Evaluation of de-fragmentation measures in the Netherlands: Report of an international workshop around implications of the Dutch MJPO

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Abstract. This paper report of a three-day international workshop, held in The Netherlands, to investigate the implications of the Dutch Long-Term De-fragmentation Program (MeerJaren Plan Ontsnippering – MJPO).

Key words: habitat fragmentation, fauna passages, evaluation, effectiveness

1. Exploration of the implications of the MJPO

Roads, railroads, and waterways heavily fragment nature areas in The Netherlands. This fragmentation causes barriers and the destruction of habitats for both animals and plants, and causes disturbance and road kills for animals. Fragmentation can therefore have strong negative effects on the sustainability of populations, with most visible effects on animal populations.

However, in the Agenda for a Living Countryside, from the Dutch Ministry of Agriculture, Nature, and Food Quality, is stated that '*migration and dispersal of animals and plants must no longer be impeded by the presence of roads, railroads and, waterways, in so far as such migration and dispersal is necessary to the sustainable survival of populations at provincial, national, and international levels*'.

In The Netherlands, a bottleneck analysis has been preformed and, based on this analysis; an inventory of needed de-fragmentation measures has been made. These de-fragmentation measures are listed in the Long-term De-fragmentation Program (with the Dutch acronym MJPO – MeerJaren Plan Ontsnippering). Dutch politics budgeted Mil. € 410 for these specific de-fragmentation measures, to reach the goals stated by the Agenda for a Living Countryside. A first evaluation of the MJPO will take place in 2008. The whole program will be completed in 2018, together with the completion of the Ecological Main Structure in The Netherlands.

To prepare for the evaluation in 2008, an international workshop of three days has been held in The Netherlands. During this workshop, several questions have been addressed, with a main focus on the questions how to evaluate, what is already known, and what research and monitoring will be needed. The workshop has provided numerous success stories about fauna infrastructures, and has led to an outline of a monitoring and research program, which will be discussed in this report. Prior to the workshop, and also afterwards, the CML has interviewed several experts on the subject of fragmentation and de-fragmentation.

The outcomes and insights obtained by the workshop and the interviews can be divided into four groups of interest: construction and maintenance of the fauna infrastructure, use of the fauna infrastructure, population and biodiversity effects, and political relevance. Throughout this report these four groups will be used to organize all insights.

2. Seeking a base for evaluation of de-fragmentation measures

2.1. Introduction

In The Netherlands, at this time, there is no need to argue the threats to biodiversity by habitat fragmentation, as already € 410 million has been allocated for habitat de-fragmentation projects in the next fourteen years.

Still, for reasons of accountability and responsible governance, insight in the effects of various de-fragmentation projects is indispensable. The infrastructural constructions designed for fauna mobility will have to be evaluated, both by monitoring its use and effectiveness, and, more fundamentally, by its contribution to the achievement of ecological goals. This is not trivial. It has been demonstrated that fragmentation of habitat leads to extinction of some populations, but that does not mean that increasing connectivity automatically leads to a revival of these populations. The argument just cannot be reversed. Moreover, the time span of ecological processes is far longer than that of politics and administrations. And worse, ecological processes are extremely hard to measure and even harder to predict. On the other hand, good governance demands that the spending of public money is closely monitored and evaluated. The Dutch parliament expressed the wish to have a first evaluation of the MJPO projects in 2008. A final evaluation can be expected in 2018.

The question is: how to prepare for these evaluations? What can be the foundation of these evaluations? Are the data and insights that will be needed already being collected and if not, what constructions are needed to collect these data and insights? In this paper, we explore four different approaches to build a foundation for the future evaluations.

2.2. Evaluating measures

In trying to construct a robust evaluation of the measures, two main questions present themselves. First, was the decision making procedure correct and consequent? This leads to a policy based answer. Second: are the measures effective? This leads to ecological answers, which can be further divided into argumentations based on landscape, populations or opportunities.

Of these, the policy-based evaluation proves to be the most easily constructed. The other approaches are far less easy. We start with the question of legitimacy.

2.3. Policy based evaluation

Was the decision to spend € 410 million reached in a legitimate way?

It can be shown that de-fragmentation policies can be derived from stated and accepted policy goals. The Netherlands are signatory to the Convention on Biological Diversity and as such are committed to pursue '...*the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources ...*' (Article 1).

