VIABILITY OF HEDGEHOG POPULATIONS IN CENTRAL NETHERLANDS

by

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ABSTRACT

The hedgehog *Erinaceus europaeus* is a common species in the Netherlands. It is also the most frequently observed mammal traffic victim. Using the LARCH expert system hedgehog population viability in the present situation was assessed in the central part of the Netherlands. Thirty local populations, all belonging to the same network population, were found to exist in the research area. Nine of these did not meet the viability criterion. Population viability was shown to be affected, in decreasing order, by carrying capacity (area x quality), road induced density reduction and the presence of badgers. In a second analysis, the effect of the fencing in of roads was determined. Although no more animals were killed on the roads, population viability decreased dramatically. The total area inhabited by viable populations was reduced to 12% of the present situation. Therefore we do not recommend the fencing in of roads unless they are accompanied with effective wildlife passages.

Key words: badger, carrying capacity, *Erinaceus europaeus*, hedgehog, infrastructure, mitigation, population viability.

1. Introduction

The hedgehog *Erinaceus europaeus* (L., 1758) is a common species in the Netherlands (Hoekstra, 1992). It is found in nearly all survey grid cells and landscape types. At first, the species benefitted from human influence on the landscape. In forests, the original pre-human vegetation, hedgehogs occur in low densities (2-5 hedgehogs per 100 hectares). Parallel to human influence, hedgehog densities increased to about 30 animals per 100 hectares in small scale agricultural landscapes and about 80 animals per 100 hectares in suburban areas. With increasing human pressure, hedgehog densities drop. In large scale agricultural landscapes and urban centres densities of respectively 0-7 and 4-6 animals per 100 hectares are found (Huijser, 1999).

Landscapes that are preferred by hedgehogs are also frequently inhabited by badgers (Reeve, 1994). Doncaster (1992) showed badgers to be an effective hedgehog predator. The presence of badgers in an area causes much lower hedgehog densities (Doncaster, 1994; Johansen, 1995). Badgers are therefore a factor to be accounted for in hedgehog studies.

The hedgehogs' preference for suburban areas and small scale agricultural landscapes causes them to become a common traffic victim since both road density and traffic intensity are high here. In many road kill studies, hedgehogs are the most frequently found mammal species (Rodts et al., 1998).

Huijser & Bergers (1998) estimated the annual number of hedgehogs killed by traffic in the Netherlands to lie between 113,000 and 340,000. Traffic mortality was estimated at 6.1-9.0% of the population size in a study area in the central Netherlands (Huijser et al., 1997). In a 200-m wide zone, directly adjacent to a road, hedgehog densities were estimated to be 30% lower than in control zones situated at least 400 m from a road (Huij-

ser & Bergers, 1997). However, statistical significance could not be established for this difference, because of an insufficiant number of experimental plots.

Effects of hedgehog traffic mortality have been measured on the population level. It is not known, however, whether these effects are severe enough to lead to the extinction of populations on a local or even regional scale. We performed a population viability analysis to get insight into this problem. The analysis was restricted to non-urban areas. High densities of hedgehogs in suburban areas suggest there is no viability problem there. Furthermore, no knowledge exists on the relationships between (sub-)urban populations and the populations in the surrounding areas.

The analyses were conducted for the present situation and for a hypothetical situation in which fences without fauna passages prevent hedgehogs from getting on the roads. Although hedgehogs do use fauna passages (Hollander, 1993; Nieuwenhuizen & Van Apeldoorn, 1994), no knowledge is present to what extent they do so. Furthermore, Ward et al. (1997) showed that hedgehogs react strongly negative to badger odour and that hedgehogs avoid sites with badger odour. This is also thought to hold for fauna passages which are frequented by badgers (Doncaster, 1999). The effectiveness of fauna passages for hedgehogs may therefore be reduced to zero. At this moment we lack the knowledge to assess the effect of fauna passages on a population level.

