, or in addition, new patches may be located so as to serve as links between the core areas of species, thus reinforcing or creating ecological corridor functions. This strategy does not appear particularly effective for old-growth forest plants, however (Grashof-Bokdam 1997). Generally, compensation is more effective in or close to the core areas of species than in areas at the edge of their distribution range.

If infrastructure is rendered more permeable for wildlife movements through mitigation measures (e.g. fauna tunnels and ecoducts), then compensation

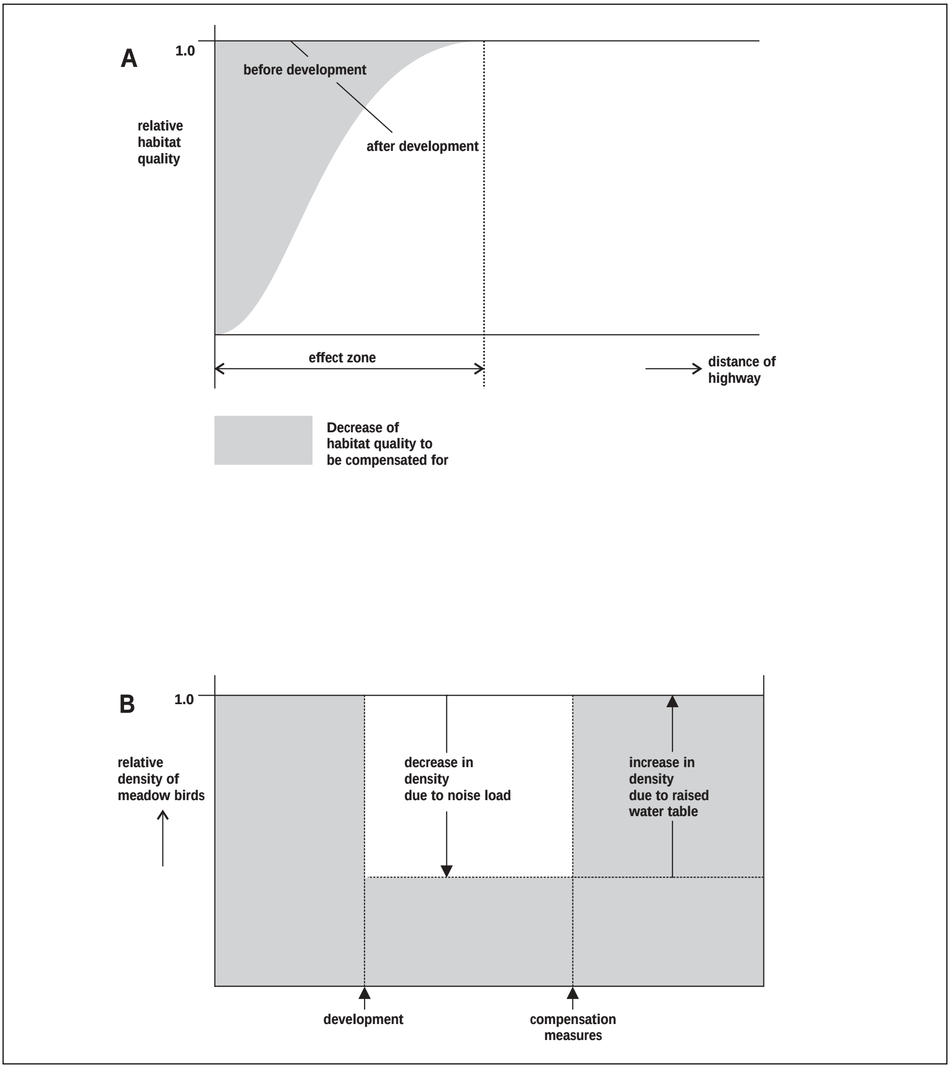

Fig. 3: Compensation for impacts of habitat degradation.

A. In-kind compensation derived from dose-effect responses (curve adapted from: Reijnen et al. 1995).

B. Close in-kind compensation in the effect zone of the highway for degradation of meadow bird habitat, by intervening on other habitat conditions. Realization of the infrastructure and the compensation measures are not successive in practice, but separated here for exemplification.

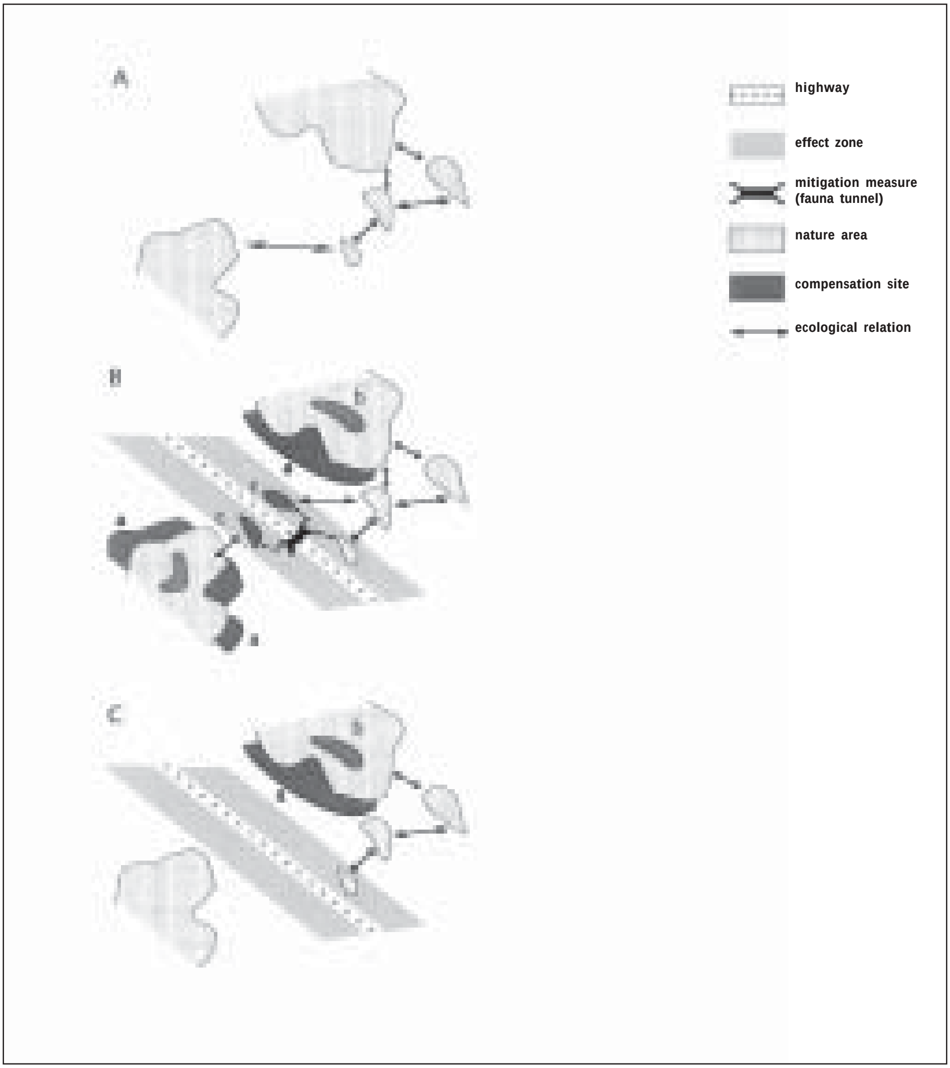

Fig. 4: Compensation for effects on habitat isolation.

A. *Reference situation (without highway).*

B. *Combination of on-site and on-site compensation through enlarging (a), upgrading (b), and connecting (c) habitats, requiring an effective mitigation.*

C. *Off-site compensation through enlarging and upgrading habitats, the compensation sites located at one side of the highway, thus avoiding mitigation measures.*

measures in the vicinity of the highway may increase the connectivity of habitats on either side of the infrastructure. Such a strategy requires effective mitigation as well as compensation sites located within the effect zone of the infrastructure (Fig. 4A). From metapopulation perspectives, however, intensifying habitat-network components on just one side of the highway may sometimes yield greater benefits, as this avoids the risks of ineffective mitigation (Fig. 4B).

4.2 Out-of-kind compensation measures

Unlike in-kind compensation, out-of-kind compensation provides scarcely any scope for objective identification of equivalent habitats or species, since there is seldom any strict ecological relationship between impacted and trade-off habitats. As a rule of thumb, habitats may be traded by employing a nature conservation strategy in which habitat exchange is permitted only within the context of equivalent ecosystem or management properties. In the Dutch situation this would imply that habitat exchange to compensate for impacts on the National Ecological Network is permitted within a number of individual network units, but not between these units (Table 1).

5. Realization of ecological compensation in the Netherlands

5.1 Realization and evaluation of compensation measures

Compensation measures should support current nature management policies and should be physically located outside areas where specific nature-policy objectives are already operational, for example the core areas of the Dutch National Ecological Network (Bal *et al.* 1995). Compensation objectives should take account of the habitat conditions and the actual habitat qualities of the site prior to acquisition, design and management (the ‘pre-compensation site’) as well as the long-term quality of the site to be pursued under the terms of current policies. In practice, sites for ecological compensation are determined by a combination of administrative goals set by the competent authorities, the availability of suitable soil conditions and other criteria determining the ecological potentials of the site (cf. MTPW 1995). Once the site or sites are acquired, design and management plans must be drawn up if necessary on the basis of the habitat-quality objectives envisaged and subsequently implemented. Ideally, these plans should be operative

Table 1: Features of the four units of the Dutch National Ecological Network (adapted from: Bal et al. 1995).

	nearly natural unit	**managed natural unit**	**semi-natural unit**	**multi-functional unit**
conservation strategy	no human interaction, only design and external maintenance	imitation and stimulation of specified processes	maintenance of a vegetation stage	joint use of area functions
succession stage	several stages	several stages	one stage/mosaic nature reserves such as:	one stage
examples	- natural woodland - dynamic dunes - sea, incl. coastal zones	- tidal waters - river beds, basins and banks - sand-drifts	- heathlands - peat bogs - oligotrophic grasslands	- multifunctional woods - flower-rich arable lands - water-catchment areas - military exercise areas

prior to highway construction, thus allowing compensation sites to be colonized by source-habitat fauna and vegetation through dispersal or, in the case of vegetation, via seed banks (Bakker *et al.* 1996). Purchased compensation grounds will be transferred to well-equipped conservation trusts.

5.2 Legislation and instruments

In the Netherlands, the compensation principle is the policy line adopted by the national government. There is not yet any statutory legislation in place through which the compensation principle can be enforced by law if necessary, however. Compensation measures are instead to be realized on a voluntary basis, rooted in agreements between affected parties. This voluntary character has several operational implications. Land-use changes are permitted only on the basis of authorized zoning plans, for which municipalities bear prime responsibility. Highway initiators and municipalities must therefore agree upon implementation of permit-related measures in zoning plans, thus furnishing the initiators with legal grounds for the expropriation of land for compensation purposes. Under the terms of these agreements, land may be acquired through purchase from individual owners. In addition, though, project initiators may otherwise create opportunities for land to be exchanged among two or more cooperating owners, to achieve better spatial organization of the compensation lands. In order to accomplish this, the initiator must then himself own sites in order to act as a negotiating party in the real-estate market. As land-owners will sell real estate on a non-committal basis only, opportunities for initiators exist mainly in (rural) regions that are economically weak. In such regions land-owners are more likely to be willing to sell properties since they do not depend entirely on revenues from their lands. In the case of potential purchase of compensation sites by the initiator, it is favourable to tie in with existing spatial plans, such as ongoing land re-allotment projects. Alternatively, one may initiate new plans, for example by using the concept of Land Adaptation (*aanpassingsinrichting*), developed under the Dutch Land Use Act (Official Gazette 1985) to compensate for the adverse effects of large-scale infrastructure works on agricultural, nature and recreation functions (MANF 1993).

5.3 Costs

Compensation costs are all those involved in transforming a pre-compensation site to one with suitable long-term habitat qualities. Acquisition costs are determined primarily by the regional availability of real estate. Site design and long-term management costs are variable and depend on actual and potential habitat conditions, the long-term quality objectives being pursued and the time available to develop the site. Supplementary to the design and management costs, the Dutch government has added a variable per-hectare quality allowance for compensation sites, to be paid by the initiator. The exact allowance depends on the replaceability of the lost habitat quality; it is intended for preparatory work such as top-soil removal, for example. Quality allowances, donated by the initiator, will be awarded to the conservation trust involved through the so-called ‘Green Fund’ (MANF 1995).

The total costs of the mitigation and compensation measures have been computed in some detail for several actual highway projects. The estimated costs of offsetting the adverse impacts on nature associated with construction of highway A50 between Eindhoven and Oss (30 km) run to 5.0% of total construction costs of the highway (mitigation US$ 11.5 million, compensation US$ 5 million, construction US$ 330 million); in the case of highway A73 South (40 km) 5.8% of construction costs are earmarked for mitigating (US$ 10 million) and compensating for (US$ 14.5 million) adverse impacts on nature (MTPW 1995, 1997, respectively). In both projects, long-term management is incorporated in the compensation costs as a one-off lump sum capitalization over a period of 10 years.

If compensation measures are physically unfeasible, owing to non-cooperation on the part of landowners or municipal authorities or an absence of suitable habitat conditions, the government agency involved imposes a financial charge, to be donated to the Green Fund. This charge can be used to finance projects that would not otherwise have been realized, and must be proportional to the costs of restoring or recreating the ecological values impacted by the development. Because measures financed by the charge are unrelated to the ecological and spatial aspects of the development in question, a physical no-net-loss situation will never be achieved. The financial contribution should therefore be postponed as long as possible, since it can readily be interpreted as a ‘redemption’ of the development by the initiator. In the context of Dutch highway planning, the intention thus far has been for the portion of the earmarked compensation costs that could not be invested in compensation measures until after opening of the highway to be treated as financial contribution (MTPW 1995, 1997).

6. Discussion

6.1 Dilemmas in planning and realizing compensation measures

6.1.1 Planning aspects of ecological compensation

On-site, in-kind compensation will generally prevail over the other alternatives. This option is more likely to offset the lost functions of impaired sites, since habitat conditions are then already in place (Brinson & Rheinhardt 1996), the potential for minimizing disruption of remaining ecological functions will be higher (Race & Fonseca 1996) and compensation sites are often part of a larger system (Hashisaki 1996a). Nevertheless, there are also motives for adopting off-site compensation: in this way larger ecosystems can be connected (Hashisaki 1996a) and better results achieved, since the compensation sites are not adversely influenced by the infrastructure itself (Mitsch & Wilson 1996).

General standards and guidelines for choosing between 'on-site/off-site' and 'in-kind/out-of-kind' compensation cannot be given, as these depend on the availability of suitable compensation sites and must therefore be determined on a case-by-case basis. In the USA 'mitigation banking' has recently been introduced, a scheme whereby large areas of 'reserve land' are built up from which initiators can buy a compensation site once a project has gained approval (cf. Glickfield *et al.* 1995, Zedler *et al.* 1997). Banking of credits in advance favours acceleration of the approval procedure, apart from the 'redemption' issue, because the compensation site is acquirable; furthermore, it lowers mitigation and compensation costs, and increases compensation efficiency, as one large compensation site avoids the fragmentation associated with smaller sites (Hashisaki 1996b). These arguments — and particularly the fact that acquisition of Dutch real estate will be difficult in some regions — make it worth considering the application of mitigation banking in (parts of) the Netherlands.

Equivalences in species diversity and the regional, national or even international rarity of habitats and species may form the basis of out-of-kind compensation (Rossi & Kuitunen 1996). Although these criteria may be appropriate tools for the design and management of replaceable nature areas, it should be realized that in assessing ecosystem functions, compensation ratios (i.e. the ratio of replaced to lost area) and interchange of habitats are based on institutional mandate or public input (Abbruzzese & Leibowitz 1997). Compensation resulting from habitat trade-off should be consistent with the composition of the landscape. Calculation of the theoretical in-kind compensation costs that need to be incurred to obtain a standard for out-of-kind compensation, as exemplified by Von Kiemstedt *et al.* (1996), can serve as a practical tool for trading dissimilar habitats or species.

6.1.2 Realization and evaluation of compensation measures

Successional trends of habitat types are generally predictable only in broad terms (cf. Atkinson *et al.* 1993). A compensation plan should therefore be based on processes (e.g. erosion, sedimentation, humus formation, grazing) and species groups as representatives for the ecosystem that it is intended to develop. In such a compensation plan, initiators and conservation trusts should — prior to transfer of lands — reach agreement on mutual responsibilities, compensation objectives, valid monitoring activities (Howald 1996) and the one-off lump sum to be paid to the managing body (Box 1996). Complex issues involving timing and responsibility arise, however, whether initiators are freed of their obligation to meet no-net-loss objectives at the moment of transfer, or after a substantial period, once biological evaluations and adjustments have been carried out.

The Dutch government should become intently aware of potential pitfalls associated with compensation projects. Practical American and German experience indicates that compensation measures may be relatively ineffective for several reasons: lack of proper ecological input, incorrect habitat conditions at compensation sites, inappropriate site design and management, inadequate compliance with compensation requirements on the part of the initiator, inadequate liaison of authorities and initiators with environmental groups, and lack of an accurate registration system allowing the controlling authority to adequately supervise compliance (cf. Hoffmann & Hoffmann 1990, Race & Fonseca 1996). Failures due to ecological factors and insufficient compliance can be minimized by introducing evaluation and monitoring criteria in the compensation plan, and by attaching stringent compliance conditions to a bank guarantee, including contingency measures for use in the event of unsatisfactory results (cf. Treweek & Thompson 1997). The guarantee might be significantly higher than the estimated cost of restoration or recreation of the ecological values, stimulating the initiator to meet his obligations (cf. Province of Overijssel 1998). If the compensation measures fail to comply with the permit conditions, the guarantee will accrue to the relevant authority. This will then be responsible for guaranteeing that compensation is properly made. It should be noted that compensation credits are probably sensitive to economic cycles (Glickfield *et al.* 1995). This will never provide complete guarantee in practice that compensation plans will be eventually realized (Hashisaki 1996b). In the Netherlands, registration and progress of compensation plans will be supervised by provincial authorities (e.g. Province of Overijssel 1998, Province of Zuid-Holland 1997), since the national government has decentralized policy implementation.

Another aspect of achieving compensation objectives is the role of public interests as related to specific compensation projects. In some cases surplus value can be created by moulding ‘win-win’ situations in which compensation objectives are combined with other regional nature conservation projects, and with agricultural, recreational or other landscape functions. When such integrated solutions can be designed to achieve surplus value, they may enjoy greater public support and thus be more sustainable over time and space, than, for example, nature reserves enforced by expropriation as a means of compensation.

6.1.3 Legislation and instruments

Legislative embodiment of the compensation principle — as in the US Clean Water Act and the German *Eingriffsregelung* — is under discussion in the Netherlands. The Dutch government is to decide in the near future whether or not to give the compensation principle a legislative footing (MANF & MHPE 1993, MANF 1997). Serious consideration should be given to developing more appropriate legislation on compensation in the Netherlands to provide due guarantees to society that no-net-loss will indeed be achieved, in the final case by citizens filing a notice of appeal. Such a legal, national basis may be provided through adaptation of the Nature Conservation Act (Official Gazette 1967) or Environmental Planning Act (Official Gazette 1965). Although still premature at the moment, legislation may include provisions for audits, fines and civil penalties in cases where a compensation plan is not ultimately achieved (cf. Race & Fonseca 1996).

Furthermore, as a procedural step within the Routing Act (Official Gazette 1994), decisions on highway routes are based on elaboration of the ‘preferential’ route, i.e. the alternative intended to be chosen by the Minister of Transport, Public Works and Water Management. To date, in the preferential alternative and the routing decision, the mitigation (not compensation) measures associated with the route are to be specified in terms of exact spatial occupation. Under the terms of the Routing Act, municipalities unwilling to act on a voluntary basis can be obliged to adapt their zoning plans to the development, thus giving initiators a legal basis to expropriate land for highway construction and — to a certain extent — mitigation measures. If the government were empowered to incorporate the compensation sites into the routing decision (which is not the case at present), a legal basis would be procured for expropriation for the purpose of compensation. Such a procedure would put greater pressure on initiators, however, because elaboration of the preferential alternative in the routing decision, including due environmental measures, is subject to a statutory timetable. In addition, the procedure would also confront society with the radical consequences of land expropriation for compensation purposes.

6.1.4 Costs

There is growing international experience with financing compensation projects (cf. Glickfield *et al.* 1995, Torok *et al.* 1996). Today, Dutch highway initiators estimate the approximate costs of measures in environmental impact assessment studies and in compensation plans. However, the true compensation costs cannot yet be assessed, for more knowledge must be gained in the realm of habitat creation and population restoration at compensation sites (Treweek & Thompson 1997). Furthermore, there is a potential for undesirable inflation of regional land prices being triggered by compensation and current nature-policy activities, such as realization of the National Ecological Network or establishment of farm re-allotment areas. Initiators and other affected government parties should therefore agree upon the desired time schedule of land purchase (spread in time) and suitable potential target areas for compensation measures (spread in space).

In the German context, Schemel *et al.* (1995) have developed a detailed system for calculating additional fees at the federal level. Besides the technical costs, overall compensation payments include a ‘time fee’ to counteract the functional breakdown of a habitat, a ‘value fee’ to compensate for the loss of ecological values and a ‘risk fee’ to cover possible failures during restoration. Depending on the follow-up to the first evaluation of several compensation plans in the Netherlands (MANF 1997), it may be desirable to supplement the Dutch quality fee with the ‘risk fee’ of the German approach.

6.2 Dealing with uncertainties

Research is in progress on the forecasting of infrastructure impacts, on ecological modelling in which temporal and spatial scales can be expanded artificially, and on evaluation of the effectiveness of mitigation and compensation measures. There are several high-priority problems that are still to be solved, e.g. habitat isolation effects of infrastructure (Canters 1997), prediction of species succession rates in created or restored habitat sites (Atkinson *et al.* 1993), and the real cost of replacing habitats (Treweek & Thompson 1997). The reliability of predictive and evaluative research is the subject of ongoing criticism, however (Atkinson *et al.* 1993). After years of research, some authors (cf. Wilson & Mitsch 1996) continue to argue that ecologists and engineers need better, scientifically-based guidelines for compensation, while others (cf. Race & Fonseca 1996) dispute the possibility of creating guidelines that are 'scientifically defensible and fair'. We believe that, notwithstanding a number of unresolved problems, our overall knowledge of restoration processes, e.g. key factors determining succession trends in specific habitat types, justifies the use of assumptions for identifying compensation measures. These assumptions can be used until new ecological information, gained in ongoing field and modelling studies and from evaluation of compensation projects, reopens the debate on modification. Moreover, unpredictable effects and uncertain effectiveness of measures should be tackled; therefore, compensation ratios greater than one may be employed in the Netherlands for in-kind as well as out-of-kind compensation (cf. Allen & Feddema 1996). This approach will also increase the public support for compensation plans.

6.3 Strategic considerations

6.3.1 Ecological compensation, not redemption

By enforcing the compensation principle, governments may inconsistently entangle two successive goals: (a) introduction of conservation interests in the decision-making process, and (b) realization of compensation measures once a development has been approved. Within Dutch highway projects there is a strong tendency to draw up an environmental impact assess-ment in which alternative routes, including associated compensation measures, are compared and assessed. By authorizing one specific alternative of the development, both the above goals are tackled simultaneously. In this ambiguous situation compensation measures can easily be interpreted as a redemption of the development ('buying off'), which contradicts the aims of the principle. To date, the moment of questioning the legitimacy of a Dutch development is not quite clear. To counter this, decision-making should be preceded by official establishment of the development's legitimacy, independent of the consequences for ecological compensation. This may be achieved, for example, by tying in with a strategic environmental assessment (cf. Bina *et al.* 1997), which explores the rough implications of a highway project for nature conservation at an early stage.

6.3.2 Nature conservation versus other interests

When land-owners such as farmers voluntarily agree to manage parts of their land according to compensation objectives, conservation and agricultural interests may coincide. On the other hand, realization of measures aimed at restoring or recreating ecological functions may not always be compatible with agricultural interests. In such cases, the problems associated with no-net-loss for nature impinge upon agriculture, as the no-net-loss principle is not among the policies formulated for this sector. However, this last observation is a consequence of a policy that explicitly opts for prevalence of ecological over other interests in specific areas.

6.3.3 Achieving no-net-loss

Within the context of the decision-making process for Dutch infrastructure, the replaceability of ecological values is rarely discussed. Some ecological values are replaced quickly, given relatively short development times, less stringent habitat conditions and high management efficiency; this is the case with meadow-bird reserves, for example. More difficult to replace are the ecological values associated with ecosystems that have longer development times or involve more complex processes such as pedogenesis and nutrient cycling, e.g. oligotrophic grasslands, peat moors and ancient woodlands. With these systems, evaluation of functional replacement is complex, although some studies indicate a lower degree of biodiversity compared with the replaced ecosystems (see, for example, citations by Allen & Feddema 1996). At the moment it is unknown whether compensation measures associated with impacts on ecological values that are difficult to replace will lead to no-net-loss in the distant future. Moreover, questions remain concerning the contribution of compensation ratios greater than one to long-term ecosystem health (cf. Atkinson *et al.* 1993). One thing is clear, however: no-net-loss for highways implies not only one-to-one replacement of each hectare destroyed through land development, but also substantial compensation for areas of habitat that become degraded and isolated.

7. Conclusions

Policies on ecological compensation, as a third concept following avoidance and mitigation of adverse impacts, move highway initiators to broaden their activities beyond the traditional management realm of infrastructure and negotiate with parties for compliance. Compensation measures aim to replace ecological values and functions that are affected through the loss, degradation and isolation of habitats. This article presents guidelines associated with ecological compensation for the negative impacts of highways on nature, and addresses problems and potential solutions. A coherent framework has been developed that enables compensation measures to be planned through derivation from infrastructure impacts and to be realized using ecological, spatial-planning and financial instruments. The guidelines offer viable opportunities for practical implementation of the Dutch compensation principle. The principle relates to various aspects of restoration ecology, and its implementation is linked closely with other societal interests such as spatial planning, including landscape and nature conservation, as well as agriculture and outdoor recreation. Future experiences with compensation projects may help elucidate the problems addressed.

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Chapter 4

Ecological compensation in Dutch highway planning

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Ecological compensation in Dutch highway planning

Abstract
The ecological compensation principle was introduced by the Dutch government in 1993. This principle is designed to enhance the input of nature conservation interests in decision-making on large-scale development projects and to counterbalance the ecological impacts of such developments when implemented. This article evaluates the application of the Dutch compensation principle in highway planning. Six current highway projects reveal consistent implementation of this principle, although provincial policies on compensation and a national method for identifying compensation measures are still under development. As the planning process has not yet been completed for all the projects, no general conclusions can be drawn on the impact of the compensation principle on highway decision-making. Nevertheless, several examples show that the principle stimulates project initiators to develop alternative routes or route sections in order to avoid or reduce ecological impacts and the need for coherent compensation measures. If the compensation principle is to be properly implemented in the context of highway planning, particular attention should be paid to the following aspects: (a) sequential assessment of overall project legitimacy, necessity of intersecting protected areas and compensation measures, respectively, (b) the initiator's attempts to avoid and mitigate ecological impacts in developing alternative routes, prior to compensation for impacts, and (c) the role of uncertain ecological impacts in identifying compensation measures, especially those concerning habitat isolation.

Key words: decision-making procedure, alternative routes, nature, policy, legislation, instruments, costs.

1. Introduction

'Compensation' in environmental management terms refers to the balancing of negative impacts of development against societal functions, and is becoming an increasingly accepted phenomenon, cf. payments to agricultural producers for losses in income by wildlife damage (Wagner *et al.* 1994) or agrarian reform

(Swinnen 1997), plantation of woods to fix CO_2 emissions (United Nations 1993), and measures to offset environmental damage to wetlands (National Research Council 1992. The *ecological* compensation principle was introduced in the Netherlands in 1993 by national initiative for use in the context of large-scale development projects (MANF & MHPE 1993). The principle has two objectives. Firstly, it aims to enhance the input of nature conservation interests in decision-making on large-scale infrastructure projects and similar developments. It explicitly confronts a project initiator with the ecological impacts of the various options for a development project, the measures required to counter these impacts, and the overall project costs (MANF 1995). Secondly, the compensation principle is designed to bring about a 'no-net-loss' situation for nature when a given development project is implemented. It follows other national policies in this area, e.g. those in force in the USA (since 1986; cf. the Clean Water Act), Canada (cf. Rubec 1994) and several European countries like Germany (functioning since 1976; cf. Meier 1987).