In translation of this principal into Dutch nature policy, and inspired by meta-population theory, an important role has been assigned to the connectivity of habitats, to be implemented in the form of the EHS, the National Ecological Network. This coherent network of nature areas is to comprise 728,500 hectares of nature by 2018.

The goal has been restated in various papers and bills, among others in the Agenda for a Living Countryside (2004, p 56).

The Agenda for a Living Countryside is part of the *Nota Ruimte*, the bill on spatial planning, which defines the spatial planning in The Netherlands for the coming 20 years and came into force on January 17, 2006. As a consequence, concrete measures to mitigate habitat fragmentation by transport infrastructure are needed and these are listed in the MJPO.

The *Nota Ruimte* contains maps delineating the ecological links to be constructed and has a very strong policy status. The ecological network has a remarkably long and stable history in Dutch nature policy making. Clearly, the decision to spend € 410 million is correct, consequent and well founded on earlier parliamentary decisions.

2.4. Effectiveness

The question of effectiveness is far more complicated. Understanding the effect of de fragmentation measures is theoretically equal to understanding the spatial dynamics of metapopulations and metacommunities. Large progress has been made in the field (Holyoak *et al.* 2005), but the theory is still in a rather abstract phase. Consequently, the value of de fragmentation projects has often been derived from variables that are assumed to be an acceptable indicator. Various approaches have been attempted, as for instance economically by measuring willingness to pay for de-fragmentation scenarios (Van der Heide *et al.* 2005), spatially by modeling the permeability of connected area (Loehle *et al.* 2005) or calculating the infrastructural fragmentation index (Biondi *et al.* 2003), and genetically by showing that linking forest fragments increased the genetic diversity of the red squirrel in northern England (Hale *et al.* 2001).

One of the more sophisticated ecological models, developed and maintained by Alterra in The Netherlands, is LARCH, which stands for Landscape Assessment using Rules for Configuration of Habitat. As the name says, LARCH is a landscape assessment model, which assigns a measure of habitat suitability for a certain species to a certain landscape, based on vegetation, size and the needs of the species (Van der Grift *et al.* 2003).

It seems there are two main schools of thought in analyzing the effect of connecting fragmented habitats: landscape centered and population centered.

2.5. Landscape based evaluation

De-fragmentation measures can be seen as a way to mitigate and minimize the disturbing effects of transport infrastructure on landscape. In this case, the measure of success is the degree in which the landscape that existed before the disturbance is recreated. Landscape is also a potential habitat and landscape is far easier to measure and to govern than populations, so there are clear methodological advantages to this approach.

Assuming there is a clear understanding of the original state of the landscape, which is now fragmented by transport infrastructure, de-fragmentation measures can be interpreted as restoration work. The idea is easily associated with restoration of valuable art works and it seems to assign a value as lost natural capital to ecosystems that disappeared. By technical means the ecosystem is restored and the natural capital is retrieved. This approach is attractive to large groups of the Dutch population, as the explosion of transport infrastructure took place during their lifetimes and many people remember quieter and wider landscapes.

There are some complications to the landscape centered approach. First, there is no clear definition of the 'before', as it very much depends on the year one has in mind. Also, concentrating on the natural features of the former landscape may deny the multifunctionality of many former landscapes (Haines-Young *et al.* 2006). The main problem seems to be that restoring landscape only creates potential habitat. Survival or revival of populations will be dependent on many other factors. Still, an evaluation of the de-fragmentation projects in terms of hectares of landscape restored and connected has many advantages. It is relatively easy to do, can be checked by others, and has a relevance to biodiversity, though indirect.

2.6. Population based evaluation

To justify the de-fragmentation policies more directly to the biodiversity goals as agreed upon in the convention, a proof of direct effect on populations would be convincing. Political issues easily

confuse this discussion. Large mammals are popular with the general public, and measures to protect these groups are politically attractive. These mammals are very vulnerable to road deaths and habitat fragmentation, so measures to decrease traffic accidents and to increase mobility have easily a positive effect on these species (and on road safety). Measures like ecoducts or other fauna passages have a high visibility. However, the policy goal should not be limited to large mammals only, but should cover biodiversity in all its complexity. De-fragmentation measures can have effects that are specific to species, or are possibly specific to trophic levels.

