Defragmentation in the Netherlands: A Success Story?

Edgar A. van der Grift

Among European countries, the Netherlands has played the role of a forerunner regarding landscape defragmentation. In what way does the new national Long-Term Defragmentation Programme *aim at reconnecting fragmented habitats, and how effective are the implemented measures?*

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GAIA 14/2 (2005): 144–147

Abstract
In the Netherlands the problem of habitat fragmentation due to transport corridors is being addressed by a *Long-Term Defragmentation Programme.* Priority spots for defragmentation measures (i.e., locations where wildlife passages are most urgently required) were assessed by combining population viability modelling with local knowledge of critical road sections. Monitoring studies proved that wildlife passages are frequently used by a variety of wildlife species, but only if regularly inspected and maintained. Model simulations suggest that improperly managed passages may result in the extinction of local populations. More robust passages may considerably mitigate problems associated with poor management. In order to judge the success of the implemented defragmentation measures, their long-term effect on population viability needs to be assessed in future monitoring studies.

Keywords
defragmentation, ecological network, habitat fragmentation, population viability, transport corridors, transportation infrastructure, wildlife passages

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In the Netherlands, the problem of habitat fragmentation by transport corridors is widely recognised and comprehensively studied (Van Bohemen 2004). For a general overview of the effects of habitat fragmentation, see Jaeger et al. (2005, in this issue). Being one of the countries in Europe with the highest relative land take by transport corridors, the Netherlands was among the first to develop a systematic approach for preventing and restoring loss of habitat connectivity due to transport corridors. Consequently, the country has long been seen as one of the forerunners in planning and implementing defragmentation measures. It was also one of the initiators of Infra Eco Network Europe (IENE) and *EU COST 341 Action* (for a description see Tillmann 2005, in this issue) to develop a European handbook on defragmentation (Teodorascu 1997). What is the Dutch approach to the problem of habitat fragmentation due to transport corridors? What measures have been taken or are planned? How are the best locations for mitigation measures identified? How are mitigation actions prioritised? And how effective are the established mitigation measures?

Thirty Years of Defragmentation Efforts

The large number of animals – such as toads, hedgehogs, and badgers – killed on Dutch roads caused nature conservation groups and governmental agencies to start addressing habitat fragmentation about thirty years ago (Van der Grift et al. 2001). The first wildlife passage was built in 1974 (Bekker and Canters 1997). Since then, a variety of wildlife passages have been constructed: tunnels for amphibians, eco-culverts for (semi-)aquatic animals, small and large underpasses for various mammals, and wildlife exits from canalised waterways. Also, bridges and viaducts have been modified to facilitate co-use by animals (figure 1) (Bekker et al. 2001 a). A milestone was reached with two "ecoducts" (wildlife overpasses) over a new highway in 1988, which were designed for a multitude of species. By now, over 800 wildlife passages have been built at national trunk roads (see table), and a similar number at railroads, provincial, and municipal roads (Bekker et al. 2001 a).

Nowadays, wildlife passages are standard procedure in highway and railroad (re)construction in the Netherlands.

The initiatives in the 1970s and 1980s can be characterised as *ad hoc* attempts to prevent road kills or isolation of populations. Only in 1990, a coordinated national defragmentation plan was initiated: the National Ecological Network (NEN) (see box).

Long-Term Defragmentation Programme

Following the introduction of the NEN, various studies identified, often independently, a multitude of "bottle-necks", i. e., spots where defragmentation measures at transport corridors are most urgent to reach NEN objectives. Because the studies varied widely in research approach and scale, an overall prioritisation of defragmentation spots was impossible. The ecological benefit of individual measures also was not always clear.

Therefore, the government started developing a *Long-Term Defragmentation Programme*[1] in 2001. It aims at identifying problem spots in a standardised way, developing solutions, and prioritising actions. In March 2005, it was approved by parliament. A regional planning approach was chosen in order to coordinate measures at neighbouring infrastructural barriers.

Population Viability Analysis

A first step of the programme was to point out all spots where existing transport corridors impair the viability of wildlife populations (Van der Grift and Pouwels 2005). Most previous studies had simply identified intersection points of transport corridors with existing or proposed ecological networks as defragmentation spots. This, however, provided no insight into the cumulative ecological benefit of mitigation measures at various locations.

