Mitigation Measures to Reduce Habitat Fragmentation by Railway Lines in the Netherlands

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Abstract

Rail infrastructure contributes to the fragmentation of wildlife habitats in the Netherlands. Plans for a large-scale extension of the Dutch railway network and an intensification of track use have made this problem even more serious. The most important fragmentation effects of railway lines for fauna are the loss of habitat, mortality, barrier formation and disruption in general. As a result habitats are reduced or become isolated from each other. This means that the chance of survival of (sub)populations is decreased.

A large range of measures may contribute to a reduction of the fragmenting effect of rail infrastructure. These measures, as this article shows through practical examples, include: a restoration or development of a (substitute) habitat, placing wildlife fences as a protection against railway lines, constructing fauna passageways and sound-reducing provisions. Railways also offer opportunities for defragmentation. By taking nature-oriented measures along railway lines they may have the function of habitat, refuge or corridor. Mitigating measures in rail projects are on the one hand aimed at minimising the fragmenting effect of railway lines, and on the other hand at utilising the opportunities for defragmentation in an optimal way.

The knowledge regarding the precise scale of fragmentation by railway lines in the Netherlands is still incomplete. A study that was started in 1996 will have to fill this gap in expertise.

Introduction

The construction and use of rail infrastructure contributes to the fragmentation of nature in the Netherlands. When nature areas are transected wildlife habitats will fragment into smaller units. The various fragments are isolated from each other to a lesser or greater degree. In this way populations are reduced and the exchange of species is made more difficult or restricted. The chance of survival of many species is therefore decreased (Opdam et al., 1993).

Plans to increase the capacity of the already dense and busy railway network in the Netherlands reinforce the problem of fragmentation (NV Nederlandse Spoorwegen, 1988; 1990). Track extension does not merely imply that existing lines will be extended to 2, 4 or 6 tracks, but also that completely new railway links will be created, including two high-speed rail lines. In addition, the use of the existing railway network is optimised. All this means that the railway transport volume will have doubled within 15 years.

On the other hand nature conservation has increasingly been the focus of national policy. This has resulted in the Nature Policy Plan (Ministry of Agriculture, Nature Management and Fisheries, 1990) and the Structure Plan for Open Areas (Ministry of Housing, Spatial Planning and the Environment, 1993).

An important aspect in these plans is the development of a national network of nature areas, the so-called National Ecological Network (NEN). This NEN consists of existing nature areas, nature areas which still have to be developed as well as the intermediate connecting or corridor zones. Both existing and planned extensions of railway lines transects these NEN areas at many places (Morel & Specken, 1992; Van der Grift & Aartsen, 1997; Van der Grift & Smeets, in prep.). Mitigating measures will have to contribute to minimising or even halting this fragmenting effect.

This article will give a brief overview of the fragmenting impacts of railway lines on Dutch wildlife and mitigating measures that can be taken. Through practical examples possibilities are shown of ecological engineering in order to reduce the fragmenting effect of railway lines and reinforce nature along rail infrastructure.

Rail Infrastructure and Wildlife

The degree in which a railway has a fragmenting effect on wildlife habitats depends on the type of species and, amongst other things, on the number of tracks, the technical design, lay-out and height of the track, the frequency of use of the track and the presence and effectiveness of defragmentation measures. The fragmenting or isolating effect of the rail infrastructure includes (see Figure 1A):

1. loss of habitat; at the location of the track the original habitat disappears and an unattractive landscape is created that isolates the habitats on both sides.
2. mortality; the track can be crossed, but animals run the risk of having a fatal accident.
3. barrier; the track can only be crossed partly or not at all, because of the physical features and use of the track.
4. disruption; as a result of the construction and use of the track the quality of the nature areas on both sides of the track is reduced or will deteriorate to such an extent that these areas will become completely unsuitable as a wildlife habitat.

On the other hand railway lines also offer opportunities for defragmentation (see Figure 1B). At many places railway cess sides and ditches are a suitable (temporary) habitat for fauna. Therefore tracks may also have a function of habitat, refuge or corridor when these zones on both sides of the track are structured and managed with care (see box: Railroads; highways for nature?).

Implementing the track extension schemes requires thorough planning and specific mitigating measures: on the one hand toreduce the effects of fragmentation, and on the other hand to make use of the opportunities for defragmentation.