This article discusses the application of the compensation principle in Dutch highway planning. After describing the setting of compensation measures, the compensation policy and the official planning procedure for highway development in the Netherlands are outlined. Next, methodological aspects and experience with the Dutch compensation principle in six ongoing highway projects are described. Finally, the results are discussed in an international context and recommendations given for improved implementation of the compensation principle in Dutch highway development.

2. Setting of compensation measures

Ecological compensation is defined here as the substitution of ecological functions or values that are impaired by (highway) development. It may require 'no-net-loss' of habitat conditions (i.e., soil and hydrology), habitat types (area and quality), populations of single species or species groups (numbers), or ecological functions (occurrence), in so far as they are ecologically significant or characteristic for a specific ecological site (cf. Cuperus *et al.* 1999).

Under Dutch policy, in practice ecological compensation is confined to 'nature' functions in the strict sense, although in a limited number of designated areas recreational functions are also included (MANF & MHPE 1993). In the Netherlands, the compensatory development of ecological values can be achieved primarily by habitat creation through land acquisition, adaptive design and subsequent management of, mainly, farmland. It can also be achieved by enhancing existing ecological values. At the moment this approach is applied specifically to grassland, the aim being to increase meadow-bird densities. One means of achieving the latter aim is adaptive management (e.g., postponing mowing dates and decreasing cattle density), if necessary preceded by adaptive design (e.g., raising the water table). Acquisition of land is not required in these cases.

At least two aspects determine the type of ecological compensation to be adopted (cf. Brinson & Reinhardt 1996): (a) the feasibility of realizing the same ecological functions or values, which determines the degree to which the criterion of equivalency of habitats or species can be met (in-kind versus out-of-kind compensation), and (b) the location of the compensation site relative to the development site, i.e., within or outside the effect zone of the highway (on-site versus off-site compensation).

3. Dutch policy on ecological compensation

In the 1980s and early 1990s several Dutch policies were established to regulate nature conservation aspects of development projects. The Second Transport Structure Plan (MTPW 1990) laid down the objective of ‘reducing habitat fragmentation in the long term and preventing it in the short term’. This objective was to be realized by applying mitigation and/or compensation measures, i.e., activities which, respectively, reduce or substitute for the ecological damage resulting from a given development. This approach is supported by other Dutch policy documents such as the National Environmental Policy Plan (MHPE 1989) and the National Nature Policy Plan (MANF 1990).

Until 1993 application of compensation measures was optional in the Netherlands. With the publication of the National Structure Plan for the Rural Areas (MANF & MHPE 1993) the compensation principle came into force, however. In cases where the national government acts as the initiator of development projects its application is based on ‘self-commitment’. The compensation principle ties in with the 'no-unless' postulate of the Spatial Planning Act (Official Gazette 1965), which prohibits any development in officially protected areas unless nature conservation interests are outweighed by other urgent national, e.g., economic interests. Under the terms of the National Structure Plan, provincial authorities are requested to incorporate the principle in their regional plans (*streekplannen*). Most of the twelve Dutch provinces have initiated implementation activities, although the individual time schedule varies.

However, actual implementation of the compensation measures is not rooted in national legislation. Up to now, such measures have been implemented by means of a non-regulatory approach, i.e., by way of agreements between affected parties (cf. the Canadian no-net-loss policy for federal wetlands; Rubec 1994). This contrasts with the regulatory compensation principles embedded in Section 404 of the USA Clean Water Act (1986) and the formal German *Eingriffsregelung* (1976), for example.

The Dutch compensa-tion principle is to be applied if any of the following types of area are ecologically impacted: (a) core areas of the Dutch National Ecological Network, (b) nature-development areas created as part of the National Ecological Network, (c) nature areas outside the National Ecological Network that are designated as such in regional plans or zoning plans (*bestemmingsplannen*), or covered by the terms of the Nature Conservation Act (1967), (d) habitat sites covered by regional or zoning plans as designated in national species-protection plans, and (e) ecological values in woods and plantations covered by the Forestry Act (1961).

Except for the five designated types of area, the National Structure Plan for the Rural Areas lays down the following criteria for applying the Dutch compensation principle: (a) the initiator is responsible for implementation of the compensation principle; (b) the legitimacy of a development must first be established before addressing the compensation measures; (c) the occurrence of impacts is to be avoided as far as possible, with any effects preferably being mitigated and, only in the last resort, compensated for; (d) compensation implies no-net-loss of area or quality; (e) impacts on habitats should be compensated for in terms of the same or, if not feasible, equivalent quality; (f) if physical compensation is unfeasible, financial compensation is obligatory.

Physical compensation encompasses acquisition (if necessary), adaptive design and subsequent, ongoing management of compensation sites. Supplementary to the costs of these activities, the Dutch government has introduced a ‘quality allowance’ to cover uncertainties in achieving targeted ecological qualities on such sites. It is to be used for realizing specific, non-standard design and management activities such as heavy earth-work and topsoil removal, thus to speed up the maturation process. The level of the (per hectare) allowance depends on the replaceability of lost habitat quality, and is expressed in money terms. It comprises 1/3 or 2/3 of the total costs of acquisition and design of compensation sites with development times of <25 years and 25-100 years, respectively. Quality allowances for sites (ecological qualities) with development times exceeding 100 years are to be settled on an ‘ad hoc’ basis. The quality allowances, donated by the initiator, are awarded to the conservation trust involved through the so-called ‘Green Fund’ (MANF 1995).

The national government has drawn up a framework for Dutch nature policy in terms of 132 ‘nature target types’ (Bal *et al.* 1995). These target types, defined in terms of abiotic processes and target species on different spatial scales, are strictly associated with the National Ecological Network. In 2018 the network should cover 7,000 km^2, i.e., nearly 20% of the Netherlands’ land mass (MANF 1994). The government has recommended that the ecological impacts and compensation measures associated with development projects be described in terms of nature target types (MANF 1995). However, these nature target types have not yet been delineated for all parts of the country.

4. Official Dutch procedure for highway development

The Dutch Routing Act (Official Gazette 1994) was adopted as part of national infrastructure policy, as outlined in the Second Transport Structure Plan. Its main aims are to structure the decision-making process and provide citizens with legal security by establishing statutory timetables for the various stages of the planning process and providing opportunities for public participation and appeal. The act also aims to achieve integration with Environmental Impact Assessment (EIA) and municipal zoning plan procedures.
The Routing Act requires several documents to be drawn up by the initiator of the development, viz., the Regional Directorate of the Ministry of Transport, Public

Works and Water Management. These documents are prepared under the ultimate responsibility of the Minister of Transport and must subsequently be officially approved by the government. The first, the Commencing Document (scale 1:50-100,000), marks the start of the development and informs the public about the problem and possible solutions, and their anticipated environmental impacts.

The Routing EIA study, secondly, describes the traffic, spatial, economic and environmental impacts of the solutions (scale 1:10-50,000). Solutions may include optimizing an existing route, for example by providing public transport and limiting mobility by car, or by developing alternative routes. In practice, at least two alternative routes involve reconstruction, construction or a combination of these activities. One of them usually embodies the most environment-friendly alternative (*Meest Milieuvriendelijk Alternatief*, MEFA), as required by the Environmental Protection Act (Official Gazette 1979, consolidated in the Environmental Management Act of 1994).

Based on political, economic and budgetary considerations, a preferential alternative for the development is designated from the Routing EIA. This marks the start of the activities leading to a Routing Decision, by way of a Preliminary Routing Decision. The government's Routing Decision, finally, establishes the detailed physical requirements of the route (scale 1:2,500). It forms the basis for the implementation phase, including the legal steps for obtaining the grants for construction activities, incorporating the highway in spatial plans and implementing expropriation activities, if these are required. The routing decision is the joint responsibility of the Minister of Transport and the Minister of Housing, Physical Planning and Environment. If necessary, the latter may oblige municipalities to cooperate on including the highway in their zoning plans.

5. Methods and case studies

When the compensation principle was introduced, a procedural framework for dealing with ecological compensation was developed (Cuperus 1996). The basic thrust of the approach adopted is that compensation measures are described in increasing detail as the procedure advances, with the scale level becoming increasingly detailed from (at least) 1:50,000 in the Commencing Document, through 1:10,000 in the Routing EIA to 1:2,500 in the (Preliminary) Routing

Table 1. The selected case study projects.

Highway project (reference in text in bold)	province	length (km)	kind of development[a]	most recent document in Routing Act procedure
A4 Dinteloord-Bergen op Zoom (**A4-DB**)	Noord-Brabant	17.5	C+R	Routing Decision
A2 Rondweg ‘s-Hertogenbosch (**A2-RsH**)	Noord-Brabant	11	C+R	Routing Decision
A4 Delft-Schiedam (**A4-DS**)	Zuid-Holland	6.5	C/R	Routing EIA [b]
A2 Vianen-’s-Hertogenbosch (**A2-VsH**)	Gelderland [c], Zuid-Holland, Noord-Brabant	25	R	Routing EIA
A2 Tangenten Eindhoven (**A2-TE**)	Noord-Brabant	25	R	Routing EIA
A15 Varsseveld-Enschede (**A15**)	Overijssel [c], Gelderland	45	C+R	Routing EIA

[a] R: alternatives involving mainly reconstruction, C+R: alternatives with mainly combined construction and reconstruction activities, C/R: alternatives involving either construction or reconstruction.

[b] Procedure postponed until next period of government.

[c] Province bearing main responsibility.

Decision. The various aspects of the compensation plan, which is to be drawn up after the Routing Decision and in which the compensation sites are to be delineated on the level of individual parcels (scale 1:500-1,000), are beyond the scope of the present article.

This article evaluates implementation of the Dutch compensation principle in six ongoing highway projects. The projects have been selected from some 15 projects, all of which are subject to the Routing Act procedure and the compensation principle as described above (Table 1); they are currently at an

advanced stage of the decision-making procedure. The projects are representative of Dutch highway planning in terms of the motives for the proposed developments, their scale and the range of anticipated ecological impacts. An additional criterion for selection is that compensation measures cover more than 10 ha. The evaluation focuses on construction and reconstruction alternatives, as of all solutions these have the greatest spatial consequences.
All documents published were checked for compliance with the compensation principle within the procedural framework described.

6. Results

6.1 The Commencing Documents

The Commencing Documents were first checked for compliance with the compensation principle. All of them confirm the initiator's intention to act in accordance with current policies on nature conservation by aiming to prevent or mitigate, as far as possible, the ecological impacts of the development in question. Information on alternative routes and a rough indication of their impact is presented on a 1:50-100,000 scale.

Since 1993, when ecological compensation became part of national policy, the principle has been incorporated in three of the five Commencing Documents published (Table 2). The document drawn up before 1993 anticipates the principle by announcing elaboration of compensation measures in all alternatives. Under the requirements of the Environmental Protection Act (1979), compensation measures are specified in the most environment-friendly alternatives (MEFAs) of all the projects. However, a no-net-loss objective for routing options other than the MEFA was not set until national establishment of the principle.

6.2 The Routing EIAs

The Routing EIAs for the alternative routes of each highway project address the following aspects: (a) the ecological aspects of the main design, (b) the ecological impacts, (c) the proposed compensation measures, and (c) administrative and negotiating aspects. Several different items may be distinguished within a given aspect.

Table 2. Compensation aspects in Commencing Documents.

	A4-DB[a]	A2-RsH	A4-DS	A2-VsH	A2-TE	A15
Source (year of publication)	MTPW (1992)	MTPW (1993a)	MTPW (1993b)	MTPW (1994a)	MTPW (1994b)	MTPW (1996a)
Compensation principle mentioned	-	-	-	-	+	+
Application of compensation measures, associated with:						
- the MEFA	+	+	+	+	+	+
- all alternatives	+	+	-	-	+	+

\+ : Positive/implemented.
\- : Negative/not or hardly implemented.
[a] Document published before national policy on ecological compensation

6.3 Ecological aspects of the main design of highway alternatives

6.3.1 Avoidance of adverse impacts

A distinction is made here between reconstruction and construction alternatives, although some avoidance activities are not explicitly associated with either type, cf. reducing the speed limit (to prevent disturbance by noise and spread of toxic substances) and designing verge ditches no lower than the surrounding ditches (to prevent drainage). The reconstruction alternatives outlined involve widening activities and dovetail closely with existing infrastructure, improving the current situation (see Table 3A, item a1). Reconstruction MEFAs are characterized by rigorous efforts to reduce negative impacts through (part-) sunken reconstruction, minimal width of the proposed infrastructure or its central reservation, or reduction of the highway’s traffic volume.

With new highway construction, nature conservation interests may lead to more progressive alternatives being developed. In the cases considered, this is illustrated by: a 2 km long wet ecological corridor created along the infrastructure to connect two isolated nature reserves, or a reduction of the traffic volume on the subsidiary road network. In one construction MEFA, the proposed

Table 3A. Summary of avoidance and mitigation of ecological impacts associated with the alternatives of the six Routing EIAs (measures are not always motivated by ecological interests).

a1.		*Avoidance measures*
-	R,C	verge ditches designed at the same or higher level than ditches in surrounding agricultural plots (A4-DB, A4-DS)
*	R,C	reduced speed limit (A4-DB, A4-DS, A2-VsH, A2-TE)
*	C	no construction of infrastructure (A2-TE)
*	C	reduced illumination in the rural area by technical design (A4-DS)
n	R	reduced infrastructure width or central reservation width (A15)
n	R,C	(partly) sunken highway construction (A4-DS, A2-VsH)
n	R,C	reduced traffic volume on highway (A4-DB) or subsidiary road network (A15)
n	C	horizontal shift of infrastructure to avoid bisection of nature areas (A15)
n	C	tunnel (A4-DS)
a2.		*Mitigation measures*
-	R,C	reconstruction or construction of fauna passages, e.g. fauna tunnels, adapted culverts, extended bridge sections,all including wire fencing to prevent fauna access to the highway
-	R,C	sound-suppressing asphaltic concrete
-	R,C	development of natural vegetations in roadside verges or in areas adjacent to roadsides
*	R,C	deer overpass/ecoduct (A2-VsH), deer underpass (A15)
*	R,C	noise screens or acoustic walls in rural or nature areas (A4-DB, A4-DS, A15)
*	R,C	collection of polluted water by double-ditch system (A2-TE, A4-DB, MEFA A2-VsH), or gutter connected to asewer/settling basin (A4-DB, A4-DS, A15), combined with an impermeable concrete layer to prevent leaching of run-off
*	C	ecological corridor along infrastructure connecting it to isolated marshlands (A2-RsH)
n	R	adaptation of illumination regime in vulnerable nature areas (A2-VsH)

- : More or less ‘standard’ measures in all the projects.
* : Not standard, but applied more widely than in the MEFA.
n : Measures associated exclusively with the MEFA.
C : In construction alternative; R: in reconstruction alternative.

ecological corridor of 2 km is extended to 5 km. In a second a 6 km tunnel is introduced in order to prevent impacts on vulnerable ecological functions (e.g., nature, landscape and air). A third construction MEFA provides for reduced illumination of the surroundings through improved technical design along the entire route. The fourth encompasses a horizontal shift to avoid bisection of nature areas. However, conservation interests are represented most prominently in the A2-TE project in which completion of the by-pass as the leading element of the construction alternatives was eliminated at an early stage of the EIA process. Elimination was due partly to the substantially larger compensation area required (172-435 ha), compared with the reconstruction alternatives (=81 ha), and the consequently higher overall project costs (MTPW 1997b). As a result, the A2-TE Routing EIA encompasses only reconstruction alternatives.

6.3.2 Mitigation of adverse impacts

Three effects of highways on nature are generally distinguished, viz., loss, degradation and isolation of habitat (Cuperus *et al.* 1996). The description of mitigation measures follows this order. Mitigation measures are not usually specific to construction or reconstruction activities (see Table 3A, item a2). Mitigation of habitat loss is obviously not feasible, because of the irreversibility of the impact. However, in all the projects the development of region-specific, natural vegetations in roadside verges or in areas adjacent to roadsides is encouraged.

Mitigation measures designed to offset habitat degradation include application of sound-suppressing asphaltic concrete in the highway lanes and/or noise screens in rural or nature areas, and collection of polluted water in areas vulnerable to deposition loads (i.e., nature areas and water-catchment areas).

Measures to mitigate habitat isolation are being taken, on generic premises, in all the projects. These generally take the form of erecting wire fencing (to prevent fauna casualties), construction of fauna tunnels (to render the infrastructure permeable) and extended bridge sections (to facilitate continuous brook and canal banks) or adaptation of existing culverts, bridges and underpasses. In one project, high numbers of fauna casualties and high-impact isolation, particularly of already isolated patches of woodland, are expected. In this project, an ecoduct with joint recreational use and a deer underpass are proposed.

Table 3B. Compensation aspects of the Routing EIAs associated with construction and reconstruction alternatives and with MEFAs (items b-g).

	A4-DB[a]	**A2-RsH**	**A4-DS**	**A2-VsH**	**A2-TE**	**A15**
Source (year of publication)	MTPW (1992)	MTPW (1993a)	MTPW (1993b)	MTPW (1994a)	MTPW (1994b)	MTPW (1996a)
Indication of ecological impacts						
b. habitat impacted	grassland, marshland, old-growth deciduous forest, agricultural land with ecological values	pools, marshland	grassland	grassland, willow coppice, river foreland	multi-functional woodland, marshland, agricultural land with ecological values	grassland, fine-scale agricultural landscape
Compensation measures and evaluation						
c. developing new habitat (in ha) (MEFA)	0-300 (0)	0-2 (2)	-	8-24 (12)	56-81 (68)	2-7 (2)
upgrading existing habitat (in ha) (MEFA)	-	-	22-190 (0)	-	-	2-104 (20)
d. search areas for compensation indicated	map 1:50,000	approximate	approximate	map 1:50,000	map 1:110,000	map 1:65,000
estimated feasibility of measures	+	+	+	+	+	+
e. mitigation costs considered (US$ mln.)	+/ns	+/ns	+/ns	4.6	+/ns	+/ns
compensation costs considered (US$ mln.)	0-16.0	1.0	0.2-1.2	6.2	+/ns	0.3-6.9
compensation relative to total project costs	0-8.2%	0.5-1.0%	0-0.7%	0.8-1.3%	ns	0.3-2.0%
financial compensation if necessary	+	nr	+	+	nr	nr
f. evaluation of compensation anticipated	+	+	+	+	+	+
Administrative and negotiating aspects						
g. provincial policy established	-	-	-	-	+	+
and applied compensation ratio	1-1.2	1	1	1	$1^{1/3}$ - $1^{2/3}$	1

\+ : Positive/implemented.

\- : Negative/not or hardly implemented

nr : (Assumed) not relevant.

ns : Not specified.

6.4 Description of ecological impacts in highway planning

Ecological impacts of highways remaining after avoidance and mitigation measures are also described in terms of loss, degradation and isolation of habitat. The impacted habitat types are described in Table 3B (item b) in approximate terms.

6.4.1 Habitat loss

In all the projects habitat loss is expressed in terms of the (additional) spatial requirements of the highway, including verges and roadside ditches, to the extent that such land falls under the terms of the National Structure Plan for the Rural Areas, i.e., the specific types of nature distinguished therein. In all the projects considered, compensation for such loss is envisaged on the basis of at least one hectare replaced for one hectare lost (see also item g); furthermore, a situation of no-net-loss of nature quality is to be pursued at compensation sites.

6.4.2 Habitat degradation

Disturbance by noise (a). In all the projects except the A2-RsH, the degradation effects of noise load on breeding birds are expressed in terms of the (increase in) disturbed area for the area types requiring compensation measures. Calculations are in accordance with Dutch research, in which an effect zone associated with noise load could be demonstrated for breeding birds of open field and woodland habitat. The effect zone ranges from the road axis to the point at which no effects on densities can be observed. Apart from species characteristics, the zone's width is dependent on speed limit, traffic intensity and area of woodland in the vicinity of the road. It may extend to over 1,000 metres for woodland birds and more than twice that for meadow breeding birds. For both habitat types, overall territory numbers show a 35% decrease within the effect zone, compared with the undisturbed situation (Reijnen *et al.* 1995, 1996). In the case of construction alternatives this figure of 35% is generally taken. For reconstruction options the factor is applied to the newly disturbed area resulting from the broadened effect zone due to a higher traffic volume. Although in the A2-RsH project the impacts of noise on breeding birds could not be predicted for lack of data, it was stated that these will be inventoried for the Routing Decision.

Lowering water table, pollution, illumination (b). No dose-impact relations are available for other effects of habitat degradation, i.e., depression of the groundwater table, pollution of by toxic substances and illumination effects. Proposed measures aiming at avoiding drainage of areas with groundwater-dependent vegetation are considered to function adequately, and no additional measures are assumed to be required. The same holds for the spread of toxic, acid or eutrophying substances: mitigation through collection of polluted water combined with an impermeable concrete layer is proving highly effective (MTPW 1995c) and no compensation measures therefore appear necessary. It is generally assumed that illumination effects are within the range of noise disturbance effects (cf. Reijnen *et al.* 1995). Mitigation of illumination effects involves using low-power lighting or introducing a special illumination regime in vulnerable areas. Compensation measures are not envisaged for this impact as well.

6.4.3 Habitat isolation

As yet it is scarcely possible to arrive at any quantitative assessment of the habitat isolation effects of highway construction or the intensification of such effects after highway reconstruction (cf. Cuperus *et al.* 1999). In the six Routing EIAs considered, isolation effects are expressed in qualitative terms only, with no information provided on the size of the remnants remaining after bisection and the probability of these being able to support sustainable populations of the fauna species concerned.

There is substantial evidence that mitigation measures designed to connect isolated habitats and reduce fauna casualties are indeed used by animals (cf. Nieuwenhuizen & Van Apeldoorn 1995), although their effectiveness at the (meta)population level has not yet been demonstrated. In all the Routing EIAs mitigation measures for reducing habitat isolation are assumed to be sufficiently effective, implying no need for compensation.

6.5 Proposed compensation measures

6.5.1 Identification of compensation measures

Compensation objectives are specified in the same terms of habitat types impacted. In five projects, development of ecological values is achieved through new habitat creation (up to 300 ha, Table 3B, item c). In two projects, enhancement of existing ecological values of grassland is applied (up to 190 ha). The extent of the compensation measures is derived from habitat loss and degradation of habitat due to disturbance by noise (see previous section). In all the projects in-kind compensation is emphasized, according to national policy. The effectiveness of compensation measures depends on actual and potential pedological and hydrological conditions.

In the MEFAs for three projects, the required compensation area is reduced almost or entirely to zero. In the other projects the area remains substantial, although considerably smaller than that of the non-MEFAs. Apparently, not all MEFAs succeed in entirely eliminating adverse impacts.

6.5.2 Areas and feasibility of compensation measures

In the Routing EIAs, compensation search areas are either roughly delineated on a topographical map (between 1:50,000 and 1:110,000), or described in approximate terms (item d). The search areas provide the compensation potential for all the alternatives identified (cf. Figure 1). Criteria for search areas vary from project to project but include one or more of the following: proximity to the infrastructure (but outside its effect zone), spatial linkage with nature and nature-development areas, and preference for a single, larger compensation site rather than several smaller sites. Furthermore, all the documents express optimism about the feasibility of finding sufficient compensation area. Feasibility is considered in ecological, spatial and economic terms: respectively, the abiotic conditions for developing ecological values, the regional availability of real estate, and compatibility with agricultural functions. Time schedules for realization are not indicated or described as uncertain, however.

6.5.3 Costs of measures and financial compensation

In three Routing EIAs compensation costs are not specified but included in the overall project costs (see Table 3B, item e). In the other three Routing EIAs a rough figure is given for compensation costs, which vary from 0%, in cases where the alternatives have zero impact on the designated types of area, to 8.2% of the overall project costs. The highest compensation costs are associated with construction activities; with reconstruction, compensation costs are at least 30% lower. Costs are based on current real estate prices and ‘nature design standards’ or unspecified estimates. Given the substantial amount of habitat to be upgraded,

the compensation costs for the A4-DS project are relatively low, because compensation is expected to comprise only a per-hectare refund to individual farmers for ecological management of (meadow-bird) grassland.
All the projects mention financial compensation either as an ultimate commitment, if physical compensation proves unfeasible in practice, or as an irrelevant factor because of the high potential for realizing physical compensation.

6.5.4 Anticipated evaluation of compensation measures

In all the Routing EIAs, an evaluation programme is anticipated after realization of the highway and the operational compensation plan (Table 3B, item f). Evaluation will involve verification of predicted effects, as required by the Environmental Protection Act, as well as assessment of the functional replacement of ecological values. The results of the evaluation programme may lead to enforcement of additional mitigation or compensation measures, compared with the specifications of the compensation plan.

6.6 Administrative and negotiating aspects

It is important that the initiator and the provincial authority reach mutual agreement on compensation at an early stage. Provincial policies on ecological compensation have been established formally only since 1997. For this reason, four Routing EIAs could not apply such a policy (Table 3B, item g). In the A4-DB project (1995) a compensation ratio, i.e., the ratio of replaced to lost area, of 1.2 was taken for the destruction of old-growth deciduous forest. This ratio was used in anticipation of forthcoming provincial policy; the latter authority intended to overrule national policy by not expressing the quality allowance in money, but in area. Ratios greater than one compensate for the relatively long time required for a fully functioning system.

In the two remaining projects, the Routing EIAs for which were both published in 1998, provincial policy could be applied. Compared with the National Structure Plan for the Rural Areas, the province of Noord-Brabant (1997) enforces compensation for two additional types of area, viz., ecological corridors and planned nature-development areas of the National Ecological Network. The province has also introduced a compensation ratio of up to $1^{2/3}$, depending on the replaceability of lost habitat quality involved; the national quality allowance system was not adopted by Noord-Brabant. In contrast, the province of Gelderland (1998) did do so.

At the same time, highway initiators also try to involve interest groups in talks on the issue of compensation. Environmental groups differ from region to region in their attitudes towards the compensation principle. They may sometimes be unwilling to cooperate with the initiator at any stage of the process, disputing the basic legitimacy of the development. There are also groups that are only willing to commit themselves after the routing decision has been taken, in order not to entangle discussions about legitimacy and compensation measures (A4-DB). Finally, some environmental groups express a commitment from the very start of the process, to bring their influence to bear on the development of alternatives and coherent compensation measures, and to gain support from their membership.

In general, agricultural organizations tend to oppose compensation measures when it comes to additional acquisition of any substantial area of land. The agricultural sector considers itself a traditional victim of land-taking for development, and any pressure from initiators to sell additional land for compensation purposes is interpreted as disadvantageous for the sector. These organizations also foresee devaluation of agricultural lands and damage due to game in the neighbourhood of future compensation sites. Still, payment for loss of income provides a certain incentive to accept compensation that aims at improving the ecological quality of agricultural land.