Rare species of plants and insects are often found in isolated places and Darwin himself already pointed out the logic of this. De-fragmentation of habitat is just another word for destruction of unnatural isolation and harmful scenarios are easy to construct. One can imagine the negative effect of newspaper headings like 'Fauna passages open up rare bird habitat for foxes' or 'Bird flu travels by ecological network'.

Though an evaluation based on proof of the existence of sustainable populations seems to be closest to the original policy goal of protecting biodiversity, it seems also to involve most practical difficulties.

2.7. Development based evaluation

Finally, it might be worthwhile to explore a totally different approach. De-fragmentation measures can be seen as constructing new ecosystems, offering new potentials, and producing unexpected results that can by definition not be known beforehand. One can be certain that living organisms will make use of the spatial opportunities provided, but it is uncertain which species will do so, what ecosystem will evolve and what ecological processes will be started.

For the evaluation, this would mean that an analysis on the newly created ecosystems would have to be made. This is certainly feasible and it has the advantage that such an approach does not have to be limited to pre-assigned groups of species. On the other hand, Dutch nature policy has also a responsibility for specific endangered groups of species and it is doubtful if these can be disregarded without raising political unrest.

2.8. Conclusion

The four approaches probably result in very different methods of evaluation. It seems there does no objection to have more visions co-exist, but to be able to interpret a given evaluation, it is important to know upon which vision it is based.

Whatever perspective is chosen, habitat fragmentation by transport infrastructure and the ecological effect of de-fragmentation measures pose some impressive theoretical questions, with implication for policies on climate change-dependent habitat movement, and isolated populations of rare species. Both the theoretical and policy issues have a scale that far surpasses that of only the Dutch territory.

3. Justifying fauna infrastructures

During the workshop the focus has been both on validating the construction of fauna infrastructures, without restarting the discussion about the negative effects of habitat fragmentation, and on giving the outline of monitoring and research programs.

The validation for de-fragmentation measures varies from moral viewpoints about the implementation of fauna infrastructures, to success stories about the effectiveness of these infrastructures. These success stories about the effectiveness in particular can be used to defend the MJPO in a political arena, which can be useful if the first evaluation of the MJPO will take place in 2008. In explaining the need for a de-fragmentation policy, success stories play a crucial role; these can per-

tain both to the political level regarding the realization of the fauna infrastructure, and to the level of the effectiveness of the infrastructure. Well-founded success stories should be carefully collected, at an international level.

3.1. Construction and maintenance of the fauna infrastructures

It is relatively new to build structures for animals. 'The world' is watching and using the implementations (both in Banff – Canada, and in The Netherlands) as a model. Therefore these implementations should be right. At this moment, we are setting standards for design and maintenance. There is a lot of exchange of information between different countries, and what we do in The Netherlands and what have be done in Banff serve as an example.

3.2. Use of the fauna infrastructures

The acceptance of the fauna infrastructures is species-dependent, but overall can be said that the infrastructures are used. Ecoducts are used by (large) animals, even during, and short after construction. Signs of this use can be found on all ecoducts, in the form of tracks, prints and faeces. For culverts, fences, and badger-tunnels there is also strong evidence that these measures work (Fig. 1), because of tracks, the presence of faeces, and pictures (Fig. 2).

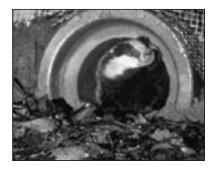**Fig. 1**. Evidence for the presence of a badger (photo by Hans Bekker)

Fig. 2. Evidence for the use of a badger tunnel (photo by 'Stichting Das en Boom')

3.3. Effects on populations

Fences led to reduction of road kills (80% in Banff), and there has also been an increase in population-size with fences in place (Banff). This stresses the importance of combined measures (ecoduct/badger tunnel in combination with proper fences) and also shows that the fauna infrastructures can have a positive effect on populations.

In The Netherlands, a package of measures involving the badger has led to an increase in population size from 1200 individuals to approximately 4800 individuals. The fact that a whole set of measures has been used and that these measures have been connected properly, may be responsible for this success.