Mitigating Loss of Habitat

The loss of habitat as a result of the construction or extension of railway lines is a major problem in the Netherlands. An important reason for this is the limited size of most nature areas in the Netherlands. Another factor is the many ecological features at railway cess sites itself and adjacent areas, which will be lost in case of extension of the track.

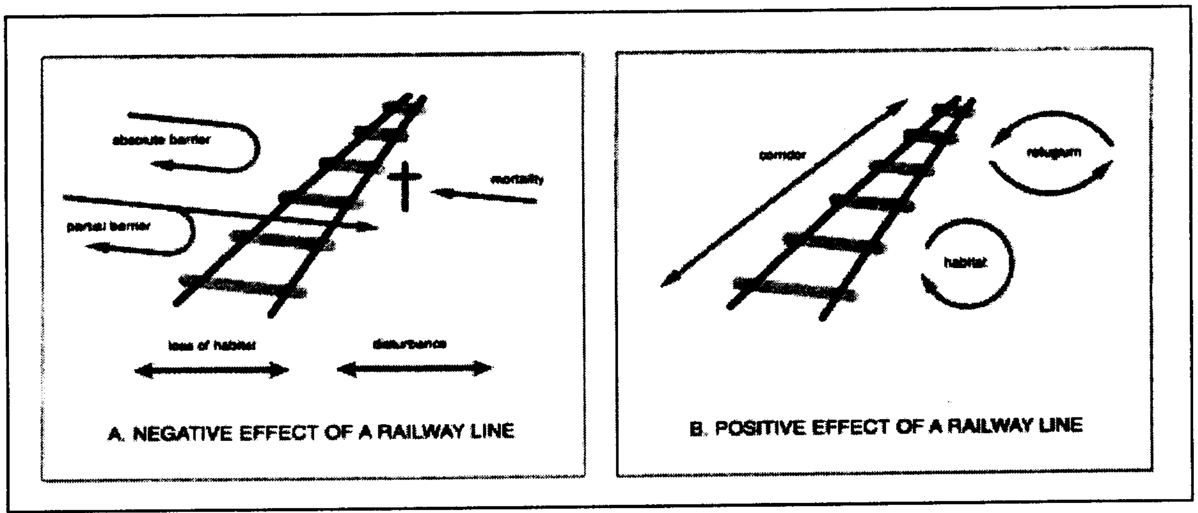

Figure 1 - Fragmenting and defragmenting effect of railway lines.

Nature areas in the Netherlands are relatively small. Only six areas are larger than 5,000 hectares; 80% of the total number of nature areas is smaller than 10 hectares (RIVM et al., 1997). This means that these areas are sensitive to a loss of biotope. The area required by a new or reconstructed railway varies. This depends on the number of tracks and the technical implementation. When (small) nature areas are transected, this need for space may result in a relatively great loss of habitat, which even threatens the survival of the nature area.

Outside the nature areas the cess sides and waterways along railway lines are places with important ecological features. This is mainly a result of the special environmental conditions found at railway sites; sandy soils with gradients in exposure, humidity and nutrients. On the other hand the relatively undisrupted character of the railway environment also plays a role, because the sites are rather inaccessible, they are managed extensively and no fertilizers or pesticides have been used. This contrasts sharply with the surrounding areas, where an intensification and increase in scale of the agricultural sector and urbanisation have meant a great deterioration of the present ecological features. As a result the railway line is a refuge at many places for plant and animal species from adjacent areas which (in the meanwhile) have become extinct (Koster, 1991). Widening a railway line, resulting in the loss of the current cess side and railway ditch, may affect or destroy these features.

When a new railway line is constructed, the effects of the loss of habitat may initially be limited by careful route planning. Nature areas should be avoided, whenever possible. When existing railway lines are widened, the direction of these extensions and the technical implementation are particularly relevant to minimise the loss of habitat.

Mitigating and compensating measures can be considered when a loss of habitat appears to be unavoidable. Mitigating measures mainly focus on creating an adequate point of departure for the restoration and/or development of valuable biotopes after the construction or reconstruction of a railway line. Compensating measures are aimed at replacing features which have been lost elsewhere. Such measures by definition do not have to remain limited to the last phase of implementation of a rail project; in some cases it may be necessary to take mitigating measures already long before the work on the tracks has started (see *Change of Address*).