6.7 The Routing Decisions

The two routing decisions that have been established are here evaluated with respect to the input of nature conservation interests and the coherence of the documents with the respective Routing EIAs (Table 4). The A2-RsH routing decision is based primarily on considerations of congestion-solving and traffic safety; ecological motives are insignificant. The A4-DB Routing Decision states that in one route section of the project, bisection of a nature reserve is avoided at the expense of impacting a greenhouse horticultural area, resulting in subsequent damage claims of over US$ 1.6 million. Both routing decisions are in line with

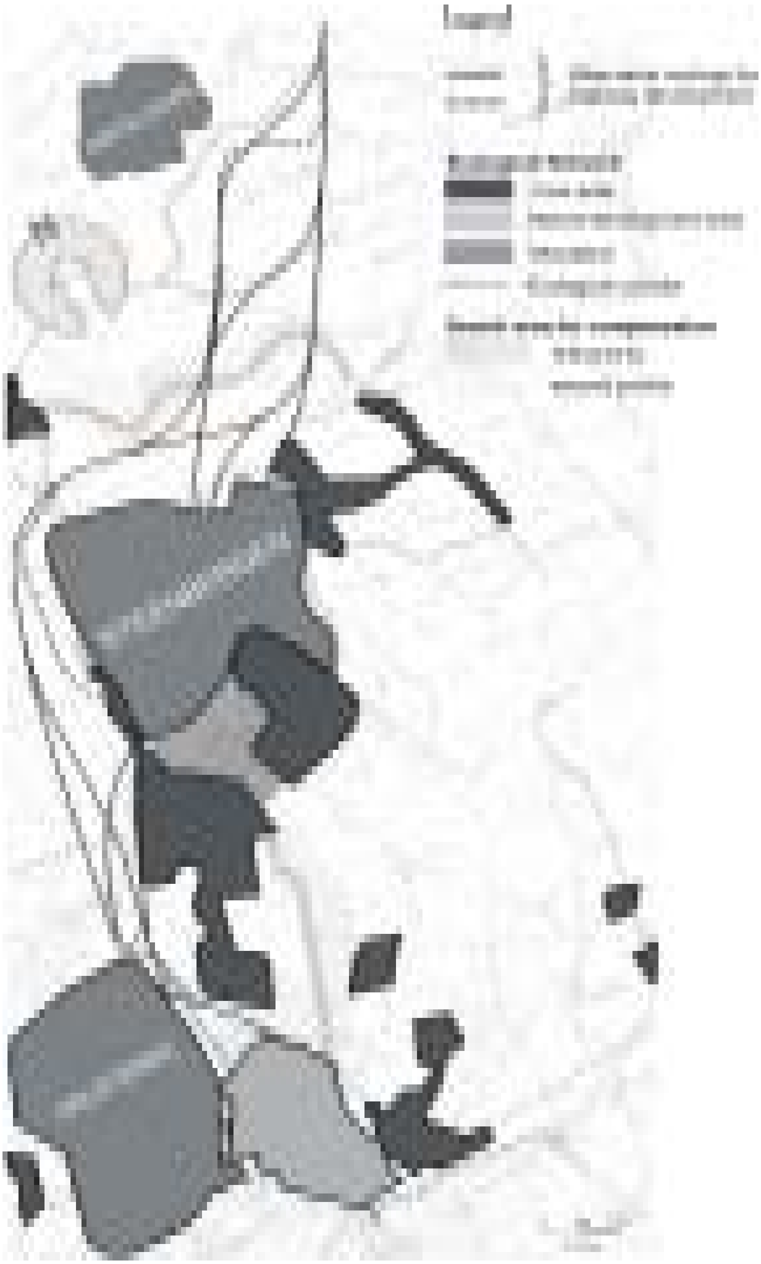

Figure 1. Compensation search areas associated with the A4-DB project (adapted from: MTPW 1995).

Table 4. Compensation aspects in the Routing Decisions.

	A4-DB	A2-RsH	A4-DS [1]
source (year of publication)	MTPW (1998c)	MTPW (1998d)	nr
established activity	highway	highway	nr
type of established route	construction	construction/ reconstruction	nr
ecological considerations in decision-making	+	-	nr
compensation area (ha)	53	27	190
search areas for compensation indicated	map 1:12,500	map 1:27,000	map 1:60,000
mitigation costs considered (US$ mln.)	1.0	0.5	ns
compensation costs considered (US$ mln.)	3.7	2.2	1.4-14.0
compensation relative to project costs	2.3%	0.7%	0.7-7.3%

\+ : Positive/implemented.
\- : Negative/not or hardly implemented.
nr : Not relevant.
ns : Not specified.
[a] : procedure interrupted (source: MTPW 1997b).

the national policy of concentrating new and existing road infrastructure together as far as possible.

The compensation area and costs for the A4-DB remain within the margins set in the Routing EIA (cf. Tables 3B and 4). In the A2-RsH project, however, the compensation area increased from 1 ha, as set in the Routing EIA, to 27 ha, set in the Routing Decision. This was for two reasons: (a) more detailed specification of the routing led to additional spatial impacts, and (b) disturbance impacts on breeding birds, omitted in the Routing EIA, were introduced in the Routing Decision. The compensation costs increased from US$ 1.0 million (though overestimated in the Routing EIA) to $ 2.2 million; however, due to an increase of the overall project costs in the Routing Decision, relative compensation costs in this phase remained within the margins of the Routing EIA (see Tables 3B and 4). Additionally, the wet ecological corridor along the A2-RsH (see Table 3A, item a2) to be constructed for use by mammals, i.e., deer and marten species, proved to be unfeasible owing to urbanization plans. The compensation objective was thus reformulated in terms of reinforcing an ecological corridor at right angles to the infrastructure.

In the A4-DB and A2-RsH Routing Decisions, ecological impacts are expressed in terms of nature target types, thus following the recommended procedure of the Ministry of Nature Management (MANF 1995). The documents indicate that financial compensation is to be applied if physical compensation has not yet been provided for by the time the road becomes operational. An administrative agreement is appended to the A2-VsH Routing Decision, in which all involved parties - including the initiator, the Province, the municipalities and the managing body involved - commit themselves to implementing the compensation measures.

One other project provided additional information. The feasibility of compensation measures following on the Routing EIA, was examined in detail for a potential routing alternative, i.e., grade-level A4 highway construction. Inquiries among involved parties showed a low degree of willingness to conclude agreements with farmers on ecological management. Compensation costs, recalculated on the basis of possibly inevitable acquisition of agricultural land, were estimated at 7.3% of overall project costs, compared with 0.7% in the case of agreements with farmers (Table 4). This information could not be implemented in the project, however, as decision-making has been postponed as a result of regional opposition to the whole project.

7. Discussion

7. 1 General aspects of the compensation principle

The compensation principle is implemented fairly consistently in the Routing Act procedure. The case studies confirm that, as the procedure advances, both the spatial delineation of the infrastructure and coherent compensation measures are computed in increasing detail. Nevertheless, a procedural problem associated with the implementation of the compensation principle emerges. Evolving Dutch experience indicates that the routing decision implicitly embodies three subdecisions, viz., on (a) the legitimacy of the development, (b) whether or not the ‘no-unless’ postulate is to be satisfied, and (c) the compensation measures associated with the development. For the parties involved, the three-in-one decision leads to the undesirable entanglement of the fundamental debate on the development itself with discussion of any compensation measures associated with each of the alternatives (cf. Cuperus *et al.* 1999).

In contrast with the experience described above, a development’s legitimacy should be established before any consequences of the compensation principle are discussed. Implementation of the compensation principle in Dutch highway development can therefore be improved as follows. First, a Strategic Environmental Assessment, preceding the Routing Act procedure, should screen the rough implications of a highway project for nature conservation. Nature conservation and other public interests should then be weighed up against one another, and on this basis a decision taken on project legitimacy. Second, the Commencing Document should indicate the scope of the compensation principle, and the degree to which the criteria of the provincial compensation policy are to be met. Third, it should be argued in the Routing EIA to what degree the ‘no-unless’ postulate can be met for the alternative routes. Also, the ecological impacts of the alternative routings, and the mitigation and compensation measures should be described. This information gives the initiator insight into the conservation consequences of the development, while simultaneously striving and arguing for the subsequent prevention, mitigation and compensation of those impacts. The Routing Decision provides secondary confirmation of the three subdecisions. This confirmation resembles the German situation in which a second weighing-up process is introduced when functional in-kind compensation appears to be unfeasible (cf. Von Kiemstedt *et al.* 1996).

The compensation principle may provide for an offensive planning strategy, for example by combining the procedures for several infrastructure projects. This strategy provides substantial scope for realizing a ‘mega-compensation plan’ (pers. comm. F. Noppert, Oost-Nederland Directorate), achieving greater effectiveness with regard to time, finance and compensation measures compared with the separate procedures of the individual projects. It requires fundamental choices regarding on-site and off-site compensation areas and subsequent large-scale reallotment of lands. Also, it demands linking up with landscape-ecological, recreational and agricultural functions which will make for greater durability than monodisciplinary projects because of the implied broader degree of public support. The result will be a more robust and durable ecological infrastructure. One question still concerns the scope of the compensation principle. As the Dutch principle is restricted to nature and recreational functions, it can be argued that other impacts, on the cultural-historic aspects of the landscape for example, should also be included in the principle.

7.2 Ecological aspects of the Routing EIA

Because of the importance of the Routing EIA in the Routing Act procedure, the results of this phase are now considered in more detail than the other documents.

7.2.1 Ecological aspects of the main design of alternatives

In the last decade EIAs have increasingly stimulated incorporation of avoidance and mitigation measures in the context of Dutch infrastructure development (cf. Wood 1995). The projects under investigation show that compensation measures are used to tackle unavoided and non-mitigated effects, in line with the compensation principle of 1993. However, a strategy in which the separate implications of avoidance, mitigation and compensation measures are evaluated for optimum effectiveness and costs has scarcely been applied in the Routing EIAs carried out to date. A retrograde strategy might be developed, in which the consequences of the extent, nature and costs of the compensation measures may form a basis for adjusting or cancelling alternative routes (cf. the procedure followed in the A2-TE project). This kind of ‘balancing’ process will make explicit any decision against or in favour of specific elements of the infrastructure design, e.g., tunnels, sunken versus elevated constructions and horizontal shifts.

7.2.2 Description of ecological impacts in highway planning

In the six projects, habitat loss and habitat degradation due to noise are described in quantitative terms, e.g., in hectares impacted. Qualitative habitat aspects are described in approximate terms. In the Dutch situation this is a temporary problem, however. Once the ‘nature target types’ have been delineated at the national level, a widely accepted standard for identifying ecological values can be set.

All other impacts are expressed qualitatively in the documents, mainly because of a lack of familiarity with the ecological impacts concerned. In spite of this, it is generally stated that impacts are to a large extent avoidable and mitigable, or even entirely so.

7.2.3 Proposed compensation measures

Compensation measures are applied quite consistently in the projects considered, which is in contrast to findings in the UK, for example (cf. Hill *et al.* 1997). In spite of this consistency, these measures are found to derive exclusively from habitat loss and habitat degradation by noise. Intuitively, mitigation measures cannot completely offset the effects of habitat isolation, this being the most profound impact of highway development on nature. Although less profound, the effects of illumination, lowered water tables and pollution may be difficult to mitigate entirely. Nevertheless, no compensation areas for these types of impact are proposed in the projects, partly due to a lack of familiarity with the issues involved. Inclusion of these effects - if acknowledged - would result in a many times larger compensation area compared to the results of the Routing EIAs. The occurrence of impacts that cannot yet be quantified implies a strong need to apply compensation ratios greater than 1 (although there are other reasons, viz., relatively slow ecosystem development time and probable failure of compensation, why ratios greater than 1 are common practice in Germany, cf. Schemel *et al.* (1995), and the USA, cf. Zedler (1996)). As a lack of familiarity with certain impacts reduces the willingness of initiators to compensate for them in terms of additional area or quality, there is an urgent need to underpin the effects of habitat isolation, in particular. Until then, compensation ratios >1 should be based on independent ‘best-guesses’ by expert judgement.

National policy documents have made only general reference to evaluating post-development impacts and the effectiveness of compensation measures. It was therefore to be expected that these aspects would not be fully elaborated in the Routing EIAs. Even so, the Dutch Environmental Protection Act requires predicted impacts to be monitored and evaluated after project completion; if necessary, provisions are to be readjusted to improve their effectiveness or to offset unforeseen negative impacts. This is in line with the application of contingency measures (cf. Treweek & Thompson 1997). However, to date little effort has been made to evaluate the impact of infrastructure developments, because of the initiator's unfamiliarity with the procedures of the act, his responsibilities and the benefits of such evaluation (MTPW 1996c). In this context Kuiper (1997) has stated that the desire to evaluate compensation plans may possibly change this situation. However, to facilitate such action, attention should be paid primarily to formulating readily assessable criteria for monitoring, evaluating and readjusting the effectiveness of compensation measures, if necessary. These criteria should also determine unambiguously the conditions that will relieve initiators of their duty to implement compensation measures (Cuperus *et al.* 1999).

Today, the costs of mitigation measures are generally integrated in the overall project costs; this contrasts with compensation measures (see Table 3B). Nevertheless, compensation costs may still not be specified in the Routing EIAs, for two reasons. First, compensation costs as well as mitigation costs may not be relevant for decision-making, as they are often marginal relative to overall costs; this is especially true in the case of reconstruction projects. Second, initiators may have reservations about publishing compensation costs, with a view to achieving fair price-setting with the managing body later on in the procedure (pers. comm. L. van Schie, Oost-Nederland Directorate). However, prior release of real cost figures will make clear how far the initiator is prepared to go in achieving the objectives of the compensation plan.

The cost of site acquisition is determined by the real estate market. National standards for site design and management are available, but it is questionable whether these standards will approximate real costs (cf. Treweek & Thompson 1997). Furthermore, initiators should reserve an administrative budget for drawing up and subsequently implementing a compensation plan by their own project workers (with certain elements possibly being contracted out to consultative or managing bodies). There is still little focus on long-term management, i.e., management after the sites have reached the desired nature quality. This should be included in the project budget as an one-off lump-sum capitalization (cf. Box 1996) to guarantee sustainable management.

Financial compensation is viewed by initiators of highway projects as a sort of 'buy-out' for development. This can be concluded from the strong tendency for all the possibilities for physical, in-kind compensation to first be investigated, which is in line with national policy. However, no unambiguous guidelines have yet been issued by the government indicating when to switch to out-of-kind compensation, and to financial compensation (Cuperus 1996). Such guidelines may prevent initiators from opting too easily for financial compensation. For the time being, financial compensation should be restricted to cases in which there are few appropriate compensation sites available, as might be expected in urbanized areas, for example. Furthermore, experience in the realization of compensation plans post-Routing Decision must demonstrate whether or not initiators have been too optimistic in the Routing EIAs about finding sufficient compensation area and meeting the objectives of the compensation principle (Table 3B, item d). International studies show that restoration projects scarcely meet the objectives associated with compensation measures (see, for example, citations by Allen & Feddema 1996, Marsh *et al.* 1996).

7.3 Legislative aspects of compensation

It is not possible to arrive at an exact delineation of the compensation sites in the Routing Decision. The availability of particular sites cannot be acknowledged until the compensation plan is drawn up later on. This logically implies an inequality of rights in the routing decision with respect to (a) the spatial requirements of the infrastructure itself, for which land can be obtained as a last resort on the basis of the Expropriation Act (Official Gazette 1851), and (b) land for the compensation sites, to be acquired solely on a voluntary basis. This situation is nonetheless recently formalized by the Minister of Transport (Official Gazette 1998). An administrative agreement (cf. A2-RsH) may elucidate the initiator's seriousness vis-à-vis future implementation of compensation measures, although it still has no legal status. To provide citizens with due legal security, appropriate legislation should be adopted in the Dutch situation (cf. Backes 1994, De Laat 1997), e.g., through adaptation of the Dutch Nature Conservation Act. Consequently, citizens have the right of appeal in the event of unsatisfactory results being achieved. As it is assumed that a regulatory approach is of limited long-term value owing to its decisive character and lack of flexibility (Andries 1994), Dutch initiators should urgently endeavour to achieve consensus with the involved parties and gain public support before it comes to an appeal.

7.4 Administrative and negotiating aspects of compensation

Within the framework of the National Structure Plan for the Rural Areas, regional authorities are free to develop their own provincial compensation policies. Of the provinces concerned, only that of Noord-Brabant (1997) has implemented a compensation policy that is more stringent than national policy (see item g). Initiators should be aware that, within the national framework, the province is the main negotiating party in compensation projects, as it is this echelon of government that authorizes implementation of developments in the context of municipal zoning plans.

The potentially distrusting attitude of some environmental groups may be a problem for initiators. To minimize these negative attitudes, initiators should be frank with the other parties by formulating clear premises on ecological compensation and compensating to an ample, reasonable extent. Having adopted this stance, the initiator should accept any non-cooperation by relevant parties. The same holds for the provincial and municipal authorities. The most important thing is that the initiator should endeavour to achieve maximum public support whilst taking his responsibility for implementing the compensation principle. Compensation costs should not be traded off by the involved parties, however, as occurred in the A4-DS project just before decision-making was postponed (pers. comm. J. Eekman, Zuid-Holland Directorate). Compensation should play a role in obtaining public support, but a no-net-loss situation must always be pursued.

8. Conclusions

The compensation principle came into force in the Netherlands in 1993. It embodies a tripartite strategy for dealing with the ecological impacts of large-scale development projects: avoidance, mitigation (reduction) and compensation (substitution). Six representative projects show that the principle has led to fairly consistent implementation of ecological compensation in Dutch highway planning. This consistency applies particularly to the strategies employed for dealing with habitat loss by land-taking and habitat disturbance by traffic noise. However, measures to compensate for other effects, such as habitat isolation, were lacking in all the projects because of unfamiliarity with these impacts. The six projects reveal, furthermore, that compensation costs are often marginal compared with total project costs and that the compensation principle may sometimes play a role in the development of alternative routes. The consequences of the compensation principle for decision-making are less profound in reconstruction than in construction activities.

Current practice leads us to make several to recommendations for improving application of the compensation principle. Firstly, to avoid procedural entanglements, the Routing Act should delink the following decisions: the development's legitimacy, the legitimacy of impacting areas protected by the no-unless' postulate, and the form compensation measures are to take. Secondly, the procedure should make more explicit the process of developing an optimized package of measures associated with the alternative routes, in terms of effectiveness and costs.

Faced with provincial compensation policies and a national method for identifying compensation measures, both still under development, initiators of Dutch highway development exhibit a progressive learning-by-doing attitude. Nevertheless, certain notorious problems remain to be solved in the planning phase of highway projects, viz., understanding the effects of habitat isolation and realistic planning of compensation costs, especially for long-term management. Initiators should additionally anticipate future problems, such as the evaluation aspects of compensation measures, at an early stage.

Finally, it is recommended that legislation be adopted in the Netherlands, to provide citizens with due legal security. Such legislation would encourage initiators to reach consensus with involved parties, with citizens having a right of appeal when such consensus is not reached.

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Chapter 5

Preparation and implementation of seven ecological compensation plans for Dutch highways

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Preparation and implementation of seven ecological compensation plans for Dutch highways

Abstract
First-generation compensation plans (CPs) for Dutch highway projects have been evaluated with respect to implementation of the compensation principle (1993), which aims to counterbalance the adverse ecological impacts of large-scale development projects. Decision-making on the seven projects took place between 1993 and 1995. Specifically, we considered: (a) the processes employed to prepare and implement the compensation plans; (b) the methods used to identify, plan, and execute the compensation measures; and (c) the results yielded by these methods. We conclude that the CPs were prepared fairly uniformly, particularly in terms of the processes and methodologies used to derive compensation measures. Five of the seven CPs had become operational by 2001 and initial experience is now being gained on land acquisition and transfer of compensation sites to nature conservation trusts. Further progress of CPs is likely to be seriously hampered by growing demand for land for development in general and associated increases in real estate prices. Several problems are addressed and recommendations made with respect to: (a) developing a legal basis for the compensation principle, (b) the relationship with reallotment projects, (c) estimation of compensation costs, (d) an annual bias of CP budgets to account for rising costs, (e) contingency measures, and (f) criteria for CP (ex-post) evaluation.

Key-words: compensation principle; no-net-loss; process and organization; methods; implementation; legislation; costs.

1. Introduction

Throughout the world, nature is under threat from development projects. Many species are in decline, in both temporal and spatial terms, as a result of habitat loss, degradation and isolation (Reed 1995, NIPHE 1999). To counter this trend in the Netherlands, elaboration of the National Ecological Network has been in progress since 1990 (MANF 1990). The network, which aims to develop and conserve a robust system of nature areas connected by ecological corridors, is expected to cover 7000 km^2 by 2018, i.e., nearly 20% of the Netherlands' land mass (MANF 1994). However, implementation of the network is being hampered by rising demand for land, mainly for urban development, road-building and reallocation of farmland (NIPHE 1999).

As a tool to enhance the effectiveness of Dutch conservation policy, the ecological compensation principle (no-net-loss) came into force in June 1993 (MANF & MHPE 1993), following earlier introduction in the United States, Canada and Germany (cf., Cuperus *et al.* 1999). The principle aims are to enhance the input of nature conservation interests in decision-making on large development projects and to counterbalance the adverse ecological impacts of such projects when implemented. We here adhere to the European terminology by distinguishing between mitigation (minimizing, rectifying, and reducing adverse impacts) and compensation (replacing natural habitat) as separate terms. In other words, mitigation measures are physically tied to the infrastructure, while compensation takes place elsewhere. This is in contrast with United States use of the term mitigation, which covers minimization, rectification, and reduction of ecological impacts as well as compensation (National Research Council 1992).

Policy implementation of the Dutch compensation principle coincided almost exactly with that of the Routing Act (Official Gazette 1994). One of the aims of this act is to structure the decision-making process on highway development and integrate it with the environmental impact assessment (EIA) procedure (Official Gazette 1979). As a result, ecological compensation has been incorporated into the various phases of the Dutch highway planning process (Cuperus *et al.* 2001). In the case of seven pre-Routing Act projects already approved between 1993 and 1995, the compensation principle was implemented too late to achieve its primary aim: to enhance the input of nature conservation interests in decision-making. However, all seven highway routing decisions state that a compensation plan (CP) was to be prepared, in line with the second aim of the principle: to compensate for adverse impacts. CPs have meanwhile been prepared for all these projects, and most are now operative (1 January 2001).

To provide relevant experience for future implementation of the Dutch compensation principle, we assessed the seven pre-Routing Act CPs with respect to how compensation measures have been identified and implemented, to the extent that they are in progress. In doing so we have tried to develop some general notions regarding (a) identification of compensation measures, (b) initiator compliance with national and provincial requirements, (c) feasibility of compensation, (d) instruments for implementation, (e) process evaluation, and (f) ex-post evaluation of the measures. Results are discussed and recommendations and conclusions presented on implementation of the ecological compensation principle in the context of highway development in the Netherlands.

First of all, though, we briefly outline standing Dutch policy on ecological compensation and the method employed here to evaluate implementation in ongoing Dutch highway projects.

2. Dutch ecological compensation principle

In 1989-1990 the option of implementing compensation measures on a voluntary basis was introduced in several Dutch policy documents dealing with the conservation aspects of land development projects (MHPE 1989, MANF 1990, MTPW 1990). Several years later the compensation principle became official policy under the terms of the National Structure Plan for the Rural Areas (MANF & MHPE 1993). The principle is to be applied if any of five types of area, for the greater part consisting of the nature areas of the Dutch National Ecological Network, are affected by national infrastructure projects.

The National Structure Plan lays down the following principles for application of the Dutch compensation principle: (a) the initiator is responsible for implementation; (b) project legitimacy must be established before compensation measures are considered; (c) impacts must be avoided, wherever possible, and otherwise mitigated or, in the last resort, compensated for; (d) impacts on habitats should be compensated for in terms of the same or, where this is unfeasible, equivalent quality; (e) if physical compensation is unfeasible, financial compensation is required. The ecological impacts of development projects and associated compensation measures are to be formulated in terms of ‘nature target types’, characterizing the desired diversity of the National Ecological Network in terms of abiotic processes and target species on different spatial scales (Bal *et al.* 1995).

Physical compensation encompasses ecological design and subsequent management of lands, not necessarily newly acquired. Beyond covering the costs associated with these activities, the Dutch government has introduced a (financial) ‘quality allowance’ for implementation of nonstandard design and management operations, designed to cover uncertainties in achieving ecological targets (through establishment of buffer zones round compensation sites, for example). For nature target types with development times of <25 years and 25-100 years, respectively, the allowance comprises one third or two thirds of the aggregate cost of site acquisition and design. Quality allowances for sites with development times exceeding 100 years are to be set on an ad hoc basis.

There is as yet no legislation to facilitate initiators’ acquisition of lands for compensation purposes, and it is up to the parties involved to reach agreement on rough delineation of search areas for compensation, and on finding actual compensation sites. In the Netherlands, it is becoming clear that the compensation principle transfers the problem of finding compensation sites to other land-intensive sectors, particularly agriculture. Lacking a no-net-loss policy on the agricultural values of its land, the latter sector will a priori suffer sacrifices.

3. Compensation plans and evaluation method

Basic data on the seven highway (re)construction projects examined and the associated CPs (as of 1 January 2001) are provided in Tables 1 and 2 and Figure 1. The initiator of all these projects is the Ministry of Transport, via the Regional Directorates for Public Works and Water Management. The A50 project is proceeding fastest and will feature prominently in this article. The CPs were evaluated with respect to how the compensation principle has been implemented. This analysis is an ex-post evaluation, implying appraisal of the activities and situations following from a particular decision (Arts 1998), viz., the decision on preparing and implementing a CP. Relevant documents were analysed in terms of: (a) the processes employed to prepare and implement the compensation plan; (b) the methods used to identify, plan, and execute the compensation measures; and (c) the results yielded by these methods. As yet there is only limited documentation on CP implementation or anticipated results, and such information was provided by those involved.

Table 1. The seven first-generation highway projects with a CP.

Highway project	Province	Length (km)	Kind of development [a]
A50 Eindhoven-Oss	Noord-Brabant	30	C+R
N57 Veersedam-Middelburg	Zeeland	12	R
N37/34 Hoogeveen-Emmen-German border	Drente	42	R
A14 Wassenaar-Leidschendam	Zuid-Holland	5	C
A2 Holendrecht-Oudenrijn	Utrecht, Noord-Holland	25	R
A73 Venlo-Maasbracht	Limburg	40	C+R
N35/36 Nijverdal-Wierden-Almelo	Overijssel	12	C+R

[a] C construction, R reconstruction

Table 2. Aspects of preparing CPs associated with seven highway projects.

	A50	N57	N37/34	A14	A2	A73	N35/36
Routing decision (month-year)	06-1993	12-1994	04-1994	12-1994	04-1995	05-1995	12-1995
Date of establishment of CP (month-year)	06-1995	11-1996	03-1999	03-1997	06-1998	03-2000	09-1998
Duration of CP preparation	2.0 [a]	1.9 [b]	4.9 [c]	2.3 [d]	3.2 [e]	4.8 [f]	2.8 [g]

[a] MTPW (1995)
[b] LB&P (1996)
[c] DLG (1998a)
[d] DHV (1997)
[e] MTPW (1997)
[f] DLG (2000)
[g] DLG (1998b)

4. Results

4.1 Compensation plan preparation

4.1.1 Process and organization

A definitive CP has been established for all projects (Table 2). The time elapsing between project approval and establishment of the CP ranged from two years (A50) to approximately five years (N37/34, A73). The CP timetable appears to be dictated by: (a) difficulty in reaching agreement among parties vis-à-vis policy and methods for complying with the compensation principle, (b) lack of experience in preparing and implementing a CP, and/or (c) delays in delineation of the Dutch National Ecological Network, rendering proper impact assessment and subsequent identification of compensation measures impossible.

The preparation of each of these CPs was supervised by a guidance group (Begeleidingsgroep) made up of representatives of external parties. In all the cases considered, the initiator (Ministry of Transport), the Ministry of Nature Management, the Provincial Authority and nature conservation trusts were represented, as well one or more of the following participants: farmers' association, polder board, municipality, reallotment commission, or potential future conservation trust. At meetings the respective guidance groups succeeded in reaching consensus on the basic elements of the CPs. Such consensus covered the methods to be employed for identifying ecological impacts and coherent compensation measures, the specific data to be used and collected for that purpose, and the outcome of the methodological analyses. The agricultural and environmental groups participating in the guidance groups took a critical stance towards the compensation principle, especially at the outset. The farmers involved responded positively to project initiators, however, offering search areas for compensation lands, in the knowledge that economically weak industries in such areas may benefit from compensation refunds. Environmental groups for their part were generally sceptical about initiator attitudes towards nature conservation, and demanded in-depth examination of ecological impacts and of the feasibility of proposed compensation measures. Municipalities, finally, tended to accept compensation sites on the lands they administer, thus yielding compensation refunds and a positive image. In those projects with substantial compensation objectives (approx. 100 ha or more: A50, N37/34 and A73), the draft CPs were also the subject of informal public hearings to supplement guidance group input. These hearings led to the plans being modified to include corrected mitigation and compensation measures, and several compensation search areas being shifted to locations with better potential for successful realization.

