

## PLANNING METHOD OF ECOLOGICAL NETWORK AND ROAD PROJECTS

Hirofumi OHNISHI, Head  
 Katsumi UESAKA, Senior Researcher  
 Hiroyuki ONEYAMA, Researcher  
 Atsushi KAWAKAMI, Technical Assistant  
 Traffic Environment Division  
 Environment Department  
 Public Works Research Institute  
 Ministry of Construction  
 1, Asahi, Tsukuba-shi, Ibaraki-ken  
 305-0804 Japan  
 Fax: +81-298-64-2274  
 E-mail: ohnishi@pwri.go.jp

Toshihiro KOSUGE, Researcher  
 Karter Art Landscape Consultant Co., Ltd.  
 1-21-10, Yebisu, Shibuya-ku, Tokyo  
 150-0013 Japan  
 Fax: +81-3-3443-6686  
 E-mail: kosuge@kalc.co.jp

**Abstract:** The importance of a linkage among wildlife habitats has been emphasized nowadays in order the ecosystem to be sustainable in a national/regional level. The local ecosystems are conserved and restored even in the urban areas by creating the ecological network in some European countries. In this paper we have proposed a planning method of the ecological network from the viewpoint of road projects in the surroundings of Japan. Firstly, we have outlined the planning process to conserve and restore the ecological network in a district. Secondly, we have analyzed the actual planning method at the grand design stage, which is the first of three stages for the planning process. Finally, we looked at the roles of roads in a context of the ecological network.

**Key words:** Ecological network, Road project, Habitat, Planning method

### 1. INTRODUCTION

The Ministry of Construction, Japan, has implemented the "Eco-road Projects" introducing the concept of mitigation to avoid, minimize and restore effects on the natural environment caused by road projects since early '90s<sup>1)</sup>. Under the Projects an attempt is made to minimize the impacts on the natural environment from the planning stage to the maintenance stage of the road projects. It has lately been considered important not only to reduce the effects of the development projects on the natural environment but also to closely connect wildlife habitats to each other aiming at the conservation of a regional ecosystem<sup>2)</sup>. However the actual method is not established for this purpose.

In this regard they have actively taken action to conserve and restore the regional ecosystem even in the urban areas as ecological network in Europe, etc<sup>3)</sup>. Some instances of the planning method of the ecological network have been shown in Japan by Hioki<sup>4), 5)</sup>. It is considered difficult to directly apply this method to our cases in Japan because of difference in climate, topographical features, social conditions and information related to the regional ecosystem. In this paper we present a planning process to conserve and restore the ecological network in urban areas in the context of the current situation of Japan. At the grand design stage of the ecological network in particular, we present a case study in the northern part of Yokohama city mainly considering terrestrial organisms. Moreover, we have shown the direction of roads' contribution to the ecological network plan and several examples of related mitigation measures. This is only related to the planning process of the ecological network from a viewpoint of the road projects and therefore further discussion would be required from other sectors.

## 2. PROPOSED PLANNING METHOD OF ECOLOGICAL NETWORK

### 2.1 Significance of Ecological Network

The concept of the ecological network was first introduced in Europe. It emphasizes the importance of securing the habitats necessary for the survival of species, and of connecting them to each other for dispersion and movement of the species<sup>3)</sup>. We recognize the habitat as place and environment where a biological community lives<sup>6)</sup>. In the Netherlands they have proposed to arrange the following structural elements of the ecological network: i) core areas; ii) nature development areas; and iii) ecological corridors, under the Nature Policy Plan which is the national policy to conserve the natural environment<sup>7)</sup>. We define the above structural elements as follows:

i) Core areas: Areas which are important and are to be conserved in order to secure the regional biota;

ii) Nature development areas: Areas which are next to the core areas and to be improved qualitatively so as to enlarge the core areas; and

iii) Ecological corridors: Spaces which connect the fragmented core areas and the nature development areas to the other for animals to move among them.

### 2.2 Objectives of Ecological Network Plan

It is required to restore the ecological network for animals to move from one habitat to another as well as to conserve each of the habitats for the survival of living things in an area where the habitats are being fragmented, reduced and disappearing by land development in urban areas<sup>8)</sup>. The objectives of the ecological network plan are to conserve and enhance the bio-diversity through restoring the fragmented and reduced habitats in line with conservation and improvement of the core areas, the nature development areas and the ecological corridors arranged<sup>9)</sup>.