Measures to Reduce Mortality

The most immediate effect of fragmentation is undoubtedly the mortality among fauna due to collisions. This means that the chance of a local population becoming extinct will increase, while on the other hand the chance of recolonisation is reduced.

The extent of the mortality problem at railway lines in the Netherlands is not known. There are no systematic registrations of fauna victims. However, on the basis of incidental reports it is possible to give a provisional picture (see figure 2). It concerns victim reports from 1996 and 1997; Birds (57%) and mammals (34%), in particular, are the victims of railway traffic, apart from a small group of domestic animals. Amphibians and reptiles were not reported. Observed accidents with birds (20 species) concerned water birds such as swans, ducks and coots, in particular. Gulls and raptors such as hawks and owls were also reported frequently. Herons, meadow birds (sandpipers, oyster-catchers etc.) and wood birds (finches, woodpeckers, thrushes, pigeons etc.) were only reported as victims in small numbers.

Nine different mammal species were reported as casualties over the entire period. Animals of prey (foxes and badgers) form the largest group. Hares and rabbits are also frequently killed by railway traffic. To a lesser degree there are also reports of hoofed animals (roe deer), rodents (squirrels, rats, etc.) and insect eaters (hedgehog).

Most reported victims are common species. Therefore the effect on the population level will be small for these species. However, the picture is different for victims that are part of small and/or isolated populations. In particular birds of prey and owls are sensitive in this respect. Railway traffic is the second cause of death in the Netherlands for the buzzard (*Buteo buteo*) as well as the kestrel (*Falco tinnunculus*), with 7.1% and 4.6% respectively of all finds of dead animals (Van den Tempel, 1993). For the little owl (*Athene noctua*) railway traffic is also a genuine danger; 3.6% of the victims died as a result of train accidents (Exo & Hennes, 1980). Railway traffic is therefore the fourth cause of death for this species in the Netherlands. A possible explanation is the attractiveness of railway cess sides as a hunting ground. The first cause of death for the buzzard, kestrel as well as the little owl is road traffic (19.0%, 28.4% and 16.7 % respectively).

Fauna mortality is an important indication of locations where mitigating measures have to be taken. For mammals the construction of wildlife fences in combination with a fauna passageway is very effective (see box: Badgers on the move). In addition to fences, a railway ditch with water may also contribute to protect the animals against railway lines. Overdimensioning the waterway and constructing a steep embankment at the railway side will make it unattractive or impossible for animals to cross. The other bank will get a gentle embankment with a rough overgrowth, which will stimulate the migration of animals along the railway ditch. As a result the animals will be guided towards a passageway.

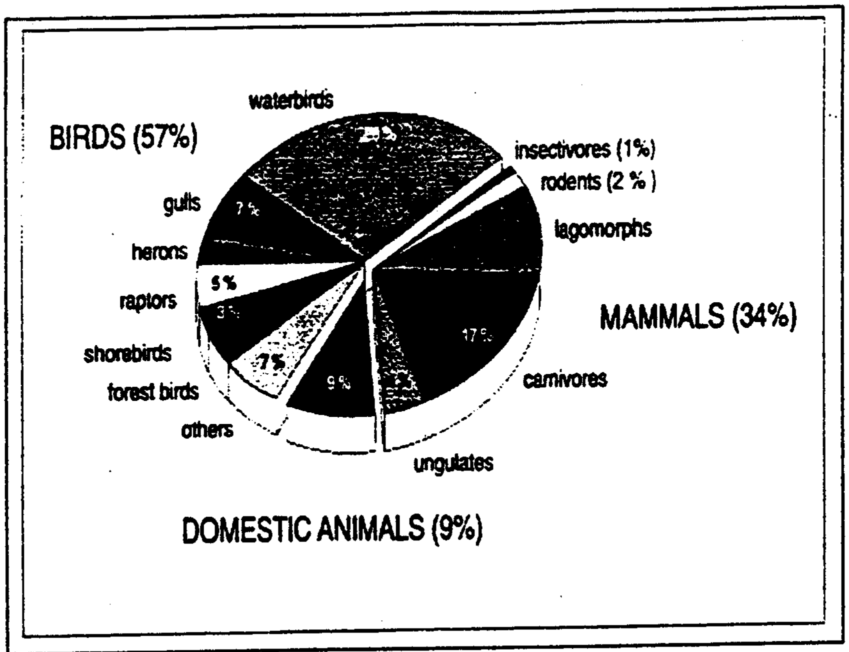

Figure 2 - Fauna victims by railway traffic in 1996 and 1997 (n=151).