In all cases the initiator bears ultimate responsibility for implementing and financing the compensation measures. Land acquisition, where necessary, may

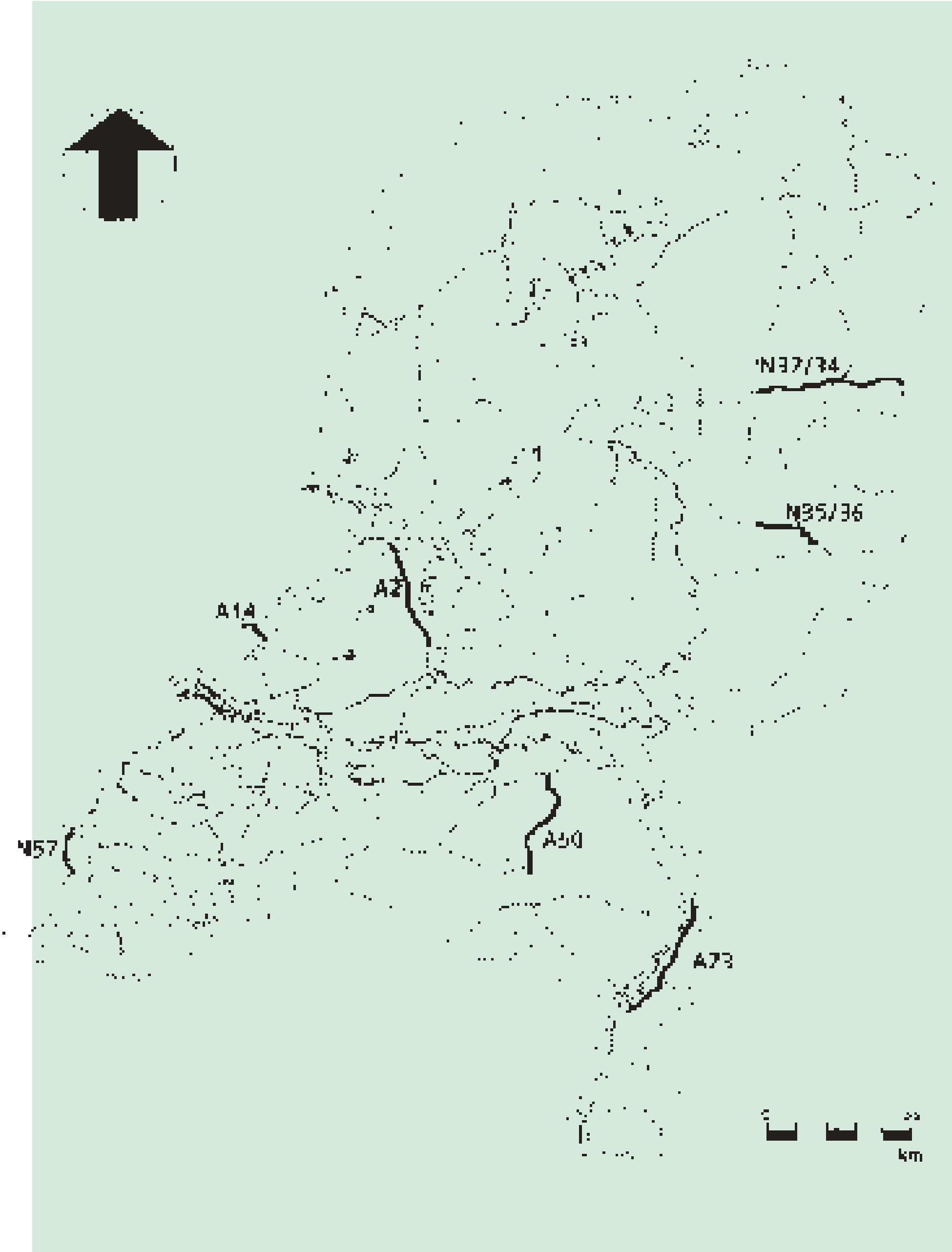

Fig. 1. The location of seven Dutch highway projects

Table 3. Avoidance and mitigation aspects of the CPs of the seven highway projects [a].

Item	A50	N57	N37/34	A14	A2	A73	N35/36
a. impact avoidance measures							
horizontal shift	-	-	+	-	-	+	-
elevated construction	-	-	-	-	-	+	-
extended sunken construction	-	-	-	+	-	-	-
marsh strips along infrastructure	-	-	+	-	+	-	-
diversion of ecological corridor	-	+	-	-	-	-	-
b. planned mitigation measures							
ecological design of roadside verges and ditches	-	+	+	-	+	-	-
fauna wire fences (km)	28	1	25	<1	-	68[b]	8
adaptation bridge/viaduct (no.)	5	-	12	1	-	2[b]	+
small fauna tunnels (no.)	23	+ (ns)	40	3	-	82[b]	10
adaptation / ecoculvert (no.)	-	-	3	3	-	20[b]	1 [c]
fauna (deer) underpass (no.)	-	-	-	-	4	2	0/2 [c]
ecoduct (deer overpass)	-	-	-	-	-	-	0/1 [c]
recreation / fauna / cattle underpass (no.)	1	-	-	-	-	-	-
noise screen / acoustic wall (km)	-	-	3.0/-	-/0.4	-	7.2/-	-
adaptation of illumination regime	-	-	-	+	+	-	-
collection of polluted water in ditch/gutter	-	-	-	+	+	-	+
bentonite screens (no.)	2	-	-	-	-	-	-
transposition of badger sett (no.)	-	-	-	-	-	2	-
transposition of ant nest (no.)	-	-	-	-	-	4	-

[a] In all projects, sound-suppressing asphaltic concrete was applied as a standard.
+: measure planned to offset impacts.
-: impact not relevant/measure not applied.
[b] Some of these measures applied to the ‘second-tier’ road network.
[c] In study: either 1 ecoduct or 2 deer underpasses.

either be realized by the initiator or delegated to other suitably equipped organizations. It is anticipated that land ownership and (long-term) management of compensation sites will be transferred to nature conservation trusts.

4.1.2 Methods for identifying compensation measures

Avoidance and mitigation of impacts. As highway trajectories had already been roughly delineated in routing decision documents, incorporation of avoidance measures in the standing design was feasible in a restricted sense only (Table 3, item a). However, in two projects horizontal shifts were applied locally in order to avoid — or at least reduce — ecological impacts on a valuable geomorphologic steep edge with seepage-water-dependent vegetations (A73) and on an ancient forest (N37/34). Furthermore, road construction was elevated locally in order to leave groundwater flows unaffected (A73). The A14 CP includes an extended sunken section, as a complement to the routing decision, in order to shield meadow birds from traffic noise. Marsh strips up to 35 m wide have been planned along two highways as ecological corridors (N37/34, A2). In another project (N57), an existing ecological corridor is to be diverted so that wildlife passage will remain functional after reconstruction.
All the CPs include mitigation measures addressing habitat degradation (noise, water table impacts, pollution, illumination) and habitat isolation. Generally speaking, the relevant reports judged these measures sufficiently effective (Table 3, item b), except for those addressing noise impacts. Only in the case of the A73 were additional compensation measures required (see next section).

Compensation methodology. When the compensation principle was introduced into Dutch policy, a method for identifying compensation measures had to be developed. This was undertaken within the framework of the A50 project (Cuperus *et al.* 1996). The method employed a limited number of indicator species, known or assumed to be sensitive to infrastructural impacts and ecologically linked to the habitat types present in the highway study area (Table 4, item a). Several breeding birds, a species group on which extensive information on breeding density was available, were selected so that the impacts of habitat loss and noise-related habitat degradation could be identified quantitatively (Reijnen *et al.* 1995). In contrast, mammal, amphibian, reptile, and butterfly species, on which only qualitative information was available, were selected as indicators for habitat isolation. The required compensation was then calculated from the number of indicator species' territories degraded and the average terri-tory size and habitat quality of the territories under undisturbed conditions. Because a method for predicting habitat isolation effects was lacking, these impacts were not covered by compensation but mediated through design and management of the compensation area.

Relevant parts of the A50 method were adopted in the CPs for the N57, N37/34, A14, and A2 (Table 4, item a). In the case of the A73, the A50 method was elaborated in greater detail and on some points substantially adapted (DLG 2000). First, infrastructural impacts on vegetation due to habitat loss and water-table depression were computed. These impacts were expressed in terms of changes in ecotopes, e.g., vegetation types associated with spatial units homogeneous in terms of vegetation structure, succession stage, and abiotic characteristics relevant to vegetation growth and development (Runhaar & Udo de Haes 1994). Second, GIS (geographic information systems) models for identifying impacts on habitat isolation were adapted for six mammalian species and 11 amphibian and reptile species. Estimated impacts were analyzed in terms of species distribution and density, home ranges, and modeled vulnerability to habitat isolation. Third, the compensation thus calculated was corrected for impact overlaps. Because the various ecological impacts are described separately for methodological reasons, giving the false impression of independent occurrence, merely totaling these impacts may overestimate the overall impact of the infrastructure in question.

4.1.3 Implementation of national and provincial policy

All the highway projects considered are in basic accordance with national policy on nature conservation and ecological compensation (Table 4, item b). In four projects quality allowances (see the explanatory section on the compensation principle) are expressed in monetary terms, in line with national policy. In the other projects, however, national policy on the quality allowance was overruled at the more stringent provincial level. The provinces in question demand a compensation ratio, i.e., ratio of replaced to degraded area, of greater than one. The ratios set by Noord-Brabant province range from 1.3 to 1.7 and are based on ecological value development times (Province of Noord-Brabant 1997). In the other province, Overijssel, compensation ratios vary from 1.1 to 1.7 and are based on development times as well as the degree of isolation of the compensation sites relative to the provincial Ecological Network (Province of Overijssel 1999).

4.1.4 Identification of compensation measures

Most of the compensation measures proposed are associated with habitat loss or with habitat degradation due to traffic noise. Compensation (Table 4, item c) for individual projects ranges from 4 to 281 ha of habitat creation (generally conversion of arable land or intensively managed grassland to the desired habitat) and from 0 to 59 ha of habitat enhancement (restoration). One project (N57) shows an unambiguous one-to-one relation between habitat loss and creation, and between habitat degradation and restoration. Restoration appears to be associated exclusively with meadow bird habitat. In the N37/34 and A14 projects, creation of this habitat type was adopted as a final resort where habitat enhancement was deemed unfeasible. The ecological values to be developed (Table 4, item c) vary in development time and are generally described in terms of national nature target types. When the A50 and A2 CPs were being drawn up, however, the national typology was not yet operational at the provincial level.

In all the projects, financial compensation is included as an option of last resort. The projects seek physical, in-kind compensation, i.e., replacement in terms of equivalent habitats, species, or functions. In the A2 study area, however, physical compensation proved unfeasible because of real estate being unavailable, and according to the CP, financial compensation was therefore adopted instead. This budget is to be used to create ‘environmentally friendly canal banks’ some 3 km from the project area. These banks, permeable for fauna, are intended to form an ecological corridor perpendicular to the A2, thus improving the effectiveness of the mitigation measures realized in this project.

4.1.5 Instruments for implementing compensation measures

From the plans, the A2 excluded, we conclude that compensation objectives can be achieved by way of several instruments (see Table 4, item d). First, initiators may seek to acquire lands in the designated search areas if suitable compensation sites are available. Alternatively, the initiators may acquire lands outside these areas. By exchanging property with one or more other landowners in the search areas, they can then try to redirect the acquired compensation sites to their appropriate position. Second, enhancing existing habitat need not necessarily

Table 4. Compensation aspects of the CPs of the seven highway projects [a].

Item	A50	N57
a. Method for deriving compensation measures	indicators	nature target types
b. Allowance in money or area, allowance/ratio	a, 1.3-1.7	m, 1/3
c. Habitat lost (ha)	ns [b]	4
Habitat degraded (ha)	ns [b]	43 [c]
Compensation measures planned		
Creation of new habitat (ha)	281	4
Enhancement of existing habitat (ha)	-	17
Total compensation area (ha)	281	21
Financial compensation	if necessary	if necessary
Nature type to be developed	woodland, shrubland, grassland, marshland, fine-scale landscape	woodland, shrubland, grassland, amphibian pools
d. Planned instruments for realization		
Land acquisition when available/land exchange	+	+
Agreements on ecological management	+	+
Participation in reallotment or other local activity	+	-
Initiation of new reallotment	+	-
Search areas for compensation	map 1:50,000	approximate
Estimated feasibility of compensation	ns	'unknown'
e. Mitigation costs (US$ mln and % of project budget)	4.9 (1.5%)	0.2 (0.1%)
Compensation costs (as above)	11.4 (3.6%)	0.1 (0.1%) [f]
Financial compensation (as above)	-	-
f. Evaluation aspects considered	process	-

[a] +: yes, planned; —: no, not/hardly planned; nr: not relevant; ns: not specified.
[b] Not specified due to complex calculation (A50) or complex modelling (A73).
[c] Compensation for degraded habitat based on a 25% (N37/34), a 35% (A2, N14) and a 40% (N57) decrease of the breeding bird population.
[d] Based on theoretical in-kind compensation of grassland.
[e] Cost of ecoduct/underpasses not included.
[f] Cost of enhancing 17 ha grassland not included.
[g] Dependent on ratio between new habitat to habitat enhancement.
[h] In the plan an equal sum is earmarked for a railway development project associated with the A2 highway.

N37/34	A14	A2	A73	N35/36
nature target types, indicators	nature target types	area typology	nature target types, indicators	nature target types, indicators
a, ns	m, 1/3-3/3	ns	m, 1/3-2/3	a, 1.1-1.7
47	5	0	ns [b]	12
59 [c]	527 [c]	23 [c]	ns [b]	1
47-94	8	(8) [d]	141	9-11
0-47	1	-	44	5
94	9	0	185	14-16
if necessary	if necessary	+	if necessary	if necessary
woodland, grassland, moist heathland, amphibian pool	woodland, grassland, marshland	(grassland) [c]	woodland, shrubland, heathland, fine-scale landscape, corn-field	woodland, shrubland, heathland, amphibian pool
+	+	nr	+	+
+	+	nr	+	-
+	+	nr	-	+
-	-	nr	-	-
map 1:10,000	map 1:50,000	nr	map 1:100,000	map 1:50,000
‘possible’	‘unknown’	unfeasible	variable	-
0.6 (0.5%)	0.7 (0.2%)	33.2 (5.2%)	13.7 (2.8%)	0.3 (0.2%) [e]
2.3-3.1 (2.0-2.7%)[g]	2.4 (0.8%)	nr	12.3 (2.1%)	0.9 (0.5%)
-	-	0.4 (0.1%) [h]	-	-
-	-	-	process	-

Table 5. Progress of the CPs (assessment date 1 January 2001).

	A50	N57
Start of highway (re)construction (foreseen) [a]	1997	(2006)[b]
Start of implementation of CP	1995	1997
Expected completion of CP and highway project	2003	2010
Compensation objective (ha)	281	24
Compensation realised as of 2001 via acquisition (ha) and relative to CP objectives	195 (69%)	8 (100%)
Transferred to managing body (ha) and relative to CP objectives	59 (21%)	0 (0%)

[a] MTPW (2000).
[b] Project delayed for political reasons.
[c] No physical compensation due to financial compensation.

involve land acquisition and may be achieved by seeking appropriate agreements with individual farmers. Such was the case in four of the projects (Table 4, item c). These agreements embody an annual per-hectare reimbursement, paid by the initiator, to facilitate ecological management of grasslands, and aim to enhance avifaunal and vegetational values. Third, the initiator may participate in a reallotment exercise under the Dutch Land Use Act (Official Gazette 1985) or cooperate with other local initiatives to effectuate a voluntary trade-off among nature, agricultural, or recreational functions by landowners and land-users. To count as a negotiating party, the initiator must first acquire land in the reallotment area. Specifically in this option, the initiator should be aware that compensation will be additional to current policy and plans. Fourth, the initiator may himself develop new reallotment activities, using the Land adaptation (*Aanpassingsinrichting*) provisions developed under the Land Use Act. In this option, reallotment is tightly integrated on a voluntary basis with large-scale development as well as with associated compensation measures for impacts on agricultural, ecological, and recreational functions in the same area (MANF 1993).

In all the projects, search areas for compensation are indicated either on a map (scale 1:10,000-1:100,000) or in general terms (Table 4, item d). Search areas are delineated in a 2-20 oversize ratio compared to the extent required for

N37/34	A14	A2	A73	N35/36
1995	1998	(2002) [b]	(2003)	(2006) [b]
1998	1997	-	2000	-
2005	2004	2010	2007	after 2006
94	15	- [c]	185	14
18 (19%)	0 (0%)	-	13 (7%)	-
0 (0%)	0 (0%)	-	0 (%)	-

compensation purposes. Compensation sites generally link up with the National Ecological Network or with other nature areas. In contrast, one plan (A73) opts to enhance habitat quality within a specific part of the National Ecological Network. In this particular case the province is willing to exclude the A73 compensation sites from the National Ecological Network area and include a similarly sized location elsewhere in the network. Generally, a rough estimate is given of the feasibility of acquiring compensation sites.

4.1.6 Costs of compensation measures

The overall cost of physical compensation is made up of the costs of acquisition, design, and management of the compensation sites and ranges from 0.1 to 3.6% of total project costs (Table 4, item e). In all the projects comprising physical compensation, the cost of long-term management is expressed in terms of a one-off lump sum capitalized over a period of 10 years. For the A2 project, the level of financial compensation is based on theoretical in-kind compensation.

The A50 and N37/34 plans have set a clear-cut moment for ending physical compensation: when highway (re)construction has been officially completed. The reimbursed compensation costs that could not be invested in compensation measures are to be donated to the so-called Green Fund (MANF 1995).

4.1.7 Ex-post evaluation of compensation measures

The CPs give scarcely any consideration to the evaluation of compensation aspects and in five projects they are not mentioned at all (Table 4, item f). The two exceptions, the A50 and A73 CPs, provide a timetable for evaluating the progress made on acquisition, design, and management of the compensation sites as well as specifying the instruments to be used for implementation. Ex-post evaluation, involving monitoring of actual ecological impacts and refinement of compensation measures where necessary, is not included in any of the plans.

4.2 Compensation plan implementation

4.2.1 Process and organization

The A50, N57, N37/34, A14, and A73 started CP implementation activities fairly soon after the terms of the plan had been established (Tables 2 and 5). The remaining two CPs (A2 and N35/35) are not yet operative, owing to postponement of highway (re)construction.

In the case of the A50 project, an administrative agreement was established six months after finalization of the CP, with each party committing itself to implementing the compensation measures according to a timetable running parallel with highway construction activities (MTPW 1996). In this agreement, the initiator confirms his primary responsibility for CP implementation. The municipal and provincial authorities are responsible for facilitating and eventually approving, respectively, the implementation of the compensation sites within relevant zoning parameters. The future managing bodies, viz., polder boards, municipalities, and the State Forestry Commission (*Staatsbosbeheer*), have committed themselves to appropriate management of the compensation sites from the moment of transfer onwards, with a view to establishing the required ecological values.

Implementation of the CPs for the A50, N57, N37/34 and A73 is overseen by one internal and three external bodies. An internal project group (*Projectgroep*) set up by the initiator handles implementational aspects, i.e., aspects relating to spatial planning, land acquisition, and realization of both the highway and the compensation measures. Aspects relating to ecological values are discussed in the expert advisory group (*Klankbordgroep*). The supervisory group

(*Voortgangsoverleg*) — under provincial directorship — monitors the process of achieving the CP objectives. Unresolved items raised by any of these bodies can be dealt with by the official group (*Bestuurlijk Overleg*), which is responsible for overall supervision of the highway project. All deviations from the CP are reported to this group, the highest project authority, by which they are approved and adapted as necessary. The participation of a sufficient number of parties in the process is taken by the initiator to signify adequate public support for the compensation measures.

4.2.2 Instruments for implementing compensation measures

Under national policy, land for compensation purposes has to be acquired on a voluntary basis. In the cases of the N57 and N37/34, initial acquisition of lands appeared to be fairly unproblematic. Although experience with the A50 was similar, it was anticipated in this project that it would be difficult to obtain all the land through negotiation with landowners. In 1997, the initiator therefore applied to the Ministry of Nature Management for approval of a land adaptation project in order to comply with the CP objectives. In 1999 the ministry approved this project, as support was pledged by the regional agricultural sector, in particular; in exchange this sector would benefit from the reallotment of lands. Clearly, the Land adaptation project has financial appeal for the initiator only if it makes implementation costs lower than they would have been if compensation measures were implemented without this instrument. From the start of land adaptation it proved difficult to acquire off-site compensation sites within the project (Table 4, item a). This was due to competing regional objectives, such as realization of the ecological network, a municipal landscape plan, and an agricultural structure plan.

4.2.3 Implementation of compensation measures

As mitigation measures are physically tied to the infrastructure, they necessarily follow the same time schedule as that of the infrastructure itself. For the highways presently under (re)construction (Table 5), mitigation measures could generally be realized according to the CP. With the A50, however, one planned underpass for deer could not be implemented because of unfavorable water tables. In exchange, one deer overpass, viz., an ecoduct combined with a cycletrack, was planned and is now under construction. Furthermore, five years after CP implementation, the A50 project shows 69% compliance with the objectives of the CP in terms of hectares acquired (MTPW 2001) (Table 5). With the N57, the upgrading of 21 ha proved unfeasible owing to competing objectives of the province. In consultation with the provincial authorities, 8 ha of grassland were acquired by the initiator and are to be transferred to a managing body. Both parties considered the 8-ha acquisition as full (100%) compliance with the CP. The N37/34 and A73 projects, for which CP implementation activities still continue, show 19% and 7% compliance, respectively. The A14 CP is suffering a serious delay in implementation because of an absolute lack of real estate becoming available in the urbanized area in question (0% compliance). Given these disappointing results, an attempt is now being made to compensate off-site, viz., approximately 5 km from the highway.

With the A50, most of the compensation sites could be acquired in or close to the search areas. During 1999 and 2000 the initiator contracted out 59 ha of acquired lands to the State Forestry Commission. The contract regulates the free transfer of property to the Forestry Commission, the design and management of the compensation sites, and the desired ecological values to be developed over the years. It also sets the (one-off, lump sum, capitalized) budget to be transferred to the Commission for achieving the compensation objectives, as well as the penalties imposed by the initiator in the event of unsatisfactory management results.

In all the operational CPs, nature conservation trusts were consulted on the subject of land acquisition. This is because the efficiency of management of a compensation site is determined primarily by its soil and hydrological characteristics and its location relative to other properties held by the trust in question.

It was arranged with the municipalities in the vicinity of the A50 that the compensation sites would be implemented in their zoning plans following completion of the acquisition stage. In anticipation of this move, these municipalities recently earmarked the (agricultural) search areas for compensation in their zoning plans. Compensation sites located in these areas will enjoy protection under the zoning plans, so that the compensation principle will also be applicable to these sites in the event of future impacts by new developments.

Implementation of the A50 CP revealed a particular type of social impact. In areas where land has been acquired for compensation purposes, farmers appear willing to exchange their land for farmland in economically stronger regions, as they fear lower land prices and negative impacts on business operations, such as wildlife damage and superabundant weed growth.

Finally, due to the time constraints under which initiators' land purchasers operate, acquisition of compensation sites often has to compete with acquisition for road-building, especially when land has to be expropriated for the latter. However, given experience to date with implementation and the instruments employed for that purpose, it is anticipated that all the CPs will be implemented before the highways are (re)constructed (Table 5).

4.2.4 Cost of compensation measures

At the local level, preparation for highway construction always pushes up real estate prices, since the market increases the value of goods as they become scarcer. At the national level, too, property prices are also increasing autonomously as a result of road construction, urbanization, and even nature development (e.g., implementation of the ecological network). As an example, the cost of acquiring compensation sites for the A50 recently rose to approx. US$34,000/ha, double the figure for 1995, the year in which the CP was established. The initiator, being a government agency, is not authorized to buy land above current market prices and is therefore unable to compete with private development corporations. This makes the initiator, along with other governmental organisations, a relatively weak partner in the real estate market.

4.2.5 Ex-post evaluation of compensation measures

Although ex-post evaluation was not foreseen in the CPs, ideas on evaluation were developed early on during implementation of the A50 CP. First, pre-impact sites were monitored for breeding birds (Braam & Teerink 1997). Second, it became clear that monitoring the design standards of the compensation sites would be more appropriate than monitoring the ecological values on those sites. The A50 project group therefore argues that the effectiveness of compensation measures, once realized, should be monitored in terms of (actual or potential) nature target type conditions (Bal *et al.* 1995) and not in strict terms of numbers of individuals of the species associated with the target types in question. The alternative would be a stringent system in which there is an obligation to restore equivalent ecological values without considering ecosystem properties. However, there have been no serious evaluation activities during CP implementation because there were no instructions to this effect from the central Ministry of Transport.

5. Discussion and recommendations

5.1 Process and organization

The timetables for both establishment and implementation of the CPs assessed are relatively long (totaled at least 5-10 years). We anticipate that future Dutch CP timetables will be shortened as experience on process, methodology, and instruments for implementation grows (cf., Cuperus *et al.* 2001). Reaching consensus on these points with all the parties involved, including the managing bodies of compensation sites, will enhance the feasibility of compensation measures and thus shorten the duration of CPs. At the same time, initiators should be aware that striving too hard for consensus may hamper compliance with the compensation principle, as it may lower quality standards (Marsh *et al.* 1996). As a consequence, during implementation of the CP, initiators should balance consensus against basic compliance with the principle.

Serious problems may arise, however, if CP implementation does not remain in step with highway construction, reducing the efficiency with which its objectives are achieved. Separating the procedures for road-building and compensation may water down efforts to implement compensation measures in favor of realizing the highway itself, because of staffing constraints on the part of the initiator, for example. This may easily lead to the initiator making less effort to achieve compliance with the compensation principle, as an incentive is lacking.

5.2 Methodological aspects

As experience grows, methods for identifying compensation measures are bound to be adapted. One of the issues that needs to be addressed is the level of detail with which ecological impacts and the associated compensation measures are described. Descriptions of these impacts will inevitably become more detailed as scientific understanding grows. Therefore, a balance should be sought between keeping up with research efforts and practical compliance with the compensation principle. Initial steps have been taken to tackle habitat isolation impacts resulting from infrastructure development and design coherent mitigation and compensation measures. A recent study (Pouwels & Van der Grift 2000) attempts to link an existing spatial decision-support expert system for predicting the stability and persistence of fauna populations after highway development. Another issue to be addressed here is development of nationally accepted methodologies for exchange of nature target types (out-of-kind compensation) and the use of compensation ratios, as applied in Germany (Von Kiemstedt *et al.* 1996) and the United States (Zedler & Callaway 1999).

5.3 Instrumental aspects

In the Netherlands, and especially in urbanized areas where little land is available, we believe that CP implementation time is not dependent on the instrument employed for acquiring land. Ad hoc acquisition preceded by property exchange to redirect the sites to suitable locations as well as reallotment projects (comprising either new or existing plots) require a relatively long time schedule owing to administrative constraints. However, the two instruments differ in their results. The success of ad hoc acquisition depends on the arbitrariness of lands becoming available, making achievement of CP objectives uncertain, while in reallotment projects compensation requirements can be met more readily as a ‘land pool’ is created and the right locations are ensured. Reallotment projects show a strong similarity with the US concept of ‘mitigation banking’ (Marsh *et al.* 1996), whereby site development and preservation are undertaken in advance of physical development, making the banking concept one step ahead of the Dutch reallotment concept. As long as mitigation banking is not yet operational in the Netherlands, initiating reallotment projects or aligning with current ones should, generally speaking, be given preference over ad hoc acquisition and redirection of lands when compensation objectives cover a substantial area, i.e., several dozen hectares.

5.4 Financial aspects

Compensation costs will continue to rise because of rising land prices, not only in the rural areas of the Netherlands, and any increase in land prices during implementation may have a dramatic impact on achieving the objectives set out in the plan. Budgets for physical compensation should therefore be estimated realistically, based on growing experience in this field, and be biased annually on an index-linked basis to deal with upward trends in land prices. Furthermore, CPs should explicitly reserve sufficient funds for monitoring and evaluation activities, and for contingencies, such as remedying unsatisfactory results (Treweek & Thompson 1997). Similarly, nature conservation activities facilitated by Green Fund financial compensation will also be adversely affected by rising land prices. Given their nature, financial donations cannot be biased in any way after transfer to the Green Fund. Financial compensation should therefore include an additional budget for contingencies.

5.5 Ex-post evaluation

Ex-post evaluation of the ecological success of CPs is very important, as these plans are originally approved on the basis of their intended results. The initiator bears prime responsibility for assessing CP implementation and for making adjustments as necessary. Serious attention should be paid to this point because monitoring activities are a rare occurrence (Brown & Smith 1998, Brawley *et al.* 1998). Furthermore, the time scale for reaching functional equivalency may exceed the usual monitoring period of 5-10 years, an issue rarely recognized by initiators (Zedler & Callaway 1999). From the Dutch CPs reviewed, we conclude that little if any progress has been made on developing ex-post evaluation criteria. As a result, adequate pre-impact studies are lacking in most of the CPs studied. In CP implementation, all that occurs is sampling of control and compensation sites (Anderson & Dugger 1998), but such an approach has shortcomings, as it may leave local environmental trends undetected.