### 2.3 Planning Process of Ecological Network

To prepare a plan of ecological network, there is the need to collect and sort information and data for the natural and social environment of the region, including land use regulations, infrastructure plans, etc. However there is generally insufficient information for the natural environment of the region in Japan. Further since there is no comprehensive plan like the ecological network plan, there is no manner well set up to coordinate several sector projects, relevant to formation of the ecological network, such as road projects, river projects, park projects etc. Nevertheless there is "the Greenery Master Plan" in Japan, which wraps up policies related to conservation and creation of urban plants. This gives a good reference when we prepare the ecological network plan in the urban areas.

In view of the aforementioned, we propose the following three stage planning process to collect the information on the natural environment and to effectively coordinate the relevant sector plans.

#### (1) Grand design of ecological network

In this stage we mainly prepare a rough arrangement plan of the core areas, the nature development areas and the ecological corridors throughout the target area with the information and data of the natural and social environment obtained from the existing materials. We do not have any detailed plan yet at this stage; and therefore coordination is not to be made between the ecological network plan and the related sector plans like the road projects.

#### (2) Master plan of ecological network

In this stage we specify the planning areas and collect information on the natural

environment mainly by site visits and field surveys. We also coordinate the ecological network plan and the other related plans, and decide on which project sites are to be core areas, nature development areas and ecological corridors to be included in the ecological network plan.

**(3) Implementation plan of ecological network**

Actual project contents are studied for each of the core areas, the nature development areas and the ecological corridors established in the previous stage (2).

**3. A PROPOSAL OF PLANNING METHOD FOR GRAND DESIGN OF ECOLOGICAL NETWORK AND A CASE STUDY**

We have outlined the planning process of the ecological network in Section 2.3. We now present a planning method of the grand design of the ecological network and make a proposal for it. Based on this planning method, we carry out a case study for the preparation of the grand design of ecological network mainly considering the terrestrial organisms in the northern part of Yokohama city.

**3.1 A Proposal of Planning Method of Grand Design of Ecological Network**

The grand design is to be examined all over the planning area mainly based on the existing information. We use maps of a scale from 1/25,000 to 1/50,000 which are compatible with the accuracy of the existing information and the size of planning area. Figure 1 shows the planning method of the grand design of the ecological network, and the details of it are as follows:

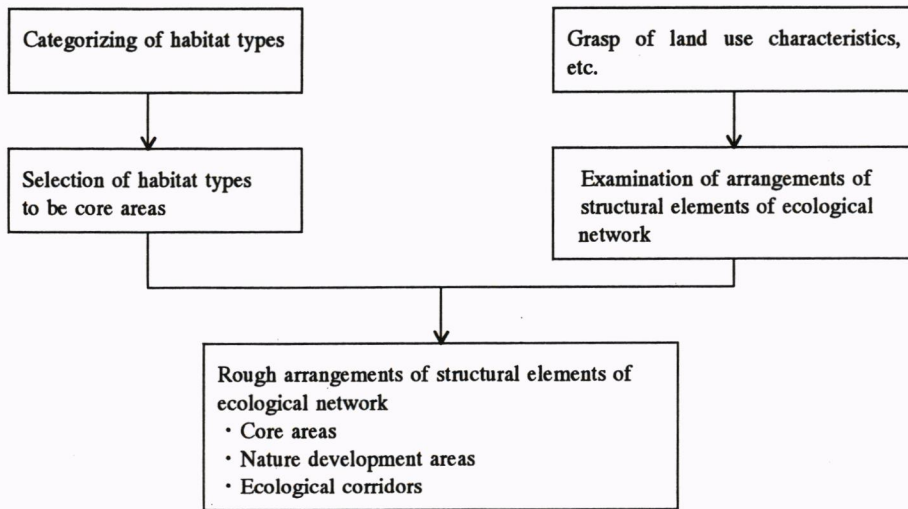


Figure 1 Planning process of grand design of ecological network

**(1) Categorizing of habitat type**

Types of habitats existing in the region are categorized on a basis of combination of basic features such as topographical and geological features, soils, water system and vegetation.

**(2) Selection of habitat types as core area**

Habitats where rare species of national value and regional value inhabit and various types of species to characterize the regions inhabit are selected as candidate of core area based on the categorizing of habitat types as mentioned in (1) above.