For birds a solution to the mortality problem is much more complicated. Apart from collisions, the overhead lines also constitute a risk for passing birds (Lösekrug, 1982). Measures will have to be derived from the specific situation and the habitat of the bird species involved (Oord, 1995). Solutions to reduce the mortality among birds are mainly to be found in the way the immediate environment of the track is planned and managed. Low approaching birds (such as water and meadow birds) may be forced to a greater altitude because of the introduction of shrubs and trees (Van den Tempel, 1993). When railway cess sides are used as nesting areas or forage areas, the creation of an in this respect unattractive buffer zone immediately next to the track may reduce the number of collisions between trains and birds.

Avoiding Barrier Effect

The barrier effect of a railway line may be partial or absolute. The railway line is an absolute barrier when the physical presence of, for example, the route body, ballast bed, embedded rails or acoustic screens means that it is entirely impossible to cross the track. There is a partial barrier effect if an animal species can cross a track physically, but it is deterred by the physical features of the railway infrastructure or the (highly frequent) railway traffic.

The physical barrier effect of the track can be illustrated on the basis of a study on the dispersion behaviour of four types of newts in the national park De Meinweg (Lenders, 1996). The exchange of the alpine newt (*Triturus alpestris*), warty newt (*Triturus cristatus*), palmate newt (*Triturus helveticus*) and smooth newt (*Triturus vulgaris*) was investigated in 10 pools by means of a catch-mark-recatch test (see figure 3). The three most southern pools (pools 1, 2 and 10) are separated from the rest by the railway line Roermond-Mönchengladbach (DL). The line is situated on a core of a dike and is not used anymore at present.

No newts were found in pool 10. In all the other pools an exchange of newts was established (see figure 3). Migrations generally take place between pools which are near each other. However, migrations over distances exceeding 100 metres also occur regularly. The largest migration distance is about 350 metres (from pool 3 to pool 6). It is remarkable that no exchange was established between the pools at the north side of the railway line with the pools at the south side. This despite the fact that the distance is quite small between, for example, pool 3 and pool 2 (about 75 metres). However, the physical presence of the track apparently constitutes too large a barrier, which therefore prevents the exchange.

The degree in which a track forms a barrier differs for each animal group and animal species. It depends on the skills of an animal to pass an unsuitable site. The nature and extent of the railway line to be crossed determines to what extent the track is a barrier.

Birds hardly consider railway lines as barriers. It is assumed that the effect of railway lines as a barrier is weak for toads and reptiles (Bergers, 1997). However, observations of the ordinary toad (*Bufo bufo*) show that railway lines may be an insurmountable barrier when there are no openings between the rail and the ballast (Igelmann, 1994; Müller & Berthoud, 1996).

Salamanders show, as demonstrated by the study at the Meinweg, an even greater sensitivity to this fragmenting effect. With mammals the degree in which railway lines form a barrier is assumed to be inversely proportional to the body size and hence the mobility of the animals (Bergers, 1997).

The construction of fauna passageways is an important means to reduce the barrier effect. It stimulates an undisrupted exchange of individuals between habitats on both sides of the track (see box: Preparations for a come-back).

The effect of a fauna passageway depends very much on the type, design, choice of location and structure of the immediate vicinity. Most types of passageways are basically suitable for several animal species. By taking into account specific design and planning requirements with regard to a number of target species, it is possible to further increase the use of these passageways. The choice of location should be made dependable on the location of (potential) habitats of the target specie(s), migration routes and/or on existing landscape structures that may have a connecting function, such as waterways or hedges. When planning the immediate vicinity of the passageway, the focus should be on the following aspects: creating an adequate route from the hinterland to the passageway, a guideway towards the passageway entrances, and the screening of the railway track, so that it can be prevented that animals cross the railway line.

At present various types of fauna passageways are constructed at railway lines in the Netherlands. These are listed in table 1. The measures referred to were explicitly taken for the fauna. However, many existing bridges or viaducts also meet the requirements of fauna passageways, because embankments or cess sides are continued under the structure. Underpasses that were built in view of an expected urban expansion also offer good opportunities. The underpasses that were built for a number of future roads at the Flevolijn, the railway line between Weesp and Lelystad, are good examples. Now that this urban expansion has not taken place, these structures function 'spontaneously' as passageways for roe deer (see box: Under- or overpasses).

