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Ecological compensation of the highway impacts: *Negotiated trade-off or no-net-loss?*

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 concerned¹.

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 reallocation 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 years². 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 reallocation 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 than 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 from 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 seem 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 from 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.