### (3) Characteristics of land use in the region

It is required to know the existing land use like the position of forests, lakes and ponds, urban areas, roads, the regulations of land use, the regional development plans, etc. Furthermore, information of the history of the land use, especially green areas, and of the status of road kills need to be collected as much as possible.

### (4) Study of possibility as structural elements of ecological network

Selected candidates of core area are to be examined from a viewpoint of sustainability of habitat value as core area based on the information of the land use, etc. obtained in (3) above. On the other hand the candidates of nature development areas and ecological corridors are to be studied from a viewpoint of possibility of improvement as those.

### (5) Rough arrangement of structural elements of ecological network

The followings need to be considered when we prepare an arrangement plan of the ecological network structures based on the outputs of (2) and (4) above.

- i) Core area: We should choose the candidates of core area of which the existing habitat quality can be secured considering the characteristics of the land use as core area.
- ii) Nature development area: We can choose the land neighboring the core area, of which quality can be improved to enlarge the core area, as nature development area.
- iii) Ecological corridor: We can select the areas, which connect the core areas and the nature development areas and in which animals move, as ecological corridor taking into account fragmentation situation of them by roads, urban areas, etc. Potential of the areas as ecological corridor is to be judged from viewpoints of similarity of habitat types of core areas to be connected, historical transition of the regional land use, occurrence of road kills, etc. Green areas being located between fragmented core areas are a factor to be considered when judging the potential of the ecological corridors.

## 3.2 Case study in the field of Yokohama city

We have carried out a case study for the grand design of the ecological network in the northern part of Yokohama city based on the planning method mentioned in 3.1 above. We conduct the study considering the terrestrial organisms in particular, prepare the grand design of the ecological network, and state the relationship between the ecological network and the road projects on a basis of the grand design. We used only existing open data and materials for the case study.

### 3.2.1 Sorting of habitat types

We sorted habitat types in the study area utilizing the existing data. At first, we sorted the current habitat types in Yokohama city, using information related to the organisms including the actual vegetation maps<sup>10), 11), 12), 13)</sup>. As a result, we categorized a number of habitats into "forest type" and "river type" where substitution forests dominantly grow and forestry organisms live, "wetland type" which includes ponds, marsh and padi fields, "grassland type" including farms and "marine type" including river mouths and bay areas. Out of the total study area of 24,699 ha, there are 2,321 ha (9.4%) of "forest type," 500 ha (2.0%) of "river type," 234 ha (0.9%) of "wetland type," 2,440 ha (9.9%) of "grassland type" and 10 ha (0.04%) of "marine type."

### 3.2.2 Selection of habitat types to be core areas

We set up criteria to select core areas as follows: i) habitats where rare species live; and ii) habitats where various species characterizing the region live. Firstly, we have selected the habitats, where "threatened species" and "decreasers" stipulated in the red data book of Kanagawa prefecture and the habitats where fireflies designated as natural monument of Yokohama city live, as core area from the first viewpoint above<sup>12), 14)</sup>. For instance, the red data book includes a fox (*Vulpes japonica*), an Indian moorhen

(*Gallinula chloropus*) and a painted snipe (*Rostratula benghalensis*) for animals, and a dogtooth violet (*Erythronium japonicum*), a calanthe (*Calanthe discolor*) and a valerian (*Valeriana fauriei*) for plants. Secondly, we chose the habitats, of which species are diversified, as core area as below. We calculated the ratios of the numbers of species, such as birds, amphibians, reptiles and insects observed in each of habitats against those recorded throughout Yokohama city. The ratios of each category are summed up and the habitats of which ratio summed is the greatest are selected as core area. Forest type of habitat is selected under this procedure, and it includes the habitats selected from the viewpoint of rare species.

### 3.2.3 Study of possibility as structural elements of ecological network

We observe a complexed mosaic pattern of land use consisting of urbanization promotion areas, which are a majority of the city area, and urbanization control areas in Yokohama city<sup>15)</sup>. We have public parks, small forests on slopes and street trees as well as artificial land use like commercial and residential areas in the urbanization promotion areas. On the other hand the urbanization control areas are almost occupied by farms and forests designated as large scale of public parks. In view of the above, the green areas even in the urbanization promotion areas need to be utilized for the ecological network, and the possibilities of the structural elements are considered as follows: Scenic zones in the urbanization promotion areas can be converted to the core areas since the planted spaces can be secured in the future. The planted spaces in the urban areas can also be converted to the ecological corridors, while the core areas, the nature development areas and the ecological corridors can be arranged in the urbanization control areas.