3.4. Political relevance

There is widespread acceptance and awareness, both local and governmental. Top-down initiated measures have led to bottom-up actions, and *vice versa*. An example of a local initiative is the building of the ecoduct Crailo in 'het Gooi' (between Bussum and Hilversum), where people wanted to contribute something themselves. The building of this ecoduct has now led to a higher prioritization of a governmental ecoduct nearby, to improve connectivity. The acceptance is even so widespread, that the rule 'for one kilometer road constructed, one kilometer road has to be removed' causes hardly any opposition.

On a provincial level there are a lot of initiatives as well. In the province Utrecht for example, seventeen parties joined in the project 'Heart of the Heuvelrug', to reconnect the northern and southern part of the Heuvelrug, by building ecoducts and providing other measures.

A complete other validation of the MJPO is that it is our moral duty to de-fragment. The last 50 years we have destroyed whole habitats, and fragmented our nature areas. Now we have the opportunity to restore (some of) the connectivity and create new areas, not only for the animals, but also for ourselves and future generations, to keep our country a nice place to live. The M€ 410 can be seen as an investment: past measures can be strengthened by new measures, and the connections themselves can become part of the protected area, which is needed in a small country. In this way a new asset is created.

4. Construction and maintenance of the fauna infrastructures

Although we think we know how to construct fauna infrastructures, there are still a lot of things that have to be taken into account when constructing these measures.

In the USA (California) has been shown that simply making the connection is not enough. An area has to meet the requirements of the target-species, before it is linked with another area, and a combination of measures is needed to get the best results. These combinations should always be custom-made, because they are dependent of the situation in a certain area. The success of defragmentation measures is furthermore dependent on the balance between the extent of isolation and the extent of links between the areas: the more links and the less isolation, the better a measure works.

We have established that ecoducts are used by different kinds of animals, but larger animals mainly use these overpasses. Overpasses are only effective for small animals as well, when the overpass provides the habitat they need, since their action-radius is much smaller.

There is also a strong need for maintenance of the infrastructure. Fauna infrastructures must be functional over their whole life span, and therefore robust measures should be chosen. Although the construction-costs are usually higher for robust measures, like ecoducts, the maintenance-costs of these measures are lower, making the robust measure more economical in the end.

Road-safety (both for animals and humans) is another issue that should be taken into account when constructing fauna infrastructures. Ecoducts and other measures work, but most important are the fences: they bring down the number of road kills, which is important for the survival of adults. Populations of longer-living animals are dependent of the survival of these adults for reproduction. Road kills should be regarded relative to the population size, and not in absolute numbers, to calculate the impact on a population. There are for example so many hedgehogs in The Netherlands, that road kill has hardly an effect on the population size, although according to the number of road kills, there appears to be a problem for the hedgehog.

Another issue that should be considered is, for example, how the interaction with the human environment is. Are the animals at risk of being poisoned? Are there side effects, like unforeseen use of the measures by humans? How are the physical conditions of the adjacent areas? During the preparation of the construction of a fauna infrastructure, these questions should be answered, and depending on the answers opportunities and solutions have to be selected.

There are also some more fundamental questions that need to be answered about the construction and maintenance of fauna infrastructures, to make them more effective in the future. We need to know, for example, how to design fauna infrastructures. It is true that this is known for ecoducts, but it is still unknown for corridors and small measures, like escape ramps. Another question is whether we should build single large or several small measures. Is it better to have 10 ecoducts connecting several areas, or will 1000 culverts do the trick? Monitoring and research should answer these questions.

5. Monitoring use, and researching effectiveness of fauna infrastructures

During the workshop, the main questions that should be asked during the evaluation of the fauna infrastructures have been discussed, and a general outline for a research program has been made.

5.1. Outline research program

First there has to be a description of the measures and of the objectives, to know what to monitor and what to evaluate. Without a clear goal, it is hard to establish whether the objectives are reached. A strategy can be, to choose a few important and easy-to-monitor species as target-species. By doing so, the effects of fauna infrastructures can be visualized, generally ensuring that, when there are positive effects, these effects can be shown.

Standard evaluation methods (in which common data is used) have to be designed. Monitoring the use of fauna infrastructures (which should be applied for all measures, to see if the maintenance is good), or performing presence/absence studies (there can be discussion whether this method should be applied on a smart selection or on as many measures as possible) can be applied.

Furthermore, specific evaluation methods have to be developed. These should be adapted to see whether the objectives are reached, like looking at population dynamics, and genetic studies. These methods should be applied on a smart selection of measures, for time-efficiency and economical reasons.