Therefore, the new programme in an innovative approach selected ten focal species for population viability analysis. Each focal species represents a group of wildlife species with similar habitat requirements and dispersal capacities. Population viability was analysed with the expert-based model *LARCH*[2] (Opdam et al. 2003, Van der Grift et al. 2003) for both the present (with infrastructural barriers) and a hypothetical future where wildlife passages remove all barrier effects. By comparing the two analyses, defragmentation spots were identified at infrastructure sections where population viability is expected to increase considerably due to crossing structures, i. e., either from *non-viable* towards *viable* or *highly viable,* or from *viable* to *highly viable*[3].

For national trunk roads, provincial roads, railroads and canalised waterways, a total of 1 126 defragmentation spots were identified (figure 2). At about 75 per cent of them, the model predicts an immediate increase in population viability due to mitigation measures. At other locations, success depends on prior mitigation of other bottle-neck spots. About 23 per cent of the spots are a bottle-neck for two or more (in rare cases up to five) focal species. If all defragmentation spots are successfully addressed, the model predicts an increase in population viability for one or more focal species in more than 60 per cent of the NEN area (figure 3).

TABLE: Mitigation measures at national trunk roads in the Netherlands, spring 2005. Source: database *WEGENSNIP*, Road and Hydraulic Engineering Division, Delft, NL.

mitigation measures	number
wildlife overpasses	6
large wildlife underpasses	4
small wildlife underpasses	189
badger tunnels	127
amphibian tunnels	2
eco-culverts	17
modified culverts	75
modified bridges	56
modified traffic tunnels	9
modified cattle tunnel	1
modified viaducts (on top)	15
modified viaducts (underneath)	23
wildlife fences	282
modified vegetation	4
total	**810**

Prioritising Actions

The *Long-Term Defragmentation Programme* prioritised actions along three criteria:

(1) spots where defragmentation measures achieve relatively greater improvement of population viability based on model results[4] (figure 2);

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BOX: **The National Ecological Network (NEN) and "robust connections"**

In 1990, the Dutch Ministry of Agriculture, Nature Management and Fisheries published the national *Nature Policy Plan* in which the National Ecological Network (NEN) was introduced. The NEN, a national plan for defragmentation, is a compilation of existing nature reserves and nature development areas, linked by proposed ecological corridors. It was seen as a crucial step to maintain a viable fauna and flora (Hootsmans and Kampf 2004).

In 1999, the effectiveness of the proposed NEN was re-estimated: Habitat modelling showed that many nature reserves would still be too small and spatial cohesion of habitats insufficient to protect a large portion of the NEN's target species (Hootsmans and Kampf 2004). Therefore, "robust connections" were introduced: These are considerably larger than the linkage zones already part of the NEN, enabling migration not only of mobile species but also of species with low dispersal capacity by offering them habitat in which their entire life-cycle can take place. In 2000, nine robust connections were roughly mapped in the updated Nature Policy Plan *People for Nature, Nature for People.*

1 *Meerjarenprogramma Ontsnippering (MJPO).*
2 *LARCH: Landscape ecological Analysis and Rules for the Configuration of Habitat.*
3 *Non-viable / viable / highly viable* populations, respectively, were defined by an extinction probability > 5 % / 1–5 % / < 1 % in 100 years.
4 High-priority spots: increase in carrying capacity ≥ size of a minimum viable meta-population in configurations with a key population. Key population: viable with one immigrant per generation (Van der Grift and Pouwels 2005).

(2) spots pointed out in workshops by regional administrations and nature conservation groups, based on knowledge of the field situation;
(3) spots situated in priority areas for sustainable regional development.

According to the first criterion, 74 out of the 1 126 sites identified by model analyses were labelled as high-priority spots. In the workshops, the participants identified 87 priority spots of which 34 corresponded with high-priority spots identified by the model. 14 of these 34 spots are located within the priority areas for sustainable regional development and received the highest priority: Mitigation measures at these locations will be constructed by 2010. All other spots should be addressed by 2018.

In addition to the aforementioned 1 126 defragmentation spots within the NEN, 1 482 defragmentation sites were identified within the robust connections (see box). Of this number, 43 sites were selected as priority spots in the *Long-Term Defragmentation Programme*. First mitigation measures will be taken in 2006.

FIGURE 2: Identified defragmentation spots in the Dutch province of Gelderland: low priority (yellow), moderate priority (orange), medium priority (red), above medium priority (blue), and high priority (black). The proposed National Ecological Network (NEN) is coloured green.