### 3.2.4 Rough arrangement of structural elements of ecological network.

The study results of Sections 3.2.2 and 3.2.3, and basic ideas about the arrangements of

Table 1 Ideas for arrangement of structural elements for case study

	Habitat types to be core area	Green spaces to be structural elements	Ideas for arrangement of structural elements	Examples of arrangements
Core area	Habitats for rare species • Areas where species stipulated in the red data book of Kanagawa prefecture live. • Areas where natural monuments of Yokohama city live.	Secured green spaces • Public park of large scale Green spaces highly possible to exist long • Scenic zones in urbanization promotion areas • Green spaces in urbanization control areas	To select existing habitats of high quality highly possible to be maintained in future. As a consequence, the habitats of rare species have been covered under this idea.	① Natural park for children • Habitat of fireflies ② Kawai-Yashi scenic zone • Seya citizen forest • Yashi citizen forest ③ Forest on slope near Ikebe-cho
	Habitats of regional importance Forest types of habitats where various species observed in Yokohama city live.			
Nature development area		Green spaces possible to convert to core areas • Scenic zones except core areas in urbanization promotion areas • Green spaces except core areas in urbanization control areas	To select green spaces, next to core areas, which can be improved to enlarge the core areas.	④ Farms neighboring Kawai-Yashi scenic zone.
Ecological corridor		Small green spaces in urbanization promotion areas • Small neighbor parks • Forest on small slope • Roadside trees • Rivers	To select spaces where trees can continue between core areas fragmented from a viewpoint of landscape.	⑤ Spot in Kawai-Yashi scenic zone divided by Hodogaya bypass. ⑥ Roadside trees and park in residential area in Aoba-ward.

structural elements of the ecological network are shown in Table 1. Figure 2 shows a result of the arrangement of structural elements in the northern part of Yokohama city. The core areas and the nature development areas have been arranged on a basis of administration units taking account of areas stipulated by the laws and the regulations. Further, the ecological corridors have been arranged particularly considering a degree of habitat fragmentation by roads and possibility of animal passage through the existing green spaces like spotted planted areas, slopes of roads, etc. Areas numbered ①~⑥ in Figure 2 correspond to those in Table 1 respectively.

### 3.2.5 Grand design of ecological network and direction of road projects

It is difficult to clarify what is done under the road projects to conserve and build the ecological network in the planning process of its grand design. However we provide an overview of the direction of the road projects for this purpose in Figure 2. For instance, the core area may be fragmented at Spot I in Figure 2 by the Hodogaya bypass. It is desired to look into the situation of road kills there and to study how to remove the fragmentation if necessary. At Spot II of Figure 2 the core areas are divided by the urbanization. It is needed to survey movements of animals there and to study the provision of an ecological corridor utilizing slopes and roadside green spaces of the Third Keihin Expressway to connect the core areas. Further, roadside trees and neighbor parks, not shown in Figure 2, are distributed at Spot III of Figure 2. It is desired to survey the living situation of birds, etc. and to consider the provision of the ecological corridor by planting along the roads there to enhance the movements of birds in the urban areas.