2. Materials and methods

2.1. LARCH

The analyses have been conducted, using the Landscape ecological Analysis and Rules for the Configuration of Habitat (LARCH) expert system, which was developed at the DLO-Institute for Forestry and Nature Research. This system uses a set of species specific guidelines to assess local population and network population viability. A local population is defined as a spatially delimitable population in which random mating occurs. A network population is defined as a spatially structured population, divided into local populations, forming a network through dispersal movements. The first step in the analysis is to make a habitat map for the species concerned. Habitat quality and patch area define patch carrying capacity, which is the measure for local population size. Patches with a carrying capacity insufficient to sustain one reproductive unit are subsequently labelled non-habitat. Local populations are then joined into network populations based on dispersal distances and landscape characteristics such as the presence of barriers. The viability of the populations concerned is then assessed according to Verboom et al. (1997).

2.2. Study area

All analyses were based on the central part of the Netherlands. The research area is restricted in the north by Lake IJssel (IJsselmeer), in the east by the River IJssel, in the south by the river Nederrijn-Lek and in the west the research area does not extend past Amsterdam. Central Netherlands comprises of four major types of landscapes (fig. 1). The Flevo polder consists mainly of arable land. The Veluwe and the Utrechtse Heuvelrug are extensive areas of forests and heathlands. Small-scale agricultural landscapes

Fig. 1. Hedgehog habitat map of central Netherlands, based on Corine Landsat data. Note: some of the grid cells were misclassified by Corine, but the overall picture describes the current situation well enough for the purpose of our analyses.

Fig. 1. Kaart van egelhabitat in centraal Nederland, gebaseerd op het Corine bestand dat gebruik maakt van Landsat gegevens. Nb.: sommige gridcellen zijn foutief geclassificeerd door Corine. Het kaartbeeld als geheel geeft de huidige situatie echter voldoende nauwkeurig weer voor het doel van onze analyses.

are found mostly around the Veluwe. Large-scale agricultural landscapes constitute the rest. The density of the road network is especially high in the western part of the research area. The Veluwe has the lowest road density.

A digital remote-sensing database with a resolution of 500 x 500 m (25 ha), the so called Corine (made by the European Topic Centre on Land Cover, Kiruna, Sweden) data base, was used to construct a map of hedgehog habitat in central Netherlands. Of every 25 ha grid, the dominant land use category is given. In the study area the following forms of land use are reported: water, urban area, small scale agricultural, grassland, forest, arable land and heathland. All forms of land use, with the exception of water and (sub-)urban areas, were characterised in terms of habitat quality for hedgehogs based on the data in table 1. Assuming a sex ratio of 1:1 (according to Kristiansson,

Table 1. Hedgehog density in different landscape types (after Huijser, 1999). The densities were used as indicators for hedgehog habitat quality.
Tabel 1. Egeldichtheden in verschillende landschapstypen (naar Huijser, 1999). De dichtheden zijn gebruikt als indicator voor de habitatkwaliteit voor egels.

Landscape type	Hedgehog density (N / 100 ha)
Small scale agricultural	30
Large scale agricultural	not in Corine
Grassland	10
Forest	4
Arable land	2
Heathland	1

1984; Huijser, 1997), the number of reproductive units (females) is half the number of adult animals in an area.

2.3. Population boundaries

Local hedgehog populations were distinguished on the basis of three elements in the central Netherlands landscape: (1) large areas of unsuitable habitat, (2) roads and (3) water.

(1) Hedgehogs can cover large distances. Dispersal distances of over 5 km have been reported (Kristiansson, 1990). It is only in the Flevo polder that the distribution map of the hedgehog (Hoekstra, 1992) shows gaps of more than 5 km, but hedgehog traffic victims were also reported from these areas (Huijser & Bergers, 1998). We therefore assume that in central Netherlands no areas of non-habitat occur large enough to give rise to different local populations.