5.2 Main questions

Questions that should be addressed when evaluating the fauna infrastructures are:
- Are the fauna infrastructures built and maintained as planned and designed? This question should be answered for all measures.
- Is the design good, or can it be improved? There should be a control-phase before the beginning of the construction; projects should be looked at beforehand. There should be a sample of different types of measures; we should learn as much as possible, vary dimensions, use it as an experiment and monitor very closely.
- Is this specific type of infrastructure being used? Why/why not? This question should be answered for all fauna infrastructures, since the answer depends on type *and* placing.

These first three questions are looking at the preconditions: do the fauna infrastructures work, and are they being used. The answers to these questions implicate whether there could be larger, sustainable effects on the populations.

The three questions are of main interest for constructors and engineers, as they are responsible for construction and maintenance of the fauna infrastructures.

Since the goal of the total set of measures is that migration and dispersal of animals and plants must no longer be impeded by the presence of roads, railways, and waterways, in so far as such migration and dispersal is necessary to the sustainable survival of populations, it is not enough to establish that there *could* be sustainable effects on populations. The questions that should be asked next are: Are this measures enough to reach and restore connectivity, and does this contribute to the sustainable survival of populations?
- Are there population effects? Sites and species should be selected for research.
- Does the set of measures contribute to the National Ecological Network? (although monitoring should be broader than NEN).

These questions are of main interest for both scientists and policy makers: the scientists will be the ones to answer these questions, whether the policy makers will use the outcomes of the researches to validate their strategies.

Problems, successes and failures must be analyzed, for instance with the 'badger success' in The Netherlands: What has caused it? Are there general trends? Is the success a result of the decrease in

mortality (less road kill), caused by an increase in connectivity between different areas, or a result of both factors? Or is the increase of the population related to a better quality of habitats?

5.3. Monitoring use

It is not enough to monitor the passage use, but it is still important. Included in the monitoring should be: where are the species and where are they going?

Routine monitoring must be focused on the functioning of the fauna infrastructure in place, but at the same time be put in the context of existing broad monitoring programs.

The advantage of monitoring at a certain location is that local factors can be included, since success and failure depend on the local problem. Measuring at location gives the opportunity to manage at location. In other words: to see in place what is right and/or wrong.

During a monitoring program, there should be looked at several species at the same time, and the whole package of measures should be monitored at the same time. In doing so, the effects of a whole set of fauna infrastructures can be evaluated. In such a monitoring program it is important that extreme years are included, to get a complete comprehension of the situation. Therefore, long-term studies should be preformed, so that changes might be observed.

As mentioned earlier, monitoring of the passage use is not enough, since the use of a crossing does not automatically lead to gene flow. Animals can cross to feed, but not to reproduce, or the animals that cross don't reproduce yet. Therefore, scientific research is needed.

5.4. Researching effects on populations and effects on biodiversity

For research programs also holds that there should be looked at several species at the same time, and that long-term studies should be performed, so that changes might be observed. The results will differ over time, and many things will change all over the place. In an ideal situation, the research should cover the full time period of the changes caused by the fauna infrastructure. Therefore it should take place during the whole lifespan of an infrastructure, which is approximately 80 years for an ecoduct.

In-depth research should be broader than the functioning of the fauna infrastructure itself; it should also take the surrounding landscape into account, including the different landscape elements with their attributes, and species composition.

Monitoring and research must focus on construction and maintenance, use, population effects, and policy relevance. Furthermore it should also pay attention to, for example, age distribution, sex, and spatial distribution of users, since willingness to travel is species-, age-, sex-, and population-dependent. Indicators might be chosen at the level of individual animals, populations, and/or genetic characteristics.

These studies should have started 'yesterday', since a comparison between the situation before and after the construction of the measure would be ideal, but there are still many sites in The Netherlands where such studies could take place. We also have a unique opportunity to analyze with controlled-impact (potentials of CI), and following from this, we should be able to do so called BACI studies (before-after-controlled-impact analysis), to analyze the total impact of fauna infrastructures.

A few things have to be taken into account when carrying out a research program.One of these things is that populations of animals always fluctuate. There is need for mitigation if population levels are low, but it is difficult to evaluate the effect of the measures. Different factors (like e.g. climate change or seasonality) may play a part as well. Furthermore, road density should be treated as an independent variable, since road density has no correlation with habitat types, but can still be a factor when analyzing the road kill. Finally, models are limiting, although they are nice to work with. They only work for larger mammals, because the conditions required by these animals are known. For smaller animals, further research is needed to make the models work.