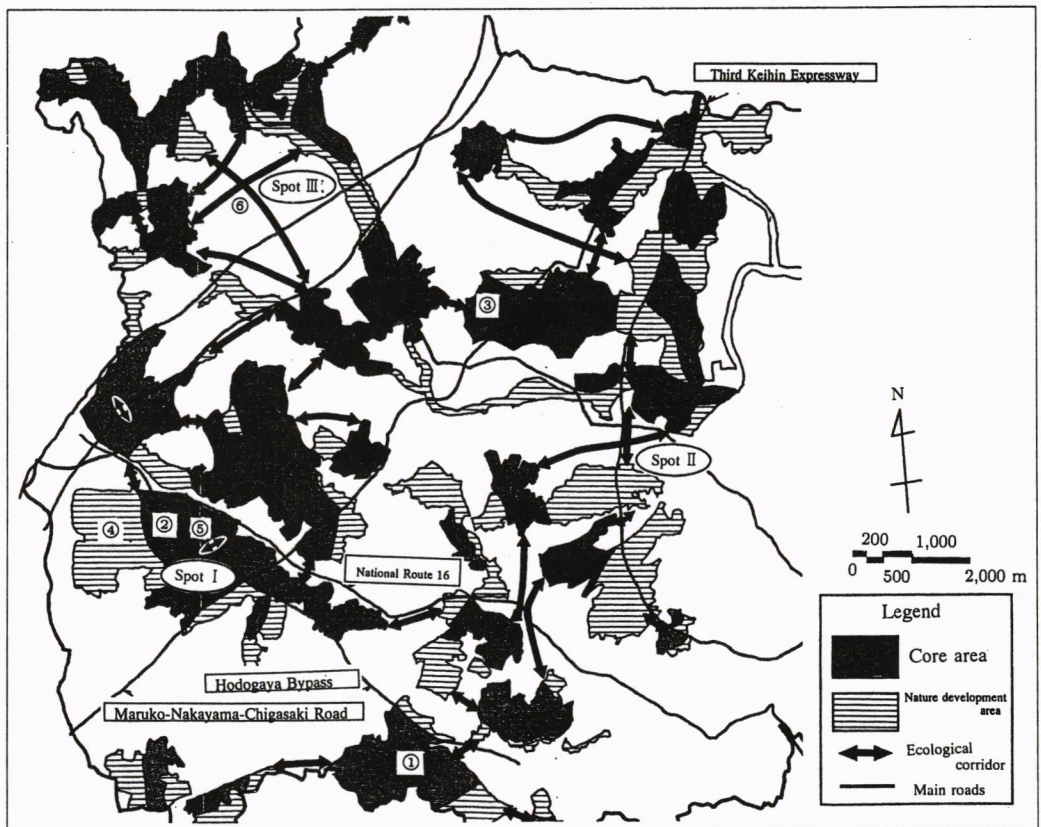


Figure 2 Grand design of ecological network in northern part of Yokohama city

Note 1) This figure has been prepared through a case study using the existing open data.

Note 2) Spots I, II, III are explained in 3.2.5 of the text. ①~⑥ are stated in Table 1.

#### 4. ECOLOGICAL NETWORK PLAN AND ROAD PROJECTS

We can know only the direction of the road projects which take into consideration the ecological network at the grand design of the network. On the other hand, the actual construction plan of the core areas, the nature development areas and the ecological corridors is prepared at the stages of the master plan and the implementation plan of the ecological network. Their planning process is now being studied. The basic idea of the plans is to minimize the adverse effects on the ecological network due to the road projects and to maximize the benefits of the road projects.

##### 4.1 Adverse Effects of Road Projects

The adverse effects of the roads on the habitats are generally considered as below: The fragmentation of the habitats makes it difficult for the animals to make daily movements to their hunting areas and seasonal moves to their breeding areas. Disappearance and reduction of their living areas cause a decrease in population. Furthermore, climatic changes in humidity, wind, sunshine, etc. along the roads alters the living environment of flora and fauna.

##### 4.2 Benefits of Road Projects

As far as the relationship between the natural environment and the roads is concerned, the negative aspects tend to be emphasized so far. Positive aspects, however, are being known through the research results of the status of the living organisms in the road space. For instance, creation of habitats in the road spaces, provision of paths for animals to shift along the roads, and areas for birds' rest like stepping stones taking advantage of green spaces inside the roads and those in their vicinity<sup>(6, 17)</sup>.

##### 4.3 Direction of Roads' Contribution to Ecological Network Plan

Table 2 shows the direction of roads' contribution to the enhancement of the ecological network plan and the several examples for it. We need to study the location of road routes and the basic road structures to be adopted such as tunnels, bridges, etc. as avoidance and mitigation measures against the adverse effects of road construction at the road planning stage. Further, we are required to study the installation of devices for animals' crossing of roads like a box culvert and an overbridge at the spots where animal passage is interfered. On the other hand, we can study the conversion of road spaces available in road stations, interchanges, road slopes, environmental buffer zones to the habitats.