(2) Huijser et al. (1997) observed hedgehogs frequently crossing a busy secondary road. Therefore we do not consider this type of road to be a population boundary. However, Huijser et al. (1998), concluded that the barrier effect of roads increases as they become wider. Occasional findings of traffic victims on main roads, the widest (and busiest) type of roads in the Netherlands, indicate that sometimes hedgehogs do succeed in crossing them (Huijser et al., 1998). This implies that main roads are not absolute barriers and hedgehog populations divided by them still belong to the same network population.

(3) Large water bodies are thought to form local population boundaries because hedgehogs do not readily swim. However, anecdotical observations of swimming hedgehogs exist (Doncaster, 1992). Therefore water in the research area is not thought to function as a network boundary. The main rivers IJssel and Nederrijn-Lek were simply used to define the research area.

2.4. Analysis

The analysis was first performed on the basis of the present situation in the study area. The effect of hedgehog traffic mortality on population viability was determined by subsequently implementing a 30% reduction of population density in a 400 m wide zone along all roads in accordance with Huijser & Bergers (1997). Correcting for badger

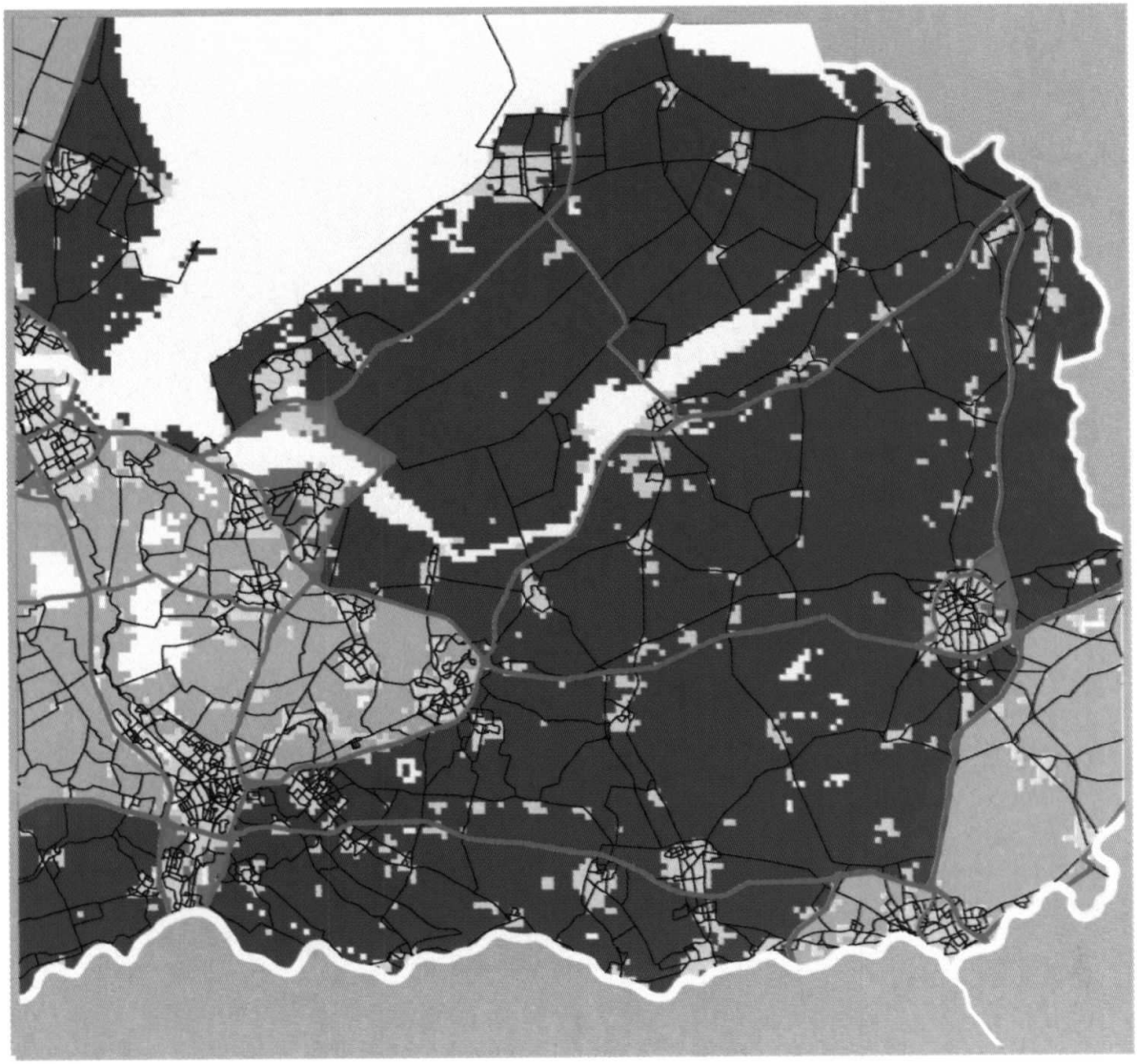

Fig. 2. Viability of local hedgehog populations in central Netherlands in the present situation.
Fig. 2. Duurzaamheid van lokale egelpopulaties in huidig centraal Nederland.

presence was the last step in the analysis of the present situation. Inhabited badger setts within the area of a hedgehog population were assumed to furthermore reduce the entire area's population density by 75% (Doncaster, 1994).

Erecting fences along all roads to prevent hedgehogs from getting killed has two opposit effects on population viability. The population density in the 400 m wide zone adjacent to the roads is no longer reduced. On the other hand, all roads become absolute barriers. This causes the network population to desintegrate. Every population enclosed by roads now becoming effectively isolated.

3. Results

Without roads (and the dams on which the roads to the Flevo polder are build) in the study area there would only be one hedgehog network population consisting of two very large local populations. The network populations and the two local populations would