Before a monitoring and research program starts, a few questions need to be answered first, like:

- What is the most effective way of monitoring? Satellite photos, tracks, radio-tagging?
- Which animals will use the infrastructure and how does that affect the program?
- Habitats will always change; how should we react to these changes in habitat, in relation to the measures?
- Do we need to calculate population viability (knowing that it is hard to monitor population dynamics), or should we look at genetic change?
- Both routine monitoring and in-depth research are needed; how can these be combined?
- What are we going to measure? Passage use, where the animals are, maybe only presence/absence, age structure, should we collect density data?

The present and future developments around fauna infrastructures should be regarded as a unique opportunity for science. The whole implementation of the MJPO can be considered as one large experiment. The results of monitoring and research programs should be communicated to the public, to create sympathy and interest, to support evaluation, and to contribute to the political validation of the measures.

6. Political relevance

The evaluation of de-fragmentation measures is necessary, but difficult. Monitoring and research may contribute to the validation of these measures, but policy makers themselves can make evaluating more effortless. First, the objectives of the de-fragmentation measures have to be stated, to know what goals will have to be reached.

6.1. Stating the objectives of habitat de-fragmentation

First there has to be a clear description of the measures and of the objectives, to know what to monitor and what to evaluate, and to know beforehand what success looks like. This means that there is a need to choose success indicators beforehand. These indicators of success have to be conceptual, as well as at the level of use and population characteristics of selected species. Too high targets, or targets based on the wrong (e.g. too endangered) species pose the threat of not reaching the goals. When selecting target species, too rare and too common species both pose their problems. Too rare species, like the otter in The Netherlands, are hard to monitor and study, whilst it is difficult for too common species (like the hedgehog) to see any correlative effects of the measures.

The policy might be considered a success when the objectives are reached, but there has to be an open eye for alternative successes as well. A fauna infrastructure might not have led to a noticeable increase in, for instance, population size of the target species. Therefore, the goal 'increase the population-size' has not been achieved. However, if there has been an increase in biodiversity as a whole, the de-fragmentation measure(s) might still be considered a success.

Policies should not be based on theoretical information alone. A problem could be posed by a model, but there is a need for clear data on collisions, mortality rate, use of fauna infrastructure, etc. as well. The problem should be explained in strong arguments, and success stories, even when based on anecdotal data, should be analyzed.

Questions that should be answered before stating the objectives and implementing a policy are: How to prioritize areas to protect and to connect, and how to measure success and failure?

6.2. Validate the choice to de-fragmentation

In the chapter 'Justifying fauna infrastructures' different approaches to rationalize the choice to de-fragment have already been discussed. However, more fundamental and political reasons to decrease fragmentation play a part too.

A political argument could be that since the European strategy is to (re) connect nature areas (Natura 2000), national policies should fit into this European plan. Although The Netherlands have been ahead of the European policy with their National Ecological Network, the national plans should still be contiguous with international policies.

Another justification of the MJPO is that the program follows logically from previous nature policies in The Netherlands. Successful new fauna infrastructures are a protection of the past nature investments, and are consistent with the accepted strategy.

A more fundamental reason to increase connectivity between nature areas is that small populations are endangered and need to be connected. By doing so, gene flow can be established and inbreeding can be prevented.

6.3. Varia

There is a political, economical, and social pressure to combine the use of fauna infr structures with human activities, like hiking. However, it is not sure what the effects of combined use will be. In the USA (California) has been shown that human use of fauna infrastructures disturbs passing animals. In areas with a high density of humans, animals tend to be shyer. Human use will therefore have a larger impact. Nevertheless, in The Netherlands has been shown that the population size of badgers could increase in an area with many dog-walkers. The effects of combined use should therefore be studied carefully. As a consequence of the pressure to combine, arguments not to combine should be very good.

At this moment, the political consistency of the de-fragmentation measures is good. In order to ensure the long-term efficiency of the fauna infrastructures however, future political consistency is needed as well to guarantee this efficiency. Finding a budget for measures and research has always been a problem, and probably will always be, but the necessity of measures and research should be stressed to politicians to come.