In the meantime plans have also been made for the construction of a large number of fauna facilities. These concern measures at existing railway lines as well as at new railway links (Van der Grift & Aartsen, 1996; Van der Grift & Smeets, in prep.; NS Railinfrabeheer & Grontmij-De Weger, 1996; Projectorganisatie HSL-Zuid, 1997).

Table 1 - List of fauna passageways at railway lines in the Netherlands.

type of passageway	number at railways (figure 1997)	target group	expected (co) use by:			
			amphibians	reptiles	small mammals	large mammals
tunnels for small fauna	24	small fauna	?	+	+	
tunnels for amphibians	2	amphibians	+	+	+	
tunnels for big game	2	roe			+	+
bridge or culvert with dry bank strip/traversing ridge	10	bank-oriented fauna	+		+	
cess-side strips on viaducts for migration across the railway track	1	small fauna	?	?	+	
cess-side strips on railway viaducts for migration parallel to the railway track ('lateral passageways')	6	small fauna	?	?	+	

Disruption and Mitigating Measures

The disrupting effect of railway lines has hardly been investigated yet. Factors that play a role include sound emissions, vibrations, light, visual nuisance or (magnetic) ground currents. Acoustic nuisance is assumed to be the most important source of disruption (Bergers, 1997).

On the basis of studies along roads it is expected that especially birds, large mammals and amphibians with a mating call are sensitive to this form of fragmentation (Reijnen & Foppen, 1991; Vos & Chardon, 1994; Bergers, 1997). The consequence of this is that areas along railway lines may become less suitable or even unsuitable as a habitat for these animal species.

Acoustic nuisance may largely be countered by building acoustic screens or embankments. In urban areas these measures are taken frequently to reduce the acoustic disruption in residential areas. Such mitigating measures have not been applied (yet) in the Netherlands for fauna. One of the reasons is that there is a lack of knowledge about the sensitivity of animal species to nuisance and about the effect of acoustic nuisance on the population level.

Implementation of such measures should also be considered in respect to the additional effects caused by these measures. On one hand screens reduce the acoustic disruption and can probably play a role in reducing bird mortality due to collisions. On the other hand screens may increase habitat loss for meadow birds because of loss of openness. Screens will also increase the barrier effect if not accompanied by the construction of proper fauna passageways. Acoustic embankments could on the contrary be a starting point to reinforce the habitat or corridor function of railway lines. Therefore, careful consideration of the pros and cons of such measures is needed, which should be based on both fundamental (quantitative) knowledge about the fragmenting effects and knowledge of the specific situation.

Study

In 1996 NS Railinfrabeheer, in co-operation with Holland Railconsult, started the project 'Fragmentation of nature through the rail infrastructure' (Van der Grift, 1996b).

Reason for the project was the great lack of knowledge with regard to the nature and extent of the problem of fragmentation at railway lines. Usually the implementation of mitigating measures at railway lines was mainly based on fundamental research carried out at highways. However, the differences between highways and railway lines in both dimensions, technical features and nature/intensity of traffic, are expected to cause differences in the extent of effects on wildlife habitats. Therefore, the objective of this project is to obtain specific, ecological knowledge for planning, consultancy, implementing and evaluating defragmenting and compensating measures in rail projects.

In a first exploratory study an overview of relevant literature concerning habitat fragmentation effects of railway lines was given (Bergers, 1997). Further, the study shows which indicator species in respect to the different habitat fragmentation effects can be distinguished. Based on similarity in response to the presence or use of railway lines, indicator species were grouped into risk-groups. These risk-groups were linked to characteristics of the tracks, the trains and railway noise-barriers. In this way insight was acquired of locations where in potential the distinguished fragmentation effects may occur. This study was finalized by identifying the specific gaps in our knowledge concerning the habitat fragmentation effects of railway infrastructure. Additional field research which is to start in

1998 will have to fill this gap in expertise. This will lead to a better qualification and quantification of the fragmenting effect of rail infrastructure for fauna, on the basis of which it will be possible to introduce mitigating measures more effectively.

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