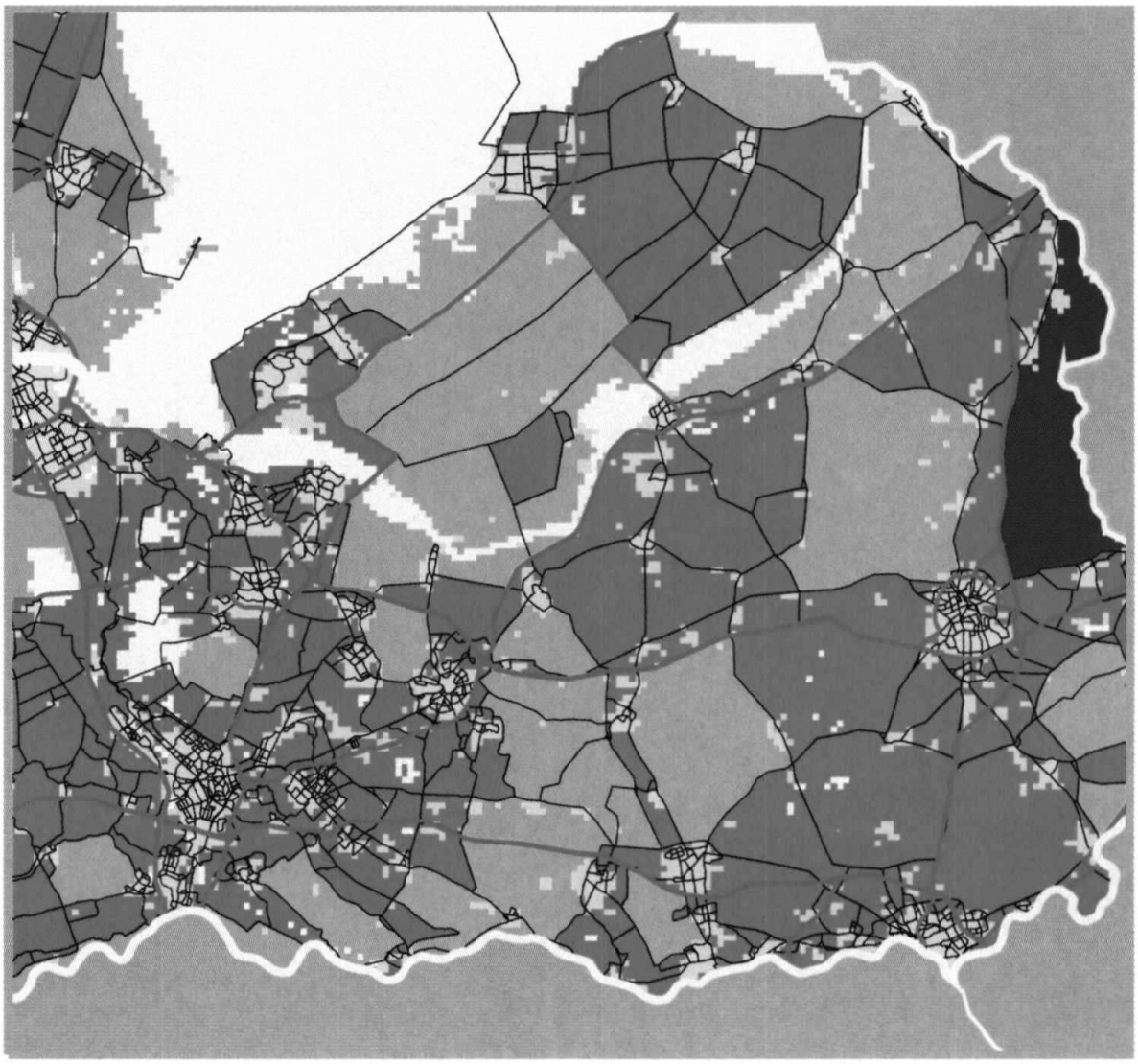

Fig. 3. Viability of local hedgehog populations in central Netherlands assuming impermeable fences are erected along all roads.
Fig. 3. Duurzaamheid van lokale egelpopulaties in centraal Nederland, na uitrasteren van alle wegen.

be strongly viable. It is highly unlikely, however, that a situation without roads will occur in the Netherlands in the near future. This situation is mentioned here because it enables us to determine the effect of patch carrying capacity. In the present situation in

Table 2. The number of viable local hedgehog populations in central Netherlands when accounting for the cumulative effects of carrying capacity (1), roads (2) and badgers (3).
Tabel 2. Het aantal duurzame lokale egelpopulaties in centraal Nederland, rekening houdend met de cumulatieve effecten van draagkracht (1), wegen (2) en dassen (3).

viability	(1)	(1+2)	(1+2+3)
not viable	6	9	9
viable	7	9	10
strongly viable6	17	12	11