When it comes to justifying the choice to de-fragment, it is important not to have a defensive attitude. It is rather self-evident by now that de-fragmentation is important, and that policy objectives can be reached if the fauna infrastructures are implemented well.

One of the results of the workshop was a matrix (Table 1). This matrix can be seen as a way to think about the subject of habitat de-fragmentation. The following matrix is far from complete, but gives a design for future additions With (+) is noted how, and how much, certain monitoring, research, or communication is related to the four groups of interest. The amount of political relevance of monitoring, research, and communication as a whole is stated as well.

Table 1. The matrix of factors connected with the de-fragmentation of habitats

		Construction and maintenance	Use	Population effects	Political relevance
Monitoring	Control (by RWS)	+			
	Standard monitoring: - PGO - NGO		+		
	Adapted monitoring		+	+	
	In whole				-/+
Research	Presence/Absence study			+	
	Population structure: age, sex, etc.			+	
	Genetics		+	+	
	Vegetation structure	+	+	+	
	In whole				+
Communication	Architects	+			
	Classical lovers of nature	+		+	
	Active collectors and obse-rvers		+	+	
	Scientists	+	+	++	
	In whole				++

References

Biondi M., Corridore G., Romano B., Tamburini G. & Teté P. (2003). Evaluation and Planning Control Of The Ecosystem Fragmentation Due To Urban Development. No UCD-ITS-REP-00-01, Institute of Transportation Studies, Working Paper Series from Institute of Transportation Studies, University of California, Davis.

Canters K. A. Piepers & Hendriks-Heersma D. (1997). Proceedings Habitat Fragmentation and Infrastructure. Ministry of Transport (Netherlands).

COST 341 (2003). Habitat fragmentation due to transportation infrastructure. Wildlife and traffic. A European handbook for identifying conflicts and designing solutions. KNNV Publishers.

European Commission; Directorate-General for Research (2003). COST Action 341 Habitat fragmentation due to transportation infrastructure: the European review.

Europese Commissie (2000). Beheer van "Natura 2000"-gebieden – de bepalingen van artikel 6 van de habitatrichtlijn (Richtlijn 92/43/EEG).

Grift E. A. van der, Pouwels R. & Reijnen R. (2003). Meerjarenprogramma Ontsnippering. Knelpuntenanalyse. Alterra-rapport 768.

Haines-Young R., Watkins C., Wale C. & Murdock A. (2006). Modelling natural capital: The case of landscape restoration on the South Downs, England. Landscape and Urban Planning 75(3-4), Landscapes and sustainability: 244-264.

Hale M.L, Lurz P.W.W., Shirley M.D.F., Rushton S., Fuller R.M. & Wolff K. (2001). Impact of Landscape Management on the Genetic Structure of Red Squirrel Populations. Science 293 (5538): 2246-2248.

Heide C. M. van der, Bergh J.C.J.M. van den, Ierland E.C. van, & Nunes P. A. L. D. (2005). Measuring the Economic Value of Two Habitat Defragmentation Policy Scenarios for the Veluwe, The Netherlands. NOTA DI LAVORO 42.2005, The Fondazione Eni Enrico Mattei Note di Lavoro Series Index.

Holyoak M., Leibold M.A. & Holt R.D. (eds.) (2005). Metacommunities: Spatial Dynamics and Ecological Communities. Chicago University Press.

Loehle C., Bently T., Wigley P. A. Shipman S. F., Fox S., Rutzmoser R.E. Thill R. E. & Melchiors M. A. (2005). Herpetofaunal species richness responses to forest landscape structure in Arkansas Forest. Ecology and Management 209: 293-308.

Ministry of Agriculture, Nature and Food Quality (2004). Agenda for a Living Countryside. Multi-year Programme for a Living Countryside Responding to change.

Ministry of Agriculture, Nature and Food Quality (2004). Ecological Networks: Experiences in The Netherlands. 'A joint responsibility for connectivity'.

Ministerie van LNV (2005). Concept –Natura 2000 doelendocument- hoofddocument.

Ministerie van V&W, Ministerie van LNV, Ministerie van VROM (2004). Meerjarenprogramma Ontsnippering.

Ministerie van V&W, Rijkswaterstaat, Dienst Weg- en Waterbouwkunde (2005). Leidraad faunavoorzieningen bij wegen.