5.6 Legislation

It would be logical to provide the compensation principle with a legal basis, as this would grant citizens a right of appeal in the event of unsatisfactory results (cf., Cuperus *et al.* 2001). Appropriate legislation would improve initiators' efforts to implement CPs and evaluate the efficiency of their measures, as they would try to avoid citizen appeals to the State Council. In addition, the possibility of appropriating sites on the basis of a zoning plan should be seriously examined. If agreement can be reached between highway initiator and municipality on 'advance' implementation of compensation sites in the zoning plans, these sites can be legally expropriated for coherent reasons (Official Gazette 1965). Initiators should be aware that the (initial) step of implementing compensation sites in the zoning plan is crucial to success, as this option is grounded in consensus. There is also a need to optimize legislative instruments at the provincial level, as Dutch regional plans may, under well-defined circumstances, provide an expropriation title for initiators (De Laat 1997). Whatever the case, when it comes to developing specific expropriation tools at the national level, consensus with the government authorities in question must be reached.

5.7 Lessons for future CPs

Several lessons can be learned from the first-generation CPs that may lead to improvements in future plans. First, preparation and implementation of new plans are expected to speed up as ongoing experience gives initiators a better notion of the organizational, instrumental, and process aspects of ecological compensation. As time goes on, it is likely that compensation measures as well as the methods used to establish them will be more readily accepted by all the parties involved. Second, future projects will be subject to the Routing Act and some elements of the first-generation CP may therefore be examined earlier in the decision-making procedure, viz., prior to the routing decision. Aspects such as ecological values degraded, potential locations of compensation sites, and compensation cost estimates will then be covered by the routing decision. Furthermore, the citizens and parties involved can take advantage of the Routing Act's provisions for official public participation, superseding the form of participation described in this article, which lacked both formal grounds and clear consequences. As a result, in the future, a CP can be drawn up fairly soon after the routing decision, as the conditions for further elaboration have then been set and the relevant information is already available. In conclusion, then, ongoing experience and linkage with the Routing Act procedure will mean that initiators will be better able to comply with the objectives of a CP.

6. Conclusions

In the Netherlands, initial experience has been gained in implementing the 1993 compensation principle. From this assessment of the first-generation compensation plans (CPs) associated with seven highway development projects, three conclusions can be drawn: (a) in terms of both preparation and content, the CPs have been elaborated fairly uniformly; (b) the parties involved in compensation, frequently representing different interests, appear to be satisfied that most of their requirements are covered by the CP; and (c) this leads to the conclusion that the compensation principle is a potentially strong planning concept.

Several comments are in order, however. First, the plans studied are being implemented slowly because of the relatively long lead times of highway development and of the time required for finding and acquiring compensation sites. Second, it is too early to decide whether or not to adapt the Dutch land expropriation regime for the purpose of acquiring compensation sites. Additional experience with existing legislation and instruments must first be gained, on the basis of zoning plans, for example. However, from the angle of achieving compliance with no-net-loss, a legal footing of the compensation principle is desirable. Third, the ‘fixed-price’ character of Dutch highway planning may render CP implementation problematic, because of unexpected increases in compensation costs and introduction of contingency measures in the CPs. Fourth, evaluation of the CP implementation process appears to have received little attention in the CPs. In addition, ex-post evaluation, which serves to check, justify, and balance the efficiency of compensation measures, is lacking entirely in the seven CPs assessed due to the absence of an incentive.

The following recommendations are therefore made: (a) a legal basis should be created for both the compensation principle and ex-post evaluation; (b) the scope for introducing expropriation tools under the terms of regional and zoning plans should be investigated; (c) the pros and cons of the land adaptation concept on behalf of compensation should be investigated extensively; (d) compensation costs, which are subject to inflation, should be estimated more accurately in CPs; (e) the budget associated with CP implementation should be biased annually for the (scarcely predictable) rising costs of real estate; and (f) contingency measures should be included in CPs (including coherent budgets) and applied as necessary.

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Chapter 6

Compensating for ecological impacts of road development: seven years' experience with highway A50 *(Eindhoven - Oss, Netherlands)*

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Compensating for ecological impacts of road development: seven years' experience with highway A50 *(Eindhoven - Oss, Netherlands)*

Abstract

This article reviews the implementational aspects of the ecological compensation plan for Highway 50 (Eindhoven-Oss), the first of its kind to be executed in the Netherlands as part of a structural nature conservation policy. Such compensation plans are explicitly designed to ensure that large-scale development projects do not lead to any net-loss of important ecological values, with an obligation that any impacted values be redeveloped elsewhere. The review concludes that after full implementation of the Highway 50 compensation plan as scheduled, the acquisition target will have been fully or largely achieved, but that this will not be case the case for design, ecological management and transfer of the compensation sites. From this point of view, it will take yet several years until the 'no-net-loss' criterion will be satisfied. It is also concluded that ecological compensation is not in fact amenable to a programmatic approach of this kind. For more effective implementation of the compensation principle, it is recommended that a clearer administrative framework be developed at the national level, as well as some form of policy guidelines on farm-based conservation. Future compensation plans should also specify more precisely what deviations in implementation are acceptable under the terms of no-net-loss.

1. Introduction

One of the key planks of Dutch conservation policy (MANF & MHPE 1993) is the provision that large-scale development projects such as road construction may not impact on important ecological values unless there are deemed to be other, more important interests at stake, in which case the ensuing damage must be fully compensated ('no-net-loss'). Other countries already have a fair degree of experience with compensation as a conservation tool, viz. the United States (since 1986; NEPA 1970), Canada (since 1992; Rubec 1994) and Europe, particularly Germany (since 1976; Meier 1987). Although the compensation principle had

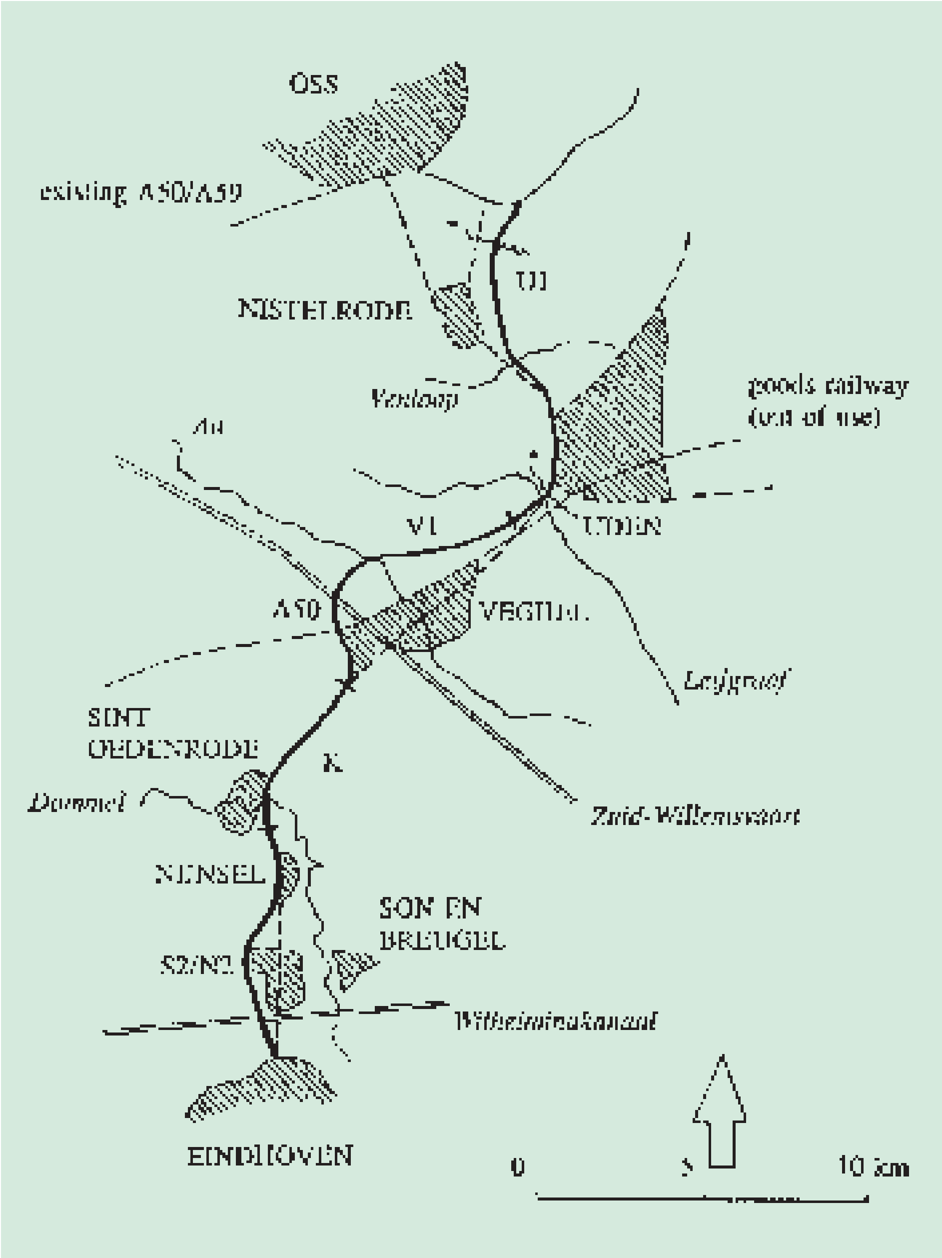

Figure 1: Study area and highway route.

been applied on occasion in the Netherlands, it was not until 1993 that formal policy guidelines were introduced under the terms of the national Structure Plan for the Rural Areas. This document lays down five basic criteria for ecological compensation: (a) the initiator is responsible for implementation; (b) project legitimacy must be established before compensation measures are considered; (c) impacts must be avoided, wherever possible, and otherwise mitigated or, in the last resort, compensated for; (d) impacts on habitats should be compensated for in terms of the same or, where this is unfeasible, equivalent quality; (e) if physical compensation is unfeasible, financial compensation is required.

Responsibility for physical implementation of the compensation principle in Dutch highway development lies with the Directorate-General of Public Works and Water Management (*Rijkswaterstaat*, RWS). Because of the lengthy administrative procedure involved, however, ecological compensation has been applied in only a handful of development projects to date. The first compensation plan (CP) to be elaborated under the new legislation was for the new A50 highway link between Eindhoven and Oss, although the compensation issue had in fact played no part in decisions on the project, as the Routing Decision (MTPW 1993) was finalised at approximately the same time the Structure Plan for the Rural Areas came into force. The Routing Decision provided for a CP nonetheless, and two years later this had been duly elaborated by the regional, Noord-Brabant Directorate of RWS. In principle the CP has been implemented parallel with highway construction, the timetable for both being about 10 years. Under the Structure Plan the obligation for compensation applies only to the core areas of the National Ecological Network (MANF 1990). The A50 roadworks caused no damage to ecological values covered by the European Habitat and Bird Directive.

The methodological and planning aspects of ecological compensation have been discussed elsewhere (Cuperus *et al*. 1996, 1999, 2001). This article addresses implementational aspects, with special reference to the A50 CP, which serves as a model project for RWS. It seeks to assess whether the plan fulfils the conditions laid down in the Structure Plan, in particular the ‘no-net-loss’ criterion, and whether the compensatory measures are indeed being implemented according to plan.

A brief description of the A50 and the associated ecological compensation plan are first presented. The practical issues that came up during implementation of the plan by the regional Directorate of Noord-Brabant are then discussed in some detail. Finally, several conclusions and recommendations are presented.

2. Towards ecological compensation on Highway A50

2.1 The route

The government Routing Decision for the A50 road link joining the towns of Eindhoven and Oss (MTPW 1993) provides for construction of 30 km of road infrastructure, part dual carriageway and part motorway. The route passes around the villages of Son en Breugel, Nijnsel, Sint-Oedenrode, Veghel, Uden and Nistelrode and links up with operational motorways at Eindhoven and Oss (Fig. 1). Most of the route runs through or along agricultural area which alternates with slightly elevated heathland, woodland or peat moor on poor, dry, sandy soils. Several streams (Dommel, Aa, Leijgraaf, Venloop) and canals (Zuid-Willemsvaart, Wilhelminakanaal) are also traversed.

2.2 Deriving appropriate measures

The A50 ecological compensation plan (CP) outlines a series of measures to address the ecological damage caused by road construction and associated engineering work. These measures fall into two categories: mitigation and compensation. The former comprises material provisions along the route to reduce the direct risk to animal life, such as wire fencing for larger animals (i.e. game) and fauna underpasses for smaller mammals and amphibians. Although the need for such measures had already been outlined in the Routing Decision, as recommended in the Environmental Impact Statement (MTPW 1991), they still remained to be detailed in actual engineering plans (Table 1).
It was at this stage that the scientific, methodological underpinning of ecological compensation was taken to hand. The method adopted, described elsewhere (Cuperus & Canters 1994, Cuperus *et al.* 1996), assesses the ecological consequences of habitat destruction and disturbance (Fig. 2), after due steps towards mitigation, on the basis of the estimated decline in the populations of indicator species of breeding bird. Development of replacement habitat, in the

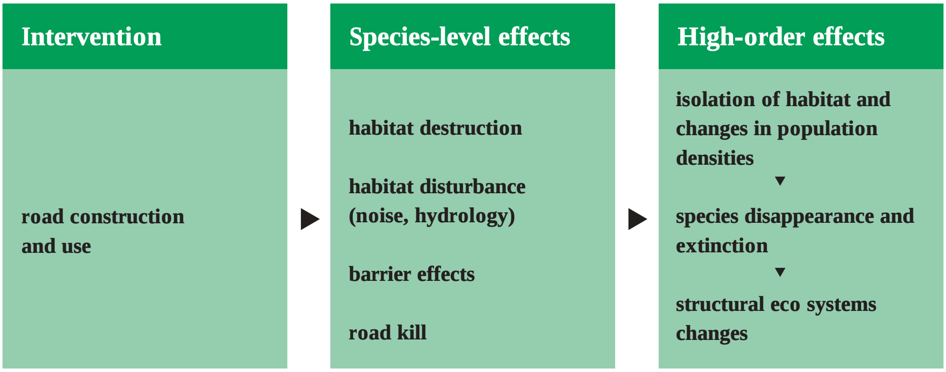

Figure 2: Ecological values affected by highway construction.

Table 1: Mitigating measures: targets and performance (MTPW 1995b, Graat 2002). 'Quiet' open-graded asphalt concrete and noise barriers are standard practice on Highway A50.

Mitigating measure	**Target (15-06-1995)**	**Revised target**	**Implementation (01-01-2002)**
wire fencing (fauna)	27,700 m	(none)	partly erected, length unknown
extended bridge span / continuous stream banks	6x	(none)	3 complete, 1 in progress, 2 planning stage
tunnel for small animals (ø50 cm)	23x	1 extra tunnel	12 complete, 12 planning stage
tunnel for large mammals (2.5x1.75 m)	2	1 ecoduct with cycleway, 1 modified viaduct [a]	planning stage, design stage
tunnel for animals / hikers	1x	(none)	1 planning stage
bentonite screens	2	1 [b]	1 complete

[a] An additional, unpaved 3.5 m verge.
[b] See main text.

Table 2: Compensatory measures: targets and performance (MTPW 1995b, Graat 2002).

Compensatory measure	Target (15-06-1995)	Acquired (01-01-2002)	Implemented (01-01-2002)
woodland	168 ha		40 ha
fine-structured dry habitats	25 ha		11 ha
wet grassland	48 ha		6 ha
marshland	16 ha		11 ha
'small landscape features'	[a] 24 ha		7 ha
total	281 ha	226 ha	[b] 75 ha

[a] To be implemented - through land acquisition - on about 600 ha of farmland.
[b] 55 ha already implemented; remainder scheduled in the short term (plans finalised).

Table 3: Costs of mitigating and compensatory measures, actual and estimated, in € mln. (MTPW 1995b, Thoolen 2001, Graat 2002).

	Original estimate 15-05-1995	Revised estimate 31-12-2000	Implementation 01-01-2002
mitigation	4.5	4.5	0.3
compensation	10.7	13.5	5.7
total	15.2	18.0	6.0

form of one or more equivalent 'compensation sites', is then specified for all species that would be lost from the area in question. No additional area is prescribed to compensate for impacts other than habitat destruction or disturbance, nor for impacts on other species (viz. mammals, amphibians and reptiles affected by habitat intersection as well as physical collision, i.e. 'road kill'), it being argued that suitably designed and managed compensation sites will provide an environment for these other species too.
In all, some 280 hectares of replacement habitat are provided for in the A50 CP, in several categories (woodland, marshland, etc.; see Table 2). No specific quality criteria were set for these various types of habitat; these were to be established in consultation with the agencies that would be managing the sites in question.

The CP identifies, on a scale 1:50,000, a number of areas within which compensation sites were to be sought. The overall area of compensation sites was several dozen times greater than the compensation target. As one of the aims of the CP is to integrate compensation sites into the National Ecological Network wherever possible, most of the search areas were located in the (direct) vicinity of this network.

2.3 Finalisation of the compensation plan

During preparation of the CP a series of consultations were held with local and regional authorities and environmental and conservation groups. The draft plan was laid open to the public informally, drawing suggestions for alternative siting of proposed mitigating and compensatory measures as well as additional conservation action. The CP was revised and finalised by the minister of transport in mid-1995, becoming effective immediately (MTPW 1995a).

2.4 Implementation strategies

The CP described, first, the forms of mitigating action that were to be taken during the process of road construction; these measures had a solid legal status. With respect to compensation, second, the implementational framework specified that suitable sites were to be acquired ‘amicably’, i.e. without expropriation or other coercive means. Another basic proviso was that RWS was not to administer the compensation sites ‘for eternity’. After completion of initial ecological management, these were to be transferred to specialised conservation agencies for further management. The objectives of the acquisition of lands were pursued as far as possible on the basis of cooperation and agreement, employing three basic strategies: (a) acquisition of lands, followed where appropriate by exchange with other parties, (b) participation in reallotment schemes, and (c) implementation of a Land adaptation project (*Aanpassingsinrichting*), primarily for the purpose of the CP.

2.5 Estimated costs

Using standard data for civil engineering and conservation work, the full cost of CP implementation was estimated at € 15.2 mln. (Table 3), 5.1% of the budget initially earmarked for highway construction (MTPW 1995b). This figure comprises two elements: initial expenditure on site acquisition and preparation, and expenditure on management of the sites to the required ecological quality, the latter sum capitalised over 10 years (subsequent management to maintain such quality is the financial responsibility of the conservation agency managing the site). It is thus the objectives of the CP that determine expenditure on site acquisition, preparation and initial management, rather than a fixed budgetary stipulation. This cost estimate does not include additional staffing at RWS or other such organisational expenditure.

2.6 Road construction and compensation timetables

Construction of the A50 road link, comprising a highway from Oss to Eindhoven, was taken to hand in 1997. Several sections were completed from summer 2002 to summer 2003; the final section is scheduled for completion at the end of 2005. There has been debate on whether the motorway should be extended north through to Oss, but no decision on this point has yet been taken. Practical implementation of the CP began in 1995 and has generally been in tandem with the roadworks. After full implementation of the CP there will be an appraisal of whether targets have been met and, if not, what compensation is to be paid by RWS into a ‘Green Fund’, as specified under the terms of the Structure Plan for the Rural Areas.

3. Implementation of the compensation plan

3.1 Organisation and consultation

The first, organisational step in implementing the compensation plan was to prepare a statement of intent, an administrative agreement (‘covenant’) supported by all parties in January 1996. Responsibilities were assigned as follows: CP implementation: regional, Noord-Brabant Directorate of *Rijkswaterstaat* (RWS-NB); long-term planning protection of compensation sites: local and regional authorities; compensation site management: conservation agencies, local authorities and polder boards (*waterschappen*); pooling compensation sites in reallotment projects (see below): reallotment committees (*landinrichtingscommissies*). One of the aims of this collective statement of intent

was to remove some of the scepticism with which the CP was viewed by several parties. Environmental organisations had initial doubts as to the effectiveness of compensation as well as about long-term safeguards for ecological quality. Farmers, some of whom had memories of land being expropriated for earlier infrastructure projects, at first saw the new concept of ‘compensation sites’ merely as a new assault on their land base (Siemes 1996). Gradually, though, both these parties came to have more faith in the CP, with the farmers showing a growing willingness to think constructively about suitable search areas, in part due to the prospect of structural income from any compensation measures implemented on farmland.
A series of consultative forums were also established, both within the project office of RWS-NB and externally. In the latter category were three forums, with hierarchic responsibilities from the administrative down to the practical, charged with ensuring that site acquisition, design and management were carried out in accordance with administrative conditions and creating and consolidating public support. The chief task of the ‘top’, administrative body was to discuss and elaborate the basic terms of the compensation plan. Between RWS and the provincial government there were often differences of opinion on the best implementational framework, particularly with respect to the location of appropriate compensation sites. Coherent decisions proved troublesome to draft, slowing down the tempo at which the ‘lower’ consultative bodies were able to do their work.

Working in conjunction with these external bodies were two forums within RWS, again in hierarchic relation. Their task was to coordinate practical implementation of the CP, motivated in part by the fact that several of those charged with the business of land acquisition were employed at RWS.

3.2 Experience with the three strategies

3.2.1 Land acquisition

Considerable experience has been gained with both land purchase and exchange. Some of the parcels of land bought by RWS were not in themselves suitable for (creating) the targeted type of habitat (being too dry, for example) and exchange was therefore sought with plots of relatively unprofitable farmland (too wet, for example) to the benefit of both parties, here in terms of hydrology. In the course of such exchanges, experience was gained with assessing and optimising the interests of the respective parties.

3.2.2 Participation in reallotment projects

As elsewhere, the Netherlands has experience with land consolidation schemes that seek to optimise the rural planning process through redistribution of land for agriculture, recreation, nature conservation, housing and other uses according to some previously established key. As a participant in the 'Sint-Oedenrode' consolidation scheme in progress in the area, RWS-NB was able to secure 25 ha for ecological compensation. Unfortunately the scheme runs from 2001 to 2005, which may cause the CP to over-run (timetable 1997-2003).

3.2.3 Implementation of a Land adaptation project

Application for a Land adaptation project (*Aanpassingsinrichting*; MANF 1993) for the area along the road section between Uden and Veghel was filed with the competent (provincial) authority by RWS-NB in 1997; the A50 itself was not included. The order was issued in 1999 and the following year a reallotment committee was appointed to oversee the process (DLG 2000). The principal aim of land adaptation is to facilitate the exchange of lands for ecological compensation and agriculture in order to tackle the local problems caused by highway construction. Additional aims were to implement and extend the National Ecological Network, improve environmental and water quality, and install several small recreational provisions. Land adaptation was chosen as a planning instrument because it allows for an integrated approach, which was held to be more conducive to regional support than *ad hoc* acquisition of lands. It was also felt that this would in principle be a more efficient, cost-effective and equitable way of implementing agricultural and conservation policy, including compensation. Land exchange under the terms of the Land adaptation project is meanwhile in full progress, with an attempt being made to achieve synergy between interests. The 10 metre 'green' zone along some of the watercourses, for example, planted with hedgerows, shrubs, wildflowers and other small 'landscape features', is to be widened to form a proper ecological corridor managed by polder boards or local councils. The plan is to widen these zones to 25 metres, planted similarly, using compensation funds for initial development and subsequent management (DLG 2000). Despite the longer timetable of the Land adaptation project, from 2000 to 2008, the compensation targets it sets are to be achieved by the year 2003.

3.3 Progress to date

3.3.1 Mitigation

Most mitigating measures have been (or are being) implemented in conjunction with actual road construction. Wire fencing has been erected along most of the section completed to date and a variety of fauna tunnels have been constructed (Table 1). As road construction progressed, the original CP had to be adapted on several points. Revisions in the design of the road itself meant that two of the tunnels for larger (game) animals could not be implemented in their original form and alternatives therefore had to be developed (Table 1). One of the two impermeable clay lenses also proved unnecessary, the water table remaining undisturbed.

3.3.2 Compensation

As of 1 January, 2002, 226 ha of the 281 ha of lands required for compensation had been acquired, i.e. 80% of the target (Table 2). Most of this is farmland, scattered in plots along the new road, all of it within the original search areas. Twenty-four hectares have been earmarked for hedgerows and other ‘landscape features’ (see above), the full CP target, and on 7 ha work has already been completed (Table 2). Fifty-five hectares have been acquired under the ‘Sint-Oedenrode’ land consolidation scheme, more than the target, and 76 ha under the Land adaptation project , against a target of 92 ha (Graat 2002). This latter achievement, however, may conflict with the secondary aims of the land adaptation.

3.3.3 Tempo of land acquisition

Between 1995 and 1998 RWS purchased a fair amount of land, about 100 ha in all, but in the following years this tempo dropped substantially as real estate prices spiralled and it was not until the end of 2001 that acquisition could be taken up again in earnest (see ‘Costs’, below). All in all, though, these market pressures did not cause any real stagnation of the CP. On the northern section of the road, particularly, it was still relatively easy to purchase land direct from farmers, who are not in a strong economic position regionally.

3.3.4 Site preparation, management and administrative transfer

Once definitive locations had been found for compensation sites (i.e. following any land exchange) plans were drawn up for preparatory work on the site and initial ecological management. At about the time this work was completed, the site was handed over to the conservation agency taking responsibility for ultimate management, the Forestry Commission (*Staatsbosbeheer*), a local council or polder board. This agency is then responsible for the hands-on work of ensuring the targeted habitat quality is indeed achieved. As of 1 January, 2002, sixty-two ha of land had been transferred in this way, mainly to the Forestry Commission. Conditions and terms were laid down in transfer deeds – the first of their kind in the Netherlands – detailing such matters as site preparation (as necessary), management, costs, local public education and physical planning (i.e. zoning) guarantees.

3.3.5 Compensation via on-farm conservation

In the past few years a growing number of farmers have expressed interest in participating in ecological compensation projects by appropriately managing specific parts of their holdings. Farmers in the area set up an association specifically for this purpose (*Vereniging Agrarisch Natuurbeheer 'Maashorst'*), sending a tender to RWS in early 2002 for some 10 ha of new landscape features. These were to be implemented and managed by the farmers, who would also retain full ownership of the land. The planning status of the land would also remain unchanged. It was envisaged that after mutual agreement of terms RWS would pay the association a lump sum for services rendered. As a legal entity, the *Vereniging Agrarisch Natuurbeheer 'Maashorst'* would then enter into short-term contracts with individual farmers (for 6 years), itself bearing responsibility for ensuring that the full 10 ha was properly and durably managed during this period. After termination of this contract, design of new landscape features and consequent management could then be transferred to other farmers. Although this seems an attractive way of achieving ecological compensation (i.e., obviating the need for acquiring new lands), negotiations between the parties recently broke down, as the compensation demanded for lost income through 'unproductive' land from the agricultural point of view in the end appeared tot be more expensive than land purchase. Another factor contributing to the failure of the negotiations were doubts by RWS on effective long-term protection of the compensation sites.

3.4 Costs

As the CP was being implemented the price of real estate in the area rose very substantially, mirroring national and regional trends (NIPHE 2000). One of the factors behind increasing land pressure was ever growing demand by regional and local government for a variety of planning functions, in particular the provincial authority (extension of National Ecological Network), local authorities (housing and 'landscape' projects) and polder boards (ecological corridors). In addition, though, local land prices inevitably rose with implementation of new infrastructure. In the vicinity of the A50 average prices have doubled in seven years, from € 22,700/ha in 1995 to € 45,000/ha in 2002. National policy dictates that RWS should pay no more than the going market price for real estate, so as not to contribute to price inflation.

Because of this rise in prices the allocated CP budget proved inadequate for implementing the full series of compensatory measures. In the year 2000 the overall budget for the A50 link was revised upwards (MTPW 2000), with a sizable portion of these new funds being earmarked for compensation, boosting the budget from the original € 10.7 mln. to 13.5 mln., or from 5.1 to 6.0% of overall project funds (Thoolen 2001).

Table 3 shows expenditure to date on mitigation and compensation. As of 1 January, 2002, less than half the compensation budget had been spent. Although expenditure on land purchase, the major budget item, is on schedule, expenditure on preparation and management of compensation sites is lagging seriously behind. Likewise, only a small slice of the budget for mitigation measures has been spent (<10%) because the most expensive provisions (ecoduct, modified viaduct, combined fauna and -hikers' tunnel) are still to be constructed.

3.5 Long-term safeguards

There are a variety of safeguards in place for long-term protection of the compensation sites. First, all lands potentially eligible for acquisition or use were checked by RWS to ensure that designation as a conservation site did not conflict with regional structure plans, reducing the risk of emerging ecological values being threatened by foreseeable future developments (prior protection). Second, once initial work on the sites had been completed, the sites were entered into local zoning plans in their new function (*post factum* protection), providing safeguards against new physical planning interventions. Third, stipulations on long-term site management were included in the deeds detailing transfer of compensation sites from RWS to conservation agencies; in the event of gross negligence RWS can demand the return of the land in question or seek due financial reimbursement.