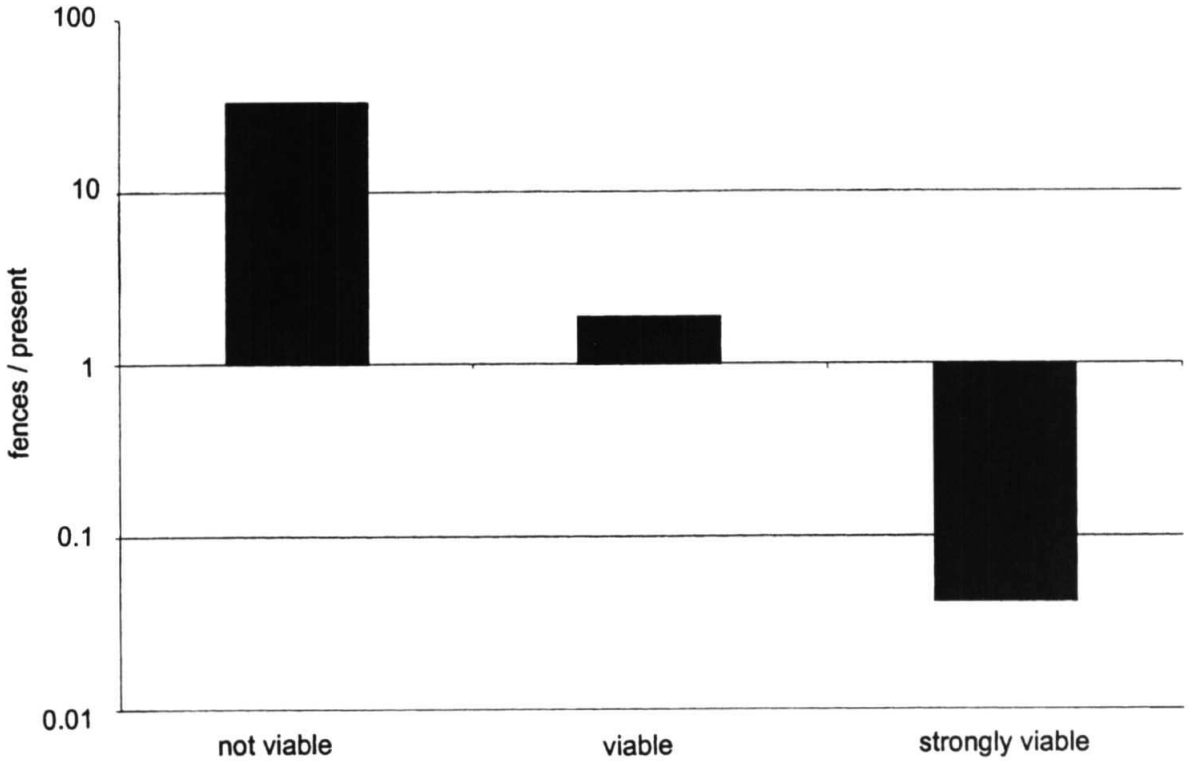

Fig. 4. Relative change in area occupied by the three classes of viability of local hedgehog populations in central Netherlands when roads are fenced in.
Fig. 4. Relatieve verandering in de oppervlakten die ingenomen worden door lokale egelpopulaties van de drie onderscheiden duurzaamheidscategorieën, na uitrastering van de wegen in centraal Nederland.

the central Netherlands there is only one strongly viable hedgehog network population left. This network population is divided into 30 local hedgehog populations by the main roads in the study area (fig. 2). Of these 30 local populations, six are not viable, seven are viable and 17 local populations are strongly viable. Carrying capacity clearly has an effect on local population viability (table 2).

The effect of roads on population viability, other than by dividing populations, was subsequently assessed. A 30% reduction of population densities in a 400 m wide zone directly along all roads caused three viable populations to become not viable and five strongly viable populations to become viable (table 2).

The last factor determining population viability in the present situation is the presence of inhabited badger setts. Correcting for this factor caused one strongly viable population to become viable (table 2).

In the present situation, according to the analysis with the LARCH expert system, nine local populations are not viable, ten are viable and eleven are strongly viable. The main factor determining population viability seems to be the patch carrying capacity.

Fencing in all roads in the research area causes the hedgehog network population to desintegrate. The local populations, which were linked together by dispersing animals, now become completely isolated. As a result a dramatic decline in hedgehog population viability occurs (fig. 3). Only one population still is strongly viable. This population inhabits a large patch of good quality habitat. The majority of populations are not vi-

able. The total area of viable populations after fencing in the roads is only 12 % of the total area of viable populations in the present situation (fig. 4).

4. Discussion

4.1. Representability

The LARCH expert system results should be interpreted in relative terms. Not too much attention should be given to details or absolute figures. Furthermore, the quality of the input data strongly influences the quality of the results, as in any model. We think the guidelines and data that were used were sufficient for the purpose of the analyses performed. Still, improvements could be made, especially concerning the habitat map and the data used for assessing habitat carrying capacity. These two-habitat quality related factors have the greatest relative effect on the results.

