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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 CO₂ 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 compensation 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 km², 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 a sewer/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 ^h	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 $1\frac{2}{3}$, 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	MTPW	MTPW	nr
(year of publication)	(1998c)	(1998d)	
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 reallocation 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 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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References

- Allen, O.A. and J.J. Feddema (1996). Wetland loss and substitution by the Section 404 permit program in southern California. *Environmental Management* 20(2): 263-274.
- Andries, K. (1994). Implementing wetland policy: lessons from the United States. In: Wetland policy implementation in Canada; proceedings of a national workshop, ed. C. Rubec, pp. 77-86. North American Wetlands Conservation, Canada.
- Backes, Ch. (1994). Possibilities and impossibilities within the Spatial Planning Act for compensation for the loss of ecological qualities (Mogelijkheden en onmogelijkheden binnen de WRO voor compensatie van het verlies van natuurwaarden). *Bouwrecht* 12: 981-987.
- Bal, D., H.M. Beije, Y.R. Hoogeveen, S.R.J. Jansen and P.J. van der Reest (1995). Nature Target Type Manual (Hand-boek Natuurdoeltypen). Ministry of Agriculture, Nature Management and Fisheries, Wageningen, The Netherlands.
- Brinson, M.M. and R. Reinhardt (1996). The role of reference wetlands in functional assessment and mitigation. *Ecological Applications* 6(1): 69-76.
- Cuperus, R. (1996). Interim Manual on Ecological Compensation (Voorlopig Handboek Natuurcompensatie). Director-ate-General for Public Works and Water Management, Road and Hydraulic Engineering Division, Delft, The Netherlands.
- Cuperus, R., K.J. Canters and A.A.G. Piepers (1996). Ecological compensation of the impacts of a road; preliminary method for the A50 road link (Eindhoven - Oss, the Netherlands). *Ecological Engineering* 7: 327-349.
- Cuperus, R., K.J. Canters, H.A. Udo de Haes and D.S. Friedman (1999). Guidelines for ecological compensation associated with highways. *Biological Conservation* 90: 41-51.
- Hill, D., D. Hockin, D. Price, G. Tucker, R. Morris and J. Treweek (1997). Bird disturbance: improving the quality of disturbance and utility of disturbance research. *Journal of Applied Ecology* 34: 275-288.
- von Kiemstedt, H., M. Mönnecke and S. Ott (1996). Method of the Eingriffsregelung; example of the application of §8 of the federal Nature Conservation Act (Methodik der Eingriffsregelung; Vorschläge zur bundeseinheitlichen Anwendung von §8 BNatSchG). *Natur und Landschaftsplanung* 28(9): 261-271.
- de Laat, F.G.M. (1997). Ecological compensation in spatial developments; an administrative-juridical reflection (Natuurcompensatie bij ruimtelijke ingrepen; een bestuurlijk-juridische beschouwing). *Agrarisch Recht* 10: 470-488.
- MANF (1990). National Nature Policy Plan (Nationaal Natuurbeleidsplan). Ministry of Agriculture, Nature Management and Fisheries, The Hague, The Netherlands.
- MANF (1994). Report on Ecosystem Perspectives for the National Ecological Network (Nota Ecosysteemvisies; drie-sporenbenadering voor de Ecologische Hoofdstructuur). Ministry of Agriculture, Nature Management and Fisheries, The Hague, The Netherlands.

- MANF (1995). Explanatory notes on application of the compensation principle in concrete projects (Toelichting op de toepassing compensatiebeginsel in concrete projecten). Ministry of Agriculture, Nature Management and Fisheries, The Hague, The Netherlands.
- MANF and MHPE (1993). National Structure Plan for the Rural Areas (Structuurschema Groene Ruimte, kabinetsstandpunt, deel 3). Ministry of Agriculture, Nature Management and Fisheries and Ministry of Housing, Physical Planning and Environment, The Hague, The Netherlands.
- Marsh, L.L., D.R. Porter and D.A. Salvesen (Eds.) (1996). Mitigation Banking; theory and practice. Island Press, Washington, D.C.