3.6 Dilemmas and insights

The lack of a clear implementational framework for the compensation plan meant that the need for RWS to operate efficiently often conflicted with other parties' desire for a well-defined 'playing field'. One recurrent dilemma in this context was what to do when a parcel of land became available without enough being known about its potential for realising the targeted type of habitat, or about unforeseen developments such as new housing, soil pollution or provincial planning changes. In cases like these the obvious strategy was to seek land elsewhere, possibly even outside the search areas, or revise the type of habitat targeted in the original CP. Unnecessary adherence to original targets may stand in the way of new insights and opportunities, but at the same time a flexible approach may mean deviating from earlier pledges to parties in the region. Other unforeseen developments proved more favourable, though. For example, purchase of a tract of land in the Aa valley by RWS for the compensation plan led the provincial government to designate more of this valley an ecological corridor than originally planned. Here, synergy resulted from two parties seeking land for nature development.

Finally, there is often the question of where the boundary lies between established and emerging policy. In the case of ecological compensation to offset the damage of infrastructure development this question is particularly relevant, because such compensation may not entail mere implementation of standing policy. For RWS, 'established policy' means a government approved plan with a specific budget attached, providing a guarantee that implementation of the CP is not interfered with by emerging policy.

4. Discussion

4.1 General

With no experience in the Netherlands to fall back on, the work of drawing up and implementing the A50 CP marked a novel, experimental phase of work at RWS. There were two main areas of experimentation and learning: mobilisation of personnel, within RWS and in the wider regional environment, and the need to act pragmatically as well as ‘boldly’. Implementation also put additional pressure on staffing and funds, given the wide range of activities involved, in particular: establishing consultative forums with a variety of parties, land acquisition, contracting out practical work and participating in land consolidation schemes. The programmatic approach to ecological compensation adopted for the A50 has proved no guarantee that targets will indeed be met. In the first place, the lack of an implementational framework meant there was no clear prior idea of how a compensation plan was to be realised in practice. Second, actual implementation of compensation measures was one of the final links in a chain of events in the hands of other regional parties: RWS-NB itself (construction of the A50 link), the regional government (National Ecological Network, land consolidation schemes), local authorities (‘landscape’ projects) and polder boards (ecological corridors). Delays in these projects impacted directly on the progress and consequently success of the CP. Third, the effectiveness of compensatory measures is governed partly by extraneous factors. In particular, the availability of land in the immediate vicinity of the road varied in the course of CP implementation, and thus also the tempo of acquisition. In some cases, though, search areas lost their eligibility as compensation sites through unforeseen developments. For all these reasons, the A50 CP could not be elaborated in detail beforehand. More generally, implementation of a CP has proven to be a rather unpredictable process, which should be seen as a fact of life rather than as a flaw in the programmatic concept itself.

4.2 Implementation and implementation strategies

In all likelihood the CP acquisition target will have been fully or largely met by 2003. This will not be the case for preparation, management and administrative transfer of the compensation sites, however. The ultimate timetable for the A50

CP is thus fairly long, similar to that of actual road construction.
The decision to establish a voluntary agreement among parties helped create and consolidate regional support for the CP. Land consolidation schemes, on the other hand, proved to be less helpful than anticipated. As a tool for land redistribution, Land adaptation projects can in principle be a useful tool for effectuating ecological compensation, but suffer from a degree of inertia because of the large number of parties involved.

One development not foreseen in the A50 CP was the interest expressed by farmers, a number of whom formed an association for the specific purpose of participating in compensation projects, by creating and managing landscape features on their farms. No agreement could be reached on the fee to be paid, however. Even so, it is to be queried whether these features will be of the desired ecological quality without land purchase and revision of physical planning status. It will be many years before hedgerows to replace those damaged or destroyed by road construction develop equivalent ecological values. It may well be the case that short-term contracts lead almost automatically to young landscape features of limited ecological value with a potentially high ‘turnover’ rate. On the other hand, the area devoted to linear ecological features on farms in Noord-Brabant is relatively small compared with the rest of the country (Manhoudt & De Snoo, 2003). In principle, then, on-farm ecological compensation can certainly help boost biodiversity on and around farms in the Eindhoven-Oss region.

One option for effectuating compensation that was rejected from the start was government expropriation of lands, although this is theoretically feasible if local authorities agree on a revision of zoning plans. It was the view of RWS-NB, however, that any potential benefits would be severely outweighed by the resultant loss of regional support. The revised Routing Act (October 2000) provides for the option of expropriation on the basis of the Routing Decision. That this option has not been used in the Netherlands to date illustrates the government’s unwillingness to resort to coercion.

4.3 Long-term safeguards

In the Netherlands as a whole, most of the experience gained over the past few years by RWS in the field of ecological compensation has been tied to land acquisition and revision of zoning plans, on the premise that land ownership by conservation trusts provides the best safeguards for long-term protection of ecological values (Cuperus *et al.* 2002). With farmers now expressing ever more interest in on-farm ecological compensation, it is becoming increasingly urgent to establish whether the strategy followed to date should be continued (Terwan 2000, 2001). Apart from Noord-Brabant this is also relevant in the provinces of Limburg (A73 Venlo-Maasbracht road link) and Zuid-Holland (high-speed rail link). The situation in Zuid-Holland is comparable to that in Noord-Brabant, while Limburg farmers have gone one step further and are now seeking a change in zoning plans so that field margins can be set aside for conservation. These developments require a policy response at the national level, to provide an optimum guarantee of long-term protection of the ecological values developed at compensation sites.

5. Conclusions and recommendations

5.1 Conclusions

(1) The material and financial input of the Noord-Brabant Directorate of the Directorate-General of Public Works and Water Management (*Rijkswaterstaat*) to design and to implement the ecological compensation plan for the A50 road link between Eindhoven and Oss provide a good indication of the scope and detail of government duties in this area.

(2) By the time work on the A50 has been completed and the compensation plan implemented, the acquisition target of the compensation plan will have been fully or largely achieved. This will not be the case for preparation, ecological management and administrative transfer of the compensation sites, however. There will also still be funds outstanding on the compensation budget. If financial compensation should prove necessary, the terms of the Structure Plan for the Rural Areas would be fulfilled in a procedural rather than ecological sense, as the criterion of no-net-loss of ecological values would then not have been respected.

(3) Ecological compensation has not been achieved entirely as planned, for several reasons; (a) it could not be enforced, (b) an unambiguous implementational framework was lacking, (c) there was no prior specification of

the precise mode of implementation, (d) it followed on from and was therefore dependent on other parties' activities and objectives in the same region.

(4) Although there is growing support for the idea of on-farm conservation, the government has not yet adopted a policy position on this as a modality for ecological compensation. It is still unclear whether this option provides sufficient safeguards for no-net-loss of ecological values.

5.2 Recommendations

(1) An unambiguous framework ('playing field') for implementing ecological compensation should be developed at the national level, specifying in greater detail the following particular issues: definition of no-net-loss and appraisal thereof at compensation sites, the ecological targets to be attained at these sites, the location of the sites, and their long-term management.

(2) Future ecological compensation plans should specify the margins by which results may deviate from targets while still satisfying the 'no-net-loss' criterion. This would provide the flexibility required in practice while still providing clear goals as to the ecological quality criteria to be satisfied at individual sites.

(3) The government should take a position on on-farm conservation as a modality for compensating for the ecological impacts of road infrastructure. In doing so, the requirement of no-net-loss must be weighed up against situations with and without land acquisition and re-zoning of the farmland on which compensation is to be implemented.

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Chapter 7

Improving ecological input in Dutch road planning

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Improving ecological input in Dutch road planning

Abstract
In the Netherlands planning and decision-making on national road schemes is a staggered process in which successive stages are characterised by growing detail. In principle, there is a need for ecological data input at each phase. In practice, problems arise: the Reconnaissance Study requires more information than is then available, for example, and the Routing EIA (Environmental Impact Assessment) Study draws in a mass of detailed information not necessarily required at that particular stage. Although there is a major need for ecological data in the next phase, the Preliminary Routing Decision, in practice there is little extra input because of the deadline in force for this stage. This article reviews the main bottlenecks in the current procedure and suggests several improvements.

1. Introduction

Major road-building schemes generally have a substantial impact on nature and wildlife, and it is therefore essential that ecological considerations be adequately incorporated throughout the planning and decision-making process. In the Netherlands this has indeed been the wish of the public and legislators for many years now; witness the Environmental Protection Act (Official Gazette (1979) and Routing Act (Official Gazette 1994). At present, ecological input to the process is in the form of a description, first, of the (protected) plant and animal species occurring on and around the site of the proposed scheme and, second, of the implications of the scheme for survival of those species.

The Routing Act sets out the decision-making process to be followed for large transport infrastructure projects, including construction and widening of trunk roads and motorways, or ‘national’ roads as they are known in the Netherlands. In the course of the various phases of this process, all relevant information and descriptions of potential impacts are fed in, from rough-and-ready information in the Reconnaissance Study to detailed in the final decision on project implementation (cf. Table 1). This progression in detail holds essentially for ecological and non-ecological information alike.

The fact that the phases of this process are staggered allows 'go / no-go' decisions on the project to be taken at virtually any time, reducing project risks while avoiding excessive, possibly unnecessary work in each of the phases. The staggered approach means that each phase requires its own level of detail in terms of ecological data input, i.e. general information and descriptions of impacts. In practice, though, this information is not always properly matched to what is needed in the phase in question. This can lead to undesirable project delays, whether in the planning stage (due to public inquiries and appeals, for example) or during implementation (if construction permit data are inadequate, for example). There is public and political pressure to speed up the decision-making process, moreover, putting high demands on planning the work to be done in each phase and the time available to do it.

The question that is often asked but that has as yet scarcely been answered, then, is how data input on species presence and estimated ecological impact can best be matched to the respective phases of the decision-making process in force for national road schemes. It is this question that is addressed in the present article.

2. Phases of decision-making on Dutch national roads

In the Netherlands a multi-stage decision-making procedure is in force for national road-building schemes (Table 1), an area in which competence is borne jointly by the Minister of Transport, Public Works and Water Management and the Minister of Housing, Spatial Planning and Environment. The following stages can be distinguished.

The *Multi-Year Program Infrastructure and Transport (MIT)*, published annually, reports on the bottlenecks in the Dutch road grid requiring most urgent review (e.g., MTPW 2002a). These are road sections no longer meeting the requirements of the Second National Transport Structure Plan (MTPW 1990) and the National Traffic and Transport Plan (MTPW 2001) in terms of accessibility (excessively long journey times due to congestion), safety (too many accidents) or quality of life (too much air pollution or noise nuisance).

For each road section identified in the MIT there follows a so-called *Reconnaissance Study*, to establish the approximate nature and magnitude of the

Table 1: Decision-making on national road schemes in the Netherlands.

Phase of planning process	**Aim**	**Scale level**	**Question to be answered**
MIT*	To identify bottlenecks in the national road grid	1:>100,000	Where and why is action required? (political agenda)
Reconnaissance Study	To improve insight into a specific bottleneck and identify policy options for addressing it	1:50-100,000	Where and why must action be taken? (initial elaboration)
Commencing Document	To inform the regional population about the problem and available policy options	1:50-100,000	What are the alternatives?
Routing EIA	To assess and compare the alternatives	1:10-50,000	Where can the problem be solved?
(Preliminary) Routing Decision	To establish the location and elaborate the route in detail	1:2,500	How can the problem be solved?

* Multi-Year Program Infrastructure and Transport

problem and possible strategies for remedial action, in terms, say, of public transport versus new infrastructure, road-widening versus road-building, or bridge versus tunnel (MTPW 2002b). The study also states whether additional study is required and the aims of any such study.

The start of the Routing Act procedure proper is marked by publication of an *Commencing Document*, designed to inform the local or regional population of the problem and the basic strategies available to address it. It describes any alternative routing options and the kind of (environmental) studies to be conducted in the course of the ensuing process. This phase concludes with legal advice to the government and a first round of public consultation.
In the *Routing EIA Study* the various routing options (and variants) are described (the question ‘Where?’) and provisionally evaluated, with their likely consequences being compared, including ecological impact. This phase also

concludes with legal advice to the government and public consultation.
A political decision is then taken to adopt one or other alternative: the ‘preferred option’. This is laid down in the official Position of the Minister of Transport, Public Works and Water Management, which is subsequently worked up into a *Preliminary Routing Decision*. This (sub-)phase again concludes with legal advice [dito]and public consultation. After possible revisions on specific details, this draft document is finalised in the form of an formal *Routing Decision*, which, after the hearing of any appeals, then becomes irrevocable. The aim of this final part of the procedure is to optimise the design of the preferred option, including any conservation measures (the question ‘How?’). Following the Routing Decision, preparations for actual project implementation can then be started.

3. Review of ecological methods

There are a variety of methods in use for assessing the ecological impact of road schemes and similar large-scale development projects. These can be broadly categorised as follows.

3.1 Fragmentation of protected areas

The first type of assessment, at the relatively coarse scale level of the landscape, is rough-and-ready and focuses on the spatial unity of areas enjoying official ‘protected’ status (Udo de Haes 1975). The goal here is to estimate how fragmentation of the landscape due to road presence and disturbance by traffic affect the overall ecological and physical continuity of the protected area. In today’s policy framework, this approach can be adopted for areas forming part of the (national) Ecological Main Structure and areas protected under the (European) Bird Directive (79/409/EC) and Habitat Directive (92/43/EC). The number of segments into which the area is fragmented as well as the total area affected, both visually and through noise nuisance, are then taken as indicators for overall (landscape) ecological impact.

This approach has been adopted for landscape and road planning in the United States (cf. Forman & Hersperger 1996) and Germany, too. The US approach has been elaborated a little further, taking ‘road density’, i.e. total road length per unit area (km/km^2), as a yardstick for fragmentation. Although there is no quantitative relationship with ecological integrity as such, it has proved feasible to establish a threshold road density at which populations of wolves and other species are not threatened in their survival.

3.2 Specific impacts

The next set of methods, at a more detailed level of analysis, seek to describe the likely ecological impacts of a given road scheme. Three types of impact are usually distinguished: habitat loss, habitat disturbance or degradation (particularly by noise, but also by pollutants and changes in groundwater levels) and barrier effects. Today we know a fair amount about the impact of traffic noise on breeding bird populations (Reijnen *et al.* 1996), but very little about the barrier effects of roads and associated infrastructure. All such impacts are presently described using rough rules of thumb only. Thus, based on breeding bird studies, a 35% reduction in total breeding bird numbers is assumed in the disturbance zone, i.e. the zone parallel to the road up to the line where impacts are no longer discernable.

3.3 Population models

Population models are being used more and more in the context of impact studies. Their proceed from the observation that most species are generally found in subpopulations between which there is a certain amount of gene flow. Landscape fragmentation gives rise to smaller patches of habitat spaced further apart and survival of a given population therefore depends on the dynamic equilibrium between extinction and recolonisation by subpopulations (Opdam *et al.* 1994). Most roads are above-ground, creating barriers difficult for terrestrial species to cross, so that recolonisation is often hampered. Population models require solid data on species characteristics, habitats and environmental factors (Verboom 1996).

4. Ecological data input to decision-making

Overall ecological input to the decision-making process is currently organised as follows (cf. Table 2).

Table 2: Current input of ecological data in the various stages of decision-making.

Phase of planning process	Aim	Nature of ecological input
MIT	To identify bottlenecks in the national road grid	n.a.
Reconnaissance Study	To improve insight into a specific bottleneck and identify policy options for addressing it	Areas forming part of the Ecological Main Structure
Commencing Document	To inform the regional population about the problem and available abatement options	General ecological aspects
Routing EIA	To assess and compare the alternatives	Usually specific impacts; sometimes population models
(Preliminary) Routing Decision	To establish the location and elaborate the route in detail	Always specific impacts; never population models

Multi-Year (MIT) Programme. In this initial stage of planning there is scarcely any ecological data input at present, bottlenecks in the road network being identified mainly in terms of other issues, viz. accessibility, safety and quality of life.

Reconnaissance Study. It is during assessment of the options available for addressing a specific bottleneck that ecological impacts are first reviewed. In this phase the principal data input is a description of affected areas that are part of the Ecological Main Structure (MANF & MHPE 1993).

Commencing Document. In this document relevant information from the Reconnaissance Study is simply recycled. In addition, though, the alternative options are described as well as the scope and content of the ecological studies to be conducted in the next phase.

Routing EIA. During this initial evaluation and comparison of the impacts of the various alternatives, three types of impact are examined: habitat loss, disturbance and fragmentation. Occasionally, population models are employed.

(Preliminary) Routing Decision. This document describes what conservation measures (number, nature, magnitude and exact location) are to be incorporated in the engineering design of the preferred option. Ecological impacts and conservation measures are now described in more detail than in the previous phase. In practice, these measures are keyed to the individual kinds of impact. In this phase population models are never used.

5. The problems

From the ecological perspective this procedure brings with it a number of recurrent problems, which for the respective phases of decision-making can be specified as follows (Table 3).

Mulit-Year (MIT) Programme. Under the (European) Habitat and Bird Directives certain areas have been designated as ‘protected’, or are being considered for such status. The ecological safeguards set for these areas thus constitute a new (legislative) criterion for assessing the road grid bottlenecks first identified in the MIT.

Reconnaissance Study / Commencing Document. At the Ministry of Transport all work on infrastructure projects is subject to the proviso that investment data be attached throughout the planning. At this stage, though, data on the conservation measures required for a specific project are still often lacking, whether these be in the form of integration (e.g. sunken roadways), mitigation (e.g. ecoducts) or compensation (e.g. land purchase). This makes it all the more necessary that data on such measures be collected and ecological impacts described at an earlier stage than at present, i.e. before the moving onto the next, Routing EIA phase.

Routing EIA. Overall, this phase has become steadily more detailed over the years, in part due to the growing complexity of the policy and legislative framework. This has led to ever greater demands on technical road design, environmental studies, consultation and formal public enquiries. In this phase it

Table 3: Mismatches between ecological data input and phases of decision-making.

Phase of planning process	Aim	Mismatches in ecological input
MIT	To identify bottlenecks in the national road grid	Implications of European Habitat and Bird Directives are a new issue
Reconnaissance Study	To improve insight into a specific bottleneck and identify policy options for addressing it	Implications of European Habitat and Bird Directives are a new issue
Commencing Document	To inform the regional population about the problem and available policy options	n.a.
Routing EIA	To assess and compare the alternatives	Intrinsic problem of disparate levels of ecological detail required for Ministerial Position and Routing Decision; as this phase has no deadline, it acts as magnet for additional work
(Preliminary) Routing Decision	To establish the location and elaborate the route in detail	Major need for detailed input on ecological impacts and conservation measures, despite this phase having a tight deadline

becomes clear that the Routing EIA is in fact a springboard for two separate official decisions, viz. the Ministerial Position and the Routing Decision, requiring ecological data input at different scale levels. This is an intrinsic and recurrent problem. Because there is no mandatory deadline for completing this phase, moreover, it tends to draw in far more work than is strictly necessary.

(Preliminary) Routing Decision. With road design now optimised in detailed engineering plans, likely ecological impacts can be specified with greater precision than in the previous phase and mitigating and compensatory measures better elaborated in terms of both design and location. As mentioned, though, despite the greater need for ecological input here, in practice such input is sorely

Table 4: Improved match between ecological data input and phases of decision-making.

Phase of planning process	Aim	Matching of ecological data
MIT	To identify bottlenecks in the national road grid	Assessment of safeguards for European Habitat and Bird Directive areas
Reconnaissance Study	To improve insight into a specific bottleneck and identify policy options for addressing it	Bisection of protected areas, species presence; rough-and-ready assessment of ecological impacts in study area
Commencing Document	To inform the regional population about the problem and available policy options	General ecological aspects, ecological considerations via-à-vis prevention of impacts, potential conflicts with conservation legislation and policy
Routing EIA	To assess and compare the alternatives	Approximate assessment and comparison of ecological impacts, combined with shorter deadline
(Preliminary) Routing Decision	To establish the location and elaborate the route in detail	Extension of this phase, making it a 'phase 2 Routing EIA' in which population models can be more effectively used

lacking, mainly because of the relatively tight deadline for this final phase of decision-making.

6. Matching ecological input

Ecological data input information must be better matched to the respective phases of the decision-making process, as follows (cf. Table 4).

Multi-Year (MIT) Programme. As the presence and use of (new) transport infrastructure may jeopardise the ecological safeguards in force for areas protected under the European Habitat and Bird Directives, some form of preliminary assessment of such risks, i.e. likely impacts, is required at the MIT stage. In this phase, then, it is essential that there be more input of (area-wide) ecological information than is presently the case.

Reconnaissance Study. It is in the Reconnaissance Study, though, that more detailed ecological data and specification of likely impacts first become really indispensable. The specific focus should now be on areas protected under the cited EU Directives and on inventorying protected species in these and other parts of the study area. To avoid any false sense of security this area-wide impact assessment should be fairly rough-and-ready, rather than striving to be quantitative. At the same time, though, it should be firmly rooted in key statistics like the length of road bisecting the area, the amount of land required for the associated infrastructure, the total acreage of protected area affected and so on. In designing impact abatement strategies, the guiding principle should always be: avoid impact whenever possible, moving on to minimise the area affected only if this proves unfeasible. Based on the Reconnaissance Study, the competent authority can then decide whether or not to give the go-ahead despite, or because of, any project risks arising at a later stage of planning (due to public pressure, for example, or conservation measures being too costly). Another motive for improving ecological input at the Reconnaissance Study stage is the ministerial requirement that investment levels already be specified at the earliest planning stages. The problem remains, though, that the relevant ecological information is often not available at this stage or has not yet been properly pulled together.

Commencing Document. Building on this new platform of information, the Commencing Document should specify the kind of research that needs to be undertaken to ensure the safeguards in force for the European Directives are duly respected. These directives oblige principals to adopt the option causing least ecological damage and, more so than in the past, efforts will therefore have to be made to demonstrate the extent to which the physical design of the preferred option has been influenced by ecological considerations and whether or not the alternatives under review conflict with standing conservation legislation and policy, particularly at the European level.

Routing EIA. Even at this stage all that is needed is a fairly rough assessment and comparison of impacts, and population models should therefore be used only sparingly, for two basic reasons. First, such models require a substantial body of primary and derived ecological data over a relatively large geographical area, viz. the entire study area of the project. Second, until such time as the need for the project and its potential benefits have been formally established, overly complex impact studies should be avoided. By extending the period available for researching and reviewing impacts and measures to include the following, Preliminary Routing Decision (PRD) phase, the quality of that research can be improved and the 'intrinsic problem' cited substantially alleviated. This would also make it easier to meet the procedural deadline for presenting the PRD.

One way to improve matters would be to reconceive the PRD phase as a 'phase 2 Routing EIA', much the same as the current EIA procedure for new housing developments and industrial estates, where basic proposals are currently elaborated in a number of physical variants. This would allow the Routing EIA phase to be kept shorter, for at that stage all that is needed is a 'first-pass' comparison of alternatives. This would mean a stricter and more logical division between the two basic questions of 'Where?' – i.e. which physical option is to be adopted? – and 'How?' – i.e. actual engineering of the preferred option in the (D)RD phase. What is more, the time gained by shortening the Routing EIA phase could be used to improve the analysis of likely ecological impacts and recommended conservation measures in the following PRD phase, or 'phase 2 EIA'.

Unfortunately, it seems that legislators would rather maintain the (time) constraints on the PRD phase (MTPW 2002c), which does not omen well for the suggested changes in the decision-making procedure. However, this would mean a missed opportunity for enhancing the quality of that procedure – in this case specifically from an ecological angle – and leave unaddressed the intrinsic problem of the disparate levels of detail required in the Routing EIA phase.

(Preliminary) Routing Decision. If the PRD phase were indeed extended as proposed, population models could then be usefully applied to help establish the required number, nature, size and location of conservation measures. Given the statutory time constraints on this phase, this is an impossible task at present. During finalisation of the Routing Decision ecological data input can in principle remain unchanged.

7. Conclusions and recommendations

(a) The general public as well as legislators would like to see improved input of ecological data in the early stages of decision-making on national road schemes, particularly in view of the commitments arising under the European Bird and Habitat Directives and the need to identify potential problems arising within that framework. To ensure these safeguards are duly respected, it is essential that proper information on protected areas and species occurrence within the project area is available at an early stage of the decision process. As an added benefit this would also contribute to society's general desire to speed up decision-making.

(b) The departmental requirement that investment sums be attached to (aspects of) road-building schemes at an early stage of planning means that, with detailed ecological information still lacking, all-purpose indicators will have to be used if ecological uncertainty is to be avoided at this stage. A standard list of conservation measures should therefore be drawn up, specified in terms of geographical factors and protected status of areas and species, for mandatory inclusion in the basic engineering of road schemes. In the case of new roads this would mean an obligation for the principal to incorporate X ecoducts for every 10,000 ha of Habitat Directive area bisected, say, or install Y fauna tunnels per km of the Ecological Main Structure bisected, or fund Z ha of 'habitat reconstruction' in compensation for every km of road. This would allow solid indicators to be derived with which to arrive at proper cost estimates for the measures in question.

(c) What is needed at the Reconnaissance Study stage is a rough-and-ready overall assessment of the project area from the physical planning and ecological perspectives, for use by the competent authority – the Minister of Transport, Public Works and Water Management – to arrive at an early decision on any further research that may be required. The simpler type of assessment proposed here requires only a modest research effort and avoids work being started on projects that are simply unrealistic or unfeasible within the framework of the cited European Directives.

(d) Extending the deadline for the Preliminary Routing Decision phase combined with limiting the Routing EIA to a rough assessment and comparison of the basic alternatives would enhance ecological input to the decision-making process enormously, It would do greater justice to the approximate character of the Routing EIA and allow for incorporation of better-reasoned ecological impact descriptions and conservation measures in the PRD stage. This would mean (more logical) separation of the 'Where?' and 'How?' questions (cf. Table 1).

(e) In principle, the three sets of methods available for estimating the ecological impacts of road schemes dovetail well with the various scale levels encountered in the decision-making process: first, overall assessment of the study area in the MIT and Reconnaissance Study; then assessment of specific impacts in the Routing EIA phase; and, finally, studies using population models in the (Preliminary) Routing Decision phase. In the second phase ecological models should be used sparingly if at all, as they distract from the basic benefits-and-need discussion on the scheme in question. In a PRD stage as reconceived under d, population models could be used to far greater effect.

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Chapter 8

Summary of results

Summary of results

This chapter, concerned mainly with use of the ecological compensation principle in the context of national road schemes, presents the results of the articles reprinted in the chapters of Part 2. These are grouped under eight headings, as follows:

- planning and decision-making (8.1)
- implementation and results (8.2)
- compensation costs (8.3)
- evaluation and monitoring (8.4)
- legal aspects (8.5)
- public support (8.6)
- gaps in knowledge (8.7).

In the following text, numbers in square brackets and bold type indicate the chapter of Part 2 to which the results in question refers, viz.:

[2] Ecological compensation of the impacts of a road; preliminary method for the A50 road link (Eindhoven-Oss, the Netherlands).
[3] Guidelines for ecological compensation associated with highways.
[4] Ecological compensation in Dutch highway planning.
[5] Preparation and implementation of seven ecological compensation plans for Dutch highways.
[6] Compensating for ecological impacts of road development: seven years' experience with Highway A50 (Eindhoven-Oss, Netherlands).
[7] Improving ecological input in Dutch road planning.

The aspects of compensation treated in each of the chapters of Part 2 are summarised below in the form of a matrix, used as a reference point in drawing the conclusions presented in the following eight sections.

Chapter		Planning, decision-making	Implementation	Costs	Evaluation, monitoring	Legal aspects	Public support	Gaps in knowledge
2	Preparation of compensation plan method for A50 road link						X	X
3	Guidelines for ecological compensation	X	X			X	X	X
4	Ecological compensation in highway planning	X		X	X		X	X
5	Preparation and implementation of seven compensation plans	X	X	X	X		X	X
6	Seven years' experience with highway A50	X	X	X	X	X	X	X
7	Improving ecological input in road planning	X						

8.1 Results on planning and decision-making

1. With each new phase of planning and decision-making on a given road project, compensation measures are specified in ever greater detail in terms of nature, scale, location and cost. Nonetheless, there is still a considerable mismatch between 'supply' and 'demand' of ecological data in the respective phases.

2. In several of the national road projects investigated, certain infrastructure alternatives (A2: Tangenten Eindhoven) or variants (A4: Dinteloord-Bergen op Zoom) were abandoned during the planning stage as unrealistic given the scale and cost of the compensation measures implied **[4]**.