Effectiveness of Wildlife Passages

In the Netherlands, evaluations showed that wildlife passages are usually soon accepted and frequently used by red deer *(Cervus elaphus)*, wild boar *(Sus scrofa)*, fallow deer *(Cervus dama)*, roe deer *(Capreolus capreolus)*, badger *(Meles meles)*, red fox *(Vulpes vulpes)*, rodents, amphibians, and possibly vipers (Bekker et al. 2001 b, Van Wieren and Worm 2001). Recently built wildlife overpasses are also used by beech marten *(Martes martes)*, polecat *(Mustela putorius)*, hedgehog *(Erinaceus europaeus)*, hare *(Lepus europaeus)*, and rabbit *(Oryctolagus cuniculus)* (Bekker et al. 2001 b).

Regular inspection and management of passages is paramount: Surveys of badger underpasses and accompanying measures (i. e., fences, escape gates) showed that almost half of them were not functioning properly because of faulty design or improper management, resulting in broken fences, blocked-up tunnels, and high water levels in tunnels (Vereniging Das & Boom 2002).

Similar findings were reported for amphibian tunnels (Prudon and Creemers 2004). Model simulations suggest that if half of the underpasses and fences are not fully functional, some badger populations are likely to disappear (Van der Grift et al. 2003). Emphasis should therefore be put on the construction of more robust wildlife passages. For example, large wildlife over- or underpasses will not be easily blocked-up or flooded. Higher construction costs are balanced by lower costs of maintenance and a reduced risk of failure.

The configuration of transport infrastructure networks should also be evaluated. Especially road networks, constructed over centuries, often are not very efficient. Remodelling the transport network, however, is difficult because usually both the public and government are reluctant to give up "rights of passage". New spatial planning procedures should combine efforts to increase the efficiency of transport networks with measures to restore habitat connectivity. Removing roads may compensate negative impacts of constructing or upgrading roads at other locations (see Penn-Bressel 2005, in this issue).

In most evaluations of wildlife passages, wildlife species are identified and the number of crossings is counted. This may lead to errors: A high count of crossings in one place may be the result of only one frequently crossing individual. A serious knowledge gap is that the impact of wildlife passages on the viability of populations has not yet been studied empirically. A research method has recently been developed, but applying the method is not yet financed (see Veenbaas et al. 2003, Clevenger 2005).

FIGURE 1: Railroad bridge allowing co-use by animals: The verge enables wildlife to migrate along the railroad line.

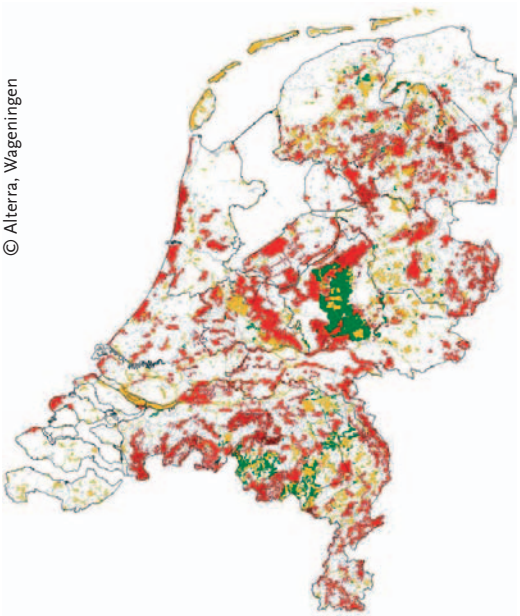

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FIGURE 3: Expected improvement (based on model results) of population viability for the selected focal species if habitat links are fully restored at all identified defragmentation spots: wildlife populations highly viable even without defragmentation measures (green); no improvement in population viability despite defragmentation measures (yellow); improvement of population viability for one (light red) or for two or more (dark red) focal species.

Conclusions

Only through a *Long-Term Defragmentation Programme* that includes a standardised research method to assess bottle-neck spots, the need for defragmentation measures can be assessed, priorities can be set, and a regional planning approach becomes realistic. In such a programme, defragmentation measures should be prioritised based on the expected increase of population viability due to mitigation measures. It is recommended to combine model simulations with expert knowledge. Government agencies at all levels should take the lead in the setup of a defragmentation programme, but the involvement of non-governmental organisations, research institutes, and the public is indispensable for reaching the planned defragmentation objectives. Monitoring of wildlife passages, coordinated by transport administrations, needs to become standard procedure. Only when actual improvement of population viability is demonstrated in future monitoring studies, it will be possible to answer the question whether the defragmentation efforts in the Netherlands can be called "a success story".

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Submitted December 1, 2004; revised version accepted May 3, 2005.

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