- Meier, H. (1987). The Eingriffsregelung of the Nature Conservation Act of Niedersachsen (Die Eingriffsregelung der Niedersächsisches Naturschutzgesetzes). Schriftenreihe Naturschutz und Landschaftspflege in Niedersachsen, no. 16, Hannover, Germany.
- MHPE (1989). National Environmental Policy Plan (Nationaal Milieubeleidsplan). Ministry of Housing, Physical Planning and Environment, The Hague, The Netherlands.
- MTPW (1990). Second National Transport Structure Plan (Tweede Structuurschema Verkeer en Vervoer). Ministry of Transport, Public Works and Water Management, The Hague, The Netherlands.
- MTPW (1992). Commencing Document on A4 Dinteloord-Bergen op Zoom, A16 Moerdijk-Breda (Startnotitie A4 Dinteloord-Bergen op Zoom, A16 Moerdijk-Breda). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1993a). Commencing Document on A2 Bypass Road (Startnotitie A2 Rondweg 's-Hertogenbosch / Knooppunt Empel - knooppunt Vught). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1993b). Commencing Document on A4 Delft-Schiedam (Startnotitie A4 Delft-Schiedam). Directorate-General for Public Works and Water Management, Zuid-Holland Directorate, Rotterdam, The Netherlands.
- MTPW (1994a). Commencing Document on Widening the A2 (Startnotitie verbreding A2). Directorate-General for Public Works and Water Management, Gelderland Directorate, Arnhem, The Netherlands.
- MTPW (1994b). Commencing Document on Tangenten Eindhoven (Startnotitie Tangenten Eindhoven). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1995a). Routing Study on A4 Dinteloord-Bergen op Zoom, A16 Moerdijk-Breda (Trajectnota A4 Dinteloord-Bergen op Zoom, A16 Moerdijk-Breda). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1995b). Routing Study on A2 Bypass 's-Hertogenbosch (Trajectnota A2 Rondweg 's-Hertogenbosch). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.

- MTPW (1995c). Micropollution along motorways: an evaluation. Directorate-General for Public Works and Water Management, Road and Hydraulic Engineering Division, Report W-DWW-95-735, Delft, The Netherlands.
- MTPW (1996a). Commencing Document on A15 Varsseveld-Enschede (Startnotitie A15 Varsseveld-Enschede). Directorate-General for Public Works and Water Management, Oost-Nederland Directorate, Arnhem, The Netherlands.
- MTPW (1996b). Routing EIA Study on A4 Delft-Schiedam (Trajectnota/MER A4 Delft-Schiedam). Directorate-General for Public Works and Water Management, Zuid-Holland Directorate, Rotterdam, The Netherlands.
- MTPW (1996c). Assistance on evaluating road infrastructure EIAs (Handreiking evaluatie m.e.r. weginfrastructuur). Directorate-General for Public Works and Water Management, Road and Hydraulic Engineering Division, Report W-DWW-96-045, Delft, The Netherlands.
- MTPW (1997a). Routing Study on A2 Vianen-'s-Hertogenbosch (Trajectnota A2 Vianen-'s-Hertogenbosch). Directorate-General for Public Works and Water Management, Oost-Nederland Directorate, Arnhem, The Netherlands.
- MTPW (1997b). Feasibility study on compensation plan for A4 Midden-Delfland (Haalbaarheidsstudie compensatieplan A4 Midden-Delfland). Directorate-General for Public Works and Water Management, Zuid-Holland Directorate, Rotterdam, The Netherlands.
- MTPW (1998a). Routing EIA Study on A2 Tangenten Eindhoven (Trajectnota/MER A2 Tangenten Eindhoven). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1998b). Routing Study on A15 Varsseveld-Enschede (Trajectnota A15 Varsseveld-Enschede). Directorate-General for Public Works and Water Management, Oost Nederland Directorate, Arnhem, The Netherlands. Internal document.