Table 2 Direction of Roads' Contribution to Ecological Network

	Direction of Roads' Contribution to Ecological Network		Examples
Mitigation of effects due to roads	To avoid alteration of habitats to be conserved.		<ul style="list-style-type: none"> <li>• Selection of road route location and alignments</li> <li>• Adoption of tunnel and bridge structures.</li> </ul>
	To mitigate interference of animal passage caused by roads.		<ul style="list-style-type: none"> <li>• Road crossing facilities such as box culverts and overbridges.</li> <li>• Installation of fences and covered side ditches.</li> </ul>
Creation of habitats and moving paths for living things	Provision of habitats using available road spaces.	<ul style="list-style-type: none"> <li>• Creation of habitats using only road spaces.</li> <li>• Enlargement of habitats by combining neighboring habitats.</li> </ul>	<ul style="list-style-type: none"> <li>• Interchanges.</li> <li>• Parking areas such as road stations.</li> <li>• Environmental buffer zones.</li> <li>• Road slopes.</li> <li>• Roadside trees.</li> </ul>
	Provision of moving spaces for animals using available road spaces.	<ul style="list-style-type: none"> <li>• Provision of continuous moving paths for animals.</li> <li>• Provision of moving paths like stepping stones.</li> </ul>	<ul style="list-style-type: none"> <li>• Environmental buffer zones.</li> <li>• Road slopes.</li> <li>• Roadside trees.</li> </ul>

## 5. CONCLUSIONS

We have proposed the three stages of the grand design, the master plan and the implementation plan as planning process of the ecological network in this paper and particularly the actual preparation process of the grand design based on the case study conducted in the northern part of Yokohama city. Further, we have also shown the direction of roads' contribution to the enhancement of the ecological network when preparing the master plan and the implementation plan of the ecological network. We still have remaining issues to consider involving the planning process of the basic plan and the implementation plan for the ecological network. As stated earlier, this paper shows our proposal for the ecological network plan from the viewpoint of the road projects. We think further discussion including participants from other sectors is needed to set up the planning method of the ecological network.

## REFERENCES

- 1) Eco-road Study Committee (1995) Road projects in harmony with nature -Eco-road handbook-. Taisei Publishing Co., Ltd. Tokyo.
- 2) Handa, M. (1998) Creation and conservation of environment and national land management -Formation of national ecological network-. **Proceedings of Annual Meeting of Public Works Research Institute**, Tokyo, 23 January 1998.
- 3) Bennett, G. (1991) Towards a European Ecological Network. Institute for European Environmental Policy. Arnhem, The Netherlands.
- 4) Hioki, Y. (1996) National ecological network plan in the Netherlands and its implementation strategy. **Journal of Japan Landscape Society**, Vol. 59, No. 5. p.205-208
- 5) Hioki, Y. and Ide, K. (1997) Comparison of three ecological network plans in the Netherlands and their planning process. **Journal of Japan Landscape Society**, Vol. 60, No. 5. p.501-506
- 6) Numata, M. (1974) Dictionary of ecology. Tsukiji Publishing Co., Ltd., Tokyo
- 7) Ministry of Agriculture, Nature Management and Fisheries of Netherlands (1996) Nature conservation policy in the Netherlands. The Netherlands.
- 8) Higuchi, H. (1996) Conservation ecology. Press of University of Tokyo. Tokyo
- 9) Decision of Ministers related to global environment conservation (1995) National strategy of bio-diversity. Tokyo
- 10) Department of Pollution Control, Yokohama City (1991) Report on terrestrial biota and ecosystem. Yokohama, Japan.
- 11) Environment Department, Kanagawa Prefecture (1992) Birds and animals in Kanagawa. Yokohama, Japan.
- 12) Department of Environment Conservation, Yokohama City (1993) Map of transition of land use and vegetation, and historical heritages. Yokohama, Japan.
- 13) Department of Environment Conservation, Yokohama City (1993) Actual vegetation maps. Yokohama, Japan.
- 14) Survey Team of Red Data Species, Kanagawa Prefecture (1995) Report on survey results of red data species in Kanagawa. Earth Museum of Kanagawa Prefecture, Yokohama, Japan.
- 15) Department of Parks and Landscape, Yokohama City (1996) Arrangement map of parks and green spaces. Yokohama, Japan.
- 16) Kameyama, A. (1997) Eco-road. Soft Science Publishing Co., Ltd., Tokyo.
- 17) Ministry of Transport, Public Works and Water Management (1995) Nature across motorways. Delft, The Netherlands.