Not including the urban areas is a probable shortcoming in the analyses. The populations in these areas could well act as source populations for the surrounding areas. This implies that the present situation in the analyses of this paper probably depicts an image that is worse then it is in reality.

Despite the above-mentioned shortcomings, the analysis clearly shows traffic and roads do not seriously threaten hedgehogs in central Netherlands. The main reason for this is the abundant presence of suitable habitat for this generalist species.

4.2. Local extinctions?

The analysis of the present situation shows a negative effect of traffic mortality on hedgehog population viability. This effect is only apparent in relatively small local populations. Reichholf (1983) presented monitoring data on hedgehog traffic victims in ten small villages and five larger ones in southern Germany. The absence of traffic victims was not randomly distributed over the ten small villages (Chi-square, two sided test, $p < 0.001$). In five of the small villages sometimes no traffic victims were found during an entire year. In all of these five small villages there was at least one period of two consecutive years without any observations of hedgehog road kills. In the larger places this phenomenon was not observed. Although there is no proof for true extinctions, Reichholf's study does indicate that small hedgehog populations in isolated areas may get close to extinction, or have indeed gone extinct, presumably as a result of traffic mortality.

Furthermore, the analysis of the present situation shows that the badger population inhabiting the Veluwe also has a local effect on hedgehog population viability. Again, this effect concerned a population inhabiting a small area with a high road density. This result indicates that local extinction of small hedgehog populations could be brought forward by badgers. There are some observations in support of this (e.g., Johansen, 1995).

4.3. Fencing and fauna passages

Fencing in all roads caused disintegration of the network population into small, iso-

lated populations and resulted in a dramatic decrease of population viability. Given the fact that those hedgehog populations were well capable of sustaining high traffic mortality, this measure is not recommended. In the Netherlands many roads with fences are also equipped with fauna passages. These passages are used by a wide variety of species, including hedgehogs (e.g., Brandjes et al., 1999; Nieuwenhuizen & Van Apeldoorn, 1994). However, little knowledge exists on the effect of fauna passages on population parameters. This is a second reason to be reserved towards erecting fences along roads, even if they are accompanied by fauna passages.

Hedgehogs can sustain high mortality levels because of their high reproductive capacity. Badgers, on the other hand, are far less capable of compensating this mortality factor because of their much smaller number of young produced annually. Badgers have also been shown to readily use fauna passages. This implies local badger populations are not cut in two by roads when passages are present. Fences, in combination with fauna passages have proven to be a very successful measure for badgers.

Our analyses, on the other hand, have shown that preventing mortality by fences alone, can be more negative on a population level than not doing so. It is therefore imperative that the fauna passages do succeed in eliminating the barrier effect of a fence. The negative influence of badgers on hedgehogs demonstrates the desirability of providing every fence with several fauna passages, or at least one very wide (at least several meters) fauna passage.

4.4. Ecological barriers

Preventing traffic mortality can also be accomplished by creating ecological barriers in stead of erecting fences or other physical barriers. Ecological barriers designed specifically for hedgehogs could well need less maintenance, and may not act as a barrier for that many other species. Huijser et al. (1998) provided an example of situating large-scale arable land along roads that would act as an ecological barrier for hedgehogs. The dimensions of these barriers should be carefully chosen. They should comprise enough non-habitats (in this case large-scale arable land) to considerably reduce the fraction of animals that cross it. On the other hand they should be as small as possible since populations will become smaller as the amount of suitable habitat decreases. Our analyses showed that the amount and quality of habitat have the greatest influence on population viability. The reduction of traffic induced mortality should be weighed against the loss of habitat in establishing optimal width for ecological barriers.