3. In the projects studied the estimated cost of the compensation measures associated with the infrastructure alternatives and specified in the Routing EIA ranged from zero (no ecological impact on areas requiring compensation) up to € 14.9 mln. (US$ 16.0 mln.). The latter figure, for the

A4 (Dinteloord-Bergen op Zoom) was 8.2% of the total project investment sum. At the Routing Decision stage, it was subsequently opted to implement an infrastructure alternative having less ecological impact, with compensation costs projected at only 2.3% of total investments **[4]**.

4. On the other hand, estimated compensation costs may rise as planning progresses. This was the case with the A4 (Delft-Schiedam), where the upper estimate rose from 0.7% of total investments (€ 1.1 mln., US$ 1.2 mln.) in the Routing EIA to 7.3% (€ 13.1 mln., US$ 14.0 mln.) in the Routing Decision. This was because more detailed information, obtained only in the (Draft) Routing Decision stage, indicated that compensation sites would have to be purchased after all, while previously it had been thought that management contracts could be concluded with farmers, with no need for property changing hands **[4]**.

5. Routing Decisions on national road projects currently embody a dual decision: first, on the envisaged costs and benefits and perceived necessity of the project and, second, on the scale and nature of the mitigation and compensation measures required **[3,4]**.

6. In the road projects investigated, between 2 and 5 years were required for drawing up and finalising the ecological compensation plan (CP) **[5,6]**. In all these cases the CP was drawn up *after* the Routing Decision. For new projects the timetable is likely to be shorter, first because compensation measures will have been largely elaborated *prior* to the Routing Decision and second because of the experience meanwhile gained in preparing such compensation plans **[5]**.

7. Deriving compensation measures at the project planning stage makes it difficult to guarantee that the principle of no-net-loss of ecological values will ultimately be respected. At this early stage there is too little focus on value ‘replaceability’, the time required to develop suitable compensation sites and whether, at the end of the day, the values impaired or lost will be adequately compensated. There are also insufficient guarantees that *Rijkswaterstaat*, as project initiator, will indeed be able to dispose over the envisaged compensation sites when the time arises **[3]**.

8. The standard additional ‘quality compensation’ sum, designed to make up for quality differences between the compensation site in virgin and ultimate state as well as the time required to achieve this transition, works well in principle and is no longer a real issue, even for interest groups **[5,6]**. This suggests that other aspects of ecological compensation might likewise be standardised, for example derivation of out-of-kind compensation. However, while such standardisation would have practical benefits as well as the appeal of increased transparency, it would be difficult to underpin ecologically **[3]**.

8.2 Results on implementation

9. Due to the implementation horizon of the CP for a national road project (several years), there will inevitably be deviations from the terms of the original CP **[5,6]**. First, there is little way of knowing when or where appropriate compensation sites will be forthcoming. Second, potential sites may later be lost to housing or other developments, or have to be rejected in the light of new information (e.g. discovery of soil pollution) **[6]**. Third, and conversely, new compensation sites may emerge that were not foreseen in the CP, following discontinuation of farming operations, for example.

10. A key bottleneck in practical CP implementation is acquisition of suitable sites, particularly in the most populated regions of the Netherlands **[5,6]**. Owing to declining ‘land mobility’ and the associated rise in real estate prices, since the early 1990s ecological compensation has had to compete ever more with other development projects for land (e.g. housing developments) or even for the conservation sector itself (e.g. realisation of the Ecological Main Structure) **[3,6]**. For the same reason ecological compensation must also compete with other interests within one and the same road project, starting with the land required for the roadway itself **[6]**.

11. Although the lands required for the A50 (Eindhoven-Oss) CP will have been acquired by the time the link is opened, or at least largely so, work on adaptive design and management of these sites is not anticipated to have been completed by then, let alone subsequent transferral to conservation organisations. If this is indeed the case, a portion of the CP budget will

remain unspent and the aim of no-net-loss of ecological values will not have been secured by the time the link is opened **[6]**.

12. The Dutch procedure for implementing CPs favours ‘patchy’ compensation over multiple, unconnected sites, generally reducing overall ecological effectiveness **[6]**. As long as the lands are acquired within oversized ‘search area’ for compensation sites (oversized compared to the extent required for compensation purposes) this will remain an intrinsic problem.

13. Acquisition of suitable compensation sites is hampered not only by the short supply of land but also by the national policy forbidding government authorities and agencies to pay more than the going market price for real estate, to prevent additional prices hikes **[6]**. As a consequence, *Rijkswaterstaat* cannot always make full use of promising opportunities for ecological compensation.

14. As the case of the A50 (Eindhoven-Oss) demonstrated, it is difficult to secure CP objectives when compensation is implemented via a Land Adaptation project. This is because compensation objectives in these projects usually conflict with conservation aims in one way or another. Implementation of the CP is generally delayed considerably, moreover, owing to the relatively large number of parties involved **[6]**.

15. In Dutch implementation of the compensation principle, scarcely any consideration is given to contingency planning, as is the case in the UK, where there is prior elaboration of steps to revise or adjust original compensation measures in the event of disappointing results (cf. Result 25) **[3,4,5,6]**.

16. Apart from the A1 (Holendrecht-Oudenrijn) none of the projects investigated involved financial compensation in the form of payments into the so-called Green Fund (cf. Result 21) **[5]**. This means that *Rijkswaterstaat* has a commitment to undertake physical compensation measures.

17. The CPs investigated indicate that in those cases where the plan remains unfinished for one reason or another, financial compensation will be paid by

the developer, the unspent portion of the compensation budget being transferred to the Green Fund **[6]**. Although this accords with the basic principle of ecological compensation, theoretically causing no-net-loss of ecological values, this is not the case in practice **[6]**. This is because there is no guarantee that the rest of the CP will eventually be implemented by others, the Green Fund administrator being free to use incoming funds for other conservation projects **[3]**.

18. When it comes to practical implementation specific guidelines are still lacking on several key aspects of the compensation principle, in particular: 1) the point in time at which the project initiator is relieved of the obligation to compensate, 2) the relationship between compensation sites and the Ecological Main Structure, in terms of spatial zoning, and 3) the relationship between long-term management of compensation sites and the EMS funding programme **[3]**.

8.3 Results on compensation costs

19. The investigated CPs that are still in progress indicate that compensation measures may be up to about 4% of the total project investment sum earmarked for national road projects **[5]**.

20. Because of the sharp rise in Dutch land prices in the latter half of the 1990s, without a revision of standing budgets none of the road CPs currently in progress will be on target with respect to compensation site acquisition, design or management **[5,6]**. Such budget revisions can in principle be based on standard price indexing.

21. There are no clear-cut guidelines on financial compensation in the event of CP targets not being secured by the time the new road section is opened. Unforeseen cost increases during implementation mean overspending on the original CP budget and as a result the sum remaining and thus available for financial compensation will no longer be adequate for the measures yet to be implemented **[4,5,6]**.

22. Even before work on implementation starts, ecological projects financed from the Green Fund will be adversely affected by any price rises occurring between transfer of financial compensation and project implementation **[5]**, thereby detracting from the original conservation aim of this fund.

8.4 Results on evaluation and monitoring

23. With the exception of those for the A50 (Eindhoven-Oss) and A73 (Venlo-Maasbracht), none of the CPs studied had any provisions for monitoring or evaluating CP implementation and the instruments employed to that end. Nor was there much attempt to develop procedures for monitoring the ultimate effectiveness of the individual compensation measures; indeed, it was only with the A50 (Eindhoven-Oss) that any ideas on this point were spawned at all **[4,5,6]**.

24. In none of the ongoing CPs examined has there been any attempt at ex-post evaluation of decisions on specific forms of ecological compensation or the underlying methods used to predict ecological impacts and derive appropriate mitigation and compensation measures **[4,5,6]**.

25. More broadly, this lack of monitoring and evaluation means that there is virtually no way of assessing whether Dutch CPs actually achieve no-net-loss of ecological values, even when fully implemented **[4,5]**. This also hampers use of contingency plans as a means of revising CPs should that prove necessary during implementation.

8.5 Results on legal aspects

26. Despite the government's pledge in the Structure Plan for the Rural Areas to assess whether the compensation principle should be duly grounded in legislation, a positive decision on this point is yet to be taken **[3]**. In other words, the ecological compensation principle still has no legal footing in the Netherlands.

27. In the course of work on this dissertation the government has substantially extended the legal leverage for expropriating land-owners on the grounds of

a Routing Decision. That this option has not yet been used until now reflects the government's unwillingness to resort to compulsion **[6]**. An additional problem is how expropriation of a particular parcel of land for the purpose of ecological compensation is to be motivated. Given the lack of jurisprudence on this issue, it is unclear whether a compulsory dispossession order taken out on the grounds of a Routing Decision would be overruled if it were challenged in the appeals court.

8.6 Results on public support

28. Engaging interest groups in the articulation of a CP has benefits in the implementation phase **[2,3,4,5,6]**. Such groups have plenty of local as well as general ecological knowledge and are consequently in a good position to assess the feasibility of proposed compensation measures. Indeed, they usually play an active role in identifying suitable compensation sites. If land users join forces, 'win-win' situations may also result **[3]**.

29. Some environmental organisations are wary of collaborating on ecological compensation in early stages of project planning and may even be critical of such an exercise, demanding that the perceived necessity and anticipated benefits of the project first be established **[4]**.

30. From a general perspective, farmers seem to be in a good position to implement compensation measures to enhance ecological values in agricultural regions **[2,5,6]**. On the other hand, farmer management of compensation sites is at odds with the approach originally envisaged by *Rijkswaterstaat*, viz.: expropriation of lands, adaptive site design (if necessary) and transfer to a conservation trust, accompanied by land-use rezoning of the site(s) in question. An additional problem in this context is that farmers have still not been sufficiently recast as 'conservationists', despite all the policy efforts in that direction.

31. Farmer management of compensation sites generally does away with the need for land purchase or rezoning. *Rijkswaterstaat*'s main motives for adopting this *modus operandi* is the potential for cutting costs (no land

purchase required) and for boosting regional support for the project in question (alternative sources of farmer income) **[6]**.

32. It is as yet unclear whether the aim of no-net-loss of ecological values can be secured under current farm-based management regimes and whether guarantees as to long-term preservation of these values (‘sustainability’) approximate those achieved with the more traditional approach of purchasing sites specifically for compensation **[6]**.

8.7 Results on gaps in knowledge

33. It is relatively straightforward to quantify the ecological impact of habitat destruction associated with road construction and subsequent disturbance of breeding bird populations by traffic noise, and it is for this reason that CPs for Dutch national road projects are based on these two impact categories **[2,5]**. In contrast, the effects on target species populations of habitat fragmentation, ‘road kill’, roadway illumination and hydrological changes are more difficult to quantify **[2,4]**. As a result, scarcely any attention has been given to measures to compensate for these latter impacts **[4,5]**.

34. Although the notion of impact mitigation has been integral to road design for many decades **[4,5]**, its effectiveness has still not been satisfactorily studied at the population level. This makes it more difficult to derive compensation measures appropriate to a given road project, hampering achievement of no-net-loss of ecological values **[3]**.

35. Ignoring impacts that are difficult to quantify when deriving the compensation measures for a particular project **[2,3]** makes it harder to evaluate whether there is no-net-loss of ecological values.

36. Experience at *Rijkswaterstaat* has shown that out-of-kind compensation, i.e. compensation of lost or impaired ecological values in terms of ‘substitute’ values, leads to lengthy debates among parties **[3]**. This is not surprising, given that there is no trustworthy ‘translation’ procedure available for this purpose and therefore no way of evaluating to what extent out-of-kind compensation indeed contributes to no-net-loss of ecological values.

37. There is insufficient insight into the costs associated with compensation site acquisition, adaptive design and management, and the same holds for overrunning of CP budgets in the implementation phase **[6]** (cf. Result 20). There is a degree of mismatch between the cost indices presently employed nationally in the conservation context and the planning procedures in force for transport infrastructure.

Part 3

Discussion, conclusions, recommendations and perspectives

Chapter 9
Discussion: answering the questions

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Chapter 10
General conculsions, recommendations, perspectives and summarising conclusions

Chapter 9

Discussion: answering the questions

Discussion: answering the questions

In this chapter the results of Chapter 8 are discussed in the light of the specific research questions addressed in this dissertation (cf. § 1.5):

1. What consequences has the ecological compensation principle had for planning and decision-making on (Dutch) national road projects? (addressed in § 9.1)
2. How have compensation measures actually been implemented in these projects and how effective have they proved? (§ 9.2)
3. To what extent can ecological compensation, as presently articulated for road projects, be more widely applied? (§ 9.3)
4. What are the advantages and drawbacks of the main options for (science-based) compensation measures? (§ 9.4)
5. What problems are encountered in practice and what options are available for addressing them? (§ 9.5)

9.1 The role of ecological compensation in planning and decision-making on national road projects

Since the ecological compensation principle was operationalised in 1993, it has been fully integrated in the planning, decision-making and implementation phases of national road projects. On the one hand this is because the Ministry of Transport, Public Works and Water Management, via its Directorate-General for Public Works and Water Management (*Rijkswaterstaat*), is itself formally responsible for national implementation of the principle. Another factor that has contributed to successful integration within the ministry, though, is the way it dovetails with the planning procedure for national road projects laid down in the Routing Act. This integration within the ministry is reflected not only in the focal issues of this dissertation, viz., incorporation of ecological information in the various phases of decision-making and the implementation of compensation measures. In addition, *Rijkswaterstaat* employs both human and financial resources in designing and implementing ecological compensation plans.

Although the issue was not systematically researched, it became clear during work on this dissertation that in a number of Dutch national road projects it was the financial incentive that moved the project initiator to develop an alternative road design having a less severe ecological impact (cf. Results 2-3, Chapter 8). The financial incentive thus proves to be a powerful means of preventing ecological impacts. However, because the ecological compensation principle is *not* currently steered on this compass – given the staggered nature of decision-making vis-à-vis the infrastructure project and, subsequently, ecological compensation (cf. Result 5, Chapter 8) – on this point the principle should be reviewed. It should be added that such monetary incentives apply only in the case of construction variants along the same basic lines, such as different grade-level alternatives, and not for radically different variants such as a cutting or tunnel, which will have less ecological impact but inevitably push up investments enormously.

None of the national road projects that were followed through the decision-making procedure (cf. Results 9-11, Chapter 8) was implemented in accordance with the original planning. Because of political developments, particularly government cuts on infrastructure spending and public pressure, projects were postponed (A4 Delft–Schiedam, A15 Varsseveld–Enschede), implemented in a scaled-down variant (A2 Tangenten Eindhoven, A2 Vianen–‘s-Hertogenbosch) or resubmitted to the planning procedure with a new scope (A4 Dinteloord–Bergen op Zoom). In the cases of projects being scaled down or resubmitted, the extent and nature of ecological compensation must be re-derived using new impact descriptions. If a project is postponed, there are two main consequences for ecological compensation. By definition, the occurrence of ecological impacts is postponed and the timetable for implementing compensation measures therefore moved forward. At the same time, though, any major delay almost inevitably means a need for one or more interim reviews of ecological data as well as for implementing any new ecological policies and/or legislation that may have been introduced in the meantime. In short, it may imply a need for major additional efforts on deriving the requisite nature and scale of compensation. This holds not only for issues of ecological compensation, it may be added, but also for many other aspects of infrastructure project planning.

The ecological compensation principle can serve to 'lubricate' decision-making in two ways. In the first place, it allows certain projects to be realised that would not otherwise receive approval. The principle of compensation follows on implementing correctly the principle of 'no-unless' and fulfils a crucial role in securing public support for the project ('approval after demonstration of benefits and necessity, with no-net-loss of ecological values') (cf. Cowell 1997). Second, project initiators may consciously publicise the compensation measures they are to take, as a means of increasing public support. This may then mean that a basic routing decision meets with relatively little public opposition and the project can be implemented fairly smoothly. The danger in such cases is that the project's ecological impacts may well be compensated – perhaps generously –, but at the expense of a proper debate on 'benefits and necessity'. In this context the cost of compensation alone may never serve as an incentive for avoiding negative impacts, for this would mean the project initiator 'buying off' those impacts at an extra price. If ecological compensation of infrastructure projects is not to be associated with such trade-offs ('approval thanks to compensation'), it is absolutely essential that the decision-making procedure and the role of compensation remain transparent for all parties and for the public at large. In this dissertation no evidence was found that ecological compensation serves as a 'lubricant' in this sense, although in one of the projects reviewed the compensation costs were evidently an element in negotiations among the parties (cf. Chapter 4).

9.2 Implementation aspects of compensation measures

9.2.1 Growing experience

It can be concluded that the process of implementing a compensation plan (CP) by *Rijkswaterstaat* is still very much under development. At the time of completion of this dissertation (2004), the focus was still largely on acquiring suitable compensation sites, followed at a distance by site preparation (as necessary), site management towards target ecological values and subsequent transfer to conservation agencies. A modest trend has been set in enlisting the aid of farmers in implementing CPs on farmland, an option that obviates the need for changes in land-use planning designations or property ownership. In practice, though, this trend is hampered by differences in culture between the policy departments involved and regulations that are problematical from the farmers' perspective. Nonetheless, national policy is geared towards an increased involvement of farmers in nature conservation.

In this context there is an urgent need for national provisions and for closer cooperation between the Ministry of Agriculture, Nature and Food Supply (formerly: Ministry of Agriculture, Nature Management and Fisheries) and the Ministry of Transport (through *Rijkswaterstaat*), because at the moment realisation of the Ecological Main Structure (via the former ministry) and farm-based ecological compensation (via the latter) compete with one another, an undesirable state of affairs. It should be added, though, that the trend to involve farmers in CP implementation needs to be critically assessed in two methodological respects. The first is that some scientists have cast doubt on the effectiveness, i.e., benefit to nature, of this kind of 'agri-environment scheme'. Thus, on the basis of empirical studies in the Netherlands, Kleijn *et al.* (2001) and Willems *et al.* (2004) conclude that the diversity of neither plants nor meadow birds increases as a result of conservation-oriented management of agricultural plots. The problem here seems to insufficient variation within this type of management and not the farming practice itself. Secondly, there are doubts as to the practical feasibility of achieving no-net-loss of certain species through this kind of scheme. Additionally, Vos & Ter Keurs (1996) doubt whether compensation is feasible at all for meadow birds in the peat meadow district of Zuid-Holland (the Netherlands): there is virtually no new suitable habitat available and improving existing habitat would require exceptional enthusiasm among farmers before they entered into management contracts.

9.2.2 Effectiveness of compensation measures

As to the question of whether ecological compensation measures are indeed effective in securing no-net-loss of ecological values, this dissertation can only provide an exploratory, provisional answer. Despite no compensation plans for national road projects yet having been rounded off or evaluated in the Netherlands, there is strong evidence that *area* targets will be secured, despite rising land prices and the growing scarcity of suitable sites at the regional level. Given the relatively slow process of ecological development, though, the requisite ecological *quality* is not generally achieved within the horizon of CP implementation. If there are built-in guarantees for securing this quality (cf. § 9.2.4), then there will in principle be no-net-loss in the longer term (Prins *et al.* 2004). The longer ecological values take to develop, the more effort will be required to achieve no-net-loss. At the same time, the difficulty of developing habitats in general (related to the unpredictability of achieving conservation targets) and developing habitats characterised by relatively short development times (for example, meadow bird habitat in farming districts; see § 9.2.1) should not be underestimated. One general conclusion is thus that although the principle of ecological compensation can now be physically implemented, the quality aspect still requires further scientific as well as procedural refinement.

9.2.3 From planning to implementation of compensation measures

In the context of Dutch national road projects, the goal of no-net-loss of ecological values proves difficult to pursue in the planning phase as well as hard to secure when it comes to CP implementation. During planning, certain ecological impacts are consciously ignored for lack of sufficient knowledge and/ or difficulty of quantification (road illumination impacts and barrier action, for example), often implying *a priori* that no-net-loss can be achieved. In the planning stage, moreover, there is generally too little focus on the actual availability of suitable compensation sites and the practical 'replaceability' of the ecological values affected. CPs may consequently often be based on overly optimistic expectations vis-à-vis acquisition of sufficient acreage and/or successful development of targeted ecological values, rendering achievement of no-net-loss problematical in the implementation phase. In practice there may also be other, extraneous factors hampering development of the ecological values targeted, including sub-optimal abiotic conditions and/or management at compensation sites. All this accords well with experience in the US, it may be added (Grayson *et al.* 1999, Marsh *et al.* 1996). At the same time, though, it should be noted that the time aspect may in fact have a favourable effect on CP implementation. Such is the case when a new site comes up unexpectedly, following early discontinuation of farming operations, say, at a site promising high ecological returns. Events like this generally yield added value relative to the original CP targets.

9.2.4 Monitoring and evaluation

In the Netherlands, there proves to be very little effort on monitoring or evaluating the actual effectiveness of CPs and constituent compensation measures. Again, this accords with experience elsewhere. The sporadic foreign evaluative exercises that have taken place show that in terms of the quantitative scale of compensation very few CPs have yet been on-target and that there is little, if any, evaluation of ecological values at compensation sites (Sudol & Ambrose 2002). Given that these values take longer, and possibly far longer, to develop than completion of road construction or widening (for national roads, generally 5-10 years), it is unwise to curtail CP implementation the moment the road is opened. Instead, the following conditions could be set:

- when the road is opened, the agreed compensation acreage must already be physically secure¸ with site design and management taken to hand wherever possible;
- any residual work on site design and management must be steered by some form of contingency planning.

If such conditions were introduced, the Ministry of Transport, as the authority with competence for the country's main infrastructure, would be responsible for supervising the enforcement of these conditions. This implies that the ministry would remain actively engaged in ecological compensation even after road projects have themselves reached completion. It would then be necessary to draw up further provisions detailing the duration of that responsibility and the scope for subsequent transfer to conservation or 'agri-environmental' agencies.

9.2.5 Tools for implementation and evaluation

After ten years of practical work with the ecological compensation principle at *Rijkswaterstaat*, a number of unresolved implementational problems are still impeding satisfactory execution of compensation plans. To some extent these can be traced back to differences in interpretation of the no-net-loss principle among the various parties and their representatives, some tending towards to the 'letter' of the principle, others to its 'spirit'. Because infrastructure project planning and implementation (but not decision-making) are decentralised in the Netherlands, interpretations differ across the country. From *Rijkswaterstaat*'s perspective this makes it difficult to achieve the 'unity of action' it would like to see at the national level. There is therefore an urgent need for consultations between the Ministries of Agriculture, Nature Management and Food Supply, and Transport, Public Works and Water Management to establish an implementation framework for the compensation principle that is acceptable to both. In this context there are two areas that deserve particular attention: long-term management of compensation sites (financial guarantees and precise relationship with the Ecological Main Structure (EMS) and farm-based implementation of compensation measures (cf. § 9.2.1, ‘Growing experience’). At present, both these issues are being handled in a far too ‘ad hoc’ fashion.

At the same time, though, *Rijkswaterstaat* itself must also find means of improving the efficiency with which CPs are implemented. There are two basic options here. The first is for *Rijkswaterstaat* to supervise the entire process of execution itself, by purchasing suitable lands and if necessary participating in further ‘land swaps’ to ensure suitable geographical location. Although this means relatively tight-reined management of the implementation process, there is a risk of the overall efficiency of compensation being reduced by the ‘patchiness’ of this approach. The second option, participation in existing farmland reallotment schemes (cf. Chapter 6), provides more opportunities for working towards larger, contiguous compensation areas. The other side of the coin, though, is reduced freedom of independent action, given that agreement must be reached among a greater number of parties. In practice, specific considerations will generally favour one or other of these approaches, viz. the horizon within which the CP must be implemented (if soon, opt for direct acquisition), the scale of the CP (if large, opt for participation in reallotment schemes), the modalities of land purchase and/or management contracts (if broad support is of the essence, opt for contracts). One positive recent development regarding CP implementation is that, by the year 2020, the Dutch governmental will actively contribute to development of ecological values prior to infrastructural development (MTPW & MHPE 2004).

Finally, in enforcing application of the compensation principle the Ministry of Transport has a statutory responsibility to monitor, evaluate and, if necessary, review standing government policy on ecological compensation, including methodological aspects, impact descriptions and derivation of mitigation and compensation measures (Official Gazette 1979). This implies a need to develop indicators for assessing the success, or otherwise, of CP implementation in terms of both physical scale and replacement of ecological values. Although the

Netherlands has a poor record in the field of evaluation and monitoring, EIA legislation could be used to improve both attitudes and action on this point.

9.3 Broader applicability of ecological compensation

9.3.1 Application of ecological compensation for roads to other development projects

Although this dissertation was concerned specifically with national roads in the Netherlands, the summary of results (Chapter 8) is, in principle, valid for other types of infrastructure too. This holds in the first place for other forms of linear infrastructure (rail and waterway projects) that are subject to the same planning procedure under the Routing Act, as has been empirically confirmed in the context of the high-speed rail link in the Dutch and the ‘Zandmaas-Grensmaas’ waterway, for example. At the same time, the results formulated here also hold, in principle, for ‘non-linear’ developments like housing projects, new industrial estates and expansion of plantation forests, as the whole process from planning to execution is very similar and the same planning provisions are in force regarding implementation of compensation measures. The difference, however, is that in the case of non-linear developments land cannot be expropriated for compensation, because in this case ‘Routing Act’-like legislation does not apply.

9.3.2 Extending compensation beyond ecology

In this dissertation the notion of ecological compensation has been elaborated from an ecological perspective, adopting a ‘1-to-1’ approach whereby the loss of 1 breeding pair of Black-tailed godwits, say, means an obligation to instate 1 new breeding pair elsewhere; equally, 1 hectare of EMS lost means a need to develop 1 new hectare elsewhere. In all this, issues relating to the landscape have been largely ignored, however. In principle, ecological compensation can tie in well with landscape management and there is no reason why basic landscape issues should not be included in CPs. The compensation principle could certainly be articulated further in this direction, by formally obliging developers to compensate for any damage caused to landscape elements and functions. Thus, as a first step the national scope of the principle might be extended to cover not only ecological values but also landscape and ‘heritage’ values (Province of Zuid-

Holland 1987), including allotment patterns of historical interest, for example. The problem here, though, is that it is difficult if not impossible to truly 'compensate' for loss or degradation of landscape elements and functions, the best that is perhaps conceivable being some form of 'rehabilitation' of elements presently in a degraded state. Nonetheless, if a wider notion of landscape were adopted, some form of compensation would be possible, for example vis-à-vis the fine network of secondary roads and cycle tracks, which often have an important 'leisure' function. This approach is in line with the philosophy of some international departments of transportation, which have drawn up similar principles for dealing with landscape impacts of roadways (Highways Agency 2000, White & Ernst 2003).

A further area to which the compensation principle might also be extended is rural development, that is to say in a broader sense, beyond mere relief of farmland bisection or farm relocation by way of reallotment schemes. Rather than taking just an individual approach, a far broader package of compensation measures could be drawn up benefiting the entire community and designed to mitigate and compensate social impacts, too. The goal would then be to improve the overall 'quality of life' of the local community, along the following lines, say:

- health: as infrastructure development schemes generally affect public health, compensation could be in the form of new indoor sports facilities;
- employment and income: as such schemes generally involve loss of farmland, compensation could be in the form of new, higher-income employment opportunities for farmers;
- nature: as such schemes cause ecological damage, ecological values could be developed elsewhere, i.e., within the current scope of compensation.

There should, in principle, be sufficient public and political support for this kind of policy, which is very similar to that currently in force for rural development projects, in that:

- the 'upside' and 'downside' of development schemes accrue to one and the same community;
- 'conservation' is not privileged over other environmental aspects, but set on the same footing;
- compensation measures have a direct, positive impact on the overall community welfare.

9.4 Advantages and drawbacks of the main options for science-based compensation measures

9.4.1 Compensation measures derived from individual impacts

In this dissertation, derivation of compensation measures has been approached based on descriptions of individual ecological impacts: habitat loss, disturbance and so on. There were two reasons for this choice. The first is that the ecological compensation principle requires proper understanding of the ecological impacts of development projects, and that understanding is currently best provided by 1-to-1 mapping between ecological impacts and compensation. The second is practical: in Dutch planning procedures for development projects it has long been customary to derive individual ecological impacts and, for this reason, it is this approach that enjoys greatest public support in the Netherlands (as evidenced by public participation in Routing EIAs). However, from a purely methodological angle there is no inherent reason why compensation should be derived from individual impacts rather than from some kind of aggregate impact arising as a result of possibly interrelated impacts. Indeed, each approach has its pros and cons.