- MTPW (1998c). Routing Decision on A4 Dinteloord-Bergen op Zoom (Tracébesluit A4 Dinteloord-Bergen op Zoom). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- MTPW (1998d). Routing Decision on A2 bypass 's-Hertogenbosch (Tracébesluit A2 Rondweg 's-Hertogenbosch). Directorate-General for Public Works and Water Management, Noord-Brabant Directorate, 's-Hertogenbosch, The Netherlands.
- National Research Council (1992). Restoration of aquatic ecosystems; science, technology, and public policy. National Academy Press, Washington D.C., USA.
- Nieuwenhuizen, W. and R.C. van Apeldoorn (1995). Mammal use of fauna passages on national road A1 at Oldenzaal. Ministry of Transport and Public Works (Road and Hydraulic Engineering Division, Delft) and DLO-Institute for Forestry and Nature Research (Wageningen), The Netherlands.
- Official Gazette (1965). Environmental Planning Act (Wet op de Ruimtelijke Ordening), no. 286. The Hague, The Netherlands.
- Official Gazette (1851). Expropriation Act (Ontheigeningswet), no. 125. The Hague, The Netherlands.
- Official Gazette (1979). Environmental Protection Act (Wet Milieubeheer), no. 442. The Hague, The Netherlands.

- Official Gazette (1994). Routing Act (Tracéwet), no. 582. The Hague, The Netherlands.
- Official Gazette (1998). Circular on the Routing Act and ecological compensation (Circulaire over Tracéwet and natuurcompensatie), no. 124. The Hague, The Netherlands.
- Province of Gelderland (1998). Draft Revision of Gelderland Regional Zoning Plan (Concept Herziening Streekplan Gelderland). Arnhem, The Netherlands.
- Province of Noord-Brabant (1997). Draft Memorandum on application of compensation principle for nature and landscape, and competence according to the Environmental Planning Act (Notitie toepassing compensatiebeginsel natuur en landschapswaarden en uitoefening van bevoegdheden op basis van de Wet op de Ruimtelijke Ordening; concept). 's-Hertogenbosch, The Netherlands.
- Province of Overijssel (1998). Guidelines for the application of the compensation principle for nature, woods and landscape (Richtlijnen voor de toepassing van het compensatiebeginsel voor natuur, bos en landschap). Zwolle, The Netherlands.
- Reijnen, R., R. Foppen, C. ter Braak and J. Thissen (1995). The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. *Journal of Applied Ecology* 35: 187-202.
- Reijnen, R., R. Foppen and H. Meeuwsen (1996). The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. *Biological Conservation* 75: 255-260.
- Rubec, C.D.A. (1994). Canada's federal policy on wetland conservation: a global model. In: Global wetlands: old world and new, ed. W.J. Mitsch, pp. 909-917. Elsevier Sciences B.V., New York.
- Schemel, H.-J., G. Hartmann and K.-C. Wedekind (1995). Equivalent monetary values for disturbances to natural systems - a method of calculating compensation payments for the mitigation of impacts (Geldwertäquivalente für Beeinträchtigungen des Naturhaushaltes - eine Methode zur Ermittlung des Ausgleichsabgabe bei Eingriffen). *Natur und Landschaft* 70(5): 213-220.
- Swinen, J.F.M. (1997). Does compensation for disruptions stimulate reforms? The case of agrarian reform in Central and Eastern Europe. *European Review of Agricultural Economics* 24: 249-266.
- Treweek, J. (1996). Ecology and environmental impact assessment. *Journal of Applied Ecology* 33: 191-199.
- Treweek, J. and S. Thompson (1997). A review of ecological mitigation measures in UK environmental statements with respect to sustainable development. *International Journal of Sustainable Development and World Ecology* 4: 40-50.
- United Nations (1993). Agenda 21, programme of action for sustainable development; Rio declaration on environment and development, statement of forest principles. UN, New York.
- Wagner, K.K., R.H. Schmidt and M.R. Conover (1997). Compensation programs for wildlife damage in North America. *Wildlife Society Bulletin* 25(2): 312-319.
- Wood, C. (1995). Environmental impact assessment; a comparative review. Longman Harlow, Essex, United Kingdom.
- Zedler, J.B. (1996). A forum on mitigation: an introduction. *Ecological Applications* 6(1): 33-37.