Finally, the many hedgehog corpses on the roads in the Netherlands are not a pleasant sight. They continuously remind us of the consequences of satisfying human demand for mobility. Preventing hedgehogs from getting killed on roads is a costly operation in terms of construction and maintenance of fences, other barriers and wildlife passages. If we choose to follow this path, it will be primarily because we do not like to be confronted with the consequences of our actions. From an ecological point of view these measures are not necessary, at least not for the hedgehog. A measure like the recently introduced reduction of speed limits within build-up areas in the Netherlands might save more hedgehogs than ever could be done by fencing in roads in the country-side. It would be interesting to assess the effect on hedgehog mortality rates of a reduction of speed limits. Saving hedgehogs by reducing speed limits might appeal to the

general public. This would help the implementation of speed reduction, which is undoubtedly a good thing both for our environment and for nature in general.

ACKNOWLEDGEMENTS

Marcel Huijser provided us with all relevant data presented at the hedgehog workshop in Utrecht. Three anonymous referees greatly improved our manuscript.

SAMENVATTING

Duurzaam van egelpopulaties in Midden-Nederland

De egel komt algemeen voor in Nederland en is tevens het meest talrijke verkeersslachtoffer onder de zoogdieren. Jaarlijks sterven 113.000-340.000 egels op de Nederlandse wegen. In de nabijheid van wegen is een, zij het net niet significant, lagere egeldichtheid gemeten. Het is echter niet bekend of de effecten op populatieniveau groot genoeg zijn om te leiden tot het uitsterven van lokale, of zelfs regionale populaties. Een duurzaamheidsanalyse met het expertsysteem LARCH is uitgevoerd om hier zicht op te krijgen. Deze analyse is uitgevoerd voor de huidige situatie en voor een situatie waarin hekken voorkomen dat egels op de weg kunnen komen. In de huidige situatie is egelhabitat getypeerd op basis van bestaande onderzoeksgegevens. Verder werd gebruik gemaakt van het Corine bestand dat gebaseerd is op Landsat beelden. De invloed van wegen op egelpopulaties is gesteld op een dichtheidsafname van 30% in een 400 m brede zone aan weerszijden van alle wegen. Tot slot is ook rekening gehouden met de aanwezigheid van dassen in een gebied omdat dassen egels prederen en egels dassengebied mijden. In het scenario waarin alle wegen werden uitgerasterd, is geen rekening gehouden met de aanwezigheid van eventuele faunapassages. De kennis over het functioneren van deze voorzieningen op populatieniveau is hiervoor ontoereikend.

In het centrale deel van Nederland zijn 30 lokale egelpopulaties onderscheiden, die allen tot dezelfde netwerkpopulatie behoren. Negen van deze lokale populaties zijn niet duurzaam. In afnemende volgorde van belang bleek duurzaamheid vooral afhankelijk te zijn van de draagkracht van het gebied, de invloed van de wegen en de aanwezigheid van dassen. Uitrasteren van alle wegen leidde tot een sterke afname van de duurzaamheid. Slechts 12% van de oppervlakte die in de huidige situatie bezet is met duurzame populaties, is nog duurzaam nadat alle wegen uitgerasterd zijn.

Het voorkomen van de egel in Nederland wordt niet bedreigd door verkeerssterfte. Alleen kleine populaties kunnen uitsterven door deze factor. Het uitrasteren van wegen is voor het voortbestaan van deze soort dan ook niet nodig. Mocht dit om andere redenen toch overwogen worden, dan is het sterk aan te raden om de rasters ook te voorzien van faunapassages. Om te voorkomen dat deze passages niet of weinig gebruikt worden doordat daar ook dassen over- of doorheen lopen, is het raadzaam om zo veel mogelijk of zo breed mogelijke passages aan te leggen. Het aantal egelslachtoffers op de wegen zou echter ook verminderd kunnen worden door de zone langs de weg egel onvriendelijk in te richten. Ook het verlagen van de maximum snelheid is een interessante optie om het aantal doodgereden egels te verminderen.

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