In the approach based on description of individual impacts (this dissertation) it is assumed that the ecological impacts of a given road project occur independently and compensation measures are then derived for each individual impact on a 1-to-1 basis. The advantages of this approach are its transparency and reproducibility. In reality, though, impacts are not unconnected and in the ‘1-to-1’ approach there is therefore a need to introduce a certain bias later to correct for any overlap, i.e. ‘double counting’. In one of the national road projects reviewed (see Chapter 5) such a correction was indeed made.

In the planning phase of Dutch national road projects, compensation measures are usually derived using numerical rules of thumb, permitting fairly rapid, straightforward and standardised derivation of individual impacts and measures. These may be based on criteria amenable to direct measurement, such as the physical area of habitat lost to the project. They may also be based on empirically determined dose-effect relationships. An illustration of the latter is a rule of thumb that is widely employed in the Netherlands, viz. in the noise-affected zone of national roads in the peat meadow district the breeding bird population is 35% lower (Reijnen *et al.* 1996). In this case, '1-to-1' compensation means that an area equal to 35% of the noise-affected area must be developed as new habitat in the EMS outside the zone impacted by the road. The basic assumption here, of course, is that a 35% decline in breeding birds implies the loss of 35% of suitable breeding habitat in the affected zone. The rules of thumb currently used for setting compensation levels thus stand in proven or reasoned relationship with the project's ecological impacts.

9.4.2 Compensation measures derived from integrated impacts

In the 'integrated' approach, by contrast, the point of departure is that infrastructure impacts do not occur in isolation but as a coherent whole, as when population models are used (cf. Chapter 7). In this approach the basket of compensation measures is similarly based on coherence, with a corrective bias introduced either beforehand or concurrently with derivation. The advantage of this approach is that it is, in principle, closer to reality. Compared with the '1-to-1' methodology, however, there are two main drawbacks: it is less transparent and reproducible, and it introduces additional uncertainties, because all manner of assumptions must be made in modelling interactions among individual impacts as well as in deriving an integrated compensation plan.

9.4.3 Compensation measures derived from indices

One logical development to have emerged from this approach is the use of (integrated) indices to establish appropriate compensation measures, a key example being the compensation ratios used in the United States ('ratios of replaced to lost area') (Allen & Feddema 1996) (cf. Chapter 1). Considerations of both time and budget (derivation of compensation measures on a project-to-project basis will require time and considerable investments) and methodology (ecological impacts do not occur independently) justify developing appropriate indices for the '1-to-1' approach, too. In *establishing* such indices, it is desirable for achieving no-net-loss of ecological values that they stand in recognisable relationship with predicted ecological impacts. They can best be established on the basis of post-hoc evaluation of completed compensation plans. In *applying* such indices, once established, although the relationship between impacts and measures need not necessarily still be explicit, it is essential that the indices command sufficient support among all parties. For this reason, indices need to be simple and transparent. Against this background, a basic index for deriving compensation measures for Dutch national road (building and widening) projects might be derived simply from the acreage of EMS that is physically affected, introducing a possibly reasoned bias for the dimensions and type of project and the types of ecosystem. An rough-and-ready index of this kind can already be developed, to serve as a provisional standard amenable to further elaboration and review as our knowledge improves. There is no reason to delay such a move on the grounds of insufficient ecological data. Our knowledge of the issues concerned will never be complete and in fact there is always a point at which new data no longer increase basic public support for use of indices in this context. The indices proposed here for the Netherlands are comparable to the compensation ratios in force in the US, albeit that the latter are rooted more in institutional mandate and far less in actual ecological impact descriptions.

Based on rough, initial calculations on the seven compensation plans currently in progress in the Netherlands (Chapter 5), a compensation index has been derived from the distance over which the EMS is bisected. In doing so, a distinction has been made between road projects concerned mainly with construction and with widening. No distinctions have been introduced with respect to the type or quality of habitat lost, however. For road construction projects, the index ‘ha compensation per ha bisected EMS’ (right-hand column of Table 1) is broadly similar to the compensation ratios used in the US, with respective values of 3-5 and 1-4 (see Chapter 1).

Table 1: First-pass indices for deriving compensation measures for ecological impacts of Dutch national roads (EMS = Ecological Main Structure).

	Index / highway compensation ratio (ha compensation per km bisected EMS)	**Index / highway compensation ratio (ha compensation per ha bisected EMS)**
Main focus on road widening*	5-10	1-2
Main focus on roads construction*	15-25	3-5

* Assumed an average land take for road widening and construction of 2 and 5 ha/km road, respectively.

9.5 Problems encountered in practice

In this dissertation a number of problem areas have been identified in applying the compensation principle in national road projects (see Chapter 8 and this chapter). These can be summarised as follows:

- in terms of methodology and procedure, no clearly defined route for translating the compensation principle into the practical terms of a CP;
- problems with CP implementation, particularly in terms of site acquisition, the unprogrammed nature of the measures involved, sharp rises in land prices, and only modest success with farm-based implementation;
- the absence of procedures for evaluating and monitoring CP implementation;
- a lack of knowledge, particularly regarding certain specific ecological impacts of infrastructure projects and the effectiveness of mitigation and compensation measures.

Recommendations for addressing these problems are presented in Chapter 10.

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Chapter 10

General conclusions, recommendations, perspectives and summarising conclusions

General conclusions, recommendations, perspectives and summarising conclusions

10.1 General conclusions

Based on the summary of results (Chapter 8) and the discussion (Chapter 9) the following conclusions can be drawn.

1. The ecological compensation principle, adopted as a policy principle in 1993 in the Dutch Structure Plan for the Rural Areas, is now a self-standing element of Dutch planning and decision-making on national road-building projects. In all such projects anticipated ecological impacts and associated compensation measures are now taken on board throughout the various phases of the decision process. The Ministry of Transport, Public Works and Water Management, via the Directorate-General of Public Works and Water Management, *Rijkswaterstaat*, has thereby achieved improved input of conservation interests in development project decision-making as a logical consequence of the ecological compensation principle.

2. The result of certain infrastructure alternatives or variants of national road schemes being abandoned during the planning stage as unrealistic given the scale and cost of the compensation measures implied, confirms that the compensation principle indeed leads to avoiding ecological damage in protected areas. In addition, during the planning phase (going from the Routing EIA to the Routing Decision), the compensation costs associated with Dutch highway projects appear to decrease significantly. It can be concluded that the ecological compensation principle is a powerful instrument for reducing the negative impacts of infrastructure.

3. Routing Decisions on national road projects currently embody a dual decision: first, on the envisaged costs and benefits and perceived necessity of the project and, second, on the scale and nature of the mitigation and compensation measures required. This conflicts with the basic aim of the compensation principle, which is to treat these issues in tandem. At the same

time, though, the present procedure provides a financial incentive for developers to seek infrastructure alternatives having minimal ecological impact, thereby reducing overall compensation costs.

4. Given the relatively lengthy nature of the decision process as well as the time required to actually implement compensation measures, it is still too early (now, in 2004) to assess the degree to which the compensation principle has led, in the Netherlands, to no-net-loss of ecological values by mitigating and compensating for the ecological damage caused by road projects.

5. There are still no standard guidelines on how the compensation principle is to be interpreted in the actual planning and implementation of compensation measures. This is due, in the first place, to the lack of a clear definition of no-net-loss of ecological values and the ambiguous status of ecological compensation within the overall framework of conservation policy. Second, there are no substantive criteria or procedural guidelines available to project initiators for facilitating choices on such matters as:
   - type of compensation (in-kind, out-of-kind, financial)
   - physical location of compensation sites (on-site versus off-site compensation)
   - the relative proportion of mitigation and compensation measures.

   On each of these issues the developer's obligations are unclear, and the same holds for the permissibility of alternatives to physical compensation.

6. The lack of standard guidelines for implementing the compensation principle (see previous conclusion) means that every new national road project sees a rehash of discussions between *Rijkswaterstaat*, as project initiator, and other parties (provincial and municipal authorities, environmental groups, private citizens) about the appropriate nature and scale of compensation and the sites to be used to that end. This process of consultation and consensus-building takes up a disproportionate amount of time and also makes it unpredictable what form compensation will ultimately take.

7. As a policy tool for addressing the ecological impact of Dutch national road projects, the compensation principle is used basically for the quantitative purpose of maintaining the overall size of target species populations.

8. The time horizon of a compensation plan (CP) (several years) means that the compensation measures actually implemented will differ to a greater or lesser extent from the original CP specifications. Given the voluntary nature of compensation, moreover, its success hinges very much on other development schemes (local, regional) rather than being integrated with them.

9. To varying degrees, the following issues all have a negative impact on achieving no-net-loss of ecological values:
   - Absence of a legal footing for the ecological principle.
   - Gaps in knowledge about certain ecological impacts of infrastructure.
   - Gaps in knowledge about the effectiveness of mitigation and compensation measures at the population level.
   - Absence of provisions for monitoring and evaluating CP implementation and the instruments employed to that end.
   - Absence of ex-post evaluation of decisions on specific forms of ecological compensation or the underlying methods used to predict ecological impacts and derive appropriate mitigation and compensation measures.
   - Lack of contingency planning as part of a CP.
   - Uncertainty about the success of current farm-based management regimes and the long-term preservation of ecological values by farmers.
   - Mismatch between ‘supply’ and ‘demand’ of ecological data in the respective phases of planning and decision-making.
   - Uncertainty about the point in time at which the project initiator is relieved of the obligation to compensate.
   - Uncertainty about the relationship between long-term management of compensation sites and the funding programme of the Ecological Main Structure.
   - Favouring ‘patchy’ compensation over large sites, generally reducing overall ecological effectiveness.
   - Low land mobility and the associated rise in real estate prices.
   - Competition of ecological compensation with other development projects for land and with the land required for the roadway itself.

10. Engaging interest groups in the articulation of a CP has benefits in the implementation phase as they have plenty of local as well as general

ecological knowledge and are consequently in a good position to assess the feasibility of proposed compensation measures. Additionally, their contribution increases public support for ecological compensation. Farmers seem to be in a good position to implement compensation measures to enhance ecological values in agricultural regions. Farmer management of compensation sites generally does away with the need for land purchase or rezoning. Yet, it is unclear whether the aim of no-net-loss of ecological values and long-term preservation can be secured under current farm-based management regimes.

11. The ecological compensation principle can only be fully effective in preventing decline of the Ecological Main Structure (EMS), in terms of both area and quality, if it compensates on a truly ‘1-to-1’ impact basis, with a new stretch of national road through the EMS only being approved if an equal length of national roadway (in the EMS) is taken out of service.

12. In this dissertation, derivation of compensation measures has been approached based on descriptions of individual types of ecological impact. Although there are no substantive reasons why compensation measures should no longer be derived from individual types of impact, it would seems sensible from a practical perspective to develop some kind of standardised index.

13. In line with this, current procedures for deriving the scale and nature of compensation measures for Dutch national road projects should be superseded by standardised and thus more user-friendly indices, in the form of standardised ecology- or infrastructure-related ratios, for example. Before such indices can be satisfactorily underpinned, however, the current procedure for deriving compensation measures from impact predictions must first be further refined.

14. The compensation principle can be extended with landscape issues, by formally obliging developers to compensate for any damage caused to landscape elements and functions. A further area to which the principle might also be extended is rural development. Rather than taking just an individual approach, a far broader package of compensation measures could

be drawn up benefiting the entire community. The goal would then be to improve the overall ‘quality of life’ of the local community, for example. As infrastructure development schemes generally affect public health, compensation could be in the form of new indoor sports facilities.

10.2 Recommendations

This section presents the recommendations of this study, which have been distilled from the summary of results (Chapter 8), discussion (Chapter 9) and general conclusions (section 10.1).

1. The policy framework of the ecological compensation principle as applied in the Netherlands needs to be elaborated in greater detail, especially with respect to:
   a. the precise definition of no-net-loss of ecological values;
   b. substantive criteria and procedural guidelines to help project initiators make choices on:
      - the kind of compensation (in-kind, out-of-kind and financial compensation) to be implemented
      - the point in time and efforts to be made before project initiators are relieved of the obligation to undertake physical compensation
      - the physical location of compensation sites
      - protection of the compensation sites in the longer term, particularly with respect to arrangements for long-term management, funding and planning restrictions
      - the relative proportion of mitigation and compensation measures;
   c. the status of ecological compensation within the overall policy framework.

2. For each of the infrastructure alternatives developed, the following issues should be duly studied in the (Routing) EIA phase: (a) the ecological values anticipated to be lost or impaired through road construction as well as their ‘replaceability’, (b) the time required for compensation sites to develop and the predictability of the substitute ecological values proposed as compensation for losses, and (c) basic guarantees that the compensation measures will be properly implemented, i.e. that suitable compensation sites will become available in due course. For the alternative ultimately adopted,

these issues must also be documented in greater detail in the Routing Decision phase.

3. Decisions on national development projects should remain unaltered, embracing two simultaneous decisions: on the costs, benefits and necessity of the project at hand, and on the mitigation and compensation measures required. While this conflicts with the basic aim of the compensation principle, it does mean that reduction of ecological damage (and attendant compensation costs) will remain a factor steering development of infrastructure alternatives.

4. The targets specified in the compensation plan (CP) should have a degree of flexibility, giving permissible margins for deviating from original specifications without jeopardising the overall aim of no-net-loss.

5. ‘The ‘patchy’ compensation currently favoured by the CP implementation framework should be minimised by combining compensation projects with implementation of reallotment schemes, the Ecological Main Structure and/ or other nature development projects. As a further option for reducing ‘patchiness’ consideration should be given to developing ‘compensation banks’ in the Netherlands, modelled on the US ‘mitigation banks’, physically combining compensation for different development projects into larger, contiguous areas. Both actions would lead to larger, more contiguous areas of nature, improving the overall effectiveness of ecological compensation.

6. The targets specified in the CP should lay down the required scale and quality of compensation measures rather than financial targets, to ensure the compensation budget does not later prove inadequate for securing ecological targets owing to rising land prices or other developments in the course of CP implementation.

7. There is an urgent need to monitor the implementation of mitigation and compensation measures and evaluate their effectiveness, for several reasons: (a) to establish the extent to which the CP indeed achieves no-net-loss of ecological values, and (b) to assess how previously specified contingency measures might usefully be applied during CP implementation. This will

contribute to the development of systematics for demonstrating achievement of no-net-loss of ecological values.

8. The ecological compensation principle should be given formal legislative footing, giving citizens the right of appeal if a CP fails to achieve the scheduled outcome and giving project initiators more incentive to implement compensation measures according to specification. In this context greater use should be made of the existing legal provisions of the Routing Decision for expropriating lands for ecological compensation of road-building impacts, particularly when there is a threat to ecological values that are irreplaceable or hard to replace. This would put ecological compensation on the same legal footing as the road project itself.

9. National governments should adopt a coherent vision on farm-based management of road project compensation sites, indicating the terms under which this type of management qualifies as securing no-net-loss of ecological values under various conditions: with or without state acquisition of the farmland concerned, and with or without the zoning status of the sites being revised. *Rijkswaterstaat* should engage farmers more closely in implementing ecological compensation measures in farming regions, even when this involves no more than site management, i.e. with no change in site ownership. This would mean both the ‘pain’ and the ‘gain’ of a national road project being passed on to the region where the project is being implemented.

10. To increase public support for ecological compensation, any residual funds paid into the Green Fund after due completion of the compensation procedure should be earmarked for regional development via culture- and landscape-related policies.

11. To secure the aim of no-net-loss of ecological values in the context of national road projects, basic rules should be drawn up for establishing: (a) how project specifications are to be translated into likely ecological impacts, particularly with respect to barrier effects, ‘road kill’, roadway illumination and hydrological changes, and (b) the effectiveness of both mitigation and compensation measures.

12. The compensation principle should be extended in scope to encompass landscape issues, such as historical allotment patterns and local roads of recreational value, and be integrated in the wider realm of rural and regional development. This would allow for compensation of a broader range of impacts, still on 1-to-1 impact basis, and provide an opportunity to improve the overall ‘quality of life’ of the local or regional community in terms of health, employment and wider issues of nature conservation. This would probably mean greater public support for the compensation principle.

13. A method should be developed for deriving mitigation and compensation measures for national roads using integrated, standardised indices so that appropriate measures can be designed with a minimum of time and effort. This method can only be underpinned satisfactorily if impact predictions are further refined.

10.3 Perspectives

In the Netherlands, the ecological compensation principle has rapidly become a familiar planning concept at *Rijkswaterstaat*. Despite the cited implementation problems, it proved to be an effective tool for steering infrastructure development projects and for implementing ecological measures in these projects. As of 2004 the main focus of government roads policy is on improved management and upkeep of existing roads (MTPW 2004). Consequently, more so than in the past the coming years will see a shift in focus at the national level from road-building to better utilisation and relatively minor widening of existing roads. Until about 2010, then, road projects are unlikely to involve any major obligations vis-à-vis compensation. Given the progressive aging of the Dutch population and the relative scarcity of real estate this may also hold beyond that date, reducing the future need for infrastructure expansion and thus pressure on the Netherlands’ remaining green areas.

At the same time, the Dutch government is delegating ever more responsibilities in the realm of physical planning to provincial and municipal authorities (MHPE *et al.* 2004), which are thus acting increasingly as ‘competent authorities’ with respect to development schemes. Regardless of which way public preferences regarding nature and conservation sway, this devolution of powers is leading to an accelerated blurring of the boundaries between ‘green’ and ‘red’, between ‘natural’ and ‘built-up’, and thus to further urbanisation (as evidenced by developments in Holland’s ’Green Belt’). The ecological compensation principle must be used to help counter this trend, by continuing to focus on avoidance and mitigation of the impacts of development projects and using impact compensation only as a ‘final strategy’ in the planning process. If ‘green’ areas are to remain truly intact, however, some kind of permanent government steering is required at the *(inter)national* level, as is the case with areas protected by the EU’s Birds and Habitat Directives.

Two remarks are in order here. First, it should be realised that development projects may sometimes create new opportunities for nature. Thus, unexpected emergence of a major new site, following closure of a civilian or military airfield, say, can be used to ‘bundle’ compensation obligations arising from several different infrastructure projects (known in the US as ‘mitigation banking’). The ecological returns will then generally be far greater than with separate compensation of each project individually. As yet, these are choices for which politicians bear prime responsibility, but whatever the case, this kind of decision will always need administrative and public support. One way to secure such support is to try and ensure that the ‘burdens’ of infrastructure projects (negative impacts) and the ‘joys’ (improved local income and broader quality of life through compensation measures) accrue to one and the same region (cf. § 9.3.2). The second thing to note is that public demand for new infrastructure may occasionally open up opportunities for nature conservation as well nature development. For example, as access to a rural area is improved through construction of a new road, some of the revenues from the ensuing house-building might be spent on ‘green’ projects. Thus, some of the income earned on ‘luxury’ housing projects, i.e. free-standing country homes set in a relatively large expanse of land, might be used to create an ecological corridor for large mammals (Schreuder 2004).
While there may be exceptions, none of this detracts from the fact that the paving-over and cross-cutting of land is an international, irreversible process. In this context the ecological compensation principle has proven to be a useful planning concept that can help counter the prevailing trend of ecological values being sacrificed to economic growth. At the same time, however, it should be borne in mind that the compensation principle makes a sharp distinction between

designated 'natural areas' and other areas, protecting only the first category (no-net-loss) and permitting development schemes in the second category. Under certain circumstances, schemes may still be approved in natural areas, however, and these will therefore never be entirely free of threat. In fact, the ecological compensation principle can only be effective in preventing decline of the Ecological Main Structure (EMS), in terms of both area and quality, if it compensates on a truly '1-to-1' impact basis, with a new stretch of national road only being approved if an equal length of national roadway is taken out of service elsewhere. In the Netherlands the first move in that direction is being taken with the N34 Ommen bypass, for which a (Preliminary) Routing Decision is in preparation that will embody a decision on construction of a new bypass through a rural area to the north of Ommen. A related decision under municipal planning procedures will provide for degradation of the existing bypass south of Ommen, which cuts through the EMS, to the 'lower-level' road network (pers. comm. B. Stegehuis, Oost-Nederland Directorate). The second decision involves a change in land-use designation, viz. withdrawal from the national road grid. This initiative is an implementation of the German principle of *Entsieglung* (INN 1991) under which any 'hardening' of land due to development must be compensated by physical 'softening' elsewhere, so that the total area of nature remains the same (road construction and compensation both in the EMS) or even increases (infrastructure outside, compensation inside the EMS). This dovetails perfectly with the philosophy of the ecological compensation principle, for ridding the EMS of 'hardened' elements has two positive effects. In the first place, it means an improvement in quality unforeseen when this 'green backbone' was first envisaged (MANF 1990). Secondly, demand for land for nature development is not shifted so much onto farming districts.

Although there have been ups and downs, since the 1960s nature conservation – understood as protection of traditional 'heritage' sites as well as 'nature development' – has become embedded ever more firmly in legislative and regulatory frameworks, at both the national and international level, and continues to have implications for many sectors of society and certainly for transport (Canter 1977, Cramer 1989, EC 2003, Luell *et al.* 2003, Van Bohemen 2004). In the Netherlands a long-term programme on 'defragmentation' is to be implemented in 2004 (MANF & MHPE 1993, MTPW 2003, MTPW *et al.* 2004). This programme, with a horizon up to 2018, provides for implementation of a broad package of measures to reduce the impact of national transport infrastructure (national roads, railways and canals) involving total investments of several hundred million Euros. This is an example of national policy, but increasingly it seems to be EU legislation that will afford secure protection of Dutch ecologies. The European Birds and Habitats Directives, implemented nationally in the Flora and Fauna Act and the 'new' Nature Conservation Act, guarantee far tougher area and species protection than the 'no unless' policy of the National Structure Plan for the Rural Areas. When it comes to ecological compensation, the European directives differ from this earlier policy framework in several key ways (EC 2000):

- the duty to compensate applies not only to tangible development projects, but to any policy plans having physical planning implications;
- barring exceptional circumstances, compensation sites must already have been secured when the affected area first suffers damage;
- no distinction is made between in-kind vs. out-of-kind or on-site vs. off-site compensation, because the aim of the EU directives is to ensure conservation of the essential features of all protected areas and the overall coherence of the 'Natura 2000' ecological network;
- there is no role for financial compensation, only for physical compensation.

In addition to the EU's Birds and Habitats Directives, EU legislation on 'Strategic Environmental Assessment' (2001/42/EC) also came into in force recently. This legislation seeks to counter the failure of the Environmental Impact Assessment (EIA) at the project level, to give adequate consideration to potentially serious transboundary, widespread, indirect, cumulative and synergistic ecological effects (Treweek *et al.* 1998). Under this legislation, which is explicitly linked to the Birds and Habitats Directives, in the very near future not only development projects but also policy plans and programmes will be subject to the requirement that alternatives with less environmental (including ecological) impacts must also be developed (De Haas 2004). However, even under these new regimes the Netherlands still has only limited legislative means at its disposal for acquiring lands for achieving compensation objectives and so standing planning European procedures will still have to be employed to that end. In this sense, then, the empirical data reported in this dissertation retain their general validity and usefully employed in the context of governmental plans (programmes) and specific projects.

10.4 Summarising conclusions

1. Since being introduced in the Netherlands in 1993, the ecological compensation principle has played a key role in planning, decision-making and implementation vis-à-vis national road projects, i.e. projects requiring an Environmental Impact Assessment and subject to the terms of the Routing Act. The principle has proved its worth as a viable planning concept that can contribute to countering the prevailing trend of ecological values being sacrificed to economic growth. Ecological compensation works well as an element and as the final of an overall procedure and is a promising way to incorporate conservation interests in planning, decision-making and implementation vis-à-vis development projects, specifically national road projects. It remains essential, though, that the sequential strategy of avoidance, (then) mitigation and (only then) compensation be adhered to in addressing project impacts, and that all interests be carefully balanced throughout the decision-making process.

2. From the material brought together in this dissertation the following provisional ‘final’ conclusion can be drawn. Despite no compensation plans for national road projects yet having been completed and evaluated in the Netherlands, there is strong evidence that area targets are generally secure, despite rising land prices and declining regional availability of suitable sites. Because ecological values at compensation sites take far longer to develop than the horizon of compensation plan implementation, however, quality targets are not always assured. It therefore seems advisable to establish a contingency planning process for ensuring that ecological quality targets are indeed achieved at each site. Although the principle of ecological compensation can now be physically implemented, then, the quality aspect still requires further scientific and procedural elaboration.

3. In the near future the ecological principle should be further refined, for example by: (a) introducing more stringent conditions (‘a new stretch of national road through the EMS only being approved if an equal length of national road (in the EMS) is taken out of service elsewhere’), (b) developing some kind of standardised index for integrated impact description, and / or (c) developing standard ratios with which to derive compensation measures,

the two latter for reasons of efficiency. The principle might also be extended to encompass landscape and / or rural development issues, as a means of increasing public support for the compensation principle, now extended to the ‘quality of life‘ of the local community.

4. The new EU regimes, i.e., the Birds and Habitat Directives and the Strategic Environmental Assessment, still have only limited legislative means at their disposal for acquiring lands for achieving compensation objectives. In this sense the results of this dissertation can be usefully employed in the context of governmental plans (programmes) and specific projects.

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Curriculum Vitae

Ruud Cuperus werd op 31 mei 1958 te 's-Gravenhage geboren. In 1975 en 1977 behaalde hij het HAVO-diploma aan de Scholengemeenschap 'Overvoorde' resp. het VWO-diploma aan de SG 'Groen van Prinsteren', beide te 's-Gravenhage.

In 1977 begon hij met de studie Biologie aan de Rijksuniversiteit Leiden, en behaalde hij daar in 1981 en 1982 het Kandidaatsexamen Biologie Algemene Richting, resp. het Kandidaatsexamen Biochemie. Hoofdvakken waren:

- Dierenecologie ('Computersimulaties en analyse van bestaande tijdreeksen van vogeltellingen', begeleider drs. G.J. de Bruyn, Rijksuniversiteit Leiden)
- Microbiologie ('Bodemactiviteit in Nederlandse representatieve bodems', begeleider dr. C. van Kreyl, Rijksinstituut voor Volksgezondheid en Milieuhygiëne, Leidschendam).

Bijvak was Aquatische ecologie ('Bioactiviteit in natuurlijke watersystemen'; begeleider dr. C.E. Wickstrom, Kent State University, Ohio, USA). In 1985 werd de studie Biologie afgerond.

In 1985 werkte hij enkele maanden bij DHV Raadgevend Ingenieursbureau BV te Amersfoort ten behoeve van het Milieueffectrapport 'C2-deponie op de Maasvlakte'. Direct daarna vervulde hij tot eind 1987 de militaire dienstplicht (opleiding voor reserve-officieren, Bussum en Ermelo).

In de periode eind 1987 – medio 1995 was hij grotendeels in deeltijd werkzaam als wetenschappelijk medewerker bij het Centrum voor Milieukunde (CML) van de Universiteit Leiden. Vanaf eind 1987 tot en met 1991 was hij tegelijkertijd ook werkzaam als secretaris Ecologie bij de Raad voor het Milieu- en Natuuronderzoek (RMNO), Rijswijk. In 1988-1989 onderbrak hij zijn dienstverband bij het CML voor een jaar en werkte hij als beleidsmedewerker bij de Rijksplanologische Dienst (RPD, VROM), 's-Gravenhage, aan het project Landschapsecologische Kartering van Nederland (LKN). Bij het CML werd de kiem gelegd voor de promotie, het eerste artikel van dit proefschrift werd in deze periode geschreven en gepubliceerd.

Vanaf medio 1995 tot op heden werkte hij bij Rijkswaterstaat, Dienst Weg- en Waterbouwkunde (DWW); eerst 7 jaar als projectleider / specialist Ecologie, en vanaf medio 2002 als projectmanager Natuur en Landschap, beide bij de afdeling Infrastructuur Milieumaatregelen.

Nawoord

De wetenschappelijke fundamenten voor dit proefschrift zijn begin jaren ’90 gelegd toen ik bij het Centrum voor Milieukunde van de Universiteit Leiden (nu: Centrum voor Milieuwetenschappen) werkte. Het was voor mij een unieke gelegenheid het werk voor het proefschrift te kunnen te voortzetten bij de Dienst Weg- en Waterbouwkunde (DWW) van Rijkswaterstaat, in het hart van de organisatie waar tal van rijkswegenprojecten te maken krijgen met het natuurcompensatiebeginsel. Het werken op het snijvlak van de wetenschap en de praktijk is de *core business* van de DWW als adviesdienst; en voor mij is het bij de DWW werken aan het proefschrift op dit snijvlak een zeer inspirerend meerjarenproject geweest. Ik kijk daar dan ook met veel plezier op terug.

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